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

Technology Descriptions
Volume VII 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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Rocky Mountain Arsenal

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DIRECTORY

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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 Technology Description Volume is intended to provide detailed descriptions of all technologies that are part of any of the alternatives considered in the Detailed Analysis of Alternatives (DAA). The volume is divided into sections according to general response action categories and technology types, and each technology type is represented by its selected representative process option (RPO). The technology descriptions address all media to which the technologies apply, e.g., direct thermal treatment is described both as it applies to the soil and structures media. It should be noted that the descriptions in this document generally represent only one aspect of a complete alternative that entails several technologies.

Each technology description provides an overview of a treatment process and summarizes which media and contaminants are treated by the process. Process performance is discussed in the document based on the limitations and effectiveness of the technologies. Studies from other sites are compared with Rocky Mountain Arsenal (RMA) conditions, and RMA-specific treatability studies are discussed. Literature reviews and cost data are presented in summary form in tables. The level of detail may vary between sections, depending on the level of development and experience pertaining to the particular technology. Detailed information about equipment needs, pre- and posttreatment requirements, and sidestreams generated is also provided, as are summaries of capital and operations and maintenance (O&M) costs for expected applications and brief discussions of applicable or relevant and appropriate requirements (ARARs). Detailed listings of the action-specific ARARs and information to-be-considered can be found in Appendix A.

Section 2

2.0 NO ACTION/CONTINUED EXISTING ACTION

The No Action General Response Action Category is the baseline from which all remedial alternatives evaluated in the feasibility study (FS) process are measured. U.S. Environmental Protection Agency (EPA) guidance (OERR-EPA 1988) dictates that a No Action alternative be developed and evaluated throughout the FS process. This alternative is normally established as the "do nothing" alternative, in which the site or operable unit is left in its existing condition. At many sites, including RMA, the No Action alternative may include previous cleanup or mitigation actions or current ongoing actions. For RMA, two alternatives were developed for this category: No Action and Continued Existing Action. The following sections will describe these alternatives in detail.

2.1 THE NO ACTION ALTERNATIVE

As required by OERR-EPA guidance (1988), the No Action alternative represents current site conditions with no remedial actions undertaken. However, baseline conditions may differ from site to site within RMA based on the planned, ongoing, or completed interim response actions (IRAs) at a particular site.

2.1.1 No Action Alternative for the Soil Medium

The No Action alternative for soil requires the U.S. Army (Army) to take no further action at a particular site. The level of protectiveness at the site is determined solely by the current conditions at the site (or, if an IRA is planned or ongoing, conditions upon its completion). For example, the No Action alternative for the surficial soil sites (the 0-inch to 6-inch depth interval) does not include any remedial activities, while the No Action alternative for the Basin F Wastepile site includes maintenance activities and inspections of the composite liner and cap currently in place. The No Action alternative for many sites requires no long-term or recurring maintenance. If remedial action has been completed through an IRA, however, the site may require continued leachate collection and treatment, cap maintenance, plowing, revegetation, or mowing. Currently, the No Action alternative would require some form of inspection or maintenance for the following sites: Basin F Wastepile, the Shell Trenches, Former Basin F, and the Lime Basins.

The No Action alternative for soil includes annual monitoring of contaminant levels in soil for all medium groups except the Disposal Trenches, Munitions Testing and Agent Storage Medium Groups. In addition, annual groundwater sampling is included for Medium Groups with human health exceedances to evaluate the potential for groundwater quality impacts. Included in the cost of the No Action alternative for soil is the cost of performing 5-year reviews for 30 years following the Record of Decision (ROD). These 5-year reviews, as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), include a site assessment and review of the ROD. These costs are built into all RMA soil alternatives.

2.1.2 No Action Alternative for the Water Medium

The No Action alternative is significantly different for the water medium at RMA than for either the structures or soil media because extensive, continuous remediation systems are currently capturing and treating RMA groundwater plumes. Continued operation of these systems is being considered in the DAA, however, as continued existing action alternatives. For the purpose of complying with the National Contingency Plan (NCP; EPA 1990) in evaluating a true No Action alternative, the No Action alternative for water requires the termination of existing groundwater treatment systems and the restoration of the original flow pathways prior to the commencement of current operating systems. Costs for the No Action alternative for the water medium, therefore, include shutting down the extraction wells and breaching the slurry walls currently in place so that groundwater could resume its natural flow. Well abandonment, treatment plant dismantling, and long-term, on-post groundwater monitoring were not estimated for each individual plume group due to the applicability of the costs to all alternatives. Treatment plant dismantling is considered under the Structures FS (Foster Wheeler Environmental 1995).

2.1.3 No Action Alternative for the Structures Medium

The No Action alternative for structures encompasses no physical activities for structures. The structures are allowed to deteriorate naturally and, following collapse, are left as is. No attempt to restrict entry with the use of locks, boards, signs, or fences is performed, and physical and chemical hazards within the structures are accessible to wildlife and humans. Asbestos and polychlorinated biphenyl PCB abatement is handled by the Army outside of the CERCLA process and is not to be identified in the ROD. If structures are impeding the remediation of the underlying soil, then the No Action alternative is not to be selected for that area.

2.2 THE BOUNDARY SYSTEMS ONLY AND CONTINUED EXISTING ACTION ALTERNATIVES FOR THE WATER MEDIUM

The Boundary Systems Only and Continued Existing Action alternatives were developed for the water medium to account for the extensive amount of remediation already ongoing for RMA groundwater plumes. The Army and Shell constructed groundwater containment and treatment systems in the 1980s to ensure that water leaving RMA was within specified regulatory or health-based standards. These boundary systems, the North Boundary Containment System (NBCS), the Northwest Boundary Containment and Treatment System (NWBCS), and the Irondale Containment System (ICS), operate continuously using granular activated carbon (GAC) adsorption to remove contaminants from the groundwater, and reinjecting the treated water at the RMA boundary.

Several internal systems have also been constructed to capture and treat groundwater. These systems include the Basin A Neck IRA, the Basin F Groundwater IRA, and the Motorpool/Rail Yard IRA. The CERCLA Wastewater Treatment Plant, designed to treat water generated through remedial activities and well testing, does not treat groundwater related to an IRA. This system is included in several alternatives evaluated in the DAA.

2.2.1 The Boundary Systems Only Alternative

This alternative consists of continued operation of the three boundary systems (NBCS, NWBCS, and ICS) but termination of the on-post groundwater IRA systems (Basin A Neck, Basin F groundwater, and Motorpool/Railyard). The CERCLA plant would continue to operate.

2.2.2 The Continued Existing Action Alternative

This alternative includes continued operation of the boundary systems and on-post groundwater IRA systems. All aspects of the Continued Existing Action alternative are also included in all on-post treatment alternatives evaluated in the DAA (Foster Wheeler Environmental 1995).

The Continued Existing Action alternative also includes all known or planned upgrades and modifications to the existing systems, although it does not include any modification to address increased contaminant loading or increased flow rates resulting from other capture/treatment alternatives.

REFERENCES

EPA (U.S. Environmental Protection Agency)
1990 (March 8) National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300 (Federal Register 55(46): 8666-8865). (NCP).

OERR-EPA (Office of Emergency and Remedial Response, EPA)
1988 (October) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. OSWER Directive 9355.3-01. EPA/540/G-89/004.

Foster Wheeler Environmental (Foster Wheeler Environmental Corporation)
1995 (October) Final Detailed Analysis of Alternatives Report. Version 4.0, 7 v.

Section 3

3.0 INSTITUTIONAL CONTROLS

The Institutional Controls General Response Action Category is often considered the minimal or limited action alternative for CERCLA response, providing risk reduction through administrative actions or through exposure pathway restrictions. Administrative actions may include deed restrictions, public education, land-use restrictions, and long-term environmental monitoring to measure potential contaminant mobility and natural attenuation. Exposure pathways can be interrupted by using fencing to restrict site access, by excluding biota from sites using physical barriers (e.g., crushed concrete or cobble layers, *Agropyron cristatum* and *Elytrigia intermedia* grasses), and by implementing health and safety protection for workers on site.

Institutional controls may be appropriate for sites where the potential for exposure is minimal, allowing finite remediation resources to be used for more contaminated or threatening areas. For example, plugging the sewer pipes and initiating restrictions on digging may be adequate institutional controls to address contamination in soil along sewer lines where relatively low levels of contamination are found at depths greater than six feet and are covered by clean soil. Institutional controls, however, may also be selected for highly contaminated sites where the risks to workers or the community during remediation would be high and would exceed the risks currently present at the site. In this case, institutional controls could include fencing the site and restricting access to prevent exposure.

Institutional controls may be included as components of other types of alternatives. For example, if a site is remediated through containment or treatment, institutional controls such as monitoring or site access restrictions may be implemented during and after the site is remediated. Costs of implementing these institutional controls are, however, included in the overall cost of the containment and treatment alternatives. Due to the NCP's preference for permanent reduction of contaminant toxicity, mobility, and volume (TMV), the Institutional Controls alternative is evaluated as less desirable than treatment or containment alternatives (EPA 1990a).

The Army conducts its CERCLA program at RMA under the direction of a Federal Facility Agreement (FFA). The FFA for RMA, signed in 1989 by the Army, EPA, Shell Oil Company, U.S. Department of Interior, U.S. Department of Justice, and the Agency for Toxic Substances and Disease Registry (ATSDR), dictates the participation of all signatories and the responsibilities of each party (EPA et al. 1989). The FFA also includes land- and resource-use restrictions that will be incorporated into all future actions undertaken at RMA. These restrictions prohibit the following:

- Residential development
- Use of groundwater or surface water as a source of potable water
- Consumption of all fish and game
- Agriculture, excluding erosion control or restoration following remedial actions

In accordance with the FFA, additional land-use restrictions cannot be unilaterally imposed by the U.S. government but require the review and approval of the parties that signed the FFA as an amendment to the Technical Program Plan or as a component of the ROD (as an institutional control alternative) for the on-post operable unit of RMA. As specified in the FFA, the United States will retain the title to RMA and could assume the long-term responsibility of implementing and enforcing institutional controls, so deed restrictions would not apply if the land does not transfer ownership. Appendix A presents other applicable action-specific ARARs.

Because the FFA restrictions are in place, the Institutional Controls alternatives for all three contaminated media describe items or actions in addition to the FFA. Because of the differing nature of the three media at RMA, the Institutional Controls alternative presents differing scenarios for each medium. The Water FS (Foster Wheeler Environmental 1995), for example, did not select the Institutional Controls alternative for on-post groundwater plumes because of the restrictions already in place through the FFA and the inapplicability of ARARs to on-post groundwater.

3.1 PROCESS DESCRIPTION

A number of Institutional Controls alternatives for RMA soil may be developed based on the potential for exposure by human and biota receptors. Institutional Controls for soil include use restrictions, access restrictions, public education programs, habitat modification, and environmental monitoring and site reviews (Table 3.1-1). Based on the exceedance at the site and the depths of contamination, a combination of these elements may apply to a particular medium group. For example, if the site is an exceedance only to biota, then monitoring, habitat modification, or exclusion of biota may be selected, and, if the site is a risk to human health, then additional access restrictions may be required. Institutional controls alternatives for the soil medium attempt to mitigate the exposure pathway for contaminants through methods that do not reduce TMV. Institutional Controls alternatives for certain sites where the threat of explosive material or Army agents exist were developed to provide alternatives that reduce risk to workers and the community and at the same time meet soil remedial action objectives through pathway elimination.

Institutional controls for structures include exclusion techniques for both biota and humans. Because of existing regulations regarding the abandonment of structures, institutional controls only include actions taken to exclude entrance into structures where there is potential for exposure to contaminants. These exclusion techniques include the use of locks, boards, fences, and signs as the primary attempt to restrict access. In the process of restricting access, additional repairs may be required to close up holes in structures or foundations; such repairs are included in the costs of the Institutional Controls alternative. These institutionally controlled structures require continual long-term maintenance to ensure that building deterioration does not allow access.

3.1.1 Access Restrictions

Locks, boards, fences, and signs are institutional controls designed to protect human health and the environment by preventing access to a structure. Implementation of institutional controls requires materials and labor to accomplish the task and is an inexpensive but impermanent solution.

Fencing to limit human access to a soil site or structure consists of a 6-foot (ft)-high chain-link fence topped by three strands of barbed wire and located around the 10-ft buffer zone of a site. Warning signs are posted every 200 ft along the fence to inform the public of potential hazards. Gates to allow pedestrian or vehicle entry would be included as appropriate.

Measures to exclude biota include fencing to limit entry, a cobble barrier layer to deter burrowing, or a visual barrier of *Agropyron cristatum* and *Elytrigia intermedia* grasses seeded in a 80-ft to 120-ft swath to prevent migration of rodents into a contaminated site. The cobble barriers are more costly and less effective than the visual barriers for deterring rodents. Except for small areas, biota exclusion is not effective in preventing birds from accessing the site because top as well as side closure is required.

3.1.2 Public Education

Public education includes producing informational exhibits, videos, and fact sheets for distribution at the visitors' center to stress the importance of respecting access restrictions to contaminated sites and to explain the potential risks of contaminant exposure. Other potential community education activities include open houses or site tours, public notices and meetings, and news releases or news conferences.

3.1.3 Pre- and Post-treatment Requirements

Pre-treatment requirements for institutional controls are limited. Prior to constructing a fence or modifying the habitat through revegetation, any remedial actions such as principal threats treatment that require access or disturb the area should be completed. Air monitoring may also be conducted prior to implementation of institutional controls to allow for the appropriate selection of personal protective equipment (PPE) for workers implementing the controls.

Post-treatment requirements include the long-term maintenance of fences and vegetation to perpetuate the effectiveness of access restrictions and controls. Soil monitoring and groundwater compliance monitoring are also conducted over the long term to monitor natural contaminant degradation/attenuation and potential migration of contaminants. Because contaminants remain on site, site reviews are conducted every 5 years, and, if justified, institutional controls can be abandoned in favor of removing or treating wastes.

3.1.4 Sidestream Generation

No sidestreams should be generated by institutional controls. However, if the control options are breached in some manner, contaminant release could likely occur.

3.1.5 Results From Other Sites

Final action RODs reviewed from fiscal year 1990 show that 56 out of 70 sites with contaminant concentrations above health-based levels used institutional controls for short-term impacts or engineering control supplements and that none used institutional controls as the primary remedy (EPA 1991).

3.2 PROCESS PERFORMANCE

3.2.1 Effectiveness

Implementation of institutional controls will not result in risks to the general public. Workers may be required to use PPE during these activities to prevent potential exposure to contaminants. Environmental impacts from this alternative are minimal, although wildlife access to fenced areas is restricted, an effect that may be desirable in implementing institutional controls for contaminated areas.

Fencing is a proven method of limiting site access and, along with other institutional control measures, reduces the potential for exposure to contaminants. Fencing and other institutional controls do not preclude the possibility of trespassers entering the site and potentially suffering exposure. Routine inspection and repair are required to maintain the effectiveness of the fence. Long-term monitoring would measure potential migration of contaminants at the site.

The technologies involved in Institutional Controls alternatives are demonstrated, readily available, and easily implementable. Soil and groundwater sampling measures potential contaminant mobility and natural attenuation at sites making use of institutional control measures and monitors their effectiveness. If future remedial actions are found to be necessary, institutional controls do not preclude or interfere with their implementation.

3.2.2 Limitations

EPA guidance states that institutional controls may not be substituted as the sole remedy for active response measures unless such active measures are determined not to be practicable (EPA 1990b). However, institutional controls should be included for mitigation of short-term impacts or as a supplement to engineering controls at a site (EPA 1991). Additionally, institutional controls may provide adequate protection for sites with very low-level risks.

Contaminants are left in place under this alternative, so the magnitude of residual risk is unchanged, contaminant TMV is not reduced, and principal threats at a site are not addressed.

Moreover, because implementation of institutional controls does not reduce contamination, the human or biota preliminary remediation goals are not met. Protection of human health and the environment relies upon restricted site access to reduce the potential for exposure; however, this alternative cannot totally preclude access by trespassers.

3.2.3 Cost Summary

The base cost for purchase and installation of a 6-ft-high fence constructed of aluminized, 6-gauge chain-link steel topped by three strands of barbed wire, along with warning signs is estimated to be $15.90 per linear foot (/LF) (Means 1994). The costs for room closure through use of locks/boards were estimated at $1.88/SF, assuming that 25 percent of the surface area is affected. Table 3.2-1 presents a summary of capital and O&M costs.

REFERENCES

EPA (Environmental Protection Agency)

1991 Fiscal Year 1991 Record of Decision Forum.

1990a (March 8) National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300 (Federal Register 55(46): 8666-8865). (NCP)

1990b Fiscal Year 1990 Record of Decision Forum.

EPA et al.

1989 (February) Federal Facility Agreement for the Rocky Mountain Arsenal. RTIC 89068R01. (FFA)

EBASCO (Ebasco Services Incorporated)

1992 (December) Final On-Post Feasibility Study, Development and Screening of Alternatives. Prepared for the Program Manager for Rocky Mountain Arsenal. Version 4.1, 7 v. RTIC 92363R01.

Foster Wheeler Environmental Corporation

1995 (October) Final Detailed Analysis of Alternatives Report. Version 4.0, 7 v.

Means (R.S. Means Company, Inc.)

1994 Means Heavy Construction Cost Data, 8th ed.

Institutional Control	Description
5-Year Site Review	Every 5 years data are compiled from monitoring activities to evaluate the current status of the site.
Environmental Monitoring	Annual groundwater, air, biota, and soil monitoring may be performed to evaluate the changing status of the site.
Public Education	Forms of educating the public include, but are not limited to, informational pamphlets, brochures, and videos. Site visits and tours may include interacting with the news media and presenting seminars.
Access Restrictions	This control consists of fencing the perimeter of a site to adequately prevent terrestrial, biota, and human access. Bilingual signs of appropriate dimensions and letter size will be posted on the fence at 200 ft spacing. In addition to fences with locked gates, sites with structures could include window and door seals, frame covers, wall covers, or locks. Boards could be used to limit access through doors and windows. Sewers can be plugged by pumping in cement and posting signs to warn against digging.
Use Restrictions	In addition to those defined in the FFA, restrictions could be imposed on particular contaminated areas to prohibit public access or intrusive activities.
Habitat Modification	Areas can be revegetated with a mix of grasses such as wheatgrass to discourage habitat use by biota.

Expenditure	Amount
Direct Costs	Unit Cost ($)
6-ft-high chain-link fence topped by three strands of barbed wire, with warning signs	15.90/LF[1]
Lock/boards	1.88/SF[2]
Public education program	1,700
Habitat modification	0.18/SY
Sewer plugging	150
Annual O&M	
Habitat maintenance	0.01/SY per yr
Fence maintenance	0.079/LF per yr
Lock/board maintenance	0.19/SF per yr
Public information	570/yr
5-year review (30 yrs)	2,700/review

1 Means 1994
2 EBASCO 1992

Section 4

4.0 EXCAVATION, DEMOLITION, AND TRANSPORTATION

This section details the process options of excavation, demolition, and transportation as follows: Section 4.1 describes excavation and handling of contaminated soil; Section 4.2 describes the processes available for demolition of the various structures, tanks, and piping present at RMA, which is applicable to the structures medium groups; and Section 4.3 describes transportation methods that are applicable to the structures, soil, and water medium groups. Section 4.4 describes various controls that can be implemented to control volatile organic vapors and odors.

4.1 EXCAVATION

Excavation is the removal of soil, debris, drums, pipes, tanks, or any other solid material from the ground. The following discussion provides a general description of conventional excavation equipment and discusses RMA-specific applications, including costs. Examples of conventional excavation equipment are bulldozers, backhoes, clamshells, drag lines, front-end loaders, and scrapers.

4.1.1 Process Description

In order to determine the best method for excavation, the equipment must not only be evaluated according to site conditions but also according to what is required of the equipment and how it is used. Four removal scenarios being considered in the DAA include the following: (1) excavate, load, haul, dump, and compact the solid material in an on-post disposal area and fill the excavation with clean backfill; (2) excavate, load, and haul the solid material to an off-post treatment facility and fill the excavated area with clean backfill; (3) excavate, load, and haul the solid material to an on-post treatment facility, return treated material to backfill the excavated area, and compact; and (4) excavate, load, and haul borrow soil to backfill and revegetate the sites.

The three most common combinations of equipment for excavation and transport of soil are a scraper teamed with a bulldozer, a front-end loader teamed with a bulldozer and trucks for transport, and a backhoe teamed with trucks for transport. A drag line, clamshell, floating dredge, or lake drainage techniques may be used specifically in areas where dredging is needed. A power shovel may be employed in areas where high, steep faces are being excavated. During remediation, the equipment used for excavation may change depending on site-specific conditions or changes in the size of the excavation. For all excavation processes, the stability of both cut and fill earth slopes is of paramount importance for worker safety. If workers are required to enter a trench deeper than 5 ft, it must be shored or shielded. Larger excavations must be sloped back or benched to protect workers and equipment. Most RMA excavations are to be no deeper than 10 ft.

Table 4.1-1 describes the applicability of excavation equipment to the soil medium groups/subgroups based on current understanding of site conditions. The contaminated sites may be fully excavated, or just the principal threat volumes may be excavated. Backfilling and reclamation is required following excavation. The selected alternative therefore affects the combination of excavation equipment required. The following subsections describe several different types of excavation equipment and their applicability to the various soil medium groups.

Additional process requirements for excavation may include dust suppression, control of air emissions, dewatering, or removal of debris or unexploded ordnance (UXO). Dust suppression may be required during excavation of sites where dry, fine-grained material exists. This may be accomplished with a water truck or by spraying a dust suppression compound on the soil. Air monitoring performed at the site will indicate whether dust suppression is required.

Some excavation sites may require the use of containment structures to control air emissions (Section 4.1.1.5). The types of emissions requiring control include volatile organic compounds (VOCs), contaminated fugitive dust, and particulates or noxious odors. The structures confine the emissions as an air pollution control system continuously removes contaminants from the air space. The control system is designed to maintain contaminants at a level that does not require Level A PPE and is designed to prevent the use of Level B PPE by workers within the structures.

Dewatering may be required in areas where the water table rises above the depth of the excavation. Excavation in parts of the Basin A and South Plants areas may require dewatering. Extraction wells are most likely to be used for dewatering purposes. The wells are designed to achieve maximum drawdown, but the exact number and placement depends on site-specific conditions determined during the design phases. If wells do not sufficiently dewater the excavation area, dewatering trenches or vertical barriers such as sheet piling may be required.

Some sites may require removal of debris or UXO before excavation can begin. Debris or UXO is removed using construction equipment such as backhoes, bulldozers, or front-end loaders. If UXO is present, special equipment (e.g., remote-controlled equipment) may be used to ensure the safety of the workers. The site is excavated and the soil is sifted to extract any UXO or debris. Once the UXO has been separated from the soil, it is shipped off post to be demilitarized by specially trained personnel. Section 9.0 describes in detail how UXO is removed and demilitarized.

4.1.1.1 Scrapers and Bulldozers

Scrapers can load, haul, and discharge material and are a compromise between the best loading and hauling machines. Scrapers may be pulled by crawler or wheel-mounted tractors or they may be propelled by single or twin engines. Scrapers may consist of one-bowl or two-bowl tandem units and may or may not have elevating scrapers. Scrapers can scrape up or deposit an uniformly thick layer of soil. They are very useful for excavating and regrading large areas at a shallow depth (2 ft to 10 ft, assuming there is no debris). Scrapers may be used in areas above the water table and in areas that have been cleared for UXO.

Bulldozers may be crawler-mounted tractors or wheel-mounted tractors. Choosing the type of tractor depends on the size of the project, site conditions, and the type of excavation that is required. Bulldozers are primarily used for clearing, rough grading, and stockpiling; they can also be used in combination with front-end loaders to push the dirt into piles for front-end loaders to place in trucks or haulers. Bulldozers may also aid scrapers in loading hard soil by pushing the scraper. However, the scrapers' blades will require frequent replacement. A bulldozer may be used for the final scraping because it is able to scrape to a more exact depth. Various blades and attachments are available to suit site-specific requirements.

A scraper will not perform well in muddy conditions or in extremely hard soil unless the soil has been previously ripped by a bulldozer, nor will it perform well in areas containing debris.

Based on the preceding discussion, a scraper and bulldozer may be used effectively and efficiently for excavating select portions of the following soil medium groups: Basin A, Secondary Basins, Lime Basins, Munitions Testing, and Surficial Soil. More specifically, scrapers may be used in these areas above the water table, outside of trenches, and where no debris or possible UXO exists. In Basin A subgroup alternatives, a scraper and bulldozer combination exposes large surface areas, possibly causing volatilization of contaminants and air emission problems as well as water infiltration into the construction site. The water table is relatively deep below the Secondary Basins and Surficial Soil Medium Groups and would not interfere with the excavation operation. Debris may be a problem for scrapers in these areas, as would be the haul distance required (as a general rule, a scraper is most efficient for haul distances of less than approximately 1,500 ft). Hauling must also be performed along controlled haul roads because scrapers tend to spill some material. Scrapers are best suited for excavation depths of 2 ft to 10 ft over large areas such as surficial soil sites.

4.1.1.2 Front-End Loader, Bulldozer, and Trucks

Front-end loaders are best suited for loading trucks or feed hoppers from stockpiles but may be used to excavate, load, or even haul material a very short distance. Front-end loaders may use crawler- or wheel-mounted tractors. Because of their large buckets, these units can excavate and load a large volume of material at one time. The front-end loader is best suited for excavating soil above the water table because the tractor must enter the excavation. Large, wheel-mounted, front-end loaders are articulated to provide more maneuverability. Small front-end loaders have front-wheel steering, and very small front-end loaders, such as a Bobcat, are skid steered.

The hydraulic- or cable-controlled power shovel on the front-end loader, used to excavate large, steep faces and to minimize volatilization and exposed surface area, excavates in the direction opposite of a backhoe: the dipper or shovel is pushed against the face of the excavation and material is forced into the shovel. It has a tractor unit that may be crawler or wheel mounted, and attached to the boom is a dipper stick and dipper.

If the excavation is below the water table, the tractor has to contend with mud, even after dewatering, unless the soil drains well. In calculating cycle times, the front-end loader must back out from the excavation, turn, and move forward to load awaiting trucks. After loading, the front-end loader must back away from the truck, turn, and return to the excavation. The operation is more complicated than for a backhoe working under similar conditions, leading to a longer cycle time. The front-end loader is not recommended in areas of potential UXO presence because the loader and the operator must enter the face of the excavation. Prior ripping of the soil by a bulldozer may be undertaken to increase the excavating efficiency of a front-end loader.

Based on the preceding evaluation, a front-end loader and bulldozer may be recommended for the excavation of sites in the Basin F Wastepile, Secondary Basins, Buried Sediments/Ditches, Munitions Testing, and Surficial Soil Medium Groups. The front-end loader and bulldozer are also considered for use in limited areas of the Basin A, Sanitary Landfills, and Ditches/Drainage Areas Medium Groups and the Former Basin F, Complex Trenches, Shell Trenches, Hex Pit, South Plants Central Processing Area, South Plants Ditches, South Plants Tank Farm, South Plants Balance of Areas, Sand Creek Lateral, Pool Ditches, Section 36 Balance of Areas, Burial Trenches, North Plants, and Toxic Storage Yards Subgroups. More specifically, front-end loaders and bulldozers may be used in alternatives developed for these subgroups in areas above the water table and where UXO does not occur. The front-end loader applies to all medium groups for which loading of stockpiled material is proposed.

4.1.1.3 Backhoes and Trucks

Backhoes are most efficient when used in trenching applications or for the excavation of relatively small pits. Backhoes may be used in excavations below the water table. The backhoe does not have to enter the excavation like front-end loaders, scrapers, or bulldozers, so it does not have to contend with mud or water. Given the design of a backhoe, the operator is shielded from the face of the excavation and so this piece of equipment is the safest choice when excavating areas with potential UXO presence. Several types of backhoes are available depending on the depth of excavation required. For linear excavations (e.g., ditches and disposal trenches), the backhoe is the most appropriate piece of excavation equipment. Conventional backhoes can reach depths of 30 ft, long-reach excavators can reach depths of 50 ft, and telescopic excavators can reach depths of 70 ft. A backhoe bucket may be changed out rather easily or can be fitted with a rammer attachment to demolish foundations.

Cycle times of the backhoe and the haul distance dictate the number of trucks that are required to maintain consistent backhoe production. Truck size, bucket size, and the type of material being excavated also affect the production rate. The backhoe contrasts with a front-end loader in that it only has to rotate to dump its material into the haul unit, thus reducing a great deal of maneuvering time. Cycle times were used to develop costs for this excavation scenario.

Based on the preceding evaluation, the backhoe is applicable to all medium groups and is the equipment of choice for areas requiring excavation below the water table and with potential UXO presence and in trenches. The backhoe is the most suitable and efficient piece of equipment to excavate Basin A, Former Basin F, Basin F Wastepile, deep areas of Basin F Exterior, Sanitary/Process Water Sewers, Chemical Sewers, Complex Trenches, Shell Trenches, Hex Pit, Disposal Trenches, Agent Storage, Ditches/Drainage Areas, Lime Basins, and South Plants Medium Groups/Subgroups. If the lakes are not drained, dredging may be required for excavation. If excavation of the more contaminated sediments near the inlets is chosen, a backhoe would be much more efficient than dredging equipment. A backhoe will also perform well at other sites that may only be partially excavated to remove principal threat volumes.

4.1.1.4 Dredges

Dredging, as applied to the lake sediments medium groups, involves the removal of sediments from the small, relatively shallow lakes at RMA. The small size of the lakes limits the types of dredging equipment that are applicable. Dredging is accomplished through either on-shore or off-shore operations. On-shore operations use conventional excavation equipment such as crane-mounted drag lines or clamshells. Off-shore operations are implemented with the use of small, portable, barge-mounted hydraulic dredges and are accomplished using either remote-controlled devices or on-board operators.

On-shore operations employ clamshells and draglines that use crane-mounted attachments, of which there are crawler-mounted, wheel-mounted, and truck-mounted crane units. The size of the attachment and boom vary according to the size of the job and the dimensions and clearance of the site. Clamshells are generally employed on large, deep excavations. The clamshell bucket, attached to a cable, is hinged and falls to the ground in the open position, thus embedding its teeth into the ground. When the cable is then drawn by a winch, the mouth is forced closed by the tension of the cable and the material is enclosed inside the bucket. Draglines make use of open buckets attached to cables. The buckets are swung out and allowed to dip into the excavation, with the cables holding the buckets in an upright position during retrieval. Clamshells and draglines may only be used to remove materials within 100 ft of the shoreline and require watertight transport units, dewatering facilities, and silt curtains in the lake to prevent spread of contaminated silt.

Off-shore operations employ small, portable barge- or float-mounted hydraulic dredges. The dredges, remotely operated by shore-bound personnel or controlled by an on-board operator, excavate sections up to 8 ft in width per pass. Dredges, usually bound to cables anchored on the shoreline, traverse the length of the cable. This technique enables the accurate dredging of an entire lake. However, several self-propelled dredges with low-torque, high-speed motors allow the efficient excavation of specific areas where contamination may be localized. Limitations of this dredging technique involve the cost of constructing settling basins and using a clarifier to dewater the dredged sediments.

Another dredging technique is to completely drain the lake prior to using heavy equipment to excavate the contaminated sediments. Draining the lakes would be effective if all the contaminants could be trapped in the lake sediments and the lake bottom was sufficiently dewatered to allow heavy excavating equipment to operate within the lake. This can be a risky technique because lakes have been known to be re-flooded, thus stranding the equipment. An additional constraint of draining the lakes would be the loss of all fish life and the destruction of lake ecosystems.

4.1.1.5 Vapor and Odor Controls During Excavation

Containment structures will be used to control air emissions during the excavation of several sites. Rigid frame structures have been selected for this purpose to avoid frequent failures and collapses experienced with air-supported structures. The rigid frame structure will also permit a negative pressure within the structure, which will decrease the possibility of any fugitive emissions released to the outside environment. The structures selected are comprised of lightweight aluminum framing, covered by a polyvinyl chloride (PVC)-coated polyester membrane. These structures are designed to withstand windloads of 130 miles per hour (mph) and do not accumulate snow. Due to the low coefficient of friction between the fabric and snow, the snow simply slides off of the roof. The use of a foundation is dependent upon the size of the structure but is generally not required for structures less than 90 ft in width. Air pollution control equipment is used to remove contaminants from the air space within the enclosure. The system includes an induced draft blower, which will create a negative pressure within the structure and prevent a buildup of contaminants. The air pollution control system consists of an induced draft blower, a wet scrubber, and a granular-activated carbon cabinet. The equipment will address airborne particulates, VOCs, and a variety of odiferous compounds (ammonia, sulfur, chlorinated compounds). Equipment sizing and operating parameters are dependent upon the individual characteristics of each site. The air pollution control systems are sized for a minimum of two air changes per hour for each structure.

Construction of these structures requires the on-site assembly of the framework followed by the installation of the fabric. Once erected, however, the structures are easily moved in sections with the use of a crane. Moving a structure therefore requires much less time than the original erection and does not require complete disassembly or assembly. Large excavations, which will require the movement of structures, will utilize a building width of no more than 90 ft, as anything larger requires a foundation.

Air emissions within the enclosure are minimized both by reducing the number of internal combustion engines used to excavate and transport excavated material and by equipping the remaining combustion engines with emission controls. For example, conveyor belts are used to move excavated material to a screw auger, which conveys the material through an opening in the enclosure for loading into sealed rolloff containers for transport to a centralized treatment/disposal facility. Moreover, the excavation and loading equipment are equipped with emission control systems similar to those used in the underground mining industry. As an alternative, equipment could be powered by hydraulic pressure via umbilicals from power units located outside the enclosure.

Excavation of the wastepile will employ two 90-ft by 850-ft movable structures. The wastepile will be excavated in four layers or lifts, which will require the structures be moved 53 times over a period of 35 months. The use of two structures will allow for continuous excavation, as excavation can proceed within one structure while the other structure and associated air treatment equipment are being moved. Excavated areas will be covered with an HDPE liner, in addition to 1 ft of soil cover prior to moving the structure to prevent odors or emissions. A detailed description of excavation procedures for the wastepile is provided in Section 11.2 of the Soil DAA. Each structure is equipped with two separate air pollution control systems, which provide a combined 2.3 air changes per hour (per UBC guidelines). Each system consists of a 35,000-

cubic ft per minute (cfm)-induced draft fan, an activated carbon adsorption unit, and a wet scrubber.

In addition, vapor enclosures will be used to excavate contaminated soil from several other sites. These excavations will also utilize two 90-ft wide structures but the length of each structure will vary based on the size of the site. The air pollution control systems associated with these structures are the same as described above for the Basin F Wastepile. The excavation procedures for these sites will consist of the initial installation of each dome structure at alternating spaced rows of the excavation, partial backfill and installation of interim soil cover, and the movement of the structure to alternating spaced rows and to the mounds formed by excavation at alternating spaced rows for continued excavation operations. The specific excavation procedures for these sites are as follows:

- Former Basin F—Two 90-ft by 810-ft structures are moved 109 times to excavate 740,000 BCY within a 34-month time frame.
- Former Basin F (Principal Threat Volume)—Two 90-ft x 640-ft structures are moved 32 times to excavate 250,000 BCY within a 12-month time frame.
- Complex Trenches—Two 90-ft x 490-ft structures are moved 55 times to excavate 440,000 BCY within a 64-month time frame.
- Shell Trenches—Two 90-ft x 490-ft structures are moved 55 times to excavate 100,000 BCY within a 5-month time frame.
- Hex Pit—Two 90-ft x 430-ft structures are moved 2 times to excavate 3,300 BCY within a 1-month time frame.
- M-1 Pits—Two 90-ft x 430-ft structures are moved 2 times to excavate 26,000 BCY within a 2-month time frame.

4.1.2 Process Performance

Excavation is performed with proven technologies. The potential risks associated with excavation to the community and workers are volatilized contaminants and fugitive dust, which are monitored throughout the excavation process. If the dust or contaminant concentrations are above safe levels, water or other vapor- and dust-suppressing agents may be sprayed to reduce the dust emission levels. Containment structures are used if required as discussed in Section 4.1.1.5.

The construction of haul roads and dewatering in areas where the water table lies above the depth of the excavation are accomplished prior to excavation. In addition, temporary staging areas may need to be constructed to stage, segregate, or temporarily store excavated materials.

Backfilling, compacting, and site reclamation are posttreatment processes related to excavation activities. The backfill may be obtained from an uncontaminated area on post or obtained off post. The use of backfill material from uncontaminated on-post areas costs less than does the use of off-post materials. Therefore, fill material is to be taken from on-post sources unless a specified type of material cannot be found on post. After soil are treated, they may be used as backfill. When backfilling is complete, the site is seeded with native grasses and plants in accordance with a future refuge management plan to reduce erosion and to provide cover for wildlife.

Water produced from dewatering and the dust generated from excavation are the major sidestreams associated with excavation. Groundwater is treated at one of the on-post treatment facilities and reinjected on post. The groundwater may be piped or hauled to the appropriate treatment systems.

Capital and operations costs for excavation are dependent upon the specific types of equipment employed at a site. Costs are based upon 1994 rental rates, maintenance materials and labor, and estimated cycle times of specific equipment types. Table 4.1-2 details the estimated excavation costs and Table 4.1-3 details the estimated vapor dome costs.

4.2 STRUCTURES DEMOLITION

Demolition is applicable to the structures medium at RMA. It forms part of 10 alternatives in the Significant Contamination History Group, seven alternatives in the Other Contamination History Group, and seven alternatives in the Agent History Group. The structure materials include wood, steel, reinforced concrete, and masonry, and the sizes of the structures range from small guard shacks to complex multistory production buildings. The structures' histories encompass a wide range of uses, including chemical processing, raw materials and finished product storage, power generation, and administrative support.

Dismantling requires the use of medium to heavy equipment to demolish a structure, i.e., to take it apart piece by piece. The structure is broken up using bulldozers, backhoes, wrecking balls, or other similar types of equipment. Contaminants are not treated through this process, but the volume is decreased and converted to a more workable form for subsequent treatment or disposal. Dust control measures are commonly taken during the operation, generally consisting of spraying or misting water over the work area. Dismantling is applicable to all types and sizes of structures as well as pipes and tanks.

4.2.1 Process Description

The contamination conditions at RMA support dismantling as the chosen method of demolition. The alternatives developed for the structures medium make use of a combination of clamshells, bulldozers, backhoes with thumb attachments on the bucket, universal processors with cutting shears, and wrecking balls. It was assumed that, prior to dismantling, process equipment, piping, and all asbestos-containing materials (ACM) are removed from the structures. Ongoing IRAs (OHMC 1989; PMRMA 1988) have removed or are in the process of removing process equipment, piping, sewers, and asbestos from selected structures, reducing the volume of contaminated materials to be handled during demolition. Agent-contaminated structures and process equipment will be decontaminated under another IRA, eliminating the potential exposure problems with those contaminants. As part of the demolition process, interim containment, storage, and transfer areas may have to be constructed. It may be necessary to stockpile metal prior to recycling or disposal. Demolition debris may have to be stockpiled prior to treatment or disposal. Decontamination facilities are to be built to decontaminate metals prior to recycling. Throughout the demolition process, air monitoring is conducted to ensure the safety of the workers and the surrounding community.

4.2.2 Process Performance

Demolition of structures at RMA requires the removal of the structure along with any contamination associated with it. The major concern for demolition is the release of large amounts of potentially contaminated dusts into the atmosphere. The airborne contamination caused by dust release is minimized using dust control measures such as water mists. Continuous air monitoring is used to monitor the effectiveness of the controls.

Demolition has been accomplished at RMA under the Hydrazine Facility IRA (PMRMA 1988) and the structures Pilot Demolition Program (Jacobs 1994). Results from these demolition projects have been included in the DAA where applicable.

Pretreatment of structures undergoing demolition requires isolating the designated structure from its surroundings, obtaining permits if required, removing any materials to be preserved, and terminating utility connections. At the conclusion of structure demolition, buried utility lines may be blind flanged and abandoned, depending on facility requirements. Separately regulated materials such as asbestos or PCBs must be removed prior to demolition. If there is potential agent presence in the structural materials, special monitoring and personnel protective measures must be taken. An exclusion zone must be established to prevent contaminant exposure by passersby and adjacent structures. Surface treatments may also occur prior to demolition.

Posttreatment of structure demolition consists of removing the debris and restoring the site.

For the purposes of the DAA, all structure quantity estimates are made with respect to the bank cubic yards (BCY) of material. BCY refers to the volume occupied by the material if it was neatly dismantled into component parts and placed into an orderly pile. In reality, the structure debris resulting from the demolition processes described in this section will occupy a larger volume than the BCY. Unpublished data from a forthcoming Army demolition experience report was evaluated for the Structures DAA. Based on the existing types and quantities of structure materials, the following volume factors were applied to the BCY totals:

- A factor of 2.5 was applied to BCY to estimate the volume of structure materials following demolition. This would apply to debris handling, hauling, and treatment steps in the alternatives.

- A factor of 1.6 was applied to BCY to estimate the volume of structure materials placed in the landfill, provided a volume reducing treatment process had not been applied to the debris. It was assumed that structure debris would be codeposited with soils in the landfill, to assist in filling void space in the structure debris matrix.

- A factor of 1.6 was applied to the BCY for materials, which were shredded prior to incineration, and the factor was reduced to 1.0 following incineration. In these cases, the landfill factor was reduced to 1.0 to account for the volume reduction caused by incineration.

Table 4.2-1 outlines the costs associated with demolition. Capital costs involved in demolition are those that would be required to initiate contractual agreements for subsequent remedial action. Demolition costs are based on unit costs for demolition of the standing volume (measured in cubic yards [CY]) of specific materials. Other costs are based on collapsed CY of material volume. Demolition costs have been developed for the Significant Contamination History and Other Contamination History Groups separate from the Agent History Group to reflect the relative levels of contaminants present.

4.3 TRANSPORTATION

Transportation is the physical removal of structural, soil, or liquid material from a site. Transportation methods include using end-dump trucks, rock trucks, off-road dump trucks, conveyor belts, railroad cars, and rolloff containers to ship materials to a designated location.

4.3.1 Process Description

4.3.1.1 Off-Post Transportation

Off-post transportation for contaminated materials at RMA is expected to be limited, especially for the soil medium, because the large volume of materials and accompanying costs do not make off-post treatment or disposal feasible. However, for structural materials, liquids, or soil containing UXO or Army agent, off-post transportation to a treatment, disposal, or salvage facility is a viable option.

For alternatives requiring off-post transportation, drummed materials are transported in 55-gallon drums on flat-bed trucks or bulked into liquid tanker trucks or railroad tanker cars. Drums containing unknown solids and sludges need to be sampled prior to transport off post to determine content, appropriate action, and compliance with applicable Department of Transportation (DOT), EPA, or state requirements.

Under the off-post landfill alternative, approximately 130,000 BCY of demolition materials from the structures medium require transportation. For costing purposes, it was assumed that contaminated materials are transported to a hazardous waste landfill approximately 70 miles from RMA and that uncontaminated materials are transported to a municipal/industrial landfill 10 miles from RMA. The actual landfills used are to be determined at the time of disposal based on availability and acceptance of the materials for disposal. Transportation to these locations is accomplished using end-dump rock trailers, gondola railroad cars, or rolloff containers carried on flatbed railroad cars.

UXO- or agent-contaminated soil may require treatment and disposal in an off-post treatment, storage, and disposal (TSD) facility. Soil containing UXO materials remains under Army control and is transported to the Army UXO treatment facility at Fort Carson in Colorado Springs, Colorado. Any materials that contain Army agent may be shipped to a similar Army facility in Tooele, Utah, for treatment and disposal. Materials contaminated by UXO or agent are transported using tractor-trailer trucks or railroad cars (if the disposal facilities have railroad access and off-loading capabilities).

4.3.1.2 On-Post Transportation

Solid materials may be transported on post by several methods, including conveyor belt systems, tractor-trailer trucks, off-road dump trucks, all-purpose dump trucks, bottom- or end-dump tractors, scrapers, or an on-post railroad system. Liquids are generally transported in vacuum tanker trucks, 55-gallon drums, or, for long-term transportation needs, dedicated pipelines (e.g., for groundwater pump-and-treat systems).

On-post transportation methods were analyzed and compared against one another to arrive at the most cost-efficient transportation type. Cost efficiency was based on cycle times of the excavation unit, load-carrying capacity of the haul unit, long-term maintenance, and a uniform haul distance of 4 miles. Based on these constraints, it was determined that off-road, end-dump trucks were the most efficient method of transportation for on-post solid materials.

The construction of haul roads for on-post transportation may be accomplished using soil in the vicinity of the site, if available, or by hauling soil from another area. The haul roads would most likely be constructed with a bulldozer, but the material could be deposited by a scraper or front-end loader or simply dumped by a hauling truck for the front-end loader or bulldozer to spread into place. A water truck may be used to obtain optimum moisture content for compaction. Once constructed, the haul road may be maintained by a bulldozer or road grader and a water truck. The cost for equipment used to maintain a haul road is recouped in the increased hauling efficiency provided by a well-maintained haul road. It was assumed that the existing RMA road system is also utilized for transporting material. Therefore, constructed haul roads should not be much more than one-half mile long because roads already exist along every section line. Any road constructed of contaminated soil or that is contaminated in the transport process requires reclamation along with the site.

Drummed materials, such as generated liquid or solid sidestreams, are transported on post. This can be accomplished by transporting the 55-gallon drums on either a vacuum truck or flatbed truck. These materials would be transported on post to either the CERCLA Wastewater Treatment Plant or another treatment plant.

4.3.2 Process Performance

All of the transportation methods described herein are proven, effective processes for the transfer of materials both at RMA and at CERCLA sites nationwide. Contamination may be mobilized during loading and transportation; however, appropriate engineering controls minimize dust generation and volatile emissions.

The effectiveness of off-post transportation is limited by the risk of release of contamination in transportation accidents and by high operating costs resulting from long hauling distances, greater costs for equipment decontamination and manifesting, and chemical sampling to ensure regulatory compliance. The potential for contamination release during off-post and on-post transportation is minimized by using dust suppressants and bed liners and covers and by evaluating alternate transportation routes to minimize potential exposures.

Prior to the off-post transportation of structural materials, sizing may be required so that landfill and transportation capacity are efficiently used. Before off-post transportation of materials from RMA can proceed, all materials need to be properly manifested, documented, and covered and must satisfy all regulatory transportation requirements. The transport vehicles may require thorough decontamination prior to traveling off post, and all vehicles traveling from an uncontaminated area, either on or off post, are required to drive through a wheel-wash station.

On-post transportation primarily involves transportation of liquid waste to the CERCLA Wastewater Treatment Plant or other treatment plants and transportation of soil and structural waste to an on-post disposal or treatment facility. Size reduction of structural materials may be required. The transport vehicles would require decontamination.

Dust generation and organic vapor emissions may occur during transportation activities. Proper lining, covering, and packaging of materials prior to transport and dust suppression on dirt roads and excavation sites minimize dust emissions. Properly selected PPE protect transportation and excavation personnel.

Table 4.3-1 lists the costs associated with off-post transportation. Capital and O&M costs for transportation are dependent upon the specific types of equipment employed at a site. Costs are based on 1994 rental rates, current maintenance materials costs, and the estimated cycle-related costs of a specific transportation method.

4.4 MATERIALS HANDLING

Several of the treatment and disposal technologies described in subsequent sections require the separation of large diameter materials, reduction in moisture content, or mixing of different soil types. These materials handling steps are associated with the excavation and transportation of contaminated soils and are essential pre-treatment processing steps.

4.4.1 Process Description

The types of materials handling required are dependent on the characteristics of the material and the requirements of the treatment or disposal process. Materials handling varies from reducing the moisture content of a soil prior to disposing of materials in a landfill to modifying the characteristics of soil to be treated in order to prepare a feed stream with more homogeneous characteristics. The following subsections describe three different types of materials handling systems.

4.4.1.1 Handling of Trench Materials

The excavation of materials from disposal trenches requires materials handling steps prior to placing the excavated materials in a landfill. Any drums removed from the excavation would need to be crushed, oversized debris would need to be separated for special handling, and free liquid encountered would need to be stabilized. This type of materials handling would be conducted during the excavation of materials from the Disposal Trenches Medium Group and would be conducted within the vapor enclosures discussed in Section 4.1.1.5.

Any drums identified during excavation would be removed using standard excavation equipment such as backhoes if a small number of intact drums are encountered, or drum grappling equipment could be used if a large amount of intact drums are encountered. Any free liquid would need to be removed from the drums prior to landfilling. The drained drums and any partially intact drums encountered during excavation would be crushed prior to disposal in a landfill. In addition, free liquids may be encountered in and around partially intact drums. Large debris, such as long lengths of piping and processing equipment, will be encountered during excavation and will be separated from the remaining debris using excavation equipment.

Table 4.4-1 presents the cost for drum and debris handling prior to landfilling. The costs for soil mixing and blending are estimated at $1.23/BCY for capital costs and $32.85/BCY for operating costs. The estimated operating costs for drum handling prior to landfilling is $498.58/BCY of soil containing partially or fully intact drums.

4.4.1.2 Materials Handling Prior to Treatment

Preparation steps such as size reduction, scrap metal removal, and solids blending are required prior to treating contaminated soils to reduce the physical variability of the contaminated soils. These materials handling steps are included in the overall treatment facilities for thermal desorption (Section 7.1) and incineration (Section 7.2) but are not included in the transportable treatment systems evaluated for solvent extraction (Section 12.2) and direct solidification/ stabilization (Section 10.1). In addition, a separate materials handling system would be required if transportable thermal desorption or incineration unit would be used instead of the fixed facilities.

Large objects (typically greater than 0.5 to 2 inches) are screened from the feed material and rejected as oversized for subsequent disposal. If metallic debris is present at the site, the next step of the pretreatment process would be to remove the metallic debris for subsequent disposal. In addition, the materials handling system would include a shredder or disc classifier to reduce the size of any clay or soil lumps to between 0.5 to 2 inches. The diameter of oversize debris and allowable size of clay/soil lumps are based on the processing requirements of the treatment system. For example, a larger size particle can be successfully solidified in a pug mill/mixing vessel than can be treated in a solvent extraction unit. The feed materials are moved between the individual pieces of equipment using conveyors, screw augers, or excavation equipment such as front-end loaders.

This type of materials handling is conducted inside a vapor enclosure similar to those described in Section 4.1.1.5 in order to control dusts, vapors, and odors generated during materials handling. In addition, the enclosed building will contain a storage area for soil that is ready to be treated. The size of this stockpile will vary based on the requirements of the treatment but will generally consist of three to five days of storage based on the processing rate of the treatment unit. In addition, several treatment process options require a small range in variability in soil properties and contaminant levels. As a result, blending of soils from different sites or medium groups could be conducted using a pug mill or mixing vessel inside the vapor enclosure mainly to reduce the variation in clay content and contaminant levels. The structure would be ventilated as discussed in Section 4.1.1.5.

Table 4.4-1 presents the costs for materials handling prior to treatment assuming an average processing rate of 32 tons/hour. The capital costs are estimated at $ 8.21/BCY based on the purchase of a grizzly for separating oversize materials, a shredder to reduce the size of clay lumps, and a pugmill to blend soil to obtain a more uniform soil feed. The estimated operating costs of $40.63/BCY are based on treating between 200,000 BCY and 1,000,000 BCY.

4.4.1.3 Drying of Saturated Materials

The final type of materials handling consists of reducing the moisture content of soil through drying, which is primarily related to the landfilling of the Basin F Wastepile. An estimated

100,000 BCY of wastepile materials are assumed to be saturated and would require drying prior to landfilling. The drying systems consist of a heating mechanism to raise the temperature of the soil to the point that the moisture is driven off. A fraction of the volatile organics present in the wastepile materials would also be driven off, collected, and treated along with the soil moisture.

Either an indirect or direct-fired drying unit could be used to raise the temperature of the soil; however, an indirect-fired drying unit produces a much smaller volume of gas exiting the dryer requiring treatment and prevents a flame from contacting the soil during heating. A soil temperature of approximately 200°F would be adequate to achieve a reduction from saturated conditions (approximately 25%) to a moisture content of 10%. A number of indirect-fired drying units are available from vendors at processing rates of 25–40 tons/hour. The off-gasses from the dryer would be collected and treated using a combination of condensation and carbon adsorption, which are discussed in Section 13 with other off-gas treatment systems.

Prior to processing the saturated materials through the dryer, the contaminated soils would be processed through a materials handling system to remove oversize materials and reduce the size of any clay/soil lumps. Section 4.4.1.2 provides a discussion of materials handling equipment prior to treating contaminated soil. The dryer can tolerate a larger variability in soils properties in driving of soil moisture than the treatment systems identified in Section 4.4.1.2, reducing the amount of materials handling and eliminating the need for blending.

Table 4.4-1 presents the costs for drying the saturated materials encountered during the excavation of the Basin F Wastepile. The capital costs are estimated at $15.79/BCY, including a system for separating oversized materials and reducing the size of clay/soil lumps. The estimated operating costs of $91.46/BCY are based on treating between 100,000 to 150,000 BCY of saturated materials.

4.4.2 Process Performance

The materials handling systems discussed above are performed with proven technologies, with the exception of the dryer, but the dryer is available from several sources. Fugitive dusts and volatilized contaminants pose potential risks to site workers during the handling of contaminated materials; however, the materials handling systems include vapor and odor controls to reduce risks to site workers and protect the community.

The operating temperature of approximately 200°F achieved by the dryer will drive off the moisture from the soil without desorbing the bulk of the contaminants in the soil. The fraction of the volatiles that are driven off during drying are collected and treated in accordance with air quality regulations. The operating temperature of 200°F is well within the operating parameters for indirect-fired drying units.

REFERENCES

Jacobs (Jacobs Engineering Group)

1994 (October) Pilot Building Demolition Project, Task 92-01, Final Pilot Demolition Assessment, Version 3.1. RTIC 94305R03.

OHMC (O.H. Materials Corporation)

1989 (July) Asbestos Removal, Phase II, Removal, Final Interim Response Action Technical Plan, Version 3.0. RTIC 89222R02.

PMRMA (Program Manager, Rocky Mountain Arsenal)

1988 (October) Final Decision Document for the Interim Response Action at the Rocky Mountain Arsenal Hydrazine Blending and Storage Facility. RTIC 88329R02.

Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Basin A (300,000 bcy)			
Load/Haul/Dump/Compact in an On-Post Landfill, Fill Excavation	+ Use in areas above water table/no debris or UXO[C].	+ Use in areas above water table with no UXO[A] risk.	⊕ Applies to all areas, including below water table. Best protection against UXO[A], loads faster[B].
Load/Haul to Treatment Facility, Return to Ground/Compact	+ Use in areas above water table/no debris or UXO[C].	+ Use in areas above water table with no UXO[A] risk. Best choice for loading soil stockpiles at treatment facility.	⊕ Applies to all areas including below water table. Best protection against UXO[A], loads faster[B].
Basin F Wastepile (600,000 bcy)			
Load/Haul to Treatment Facility, Return to Ground/Compact	– Will volatilize contaminants[C].	⊕ Best choice for loading stockpiles at treatment facility. Best option to minimize volatilization; may also use power shovel.	+ Applicable and efficient[B].
Secondary Basins (200,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Cap Excavation	+ Fastest option/no debris[C].	+ Applicable.	+ Applicable.
Load/Haul to Treatment Facility, Return to Ground/Compact	+ Fastest option/no debris (need to load at treatment site)[C].	+ Applicable, best choice for loading soil stockpiles at treatment facility.	+ Applicable.

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B A backhoe only rotates to dump and the tractor unit does not have to maneuver around to dump the load like a front-end loader.

C Scraper will only be used for hauling less than 1,500 ft and within area of contamination.

⊕ Equipment is able to excavate all of site in the most efficient manner.

\+ Equipment is only able to excavate certain areas of site or may not be most efficient method to excavate all of site.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Former Basin F (680,000 bcy)			
Load/Haul to Treatment Facility, Return to Ground/Complex	+ Applicable for shallow excavation and short haul distances.	+ Applicable, best choice for loading stockpiles at treatment facility.	⊕ Applicable and efficient[B]. Best option for areas below water table on deep excavation.
Sanitary/Process Water Sewers			
Load/Haul/Dump Compact to an On-Post Landfill, Fill Excavation	– Not applicable.	– Not applicable.	⊕ Best suited for trenching.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable.	+ Best choice for loading soil stockpiles at treatment facility.	⊕ Best suited for trenching.
Chemical Sewers (82,000 bcy)			
Load/Haul/Dump Compact to an On-Post Landfill, Fill Excavation	– Not applicable.	– Not applicable.	⊕ Best suited for trenching.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable.	+ Best choice for loading soil stockpiles at treatment facility.	⊕ Best suited for trenching.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Complex Trenches (530,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Use above water table, UXO[A] risk.	⊕ Applies to all areas, including below water table. Best protection against UXO[A] and efficient[B].
Load/Haul to Treatment Facility, Return to On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Use above water table, possible UXO[A] risk and best choice for loading soil stockpiles at treatment facility.	⊕ Best protection against UXO[A] and efficient[B]. Applies to all areas, including below water table.
Shell Trenches (100,000 bcy)			
Load/Haul to Treatment Facility, Compact to an On-Post Landfill, Fill Excavation	– Not applicable.	+ Use above water table, best choice for loading soil stockpiles at treatment facility.	⊕ Applies to all areas, including below water table.
Hex Pit (3,300 bcy)			
Load/Haul to Treatment Facility, Compact to an On-Post Landfill, Fill Excavation	– Not applicable.	+ Use above water table. Best choice for loading soil stockpiles at treatment facility.	⊕ Applies to all areas, including below water table.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Sanitary Landfills (420,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Applicable.	⊕ Most efficient[B].
Load/Haul to Treatment Facility, On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Best choice for loading soil stockpiles at treatment facility.	⊕ Most efficient[B].
Section 36 Lime Basins (54,000 bcy)			
Load/Haul to Treatment Facility, Return to Ground/Compact	– Debris and water will cause problems.	+ Water will cause problems even with dewatering, unstable ground, but best choice for loading soil stockpiles at treatment facility.	⊕ Long-arm needed, will have to backfill excavation as work proceeds. Dragline or clamshell may be best option.
Buried M-1 Pits (26,000 bcy)			
Load/Haul to Treatment Facility, Compact to an On-Post Landfill, Fill Excavation	– Debris and water will cause problems.	+ Applicable but excavation below water table will cause problems.	+ Applicable to all areas, including below water table.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
South Plants Central Processing (290,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Can use in areas above water table (may need to rip weathered bedrock).	⊕ Can excavate below water table and ram foundations. Will need bulldozer for surface rubble.
Load/Haul to Treatment Facility, Compact to an On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Can use in areas above water table (may need to rip weathered bedrock) and best choice for loading soil stockpiles at treatment facility.	⊕ Can excavate below water table and ram foundations. Will need bulldozer for surface rubble.
South Plants Ditches (57,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Not applicable to ditches, and debris may cause problems.	+ Applicable.	⊕ Best suited for trenching.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable to ditches, and debris may cause problems.	⊕ Best choice for loading soil stockpiles at treatment facility.	⊕ Best suited for trenching.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Debris will cause problems.	+ Can use in areas above water table (may need to rip weathered bedrock) and best choice for loading soil stockpiles at treatment facility.	⊕ Can excavate below water table and main foundation. Will need bulldozer for consolidating surface rubble.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
South Plants Balance of Areas (660,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Can use in areas above water table (may need to rip weathered bedrock).	⊕ Can excavate below water table and main foundation. Will need bulldozer for consolidating surface rubble.
Load/Haul to Treatment Facility, Return to On-Post Landfill, Fill Excavation	– Debris will cause problems.	+ Can use in areas above water table (may need to rip weathered bedrock) and best choice for loading soil stockpiles at treatment facility.	⊕ Can excavate below water table and main foundation. Will need bulldozer for consolidating surfaced rubble.
Buried Sediments (31,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill Excavation	– Not applicable, water and debris may cause problems.	⊕ Best choice for buried sediments.	+ Applicable.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable, water and debris may cause problems.	⊕ Best choice for buried sediments and loading soil stockpiles at treatment facility.	+ Applicable.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Sand Creek Lateral (100,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Not applicable.	+ Use in areas above water table.	⊕ Best suited for trenching and applies to all areas, including below water table.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable.	+ Use in areas above water table. Best choice for loading soil stockpiles at treatment facility.	⊕ Best suited for trenching and applies to all areas, including below water table.
Section 36 Balance of Areas (310,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	+ Applicable except for long haul application.	+ May need to rip ground and may be used in balance of areas where UXO is not present.	⊕ Applicable, efficient[B], potential UXO[A] for balance of areas.
Load/Haul to Treatment Facility, Return to On-Post Landfill, Fill Excavation	+ Applicable except for long haul application.	+ May need to rip ground; may be used in balance of areas where UXO is not present and best choice for loading soil stockpiles at treatment facility.	⊕ Applicable, efficient[B], potential UXO[A] for balance of areas.
Burial Trenches (80,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	+ Debris may cause problems.	+ Use in areas above water table with no UXO risk.	⊕ Applies to all areas, including below water table. Best protection against UXO[A]; loads faster[B].

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Load/Haul to Treatment Facility, Return to On-Post Landfill, Fill Excavation	+ Debris may cause problems[C].	+ Use in areas above water table with no UXO[A] risk. Best choice for loading soil stockpiles at treatment facility.	⊕ Applies to all areas, including below water table. Best protection against UXO[A]; loads faster[B].
Munitions Testing (450 bcy)			
Load/Haul/Transport to Off-Post Treatment Facility, Fill Excavation	– Cannot transport off post.	⊕ May need to rip ground first but most practical for shallow excavation (0-2 ft); not suggested for areas with UXO risk.	+ Could be used but not most practical choice for large areas of shallow excavation. Best protection against UXO[A].
Load/Haul to Treatment Facility, Return to Ground/Compact	+ Applicable for excavating deeper than 2 ft where UXO is not present and haul distance is small[C].	⊕ May need to rip ground first but most practical for shallow excavation (0-2 ft); not suggested for areas with UXO risk. Best choice for loading soil stockpiles at treatment facility.	+ Could be used but not most practical choice for large areas of shallow excavation. Best protection against UXO[A].
North Plants (61 bcy)			
Load/Haul to a Treatment Facility, Return to On-Post Landfill, Fill Excavation	– Not applicable.	+ Applicable but may be difficult to excavate small areas of deep contamination in North Plants, particularly near buildings.	⊕ Best choice to excavate small, sometimes paved areas in North Plants.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable.	+ Applicable but may be difficult to excavate small areas of deep contamination in North Plants, particularly near buildings.	⊕ Best choice to excavate small, sometimes paved areas in North Plants.
Toxic Storage Yards (450 bcy)			
Load/Haul to a Treatment Facility, Return to On-Post Landfill, Fill Excavation	– Not applicable.	+ Applicable.	⊕ Best choice to excavate small, sometimes paved areas in Toxic Storage Yards.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable.	+ Applicable and the best choice for loading soil stockpiles at treatment facility	⊕ Best choice to excavate small, sometimes paved areas in Toxic Storage Yards.
Lake Sediments (57,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Not applicable unless lakes completely drained.	– Not applicable unless lakes completely drained.	+ Will work for partial excavation of "hot spots" near inlets but otherwise Not applicable unless lakes are drained. Dredging with dragline, clamshell, or floating dredge is the only option if the lakes are not drained.

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Site	Scraper/Bulldozer	Bulldozer/Front-End Loader/Trucks	Backhoe/Trucks
Load/Haul to Treatment Facility, Return to On-Post Landfill	– Not applicable unless lakes completely drained and cannot transport off post.	+Not applicable unless lakes completely drained but best choice for loading soil stockpiles at treatment facility.	+ Will work for partial excavation of "hot spots" near inlets but otherwise Not applicable unless lakes are drained. Dredging with dragline, clamshell, or floating dredge is the only option if the lakes are not drained.
Surficial Soils (4,400,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	+ Applicable for excavating deeper than 2 ft, but haul distance may be too long[C].	⊕ Applicable for very large area of shallow excavation.	+ Applicable, but not most efficient for very large area of shallow excavation.
Ditches/Drainage Areas (52,000 bcy)			
Load/Haul/Dump/Compact to an On-Post Landfill, Fill Excavation	– Not applicable.	+ Applicable, but not as efficient as backhoe.	⊕ Best suited for excavation of ditches and drainages.
Load/Haul to Treatment Facility, Return to Ground/Compact	– Not applicable.	+ Applicable, but not as efficient as backhoe. Best choice for loading soil stockpiles at treatment site.	⊕ Best suited for excavation of ditches and drainages.

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Table 4.1-2 Excavation Costs

Item Description	Operating Cost ($)
Excavation	
Borrow Material, Soil Cover	1.91/BCY
Soil with Agent or Isolated Exceedances	4.61/BCY
Ditches, Sewers	3.87/BCY
Soil, Dike Materials, Landfill	3.96/BCY
Munitions Debris	3.07/BCY
Chemical Sewers	7.33/BCY

Based on bid estimates for the excavation of 100,000 CY using loaders and dozers for different types of sites and PPE requirements

Table 4.1-3 Vapor Dome Costs

	Capital Cost ($)	O&M Cost ($)	Total ($)
Basin F Wastepile			
Structure related	2,776,987	3,392,318	6,169,305
Ventilation	2,993,203	4,333,285	7,329,188
Soil Cover/Liner	1,340,696	1,657,753	2,998,449
Access Ramp		318,500	318,500
			Subtotal=16,835,442
Former F Principal Threat			
Structure Related	521,625	854,193	1,375,818
Ventilation	1,198,000	1,271,137	2,469,137
Interim Cover	165,010	77,392	242,402
			Subtotal=4,087,357
Complex Trenches			
Structure Related	1,265,207	36,470	1,301,677
Ventilation	1,198,000	6,729,849	7,927,849
Interim Cover	822,407	1,996,236	2,818,643
			Subtotal=12,048,169

Table 4.1-3 Vapor Dome Costs

	Capital Cost ($)	O&M Cost ($)	Total ($)
Shell Trenches			
Structure Related	327,098	333,176	660,274
Ventilation	1,198,000	483,730	1,681,730
Interim Cover	65,090	30,957	96,047
			Subtotal=2,438,051
Hex Pits			
Structure Related	158,036	90,973	249,009
Ventilation	599,000	13,076	612,076
Interim Cover	12,689	1,022	13,711
			Subtotal=874,796
Buried M-1 Pits			
Structure Related	158,036	107,405	265,441
Ventilation	599,000	65,503	664,503
Interim Cover	24,124	8,048	32,174
			Subtotal=962,116

Item Description	Capital Unit Costs ($)	O&M Unit Costs ($)
Demolition of nonagent structures	--	20.91/CY
Demolition of agent structures	--	34.94/CY
Shredding structure debris	0.32/CY	13.75CY
Backfill of structure excavation	--	8.07/CY

Item Description	Capital Unit Cost ($)	O&M Unit Costs ($)
Transportation of hazardous waste on post	---	1.11/CY
Transportation of nonhazardous waste on post	---	0.90/CY
Transportation of hazardous waste off post	---	0.56/CY
Transportation of nonhazardous waste off post	---	0.58/CY
Loading of hazardous material	---	1.56/CY
Loading of nonhazardous material	---	1.29/CY
Transfer station	0.24/CY	1.10/CY

Cost Item	Cost Category	Cost Estimate	Description
Drum/Soil Handling			
Soil Blending/Mixing	Capital Cost	$1.33/BCY	Vendor quote for equipment and
	Operating Cost	$32.85/BCY	labor from means, heavy equipment
Drum Handling	Operating Cost	$498.58/BCY	Vendor quote for equipment for cubic yard containing partially or fully intact drums
Sizing/Blending			
Materials Handling	Capital Cost	$1.93/CY	Vendor quote for equipment and
(Based on 1,000,000 CY)	Operating Cost	$19.44/CY	labor from means, heavy equipment
Vapor Enclosure	Capital Cost	$26.54/CY	Vendor quote for equipment and
	Operating Cost	$21.19/CY	labor from means, heavy equipment
Drying			
Materials Handling	Capital Cost	$11.98/CY	Vendor quote for equipment and
	Operating Cost	$8.88/CY	labor from means, heavy equipment
Vapor Enclosure			
	Capital Cost	$33.85/CY	Vendor quote for equipment and
	Operating Cost	$14.27/CY	labor from means, heavy equipment
Dryer		$81.38/CY	Vendor Quote

Section 5

5.0 GROUNDWATER EXTRACTION/REINJECTION

Groundwater extraction methods may be used to collect groundwater from aquifers for surface treatment and reinjection, and reinjection methods employ the same general technologies to return the water to the aquifer. Groundwater extraction methods also may be initiated to dewater areas such as the Army Complex Trenches or to dewater excavations in areas with a shallow water table. The design of the extraction system is determined by site-specific conditions and the intended purpose of the system. For example, an intercept system may be designed to capture either the leading edge of a plume or the most contaminated portion of the plume. Under a mass reduction approach, an extraction system is designed to capture the central mass or most contaminated portion of the plume. In addition to removing the mass of contamination, a mass reduction or dewatering approach eliminates contact between overlying contaminated soils and groundwater by lowering the water table. The layout, pumping rates, well spacing, etc., all differ for each of these examples depending on the desired effect. The groundwater extraction technology under consideration in the DAA is extraction wells, with provisions for trenches/drains if needed. The reinjection method under consideration in the DAA is a reinjection trench. Extracted water is pumped to a treatment facility and the effluent from treatment is reinjected. The following discussion gives a general description of the groundwater extraction/reinjection methods and then describes specific RMA applications, including costs.

5.1 OVERVIEW OF PROCESS

5.1.1 Extraction/Reinjection Wells

Extraction wells can be used to remove contaminated groundwater for treatment, lower the water table in a particular area, and/or contain a plume of contaminated groundwater. They are flexible in that they can be used to extract groundwater from any depth. Extraction wells use pumps to raise groundwater to the surface, resulting in a cone of depression that forms around each well that captures groundwater around the well. With proper placement and operation, a groundwater extraction system can capture contaminants in groundwater and control migration of contaminated groundwater. Therefore, extraction wells can serve both as a groundwater containment technology and a collection technology. Figure 5.1-1 displays a cross-sectional view of an extraction well.

Various drilling methods can be used to create the borehole for an extraction well. The drilling method is determined according to geologic conditions, which are well characterized at RMA. All drilling methods alter the hydraulic characteristics of formation materials in the vicinity of the borehole (Driscoll 1986). Therefore, wells must be developed to produce water and operate properly. There are two primary methods of well completion—natural development and filter packing. Filter packing is the method of choice at RMA. The proper filter pack size is selected based on the geologic conditions determined when drilling the borehole. The proper screen slot size is determined according to the size of the filter pack material and the chosen screen length is based on aquifer conditions.

The well-casing size and material must also be determined. The inner diameter of the casing must be large enough to accommodate the pump, which is sized according to expected extraction rates. Common casing and screen materials are stainless steel and polyvinyl chloride (PVC). The type of material chosen depends on site-specific groundwater chemical characteristics and required strength and service life.

5.1.2 Horizontal Extraction Wells

Horizontal extraction wells may be constructed with the same basic materials as vertical wells but employ different installation technology and design. Generally the casing materials must be stronger for a horizontal well than for a vertical well. Continuous borehole and blind borehole are the two types of boreholes used in the installation of horizontal wells. A continuous borehole has an entry and exit hole, whereas a blind borehole only has an entry hole. Each method has specific advantages based on site conditions. Specialized drill rigs and guidance systems are required in horizontal drilling. The actual methods and equipment used to guide the drill depend on the desired length and vertical depth of the well. The well screen for a horizontal well is usually much longer than the screen in a length and vertical well. The screen spans most of the distance of the horizontal bore. Figure 5.1-2 displays a cross-sectional view of a horizontal well. The greater coverage of horizontal area by a horizontal well compared to a vertical well implies fewer well heads and pumps than if vertical wells were installed in the same location. Horizontal wells may be more effective than vertical wells depending on site conditions. Horizontal wells can be used for pump-and-treat systems, leachate collection, in-situ ground sparging, soil vapor extraction, and bioremediation (Hall 1992). The first directionally drilled horizontal environmental wells were installed at the U.S. Department of Energy (DOE) Savannah River Site in 1988 and now have been successfully installed at several U.S. Department of Defense (DOD) and private industry sites (Kaback and Wilson 1993).

5.1.3 Recharge Trenches

Recharge trenches include any type of buried conduit used to convey liquids by gravity flow. Recharge trenches are excavated to a depth sufficient to convey water to the water table. The recharge trenches are generally 2- to 3-ft wide and excavated using a backhoe. The trenches may be excavated to a depth of approximately 30 ft using conventional backhoes and to much greater depths using telescopic backhoes or clamshells. (For more information on excavation, refer to Section 4). Recharge trenches are typically excavated within 2 ft of the water table, lined with a geotextile filter fabric, backfilled with clean gravel, and covered with a geotextile filter fabric and approximately 3 ft of soil. Well points are placed in the gravel pack during construction at a distance that would uniformly distribute the reinjected water. The recharge trenches can cross-cut possible impermeable geologic layers to ensure that water is returned to the underlying aquifer. A geotextile filter barrier encloses the gravel pack of the trench to minimize siltation of the trench. The most appropriate geotextile filter material is selected based on the geologic conditions and soil properties. Choosing the proper geotextile filter material is critical to reduce clogging and stabilize the trench walls. Figure 5.1-3 displays a cross-sectional view of a recharge trench.

5.2 PROCESS DESCRIPTION

Groundwater extraction/reinjection methods are evaluated according to their applicability to the five plume groups identified at RMA—the Northwest Boundary Plume Group, the Western Plume Group, the North Boundary Plume Group, the Basin A Plume Group, and the South Plants Plume Group.

Groundwater extraction using wells is a proven, implementable method that has been used extensively at RMA at the boundary and IRA systems. Extraction wells are recommended and costed for all plume groups. Several monitoring wells and/or piezometers are installed around the extraction wells at varying depths and distances from the wells to monitor system performance. Reinjection wells are generally not recommended due to a history of plugging at RMA and the proven effectiveness of recharge trenches at RMA.

Horizontal wells have proven to be successful at the DOE Savannah River Site and other DOE, DOD, and private sites (Kaback and Wilson 1993). The site conditions in the Basin A Plume Group and South Plants Plume Group appear to favor horizontal wells.

For reinjection, recharge trenches are effective in returning treated water to the aquifer. Such systems are currently in use at the NBCS and the Basin A Neck IRA system, where they are operating effectively. Recharge trenches are the most effective method in recharging treated water to the subsurface for most plume groups because of their applicability to typical RMA conditions and because of the history of operation at RMA. Monitoring wells and/or piezometers are installed within and around the recharge trench at various depths and distances to monitor system performance.

Appendix A presents ARARs that apply to the extraction and reinjection of groundwater.

5.2.1 Pre- and Posttreatment

Pretreatment for the extraction wells includes purging and developing the wells. Developing the wells is required so that water may be extracted efficiently through the gravel pack and aquifer material near the well. During development, very fine materials that reduce flow are removed. Posttreatment for extraction wells and recharge trenches include periodic redevelopment and the addition of a sodium hypochlorite solution containing a surfactant to prevent clogging.

5.2.2 Costs

The costs of extraction wells and recharge trenches depend on the size of the system designed and site-specific conditions: the larger a system is, the lower the percentage mobilization costs are compared to the total system cost.

The capital cost of extraction wells is approximately $60/ft to $80/ft depending on site-specific conditions. The cost per foot includes installation and pumps. The O&M and other miscellaneous costs depend on system size, design, and replacement rates determined by corrosion and wear and are described in the alternative description sections of the DAA. Monitoring wells cost approximately $30/ft, and O&M includes labor and chemical analysis costs.

The capital cost of horizontal wells less than 25 ft in vertical depth averages $316/ft, and the capital cost averages $186/ft for vertical depths between 25 ft and 100 ft (Kabak and Wilson 1993). While horizontal wells have higher initial costs than vertical wells, operation and maintenance costs of horizontal wells may be lower due to fewer well heads with fewer pumps (Hall 1992).

The capital cost for reinjection trenches is approximately $12/SF, which is determined by multiplying the length of the trench by the depth of the trench. A $30,000 mobilization cost is also associated with recharge trenches. The O&M and miscellaneous costs depend on system size and design.

5.3 PROCESS PERFORMANCE

Groundwater extraction removes contaminated groundwater from the aquifer to a surface system where it can be treated and reinjected. In terms of long- and short-term effectiveness, on-post groundwater extraction, treatment, and reinjection controls contaminants that are close to the sources and may reduce operation time of the boundary systems. Source control through extraction also reduces the possibility of vertical and horizontal migration of contaminants. Groundwater extraction methods may not completely restore aquifers to health-based drinking water standards due to aquifer characteristics and characteristics of the contaminants. The primary aquifer conditions that render pump-and-treat technology less effective are subsurface heterogeneity and low hydraulic conductivity or permeability. The primary characteristics of contaminants that render pump-and-treat technology less effective are water insolubility and high sorbing affinity for the aquifer materials (Mott 1992). Although evidence suggests pump-and-treat systems may not effectively reduce contamination in aquifers below health-based standards, pump-and-treat systems are shown to effectively contain most plumes and possibly remove a large mass of contamination (ORNL 1991). The extraction systems chosen for RMA were selected for mass removal or interception of contaminants and not for restoration of the aquifer to health-based standards because groundwater extraction for potable use is not permitted within RMA boundaries. In the long term, the extraction systems will reduce contaminant loading on the boundary systems and possibly reduce required operation time of the boundary systems.

Groundwater extraction and reinjection methods are implementable and proven technologies. The cost of extraction/reinjection methods are relatively low when compared to impermeable barrier/containment methods. The same volume of water that is extracted must be reinjected to replenish the aquifer and maintain the regional water balance. Tables 5.3-1 and 5.3-2 present information related to the performance of the extraction/reinjection systems.

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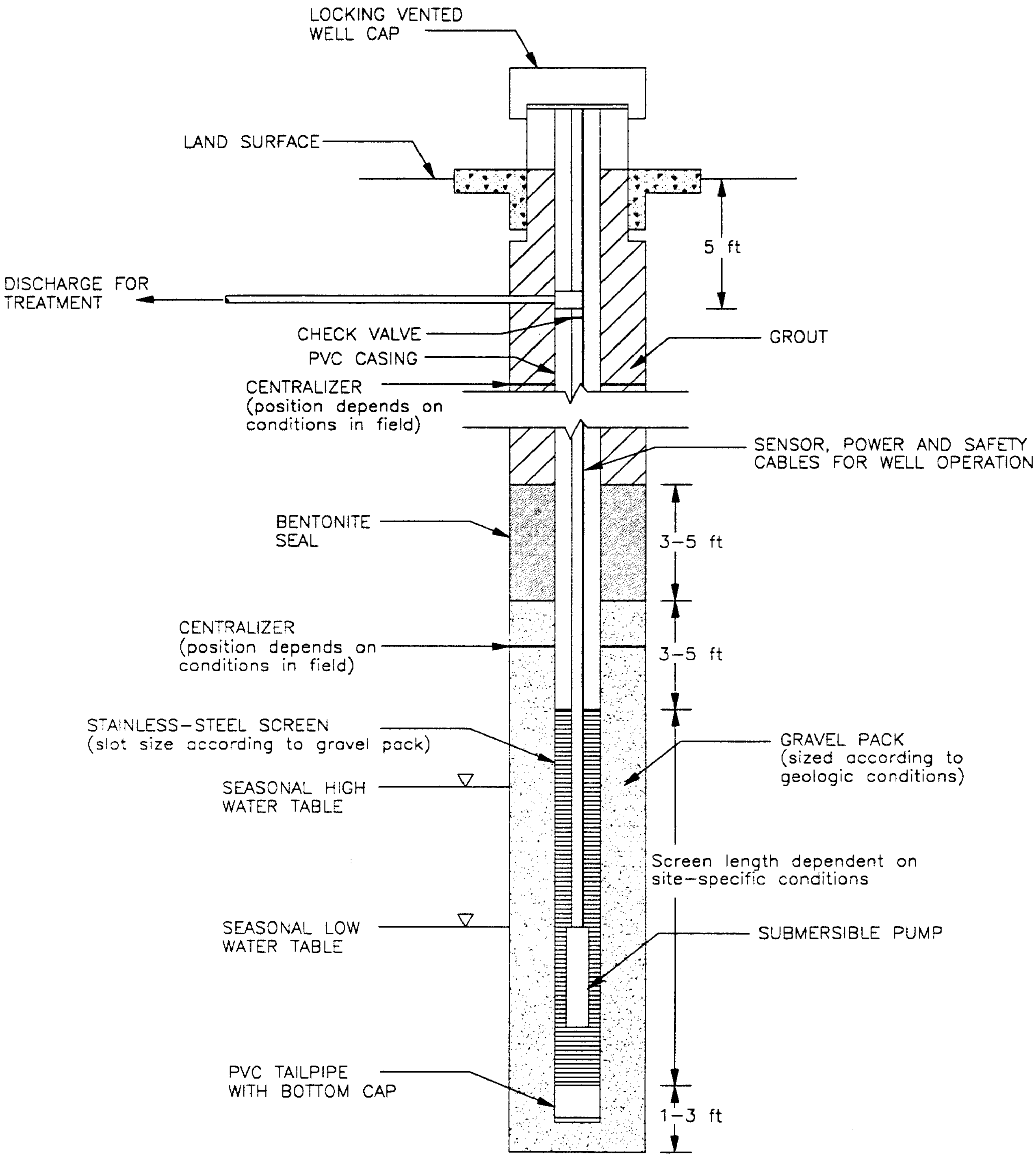
Table 5.3-1 Performance for Extraction

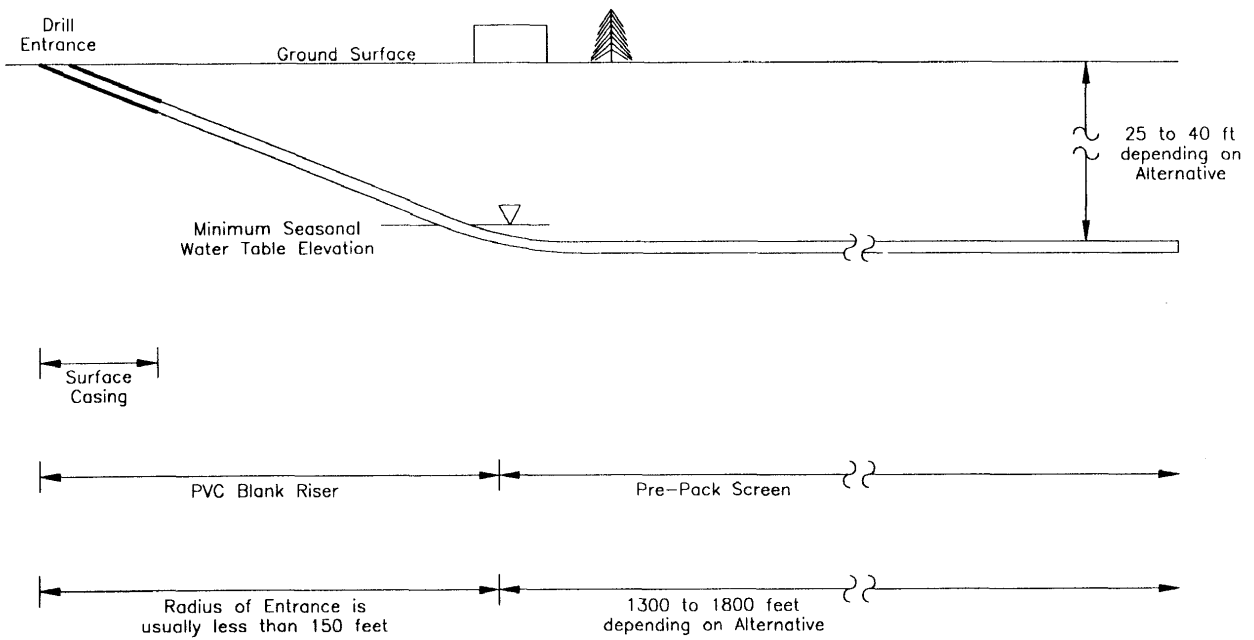
Technology	Applicability at RMA	Advantages	Disadvantages	Cost
Wells	The boundary and IRA systems have proven their implementability.	Works as a hydraulic barrier to contain/remove contaminants. Extracts high volumes of water from greater depths. Easy to maintain and cost-effective installation.	High O&M costs when used in high-concentration plumes. Not effective in low-permeability zones. Potential vertical migration of contaminants along casing.	\$60–\$80 per ft

Table 5.3-2 Performance of Reinjection Method

Technology	Applicability at RMA	Advantages	Disadvantages	Cost
Recharge Trenches	More effective at RMA because they clog less easily than wells.	Reinjects larger quantities of water over a larger area. More effective in shallow water tables and low-permeability areas. Crosscuts fractures more easily.	Not cost-effective for returning water to deep aquifers. More difficult to install than wells.	$12/SF



Prepared for: Office of the Program Manager for Rocky Mountain Arsenal
FIGURE 5.1–1 Extraction Well
Prepared by: Foster Wheeler Environmental Corporation



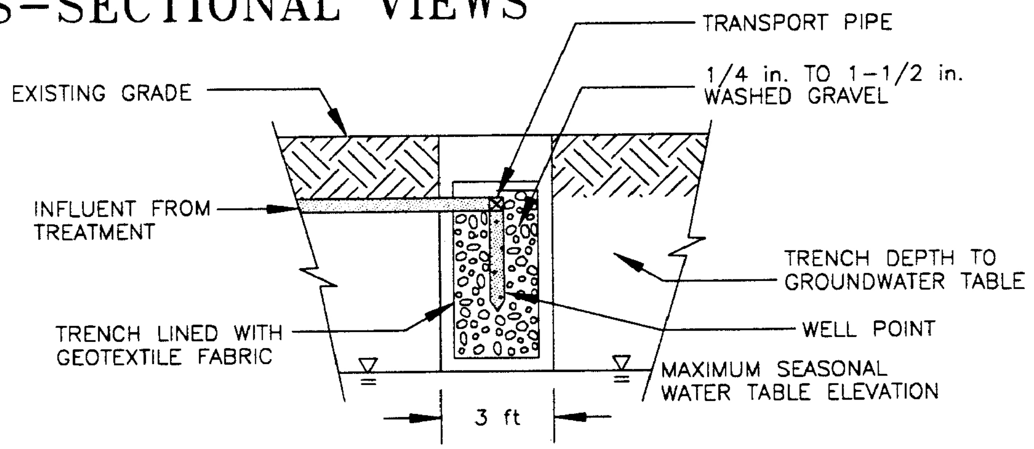
Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal

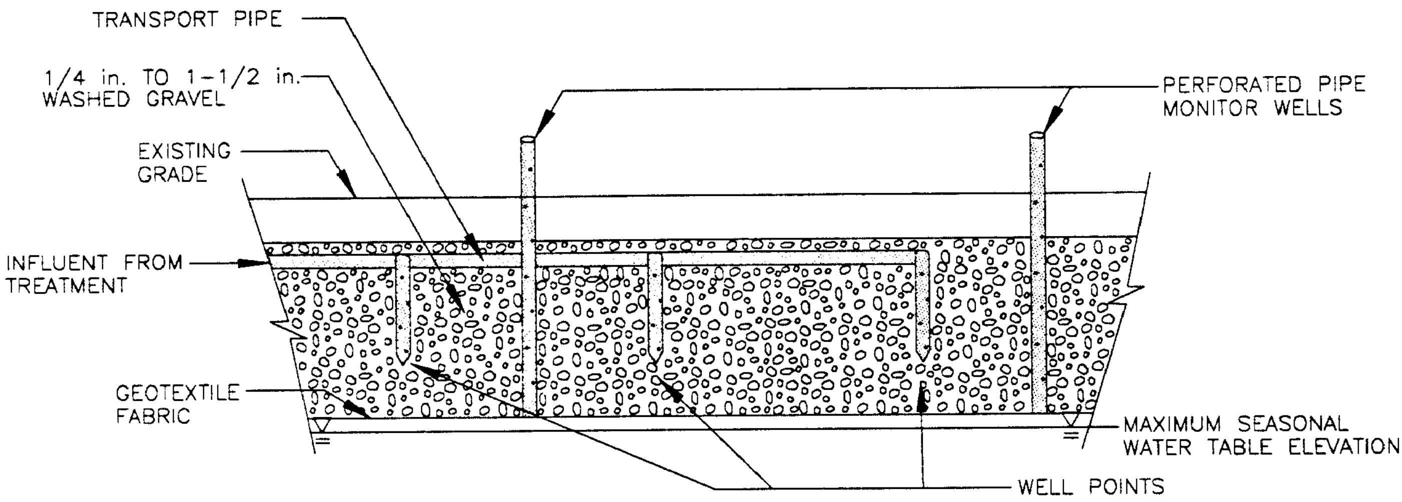
FIGURE 5.1-2

Cross Section of a Horizontal Well

Prepared by:
Foster Wheeler Environmental Corporation

CROSS-SECTIONAL VIEWS





PLAN VIEW

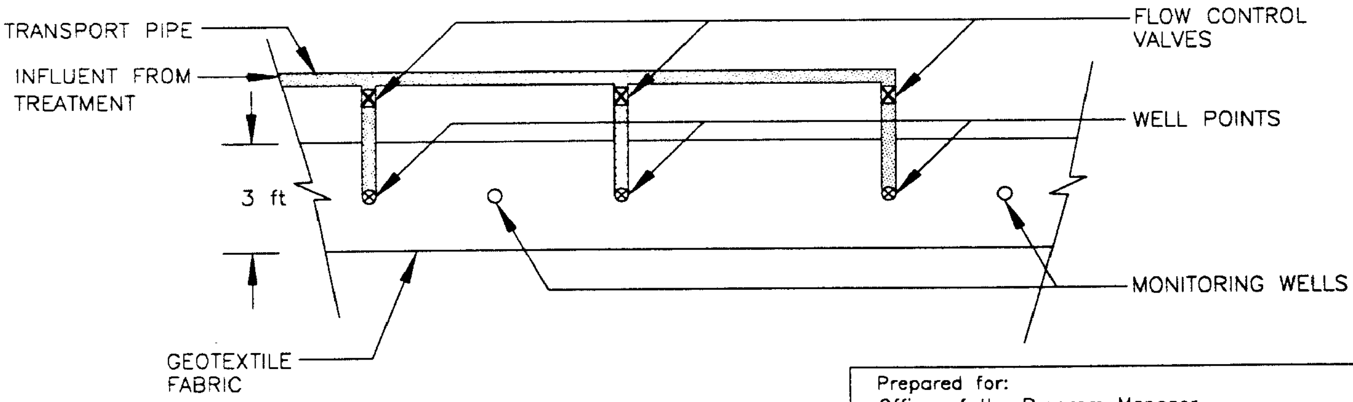


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FIGURE 5.1-3

Typical Recharge Trench

Prepared by:
Foster Wheeler Environmental Corporation

Section 6

6.0 CONTAINMENT

This section describes process options used in alternatives within the Containment General Response Action Category. These options interrupt exposure pathways through the use of physical barriers and decrease the mobility of the contaminants through the reduced leaching of contaminants from soil. The word "clay" is used for brevity in the terms "clay/soil cover" and "clay/soil cap" and does not preclude the use of other types of soil in the implementation of those alternatives so long as all remediation goals and criteria are met. Section 6.1 describes the soil cover process option, and Section 6.2 describes a clay/soil cap. Section 6.3 presents the slurry wall process option, which is used for containing soil in ditches, and Section 6.4 describes the composite cap. Section 6.5 discusses the on-post hazardous and nonhazardous waste landfills and slurry wall. Section 6.6 presents the off-post landfill process option for structural debris, which includes both hazardous waste and solid waste landfills.

6.1 SOIL COVER

A soil cover allows potential agent-contaminated soil to remain on post as long as engineering controls provide a physical barrier, but it is not intended to provide a low-permeability barrier to infiltration as does a clay/soil cap, which is described in Section 6.2. The soil cover provides a barrier to protect human and biota receptors from directly contacting potential agent-contaminated soil. This process is applicable to soils within the Munitions Testing and Agent Storage Medium Groups. Implementation of a soil cover requires the identification and removal of surface and subsurface UXO prior to installation of the cover to ensure protection of personnel and equipment.

6.1.1 Process Description

The typical soil cover consists of 4 ft of clean, noncohesive borrow soil, which provides protection to potential human and biota receptors because the exposure pathways are interrupted. The upper 6 inches of the typical 4-ft soil cover consists of conditioned soil to support the development of a vegetative layer. The 4 ft of noncohesive soils facilitate root development in plants. The soil cover is only minimally compacted to facilitate the establishment of the vegetative cover (i.e., to allow root penetration). The specific installation and design of the soil cover is dependent on the properties and engineering characteristics of the soil used for the cover.

While the typical soil cover has a thickness of 4 feet, soil covers for specific sites may use a different soil cover thickness or may include a concrete biota barrier. Soil cover variations include the following:

- Variable soil cover thickness from 1 to 2 feet for Section 36 Balance of Areas;
- Variable soil cover thickness from 1 to 3 feet for South Plants Ditches and Balance of Areas;
- Soil cover thickness of 2 feet for Secondary Basin and North Plants;
- Soil cover thickness of 4 feet overlying a 1-foot thick broken concrete biota barrier for South Plants Central Processing Area; and
- Soil cover thickness of 4 feet overlying a 6-inch thick formed concrete slab biota/excavation barrier for Basin A.

Prior to placing the soil cover, surface sweeps and geophysical surveys are conducted to ensure the safety of heavy equipment and personnel in near-surface soils with potential UXO presence. The surface sweep is conducted by personnel with expertise in UXO identification and hazard assessment. UXO personnel carefully inspect the site to ensure all areas of the site have been inspected for potential UXO presence at the surface. Following the surface sweep, a magnetometer survey is conducted to identify any near-surface UXO/debris. If UXO is found during the survey, standard clearance procedures are followed (see Section 9).

The cover will be slightly convex, with an upper slope of between 3 and 5 percent to reduce infiltration and erosion of the cover. Areas to be covered that have existing slopes within this range would not require additional fill for grading before the cover is installed, but areas with slopes less than 3 percent are graded and filled in order to achieve a grade of at least 3 percent. Prior to placement of the cover, the subgrade is compacted in a rough grading operation to improve contact between the subgrade and the cover.

The vegetation used in the soil/vegetation layer must be capable of surviving at a sufficient density to minimize erosion of the cover with little or no maintenance. The vegetation used is locally adapted perennial grasses and low-growing plants that are resistant to drought and temperature extremes. The grasses and plants are selected to impede erosion, as they allow surface runoff from major storm events and discourage burrowing animals from using the revegetated cover as a habitat.

Following the installation of the cover, site controls affecting access and biota relocation are implemented to maintain the integrity of the cover. Therefore, the controls ensure that the cover limits potential exposure to humans and biota from UXO- and agent-contaminated soils. Institutional controls ensure that the cover is not disturbed or excavated, and any burrowing animals are relocated to ensure the protection of burrowing animals from physical hazards below the cover. Maintenance activities account for the repair of any erosion damage, and the integrity of the cover is evaluated as part of the 5-year review.

Appendix A presents the action-specific ARARs governing the monitoring of a soil cover over untreated materials. Information to-be-considered (TBCs) in the design of a clay/soil cap (Section 6.2) is also detailed in Appendix A. ARARs and TBCs regarding the design of the uppermost layers of a cap should be considered in the design of a cover, including promoting drainage and minimizing erosion.

Table 6.1-1 presents the costs for installing and maintaining a clay/soil cover. The installation of a soil cover does not entail any capital costs. The operating costs for installing a cover vary based on level of PPE used during installation; the costs range from \$6.92 to \$12.61/SY. In some cases, an additional cost will be incurred to bring the existing grade of the cover to the 3 to 5 percent design grade for surface water runoff control. The operating costs include excavating and hauling the cover materials from a borrow area, placing the materials, and reconditioning the top 6 inches with conditioners. The long-term monitoring costs range from \$0.04 to \$0.18/SY annually, including anticipated maintenance and reviews.

6.1.2 Process Performance

The soil cover acts to cover agent-contaminated soil, thus preventing direct contact with human and biota receptors. Implementation requires the identification and removal of near-surface and subsurface UXO prior to installation to protect personnel and heavy equipment. Access restrictions, biota relocation, maintenance, and 5-year reviews will ensure the integrity of the cover.

6.2 MULTILAYER CAP

A multilayer cap both reduces the migration of hazardous substances into the surrounding environment by minimizing infiltration through the contaminated soil and reduces the possibility of human and biota exposure by direct contact by isolating the contaminated media. Additionally, some hazardous organic contaminants may naturally degrade into nonhazardous compounds during the life of the containment system. Multilayer caps are used in containment alternatives or in conjunction with other treatment alternatives for most of the biota and human health exceedance subgroups, as well as the Significant and Other Contamination History groups of the structures medium. In many alternatives developed for the soil medium (see Soil DAA, Section 4), the multilayer cap is used either as the sole containment structure (Alternative 6) or in combination with a slurry wall (Alternative 5). The multilayer cap is also applicable to the containment of structural debris.

6.2.1 Alternative Components

The multilayer cap consists of three primary layers, the uppermost layer being essentially the same as the soil cover described in Section 6.1.1. From top to bottom, the multilayer cap generally consists of the following:

- A 4-ft-thick soil/vegetation layer of clean borrow material capable of supporting vegetation to minimize erosion and promote drainage
- A 1-ft-thick middle layer of crushed concrete or cobbles as a biota barrier to protect the underlying low-permeability soil layer from burrowing animals
- A 2-ft-thick bottom layer of compacted, low-permeability soil

The compacted soil layer must be located entirely below the maximum depth of frost penetration to prevent damage from freeze/thaw cycles. The maximum depth of frost penetration is approximately 42 inches in the Denver area. Therefore, the 4-ft-thick soil/vegetation layer plus the 1-ft-thick biota barrier are more than adequate to prevent damage to the compacted clay layer. Additionally, a 4-ft-thick soil/vegetation layer successfully accommodates root systems of the vegetated surface and attenuates rainfall infiltration to the underlying compacted soil layer.

To prevent ponding of rainwater resulting from irregularities in the top layer of the cap, it is constructed with a slope of 3 to 5 percent. Areas with existing slopes within this range that are to be capped do not require additional fill, but areas with existing slopes of less than 3 percent are graded and filled to achieve the desired crown and 3 percent slope. Compaction of the soil/vegetation layer is minimal to facilitate root development and to allow sufficient water infiltration to maintain root development through dry periods.

Figure 6.2-1 shows a detail of a multilayer cap. As described in Section 6.1.1, the soil/vegetation layer consists of clean borrow material. This borrow material must be capable of sustaining plant species that minimize erosion. The borrow material available at RMA consists of fine- to medium-grained noncohesive soil that is capable of supporting native vegetation.

The vegetation used for the soil/vegetation layer, locally adapted perennial grasses and low-growing plants that are resistant to drought and temperature extremes, must be capable of surviving with little or no maintenance. In addition, the grasses and plants must impede erosion as they allow surface runoff from major storm events. The plant density should minimize top layer erosion to no more than 2 tons per acre per year (0.011 inch per acre per year), which was calculated using the U.S. Department of Agriculture (USDA) Universal Soil Loss equation according to EPA guidance on caps and landfill covers (OSWER 1989).

The 1-ft-thick biota barrier is comprised of a layer of crushed concrete or cobbles to prevent the intrusion of burrowing animals into the lower layers of the cap. Debris from demolished structures could be used for the biota barrier depending on the alternatives selected for structures. With time, soil from the overlying soil layer infiltrates and fills the voids even more tightly, although the effectiveness of either layer is not compromised. The grasses and low-growing plants used for cover have shallow root systems that do not fully penetrate the soil/vegetation layer.

The biota barrier for the Complex Trenches Subgroup is a six inch thick formed concrete slab instead of the crushed concrete or cobbles.

The 2-ft-thick, low-permeability soil layer provides long-term minimization of infiltration into the contaminated soil unit. This layer is constructed such that the permeability of the unit is no greater than 1×10^{-7} centimeters per second (cm/sec). The compacted clay layer is a minimum of 24 inches thick, as specified by the EPA for hazardous waste cap design (EPA 1989), and is based upon constructability considerations and the ability to provide a uniform overall permeability. The low-permeability soil layer should be installed as a series of 6-inch lifts to allow any localized inconsistencies in one lift to be sealed by another. The lifts should be compacted a few percent wet of the optimum moisture content to ensure that the lowest permeability is attained.

The specific design of the low-permeability soil layer is dependent on the properties and engineering characteristics of the clay being compacted. However, the preferred soil material has low to medium plasticity and a liquid limit of less than 50 percent by weight.

Appendix A presents the action-specific ARARs governing the monitoring of a multilayer cap over untreated materials. These ARARs include several design considerations regarding promoting drainage and minimizing erosion.

Table 6.2-1 lists the costs for installing and maintaining a multilayer cap. The installation of a multilayer cap does not entail a capital cost. The operating cost for installing a multilayer cap is estimated at $19.01/SY. Depending on site-specific conditions, an additional cost may be incurred to bring the existing grade of the cover to at least 3 percent. The operating costs include excavating and hauling the cover materials from a borrow area, placing the soil and crushed concrete layers, and supplementing the top 6 inches of soil with conditioners. The long-term monitoring cost for soil is estimated at $0.07/SY annually, including anticipated maintenance and reviews. Several sites at RMA are currently contained with a multilayer cap as part of an IRA. The cost for upgrading the caps at these sites, which consist of the Former Basin F, Section 36 Lime Basins, and Shell Trenches subgroups, is lower, $18.82/SY, because the uppermost 2 ft of the existing clay/soil cover is stripped, stockpiled, and used in the modified cap/cover.

6.2.2 Factors Determining Alternative Performance

The multilayer cap is implementable with standard equipment, and personnel with experience and knowledge of the process are available to perform the work. The containment system stems the migration of contaminants and isolates contaminated media, reducing the possibility of human and biota exposure. The process does not provide extensive reduction in TMV, although the toxicity and volume of contaminants in the soil decrease through natural attenuation/degradation (Section 3.3.3 of Executive Summary). As with a soil cover, access restrictions, biota relocation, maintenance, and 5-year reviews ensure the integrity of the cover; however, the cobble barrier assists in preventing exposure to burrowing animals.

The multilayer cap is constructed to be a RCRA equivalent cover meeting the design criteria of (1) effectively isolating hazardous materials from precipitation; (2) preventing contact between hazardous materials and humans/biota; and (3) serving as an effective long-term barrier. The individual multilayer cap components may vary depending on individual site characteristics, however the RCRA equivalency requirements should be considered in any design variation.

The major concerns regarding the effectiveness of a multilayer cap are that the cap might not be installed as designed or that the low-permeability soil layer might not be uniform. To avoid this, quality assurance/quality control (QA/QC) during construction is essential. The installation of the multilayer cap should be monitored to ensure that the layers are uniform and free from damage, the materials for each layer are as specified, and each layer is constructed as specified.

6.3 SLURRY WALL

Slurry walls are vertical barriers that serve to impede the lateral flow of contaminated groundwater. The slurry wall mixture (backfill soil, bentonite, and water) is selected based on compatibility and optimization concerns. Slurry walls are included within Alternative 5 in conjunction with the installation of a clay/soil cap. This alternative is applicable to several human health exceedance medium groups including the Disposal Trenches and Sanitary Landfills Medium Groups. The slurry wall process is also applicable for pump-and-treat groundwater systems, and the combination is already in use at the NBCS and NWBCS at RMA.

6.3.1 Process Description

The installation of a slurry wall entails the excavation of a trench with an excavator, extended-reach excavator, or a clamshell. The slurry of bentonite and water is pumped into the trench to prevent the walls of the trench from collapsing. The fill material—a soil and bentonite mixture—is then placed into the slurry-filled trench. In general, the soil excavated from the trench is mixed with bentonite and used as slurry wall backfill. There are two groundwater flow impediment mechanisms in all slurry trench cutoff walls. The first is the impermeable layer formed within the trench by the soil and bentonite fill material. The second is the impermeable layer formed in the trench walls by the bentonite material permeating into the interstices of the soil on each side of the trench wall. Both processes serve to impede the lateral flow of groundwater, although which layer acts as the primary inhibitor of flow is under debate. Slurry walls may be installed around sites in conjunction with the placement of a clay/soil cap to form an isolation cell around the contaminated soil. Installation of a slurry wall prior to a multilayer cap allows the compacted soil layer to be keyed into the top of the slurry wall (Figure 6.3-1).

Slurry walls are constructed to achieve a low permeability. In general, the average depth is estimated at 30 ft, although the required depth of a slurry wall varies across a site. The slurry wall is keyed into the Denver Formation at varying depths depending upon amount of fracturing within the formation, and the slurry wall width is generally 2 to 3 ft based on equipment used. The width and depth of a slurry wall may change based on the site-specific conditions encountered.

The slurry mixture consists of dry bentonite mixed with water to form a pumpable mixture. The ratio of bentonite to water as well as the specifications for the mixture of soil and bentonite for the fill material are based on laboratory-scale engineering and compatibility testing. In general, the soil used in the soil/bentonite backfill should contain a wide range of grain sizes with a large percentage of fine-grained materials. The selection criteria for the soil/bentonite mixture is based on the following:

- Low permeability
- Compatibility with contaminants
- Constructability, stability, and quality control of the mixture
- Cost-effectiveness

For a slurry wall to control groundwater migration, a groundwater removal system is generally installed in conjunction with the slurry wall. For example, if a slurry wall surrounds a given site, the hydraulic controls associated with a groundwater removal system maintain a negative pressure head to ensure that any groundwater movement runs from the outside of the slurry wall system to the inside. The extracted groundwater is transported to the nearest wastewater treatment facility for treatment. The groundwater removal system is designed based on site-specific conditions, and the extraction well system is designed to be flexible in meeting increased or decreased pumping demands. The location and pumping rates for the containment cell are selected based on modeling so that the required hydraulic gradient may be established and maintained.

The mixing of bentonite and water to form the slurry requires a mixing plant to adequately control and monitor the generation of the slurry, a storage pond or pit to store the slurry before it is pumped into the trench, and a covered storage area for the bentonite powder. The pond is necessary because the slurry must be mixed on a batch basis even though it is pumped into the excavated trench on a nearly continuous basis as the trench is excavated. A pug mill is also needed to mix the soils with bentonite for use as slurry wall backfill.

Appendix A presents the action-specific ARARs governing the installation of a slurry wall around untreated materials. The ARARs primarily consist of regulations related to groundwater removal as part of hydraulic controls.

Table 6.3-1 lists the costs for installation of a slurry wall. The operating cost for installing a slurry wall is governed by the depth of the slurry wall, which in turn dictates the equipment to be used. The cost for installation of a 20-ft to 65-ft-deep slurry wall is $47.72/SY of the face of the slurry wall; in this case, an extended reach arm is required apparatus on the excavation equipment. For slurry walls less than 20 ft deep, the unit cost is approximately $33.77/SY, and the cost of slurry walls deeper than 65 ft is estimated to be $100.59/SY of the face of the slurry wall because a clamshell would be required for excavation and the wall would be wider than 3 ft. In addition, the installation of a dewatering system and its annual long-term operation are estimated on a subgroup-specific basis in accordance with Sections 5 and 14.

6.3.2 Process Performance

The slurry wall containment system is implementable with standard equipment and personnel with experience and knowledge of the process who are available to perform the work. The containment system reduces the migration of contaminants and isolates contaminated media to reduce the possibility of human and biota exposure. The process does not provide reduction in toxicity and volume of contaminants.

As with the clay/soil cap, the major limitations of the effectiveness of a slurry wall are irregularities and defects in the wall that could lead to leakage. The installation of the slurry wall is closely monitored to ensure that it is installed to the design depth within specifications and that the materials used are as specified in the design.

6.4 COMPOSITE CAP

This section describes a composite cap that both reduces the migration of hazardous substances into the surrounding environment by minimizing infiltration through the contaminated soil and reduces the potential exposure of contamination to both humans and biota by direct contact. Additionally, some hazardous organic contaminants may possibly naturally degrade to nonhazardous compounds during the life of the composite cap. The composite cap alternative will be implemented at the Basin F Wastepile. Currently, as part of the IRA, the Basin F Wastepile has a clay/soil cover in place. This clay/soil cover will be supplemented with a composite cap meeting Resource Conservation and Recovery Act (RCRA) requirements. The existing 12-inch cohesive soil layer and 6-inch topsoil layer will be removed and stockpiled for reuse. The composite cap will be placed on top of the remaining existing cap.

6.4.1 Alternative Components

The composite cap consists of six layers, from top to bottom, consisting of the following:

- A soil/vegetation layer consisting of topsoil and clean borrow material capable of supporting vegetation to minimize erosion and promote drainage.
- A biota barrier layer made up of cobbles to protect the underlying layers from burrowing animal intrusion.
- A drainage layer consisting of a geotextile and a high-permeability sand that is used to convey any infiltration to the collection pond to minimize the amount of leachate generated.
- A composite geomembrane and geosynthetic clay liner placed between the drainage layer and the soil cover layer to reduce infiltration and leachate generation.
- Soil cover layer to provide a suitable foundation for the geomembrane.
- A geogrid layer placed directly over the existing cap to provide stability for the overlying cover layers.

A detail of the composite cap is shown in Figure 6.4-1. The soil/vegetation layer of the composite cap will consist of 2 ft of clean borrow material and 6 inches of topsoil capable of sustaining plant species to minimize erosion. The borrow material available near the wastepile consists of fine- to medium-grained, noncohesive soils. The topsoil removed from the existing cap will be reused in the composite cap. These materials are capable of supporting native vegetation.

The soil/vegetation layer is also required to prevent freezing and thawing from damaging the underlying low-permeability soil layer. The composite geomembrane must be located entirely below the maximum depth of frost penetration to prevent damage from freeze/thaw cycles. In the Denver area the maximum depth of frost penetration is approximately 42 inches. Therefore, the 2-ft soil/vegetation layer in combination with the underlying layers is adequate to prevent damage to the compacted low-permeability soil layer.

To prevent ponding on the surface of the cap, the cap will be constructed with a slope of 3 to 5 percent. Areas to be capped that have existing slopes within this range will not require additional fill. However, areas with existing slopes of less than 3 percent will be graded and filled in order to achieve the desired crown and 3 percent slope. Compaction of the soil/vegetation layer will be minimal to facilitate root development and allow sufficient infiltration to maintain root development through dry periods.

The vegetation types used on the soil/vegetation layer will be capable of surviving with little or no maintenance. The vegetation used will be locally adapted perennial grasses and low growing plants, which are resistant to drought and temperature extremes. The grasses and plants will be selected to impede erosion but allow surface runoff from major storm events. The plant density should minimize top layer erosion to no more than 2 tons per acre per year (0.011 inch per acre per year), which was calculated using the USDA Universal Soil Loss equation according to EPA guidance on caps and landfill covers (OSWER 1989).

The biota layer is provided as a barrier to burrowing animals. The biota barrier consists of a layer of cobbles or crushed concrete that will prevent the intrusion of burrowing animals, thus protecting the lower layers of the cap. The biota layer will be 12 inches thick and will consist of large, tightly packed cobbles with gravel filling the voids within the cobble layer or with crushed concrete. Debris from demolished structures could be used for the biota barrier depending on the alternatives selected for structures.

A geotextile is placed between the biota barrier and drainage layer to minimize the intermixing of the soil with the cobbles. The grasses and low-growing plants used for vegetation will have a shallow root system that will not fully penetrate the soil layer. Therefore the geotextile will not be impacted by the vegetation.

The drainage layer will consist of 12 inches of a high-permeability soil. The purpose of the drainage layer is to intercept water that percolates through the upper layers of the cap and transport the water out of the cover. The permeability of the drainage layer soils should have a minimum value of 1×10^{-2} cm/sec. The drainage layer will slope to an exit drain, which will allow the water to be efficiently removed by gravity flow.

A composite liner comprised of a geomembrane and a geosynthetic clay liner (GCL) is placed below the drainage layer to minimize infiltration. The geomembrane will be a very-low density polyethylene (VLDPE) liner or equivalent. A geosynthetic clay liner (GCL) will be placed directly below the VLDPE in lieu of the 4 ft of compacted low-permeability soil. The GCL will meet EPA requirements for alternative designs. The GCL will consist of bentonite and high-density polyethylene (HDPE) or geotextile and will provide an additional low-permeability barrier.

A 12-inch low-permeability soil cover layer will underlie the GCL to provide a suitable foundation. The cohesive soil removed from the existing cap will be used for this layer of the composite cap. The soil cover layer will be slightly compacted.

A geogrid is placed directly above the soil layer in the existing cap to provide additional stability between the existing cap and the composite cap.

The gas produced must be vented out of the cap. The vents in the existing gas collection system will be extended through the composite cap and the gas will be vented into the atmosphere after passing through a treatment system to remove organic vapors.

The action-specific ARARs governing the monitoring of a composite cap over untreated materials are presented in Appendix A. These ARARs include several design considerations regarding promoting drainage and minimizing erosion.

The costs for installing and monitoring a composite cap are presented in Table 6.4-1. The top 1.5 ft of the existing IRA cap at the Basin F Wastepile will be removed prior to placement of the composite cap. The top 6 inches of soil removed will be stockpiled and used as topsoil for the composite cap, with the remaining 1 ft of soil being stockpiled and used for soil cover. After removal of the existing cap, some areas of the Basin F Wastepile will need to be backfilled to increase the existing grade of the cap to 3 percent. Therefore, additional costs resulting from removal of the existing cap and grading operations may be incurred. The operating costs for installing a composite cap are estimated at $31.63/SY. The operating costs include hauling the additional 2 ft of cover materials from a borrow area; placing the soil, cobble, and geosynthetic layers; and placing the stockpiled topsoil. The long-term monitoring costs are estimated at $0.12/SY per year including anticipated erosion damage, maintenance, and reviews.

6.4.2 Factors Determining Alternative Performance

The composite cap is implementable with standard equipment, and personnel are available who have experience and knowledge of the process. The composite cap isolates the contaminated material from possible human and biota exposure and it also reduces the migration of contaminants. The process does not provide extensive reduction in toxicity and volume of contaminants. However, natural degradation/attenuation will reduce the toxicity and volume of contaminants in the soil. Access restrictions, biota relocation, maintenance, and 5-year reviews will be implemented to ensure the integrity of the cap. The cobble barrier will assist in preventing exposure of burrowing animals.

The effectiveness of the composite cap is contingent upon proper installation procedures being implemented. Uniform compaction of the low-permeability soil is necessary to attain a low hydraulic conductivity. To avoid any installation anomalies, QA/QC during construction is essential. Installation of the composite cap should be monitored to ensure that the layers are uniform and damage free, the materials for each layer are as specified, and each layer is constructed as specified.

6.5 ON-POST LANDFILL

A landfill securely contains contaminated soils or structure debris by providing a physical barrier both above and below the contaminated material. A low-permeability cover protects human and biota receptors from direct contact with the contaminants, and the low-permeability liner restricts contaminant mobility, protecting the underlying soils and groundwater. The landfill technology is applicable primarily for the disposal of untreated soils and debris but may also be used for the disposal of treated debris and soil/debris mixtures. Alternatives utilizing the landfilling technology were retained in the DSA (EBASCO 1992) for the soils medium groups within the biota and human health exceedance categories and for the Significant Contamination History and Agent History groups. In addition, oversize materials removed during materials handling activities for both soil and structures direct treatment alternatives will also require placement in a landfill.

6.5.1 Process Description

Landfill cells may be constructed and classified based on their cover and liner system designs and the types of wastes that are contained within them. Depending on the concentrations and leachability of contaminants, contaminated soil may be placed in either a hazardous waste landfill cell, which is constructed in accordance with RCRA-Subtitle C requirements, or in a Subtitle D, solid waste landfill cell. An on-post landfill would likely contain both hazardous and solid wastes, but all materials will be placed in a hazardous waste landfill cell.

Appendix A presents the action-specific ARARs governing the siting, design, and performance of a hazardous waste landfill. Based on the ARARs for a hazardous waste landfill, an area of the southwest portion of Section 25 has been identified as the most suitable location for the centralized on-post landfill (Figure 6.5-1).

The on-post landfill may consist of several cells, depending on the amount of contaminated materials to be disposed. To estimate the size of the on-post landfill, the largest potential volumes of materials to be placed in the landfill for each medium group were considered and costs for a 5.1-million-CY landfill were developed using four 1,275,000-CY cells. In addition, costs were developed for one 750,000 CY triple-lined landfill cell to isolate the contaminated soils from the Basin F Wastepile and Section 36 Lime Basins Medium groups.

A hazardous waste landfill cell is constructed according to RCRA-Subtitle C requirements. The components of a hazardous waste cell (Figure 6.5-2) include the following major components:

- Cover system, including a gas collection system
- Liner system, including both a leachate detection and collection/removal system

6.5.1.2 Cover System

The cover system acts as an impermeable cap above the waste to isolate the contaminated material from the surface environment. The cover is designed to accommodate any settlement or subsidence within or below the cell. This is achieved by employing flexible materials with which to construct the cover and by controlling waste placement to achieve adequate compaction to minimize differential settlement.

The cover consists of several individual layers (Figure 6.5-3). These cover layers are the same for both the double and triple lined landfill cells and include the following (listed from top to bottom):

- Soil/vegetation layer of common soil and topsoil
- Biota barrier layer
- Drainage layer
- Composite low-permeability layer of a geomembrane and low-permeability soil layers
- Gas collection and transmission layer

The soil/vegetation layer is capable of sustaining plant life. The vegetation (shallow-rooted plants) is capable of surviving and functioning with little or no maintenance. The types of vegetation are locally adapted perennial grasses and plants selected to impede erosion as they allow surface runoff from major storm events (OSWER 1989).

Clean fill material available at RMA or locally (off post) is used for the vegetation/upper soil layer. The uppermost 6 inches of borrow soil is supplemented with conditioners to provide a nutrient-sufficient medium for plant growth. The remaining 42 inches of borrow material consists of medium-grained soil that is capable of supporting native vegetation. Because the maximum depth of frost penetration in the Denver area is approximately 42 inches, the 4-ft-thick soil/vegetation layer is more than adequate to prevent freeze/thaw damage to the low-permeability soil layer of the cap. The 4-ft thickness of the upper layer accommodates vegetation root systems and attenuates infiltration of rainfall to the low-permeability soil layer. As discussed in Section 6.1, the upper slopes of the cover should be sloped from 3 to 5 percent. The slope of the landfill cover prevents ponding of rainwater resulting from irregularities in the upper soil layer, and compaction of the soil/vegetation layer is minimal to facilitate plant growth.

The biota barrier is composed of a layer of cobbles or crushed concrete to prevent the intrusion of burrowing animals into the lower layers of the cap and to prohibit the penetration of deep-rooted plants. The barrier is 12 inches thick and consists of large, cobbles or crushed concrete. The cobble layer is overlain and underlain by geotextile to prevent movement of soil into the biota layer or cobbles into the drainage layer.

The drainage layer intercepts water that percolates through the upper layers of the cap and transports the water out of the cover. A 12-inch drainage layer is typically used to allow sufficient cross-sectional area for transport of water. The permeability of the drainage layer soil should have a minimum value of 1×10^{-2} cm/sec. The drainage layer slopes to an exit drain, allowing the water to be efficiently removed by gravity flow.

The composite low-permeability layer provides long-term minimization of surface water infiltration into the landfill cell. This layer is composed of a flexible membrane liner (FML) and a low-permeability soil layer. According to EPA guidance on covers (OSWER 1989), FMLs should be more than 20 mils (0.020 inch) thick. The FMLs to be used in the on-post landfill are 60 mils (0.060 inch) thick and are placed in direct contact with the underlying low-permeability soil layer. The low-permeability soil layer tends to impede the flow of any leakage through an imperfection in the upper FML. Thus, each component tends to support the other in the event that either one fails. The low-permeability soil layer is constructed with a soil with permeability of less than 1×10^{-7} cm/sec and is a minimum of 24 inches thick as specified by the EPA for hazardous waste cover design (OSWER 1989). This thickness is based upon constructability considerations and the ability to provide a uniform overall permeability. The specific design of the low-permeability soil layer is dependent on the properties and engineering characteristics of the clay being compacted.

The gas collection system provides control of gases released from wastes buried in the landfill cell. Any gas produced must be vented to avoid a buildup of internal pressure that can damage the integrity of the cell. Accordingly, the gas vent layer has a gas collection and venting system constructed of HDPE geonet or granular fill and perforated HDPE pipe surrounded by a filter fabric blanket (Figure 6.5-3). Gas collection pipes run the length of the cell and are connected to a header pipe located on the high end of the cell (Figure 6.5-2). The collected gases are vented to the atmosphere after passing through a treatment system to remove organic vapors. The treatment system may include direct venting to the atmosphere, carbon adsorption, catalytic oxidation, or incineration. The spacing of the collection pipes and the treatment system design is based on the estimated amount of gas to be vented.

Controlling hazardous gas formation may be accomplished through waste control, whereby waste-to-waste incompatibilities are eliminated and uncontrolled decomposition is minimized. Proper waste control prevents commingling of incompatible wastes that can generate hazardous gases.

6.5.1.2 Liner System

The cell liner system consists of either a double composite liner system (Figure 6.5-4) or a triple composite liner system (Figure 6.5-5) that isolates the contaminated soil and leachate from the underlying subsurface environment (Figure 6.5-4). The layers of the double composite liner typically consist of two geomembranes and two low-permeability soil liners. The triple liner, then, generally consists of three geomembranes and three low-permeability soil liners. The synthetic liners must be chemically compatible with the waste contaminants and any leachate generated. Commonly used geomembrane materials include HDPE, chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE), and PVC. The low-permeability soil liner is commonly constructed of natural soil amended with bentonite or other admixtures. The soil liners are constructed such that the permeability of the liner is less than 1×10^{-7} cm/sec. The 3-ft thickness of each soil liner is sufficient to maintain low permeability and to provide a stable base for the landfill cell. The liner components may vary due to construction restrictions regarding the stability of materials on the cell sideslopes.

The leachate collection and leak detection system is an integral part of the liner system (Figure 6.5-4). Preventing the accumulation of free water within the waste cell is achieved by designing the cover so that surface water runoff is effectively managed and by controlling the water content of the waste as it is placed within the cells. As necessary, the free water in the waste is absorbed with a solidification agent prior to disposal.

The leachate collection and removal system is located inside the landfill cell directly above the primary liner. The system includes either granular material or geonet, geotextiles, and perforated collection pipes placed on approximate 50-ft centers that run the length of the landfill cell. The collection pipes are sloped at a minimum of a 1.5 percent to allow gravity flow of the leachate to a series of sumps. The leachate collected in the sumps is removed and transported to an on-post wastewater treatment facility for treatment. A leak detection layer is located below the primary (upper) composite liner(s) to ensure that leachate does not migrate below the secondary (lower) composite liner.

Table 6.5-1 presents the cost components for the 5.1 million CY hazardous waste landfill. The total capital cost for facility construction, liner construction, and cover construction is $13.18/CY. The landfill operating cost is $5.78/CY and the long-term monitoring cost is $0.02/CY of the 5.1 million CY landfill annually.

Table 6.5-2 presents the cost components for the 750,000 CY hazardous waste landfill cell. The total capital cost for facility construction, liner construction, and cover construction of the 750,000 CY landfill cell is $18.13/CY. The operating cost of this landfill cell is $5.80/CY and the long-term monitoring cost is $0.04/CY annually.

6.5.2 Process Performance

The performance of landfill cells is dependent upon their physical properties. The objective of the cell is to provide containment and prevent contaminant migration. To provide waste containment, the waste cell separates the waste from the environment and reduces the possibility of human and biota exposure. To prevent contaminant migration, the waste cell totally encapsulates the waste and provides a means to control leachate and gas generated, and, to confirm the performance of the cell, a site monitoring program is developed, scheduled, and implemented. A hazardous waste landfill could be constructed and operated at RMA in accordance with the action-specific ARARs listed in Appendix A.

The major concern regarding the effectiveness of both the landfill liner and cap is that the layers might not be installed as designed or that the layer might not be uniform. Therefore, QA/QC during construction is essential. The installation of the liner and cap layers should be monitored to ensure that the layers are uniform and free from damage, the materials for each layer are as specified, and each layer is constructed as specified.

6.6 OFF-POST LANDFILL

The process of disposing materials in an off-post landfill consists of transporting the materials to a commercial landfill. Landfilling hazardous or nonhazardous materials at a commercial facility is becoming increasingly more difficult due to restrictions on landfilling certain chemicals, restrictions on transportation of hazardous wastes (particularly across state lines), and the high costs charged by commercial disposal facilities to accept wastes. Based on the DSA screening process (EBASCO 1992), off-post landfilling was retained for the disposal of structural debris only.

6.6.1 Process Description

Under alternatives evaluated for the structures medium, the structural debris from building demolition at RMA is transferred via a loading facility into rail cars or trucks and shipped to an off-post disposal facility. The loading facility is sized to allow for an 8-hour storage capacity of debris. Trucks haul the debris from on-post locations to the central loading facility, which is collocated with the debris shredding facility. The trucks empty their loads into the shredding mill, and loaders move the shredded debris to a conveyor where it is transferred into rail cars or trucks for transport to an off-post facility. The debris is then landfilled at the contracted off-post facility after meeting all required RCRA disposal requirements.

Depending on the chosen off-post landfill facility and transportation option, pretreatment of the debris may be required. The debris is sized to aid in the loading of materials onto either rail cars or trucks. If the debris is hauled by truck, it should be sized to allow for unattended unloading.

Because debris is hauled to an off-post landfill facility, posttreatment of the debris is not necessary and no sidestreams are generated.

Appendix A lists the action-specific ARARs governing the use of a loading/unloading facility. These action-specific ARARs primarily address air emissions and worker protection during operation. Separate descriptions are presented for off-post hazardous waste and off-post solid (nonhazardous) waste landfills due to the differences in waste acceptance criteria and costs.

6.6.1.1 Hazardous Waste Landfill

Four RCRA hazardous waste disposal facilities are presented below as examples. One of the facilities is located in Colorado and was used to develop unit costs for disposal of structural debris. The other three are within the Rocky Mountain region.

- Highway 36 Land Development Company (Highway 36)—The Highway 36 facility is located in Last Chance, Colorado, approximately 70 miles east of RMA. It has a total permitted capacity of 2.5 million CY.

- U.S. Pollution Control, Inc. (USPCI)—USPCI is located in Lakepoint, Utah, approximately 600 miles from RMA. The facility has an RCRA Part B permit and has a substantial landfill capacity.

- Envirosafe Services of Idaho, Inc. (Envirosafe)—The Envirosafe facility is located in Boise, Idaho, approximately 800 miles from RMA. The facility has an RCRA Part B permit and has a land disposal capacity of 2.7 million CY.

- U.S. Ecology, Inc. (Ecology)—The Ecology facility is located in Beatty, Nevada, approximately 900 miles from RMA. The facility has an RCRA Part B permit and has a land disposal capacity of 1.5 million CY.

The capital and operating costs for off-post landfilling of hazardous structural debris are developed from vendor quotations. The capital cost for the central loading terminal is estimated to be \$0.24/CY with an operating cost of \$1.10/CY. Off-post disposal costs, including taxes and fees, and transportation costs at the Highway 36 facility are \$165.25/CY and \$0.56/CY, respectively, per loaded mile for hazardous debris.

6.6.1.2 Nonhazardous (Solid Waste) Landfill

Currently, four nonhazardous (solid waste) landfills located near RMA are capable of receiving structural debris. A brief description of these landfills includes the following:

- Browning Ferris Industries (BFI)—BFI has a landfill at 88th Avenue and Tower Road in Commerce City, Colorado, 10 miles from RMA. The landfill has a current capacity of 475 acres.

- Denver Arapahoe Disposal Service, Inc. (DADS)—The DADS landfill is located approximately 20 miles east of RMA. The landfill has a current capacity of 200 acres and has been permitted to expand up to 2,680 acres.

- Central Weld County Landfill— The Central Weld County Landfill is located near Greeley, Colorado, approximately 50 miles from RMA. The landfill has a current capacity of 1.5 million CY.

- Conservation Services, Inc. (CSI)—The CSI landfill is located approximately 10 miles from RMA. The landfill has a current capacity of 3 million CY.

In addition to these landfills, the hazardous waste landfills identified in Section 6.6.1.1 accept nonhazardous waste.

The capital and operating costs for off-post landfilling of nonhazardous structural debris are developed from vendor quotations. The current capital cost for the loading facility is estimated to be \$0.24/CY, with an operating cost of \$1.10/CY. Off-post disposal costs and transportation costs at the BFI facility are \$22.19/CY and \$0.58/CY, respectively, per loaded mile for nonhazardous debris.

6.6.2 Process Performance

Off-post landfilling is an effective method for disposal of structural debris, providing the debris meets the disposal requirements of the contracted landfill. The contaminated structures may require a treatment process in order to release the structure debris from Army jurisdiction.

There are three limitations to the off-post landfill disposal option: restrictions on landfilling certain contaminants; restrictions on transportation of hazardous waste, as described in Section 4;

and high transportation and disposal costs charged by commercial disposal facilities to accept wastes.

REFERENCES

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1988 (September) Hazardous Waste Land Disposal Facility Assessment, Task 27, Final Report. RTIC 89026R01

OSWER (Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency)

1989 Final Covers on Hazardous Waste Landfills and Surface Impoundments. EPA/530-SW-89-047.

Means (R.S. Means Company, Inc.)

1994 Means Heavy Construction Cost Data, 8th ed.

Table 6.1-1 Determination of Capital and Operating Costs for Soil Cover

Cost Category	Cost Item	Cost Estimate	Description
4 ft Soil Cover			
Operating Costs	Installation of Soil Cover Materials	12.71/SY	Source: 1
	Topsoil Conditioner	0.07/SY	Source: 1
	Cover Subtotal	12.78/SY	
Long-Term Operating Cost	Cover Maintenance	0.051/SY-YR	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover
1–2 ft Thick Soil Cover			
Operating Costs	Installation of Soil Cover Materials	5.90/BCY	Source: 1, used for Section 36 Balance of Areas
	Topsoil Conditioner	0.14/BCY	Source: 1
	Cover Subtotal	6.04/BCY	
Long-Term Operating Costs	Cover Maintenance	0.06/BCY-YR	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover.
1–3 ft Thick Soil Cover			
Operating Costs	Installation of Soil Cover Materials	5.90/BCY	Source: 1, used for South Plants Ditches and Balance of Areas
	Topsoil Conditioner	0.11/BCY	Source: 1
	Cover Subtotal	6.01/BCY	
Long-Term Operating Costs	Cover Maintenance	0.05/BCY-YR	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover.

Table 6.1-1 Determination of Capital and Operating Costs for Soil Cover

Cost Category	Cost Item	Cost Estimate	Description
2 ft Thick Soil Cover			
Operating Costs	Installation of Soil Cover Materials	3.68/BCY	Source: 1, used for Secondary Basins and North Plants
	Topsoil Conditioner	0.07/BCY	Source: 1
	Cover Subtotal	3.75/SY	Source: 1—costs for annual replacement of any eroded soil and annual inspection of cover.
Long-Term Operating Costs	Cover Maintenance	0.02/SY-YR	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover.
4 ft Thick Soil Cover and Crushed Concrete			
Operating Costs	Crushed Concrete	5.86/SY	Source: 1
	Installation of Soil Cover Materials	6.85/SY	Source: 1, used for South Plants Central Processing Area
	Topsoil Conditioner	0.07/SY	Source: 1
	Cover Subtotal	12.78/SY	
Long-Term Operating Costs	Cover Maintenance	0.05/SY-YR	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover.

Table 6.1-1 Determination of Capital and Operating Costs for Soil Cover

Cost Category	Cost Item	Cost Estimate	Description
<u>4 ft Thick Soil Cover and Formed Concrete</u>			
Operating Costs	Formed Concrete	16.04/SY	Source: 1
	Installation of Soil Cover Materials	6.85/SY	Source: 1, used for Basin A
	Topsoil Conditioner	0.07/SY	Source: 1
	Cover Subtotal	22.96/SY	Source: 1
Long-Term Operating Costs	Cover Maintenance	0.09/SY-YR	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover

Sources: 1 Means Heavy Construction Cost Data, 1994, 8th ed.

Table 6.2-1 Determination of Capital and Operating Costs for Multilayer Cap

Cost Category	Cost Item	Cost Estimate	Description
Multilayer Cap With Cobbles			
Operating Costs	Installation of Low-Permeability Soil Layer	$6.14/SY	Source: 1 Based on $9.21/CY and thickness of 2 ft with Level C PPE for installation of base courses
	Installation of Biota Barrier (Cobbles)	$5.69/SY	Source: 1 Based on $17.06/CY and thickness of 1.0 ft
	Installation of Soil Backfill	$6.85/SY	Source: 1 Based on $5.14/CY and thickness of 4.0 ft
	Installation of Topsoil	$0.07/SY	Source: 1 Based on purchase of fertilizer, conditioners, application equipment, and thickness of 0.5 ft
	Level of PPE Adjustment	$0.26/SY	Source: 1
	Cap Subtotal	$19.01/SY	
Long-Term Operating Cost	Cover Maintenance	$0.07/SY annually	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover
Multilayer Cap With Formed Concrete			
Operating Costs	Installation of Low-Permeability Soil Layer	$6.14/SY	Source: 1 Based on $9.21/CY and thickness of 2 ft with Level C PPE for installation of base courses
	Installation of Biota Barrier (Poured Concrete)	$15.15/SY	Source: 1 Based on a thickness of 6 inches

Table 6.2-1 Determination of Capital and Operating Costs for Multilayer Cap

Cost Category	Cost Item	Cost Estimate	Description
	Installation of Soil Backfill	$6.85/SY	Source: 1 Based on $5.14/CY and thickness of 4.0 ft
	Installation of Topsoil	$0.07/SY	Source: 1 Based on purchase of fertilizer, conditioners, application equipment, and thickness of 0.5 ft.
	Level of PPE Adjustment	$0.26/SY	Source: 1
	Cap Subtotal	$28.47/SY	
Long-Term Operating Costs	Cover Maintenance	$0.10/SY annually	Source: 1 Costs for annual replacement of any eroded soil and annual inspection of cover

Sources: 1 Means Heavy Construction Cost Data, 1994, 8th ed.

Table 6.3-1 Determination of Capital and Operating Costs for Slurry Wall

Cost Category	Cost Item	Cost Estimate	Description
Operating Costs	Excavation and Installation of Slurry Wall		Source: 1
	Shallow (<20 ft depth)	$33.77/SY	Based on 3 ft width and soil/bentonite slurry mixture per SY of the face of the slurry wall.
	Medium (20–65 ft depth)	$47.72/SY	
	Deep (>65 ft depth)	$100.59/SY	
	Dewatering System	Variable	Installation of eight dewatering systems based on hydraulic controls in Section 5.
Long-Term Operating Cost	Maintenance Operations/Dewatering	Variable	Operations of dewatering systems based on hydraulic controls in Section 5 and water treatment costs in Section 14.

Sources:
1) Vendor Quotes for Slurry Wall Installation.

SY square yards
ft feet or foot

Cost Category	Cost Item	Cost Estimate	Description
Operating Costs	Stripping/Stockpile Existing Cover	\$1.91/SY	Source: 1
	Installation of Geogrid	\$3.24/SY	Source: 2 Based on \$0.36/SF
	Installation of Soil Cover	\$0.57/SY	Source: 1 Based on \$6.31 for borrow soil and a thickness of 2 ft
	Installation of GCL	\$5.85/SY	Source: 2 Based on \$0.65/SF
	Installation of VLDPE	\$4.77/SY	Source: 2 Based on \$0.53/SF
	Installation of Sand	\$4.09/SY	Source: 1 Based on \$12.27/CY and a thickness of 1 ft
	Installation of Geotextile	\$1.41/SY	Source: 2 Based on \$15.69/SF
	Installation of Biota Barrier	\$5.69/SY	Source: 2 Based on \$17.07/CY and a thickness of 1 ft
	Installation of Soil Cover from Stockpile	\$3.43/SY	Source: 1
	Installation of Topsoil from Stockpile	\$0.49/SY	Source: 1
	Revegetation	\$0.18/SY	Source: 1
	Cap Subtotal	\$31.63/SY	
Long-Term Operating Cost	Cover Maintenance	\$0.12/SY annual	Source: 1 Cost for annual replacement of any eroded soil and quarterly inspection of cover

Sources:
1) Means Heavy Construction Cost Data, 1994, 8th ed.
2) Vendor Quotes

Table 6.5-1 Determination of Capital and Operating Costs for 9.3 Million Cubic Yard Hazardous Waste Landfill

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost for On-Post Landfill Facility	Site Preparation and Support Buildings and Facilities	$24,000,000 LS	Source: 1 Based on earthwork and support facilities for 4 cells each containing 1.5 million CY sized from facility with 11 cells.
Capital Cost for Cell Liner	Solid Waste Liner	$52,000,000 LS	Source: 1 Based on 4 cells with leachate collection, geomembrane, and low-permeability soil layers.
Capital Cost for Cell Cover	Solid Waste Cover	$46,000,000 LS	Source: 2 Based on 4 cells with low-permeability soil, drainage, biota barrier, and cover soil layers.
	Subtotal Capital Costs	$122,000,000	Based on 4 cells, each sized for 1.5 million CY.
Operating Cost	Placement of Materials	$5.98/CY	Source: 2 Based on transportation, sampling, placement of daily soil covers, and required dust controls for 5-year buildout.
Long-Term O&M for Facility	Postclosure Monitoring and Maintenance	$0.02/CY annually	Source: 2 Based on annual monitoring and maintenance for facility.

Sources:

1) Hazardous Waste Land Disposal Facility Assessment, EBASCO 1988.
2) Means Heavy Construction Cost Data, 1994, 8th Annual Edition.

Table 6.5-2 Determination of Capital and Operating Costs for 750,000 Cubic Yard Hazardous Waste Landfill Cell

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost for On-Post Landfill Facility	Site Preparation and Support Buildings and Facilities	$4,000,000 LS	Source: 1 Based on earthwork and support facilities for 1 cell, containing 750,000 CY sized from facility with 11 cells.
Capital Cost for Cell Liner	Solid Waste Liner	$7,000,000 LS	Source: 1 Based on 1 cell with leachate collection, geomembrane, and low-permeability soil layers.
Capital Cost for Cell Cover	Solid Waste Cover	$4,000,000 LS	Source: 2 Based on 1 cell with low-permeability soil, drainage, biota barrier, and cover soil layers.
	Subtotal Capital Costs	$15,000,000	Based on 1 cell sized for 750,000 CY.
Operating Cost	Placement of Materials	$5.97/CY	Source: 2 Based on transportation, sampling, placement of daily soil covers, and required dust controls for 5-year buildout.
Long-Term O&M for Facility	Postclosure Monitoring and Maintenance	$0.04/CY annually	Source: 2 Based on annual monitoring and maintenance for facility.

Sources:

1) Hazardous Waste Land Disposal Facility Assessment. EBASCO 1988.
2) Means Heavy Construction Cost Data, 1994. 8th Annual Edition.

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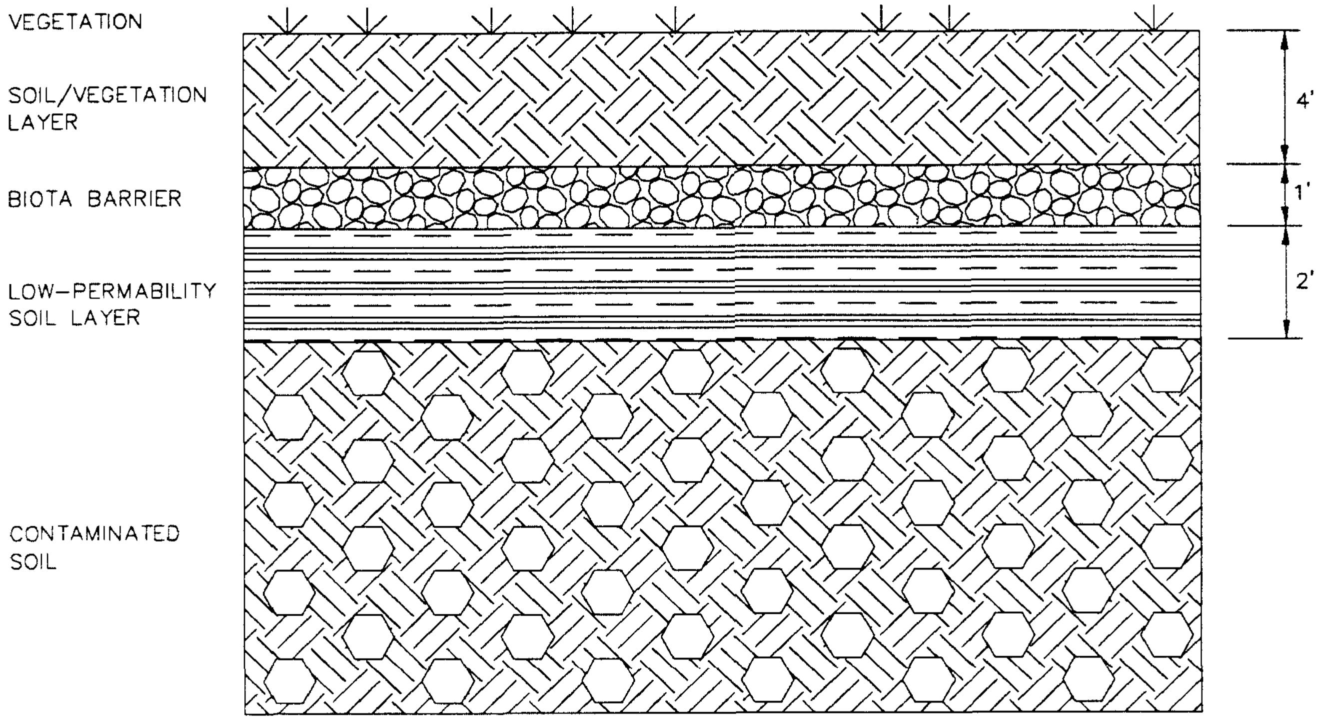

NOTE:

1. THE BIOTA BARRIER GENERALLY CONSISTS OF CRUSHED CONCRETE OR COBBLES. FOR THE COMPLEX TRENCHES SUBGROUP THE BIOTA BARRIER CONSISTS OF SIX INCHES OF FORMED CONCRETE

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U.S. Army Program Manager for Rocky Mountain Arsenal

Prepared October 1995

Figure 6.2-1

Multilayer Cap Detail

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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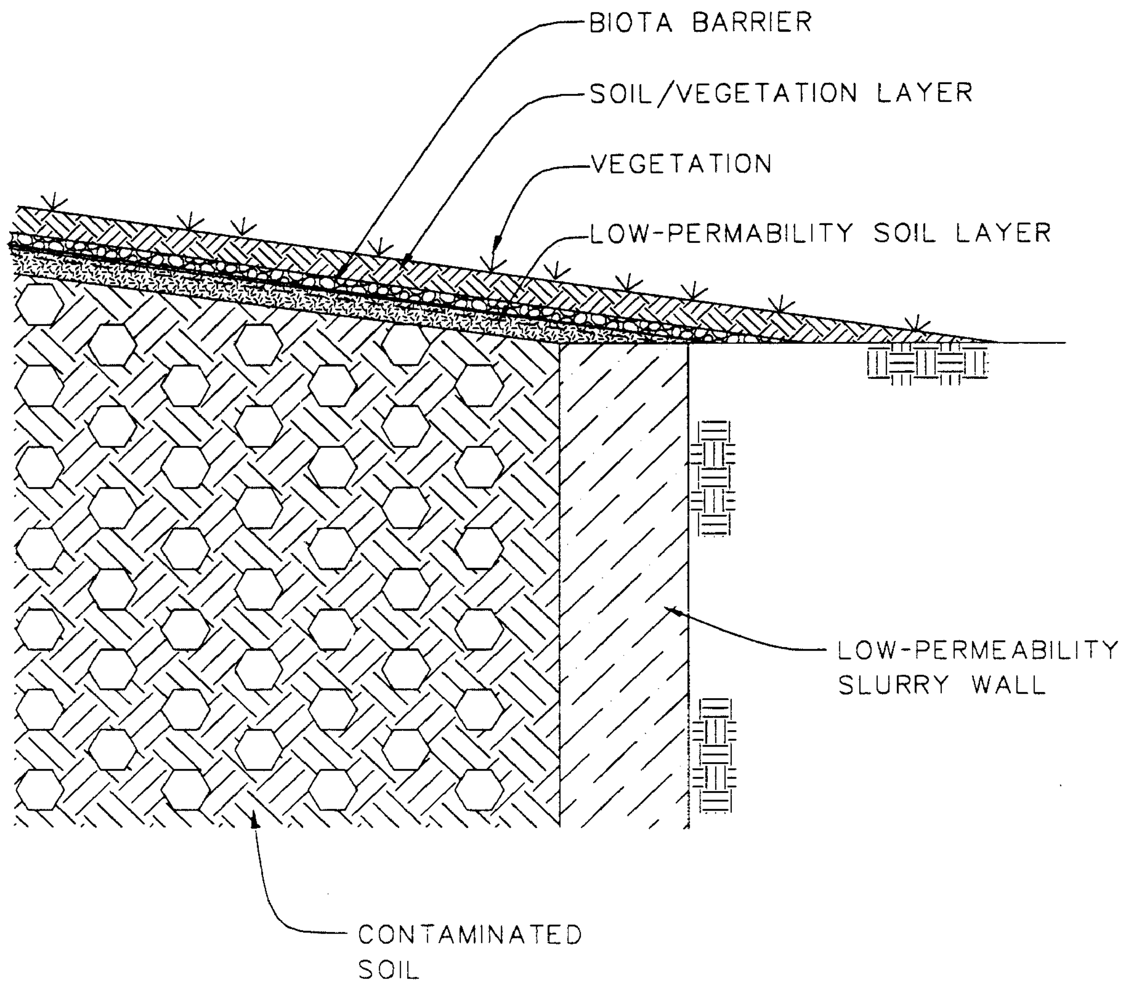

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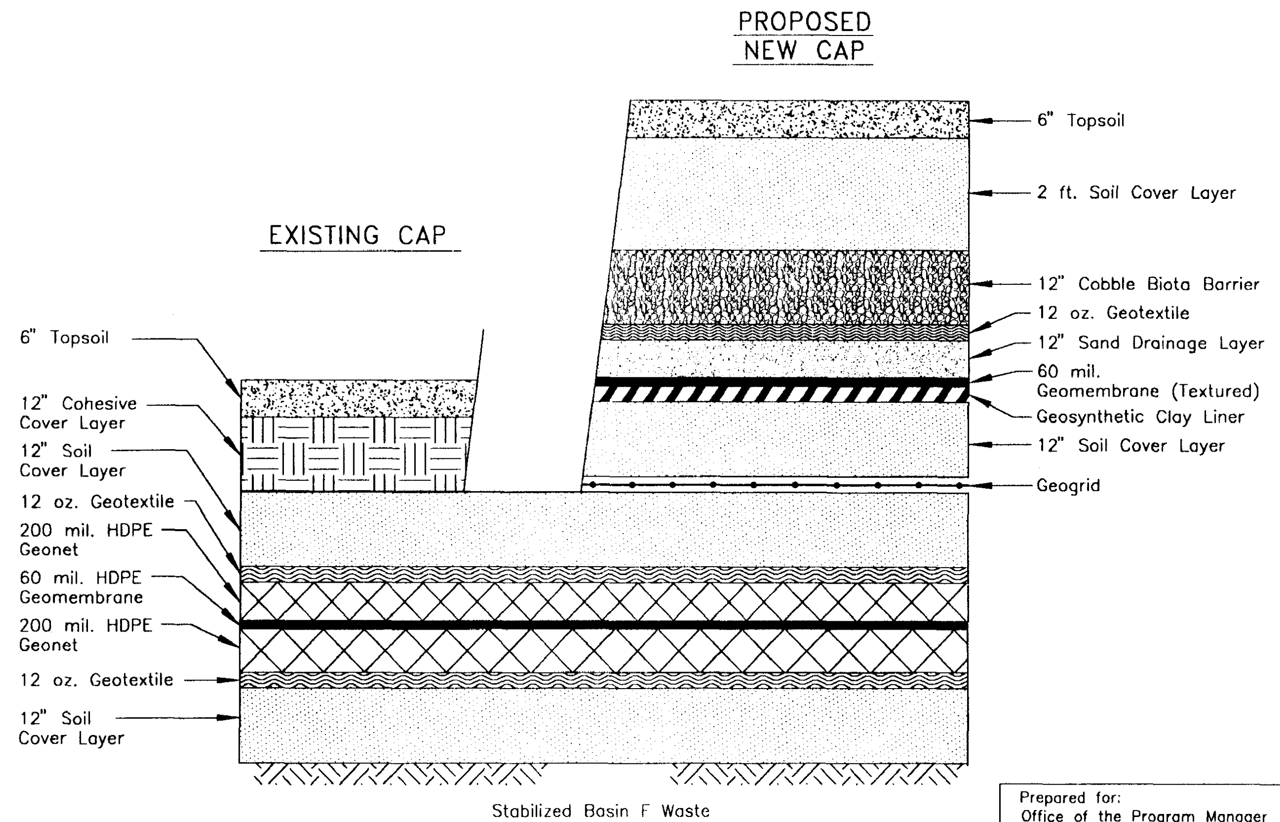
Figure 6.3-1

Multilayer Cap and Slurry
Wall Edge Configuration Detail

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

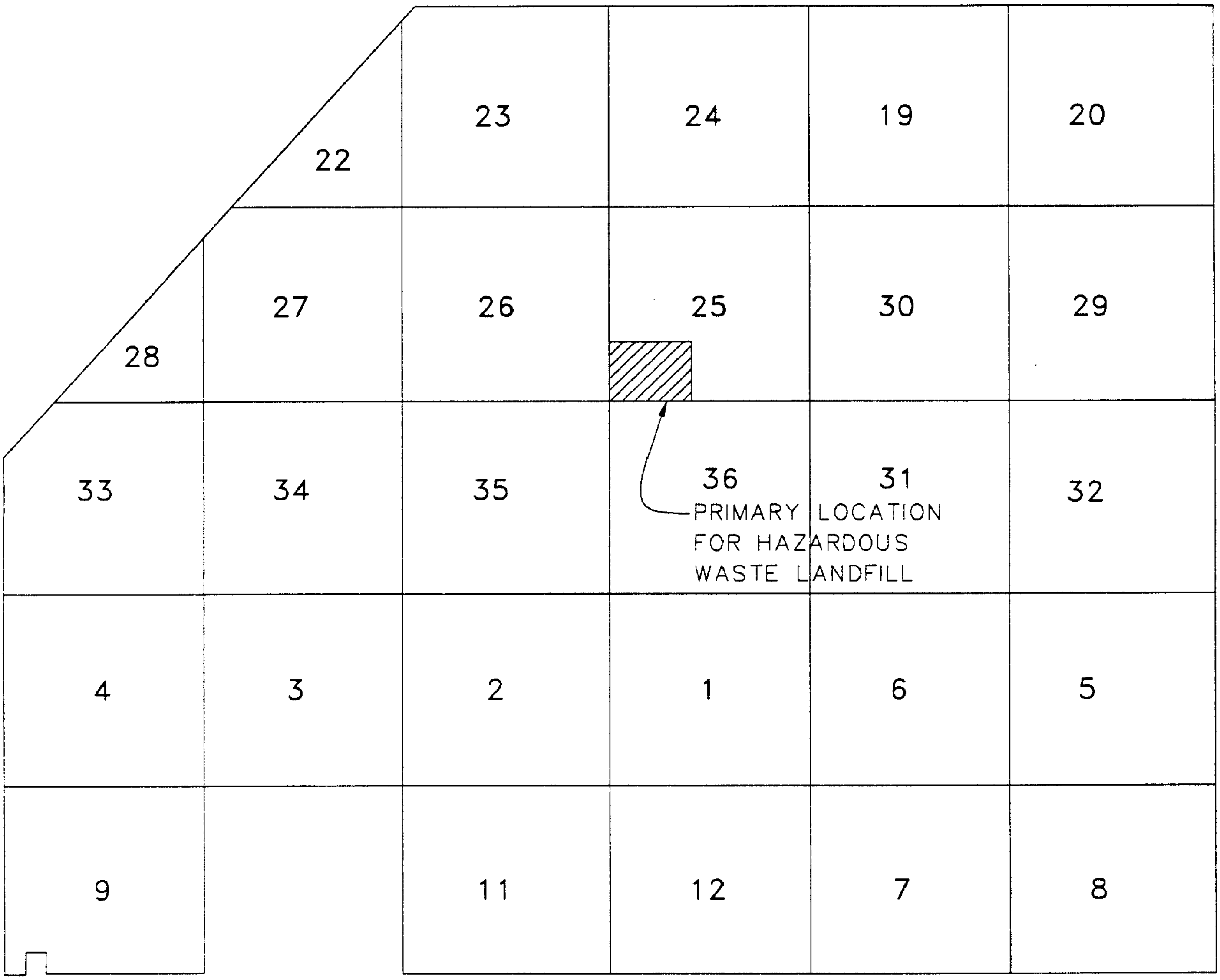


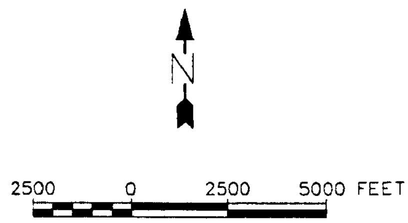
Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal

FIGURE 6.4-1

Composite Cap Detail

Prepared by:
Foster Wheeler Environmental Corporation





Prepared for:

U.S. Army Program Manager
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Prepared October 1995

Figure 6.5-1

Location of Primary Site for
Hazardous Waste Landfill

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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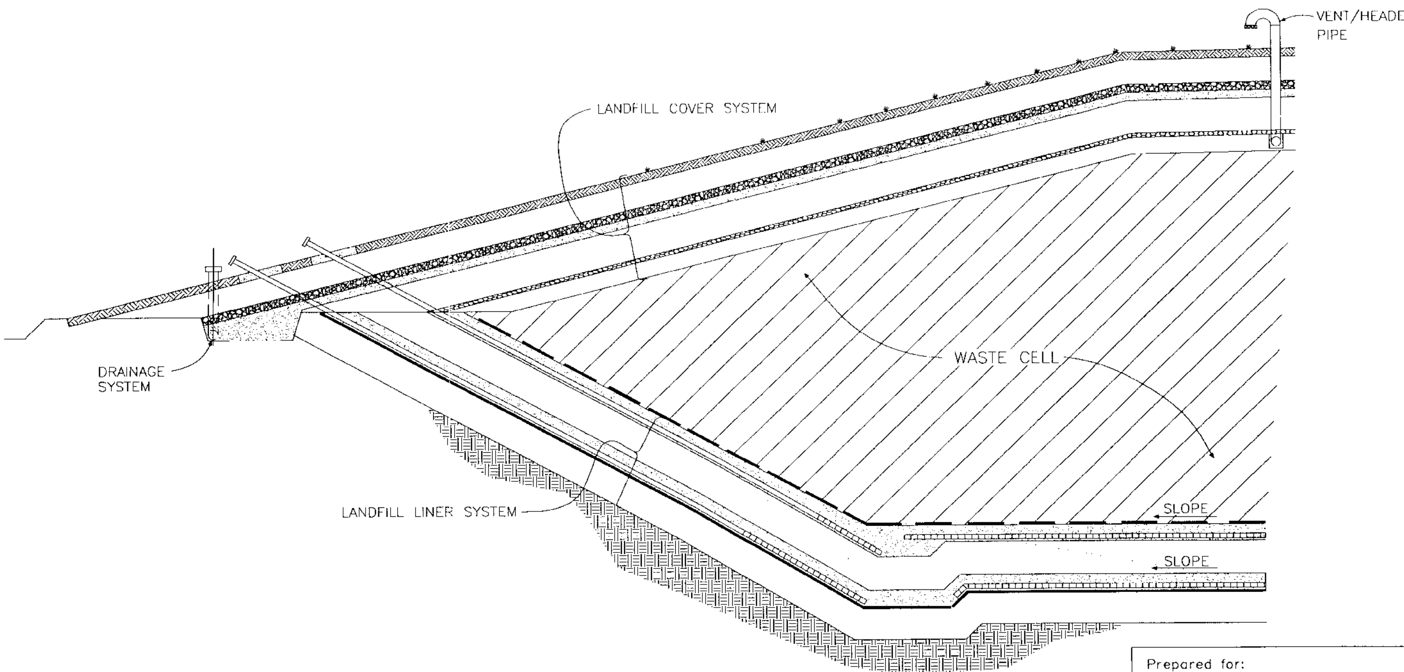

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Figure 6.5–2

Typical Cross Section
of RCRA Landfill Cell

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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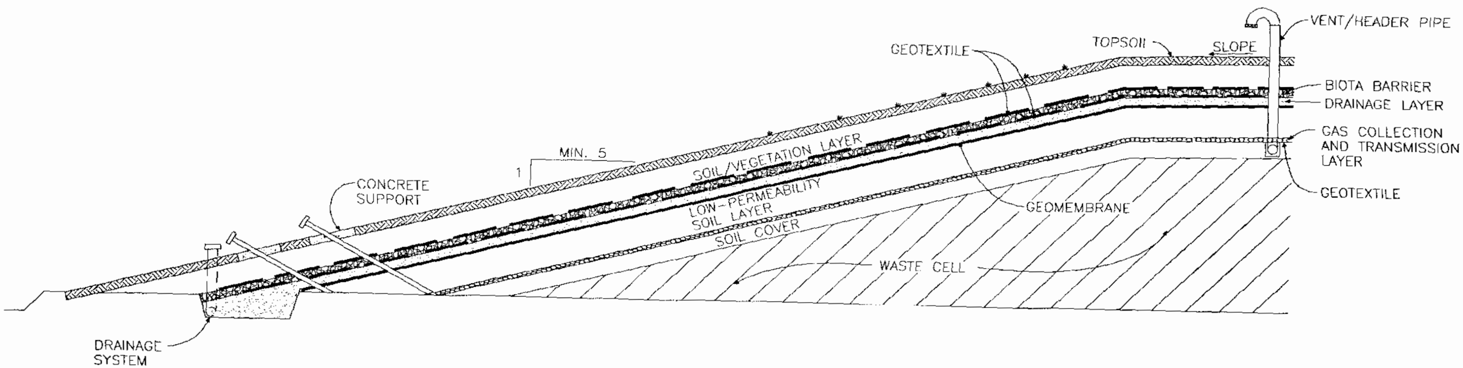

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Figure 6.5-3

Schematic of Typical RCRA Landfill Cover

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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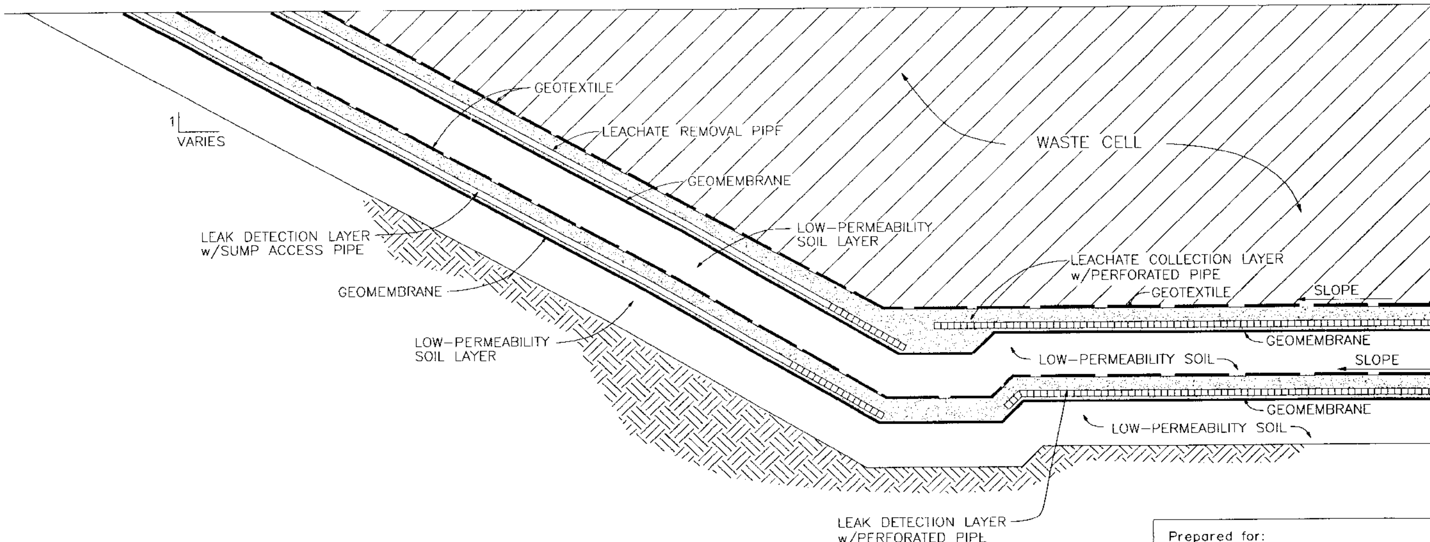

NOTE: SIDEWALL LINER COMPONENTS MAY VARY DUE TO CONSTRUCTABILITY CONSTRAINTS.

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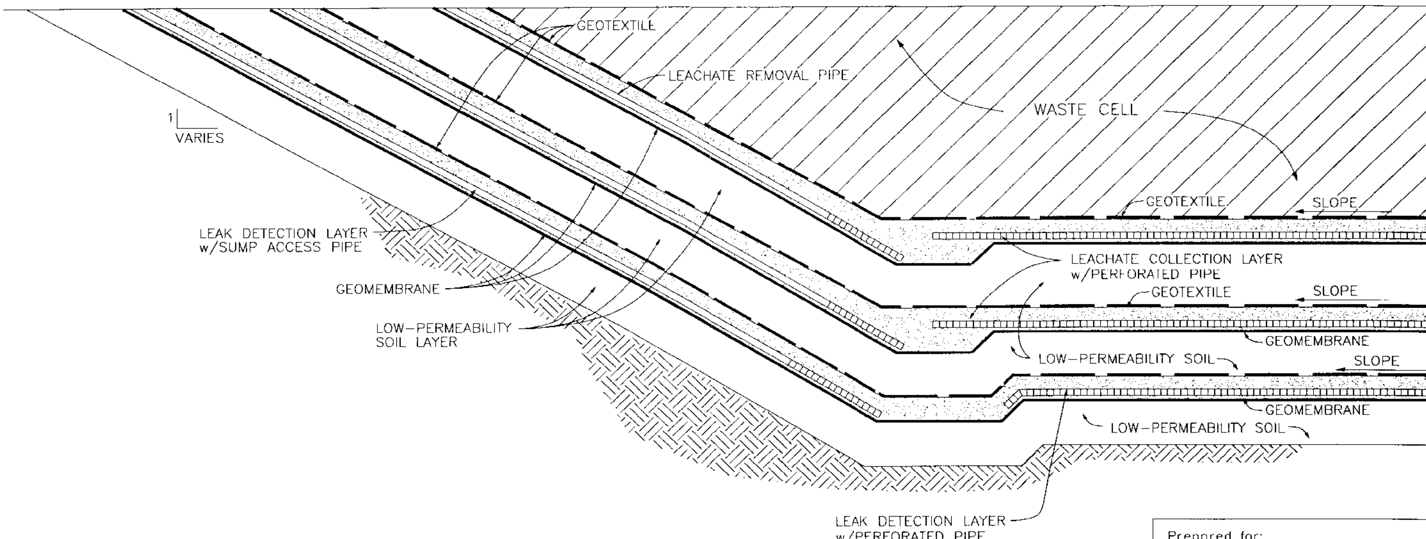
Figure 6.5-4

Schematic of Typical Double Composite RCRA Landfill Liner

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation



NOTE: SIDEWALL LINER COMPONENTS MAY VARY
DUE TO CONSTRUCTABILITY CONSTRAINTS.

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Figure 6.5-5

Schematic of Typical Triple Composite RCRA Landfill Liner

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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Section 7

7.0 DIRECT THERMAL TREATMENT

The Direct Thermal Treatment General Response Action Category consists of several process options that involve heating contaminated soil, sediments, sludges, or structural debris in a thermal treatment unit either on or off post. VOCs and semivolatile organic compounds (SVOCs) are vaporized from the solid phase and either recovered or destroyed, depending on the operating temperature of the unit. At temperatures below 540 degrees Celsius (°C), organic contaminants are generally volatilized with little decomposition; this technology type is called thermal desorption. As the operating temperature is raised above 540°C, contaminants are increasingly oxidized or decomposed into other species; this technology type is called incineration/pyrolysis. Section 7.1 describes the thermal desorption technology type, which is represented by the direct-fired process option. Sections 7.2 and 7.3 describe the rotary kiln incineration and off-post incineration process options, respectively, both of which fall within the incineration/pyrolysis technology type.

7.1 THERMAL DESORPTION

In general, the operating temperature of the desorber (95°C to 540°C) is not high enough to oxidize or destroy the organic compounds to any significant extent, i.e., the desorber separates the organic contaminants so that the secondary combustion chamber (SCC) may destroy them. Bench-scale treatability studies conducted with RMA soil indicate that thermal desorption is effective in reducing the concentrations of all of the VOCs and SVOCs of concern to less than detectable levels. Thermal desorption also volatilizes some metals; the extent of volatilization is a function of the selected operating temperature. For example, at the higher range of thermal desorption temperatures, mercury is almost entirely volatilized and arsenic is partially removed. Thermal desorption, however, cannot be used as a treatment technology for inorganic contaminant remediation.

7.1.1 Process Description

The desorption process can be accomplished using several types of equipment, depending on whether the contaminants are to be recovered or destroyed, including indirect-fired, direct-fired, transportable, or site-constructed equipment. Indirect heating was not selected as an RPO during the DSA because it is less efficient than direct heating. Contaminant destruction options generally implement direct-fired equipment similar to aggregate dryers, with the contaminant-laden desorber off gas fed to an afterburner or SCC. Direct heating is generally accomplished using the sensible heat of the combustion gases and the radiant heat of the burner flame.

Direct-fired rotary dryers are the basis of design for most transportable thermal desorption units. Depending on the moisture content of the feedstock and the volatility of the contaminants, the rated throughput for most transportable desorbers is between 15 and 50 tons per hour (tons/hour). For higher processing capacities, it is necessary to use multiple desorber units or site-constructed facilities. The following paragraphs list some examples of current transportable unit capabilities:

- Canonie Environmental/Low-Temperature Thermal Aeration (LTTA)—Direct-fired rotary kiln desorber with SCC for the destruction of vaporized organics. Full-scale capacity is 25 to 50 tons/hour. Off-gas treatment consists of a partial quench, baghouse, and venturi scrubber. The quench blowdown stream is treated with GAC. The unit may also be configured with an SCC between the rotary kiln and the partial quench.

- SoilTech Anaerobic Thermal Processor (ATP)—Zoned rotary multichamber desorber with condensation of vaporized organics. Full-scale capacity is 8 to 10 tons/hour (25-tons/hour unit under design). Off-gas treatment consists of a quench tower, baghouse, and an activated carbon system. Organics are quenched, scrubbed, and condensed out of the retort zone vapor stream and require further treatment or disposal.

- Williams Mobile Thermal Desorber—Direct-fired rotary dryer with secondary combustion of vaporized organics. Full-scale capacity is 20 to 30 tons/hour. Off-gas treatment consists of a baghouse, an SCC, a quench tower, and an acid gas scrubber.

- Halliburton/Ecotechniek Thermal Treatment System (ETTS)—Direct-fired rotary kiln desorber with SCC for the destruction of vaporized organics. Full-scale capacity is 30 to 50 tons/hour. Off-gas treatment consists of a gas-to-gas heat exchanger, baghouse, and wet scrubber.

It is likely that the standard carbon steel construction of most transportable units is compatible with most RMA soil. However, some soil near the basins is expected to have high salt content. Accordingly, the desorber used at RMA may require corrosion-resistant alloys or refractory liners.

Based on the large volume of soil to be treated at RMA and the requirement for corrosion resistance, an on-site desorber is anticipated to be technically superior and less costly than a transportable unit. The DAA has therefore considered a central thermal desorption facility built at RMA.

Given the scale of the remediation as implied by RMA soil volumes, an alternative involving thermal desorption requires the high processing capacity and relative operating simplicity of direct-fired rotary equipment. Thermal desorption treatability studies were performed on RMA soil and a preliminary conceptual design was developed by Weston (Weston 1992a, 1992b). The Weston study was used as guidance for design and costing throughout the DAA. This preliminary conceptual design calls for two 37-tons/hour rotary dryers operating with a 65 percent on-stream factor.

During direct thermal desorption, the soil or sludges are excavated and moved to the desorber unit or to a central processing area (in accordance with the process options discussed in Section 4), where they are prepared as feedstock for the thermal desorber. Figure 7.1-1 presents a block diagram for the direct thermal desorption process, including the soil handling system, which is discussed in the following sections. Preparation steps such as drying, size reduction, scrap metal removal, and solids blending reduce the physical variability of the material entering the desorber. Large objects (greater than 1.5 to 2.0 inches) are screened from the feedstock and rejected as oversize. The feed material is then delivered by gravity, conveyor, or screw augers to the desorber feed hopper.

The feed pretreatment area requires a fully enclosed building with storage capacity for 3 to 5 days of feed material. The building encloses the contaminated soil handling, sizing, and mixing equipment and the desorber feed hoppers. Based on the preliminary conceptual design and standard industry procedures, feed pretreatment equipment might consist of a feed hopper, magnetic separator, primary shredder, disc classifier, and final shredder to reduce the largest clay soil lumps to less than 0.5 inches. Based on the conceptual thermal desorber facility design prepared by Weston, the volatile emissions from soil preparation would be handled by the environmental controls for the soil preparation building. Exhaust air from the facility would be directed to either the rotary dryers or the SCC as combustion air.

According to the preliminary conceptual design, a central thermal desorption facility requires two direct-fired, inclined, rotary dryers (10 ft in diameter and 52 ft long) operating under induced draft at 300°C. The total soil processing rate at 20 percent moisture is 74 tons/hour. Overall soil residence time is 50 minutes. The main burner is located on the soil-feed end of the dryer drum so that the highest flame temperatures and highest heat release occur where soil moisture levels are highest and where the soil particles are protected by a film of vaporizing water. Soil and combustion products flow in the same direction so that particulates that entrain in the flue gas are heated to the required desorption temperature before they exit the kiln. This is termed a co-current system; in a counter-current system, the burner is located at the end of the dryer drum, opposite to the soil feed and the combustion gas flows Counter-current systems are more efficient at transferring heat to the soil being treated, but the rate of heat transfer is slower (therefore requiring a longer residence time). In addition, there is a greater potential for entraining contaminated particulates in the off-gas steam, thus requiring more extensive treatment.

Off gas from the desorber passes through a cyclone separator before entering the SCC. Depending upon the partitioning of metal contaminants between the soil and the entrained fines, the particulates removed by the cyclone are recombined with the treated soil or treated separately to immobilize the metals.

Off-gas treatment involves the removal of the acid gases formed in the SCC oxidation reactions and the particulates carried over from the desorber off-gas cyclone. The preliminary conceptual design includes a spray tower for adiabatic gas cooling, a baghouse for particulate removal, and a caustic quench step for removal of acid gases with a venturi scrubber for additional particulate removal (Figure 7.1-1). The sequence can be modified to include off gas to stack gas heat recovery and spray drying of the caustic quench blowdown stream. Although there is some concern regarding carryover of volatile metals such as arsenic or mercury, the technology is sufficiently proven and the off-gas treatment system is expected to meet air emissions standards without undertaking any extraordinary measures. Optimization of the treatment sequence is undertaken after final engineering studies.

The conceptual design employs an SCC operating at 1,200°C and a residence time of 2.5 seconds to destroy the organic components of the desorber off gas. With thorough mixing, this temperature and residence time destroys all of the organic contaminants, including any dioxins or furans created during the thermal desorption of the pesticides (Focus 1992). Given the extensive experience with incinerator off-gas treatment, proven technology is available to achieve particulate and acid gas emission requirements for stack gas standards. Depending on the sequence of unit operations, the solids from particulate removal and the brine from acid gas neutralization may exit the off-gas treatment train as a combined stream or as separate wastes.

In the conceptual design, the particulates and metal salts recovered from the off gas exit the system at several points. The necessity of solidifying some or all of these sidestreams depends on the extent of metal partitioning between the two streams. If the soil feed is high in volatile metals, the particulate sidestream may require solidification to immobilize inorganics prior to disposal in the on-post landfill (Section 6.5).

By-product acid gases such as hydrochloric acid (HCl), hydrogen bromide (HBr), and hydrofluoric acid (HF) are neutralized and scrubbed from the desorber off-gas stream in a caustic quench step. The resulting sodium chloride brine stream is evaporated and centrifuged to a wet cake with a solids content of 80 percent. The salt cake is placed in the on-post landfill and the evaporated water recycled to the off-gas treatment system.

The soil discharged from the thermal desorber is cooled and rehumidified by water sprays to minimize fugitive dust emissions. Depending on the final metals content, the treated soil is returned to the original excavation if the inorganic levels are below human health and biota preliminary remediation goals (PRGs). The treated soil containing elevated inorganics is solidified to immobilize metals and returned to the original excavation unless the layout of the excavation area precludes backfilling the solidified soil. In this case, the solidified soil are placed in a soil consolidation/containment area or a solid waste landfill cell as discussed in Section 6.5.

Because the conceptual design proposes an SCC to achieve the required contaminant destruction levels, the ARARs identified for the thermal desorption technology are essentially the same siting, design, and performance requirements associated with incineration/pyrolysis. Like an incinerator, the facility cannot be sited in a wetland area or 100-year floodplain. The unit must substantively comply with RCRA performance standards for hazardous waste incinerators (40 CFR 264, Subpart O) and achieve a minimum destruction and removal efficiency (DRE) of 99.99 percent for all organic hazardous constituents. Because RMA is in a nonattainment area, the off-gas treatment system must meet federal and Colorado primary ambient air quality standards of performance for new emissions sources. The ARARs governing the use of low-temperature thermal desorption and its associated off-gas treatment train are found in Appendix A.

The capital and operating cost for the thermal desorption technology are taken from Weston estimates (1992b). The order-of-magnitude estimate includes the cost of off-gas treatment and brine concentration and excludes the cost of soil excavation, soil transport, soil backfill, and waste sidestream disposal. Weston estimated the present day capital cost for a central desorber facility to be $53 million, with ongoing operating and maintenance costs of $22.5 million per year for 10 years. Total soil volume processed over the 10-year period was 3,000,000 bank cubic yards (BCY) for the Weston design.

For costing in the DAA, Weston's estimated capital and operating costs were unburdened of construction indirect, engineering, startup, and contingency costs. In addition, the volume processed in 10 years was adjusted from 3,000,000 BCY to 2,500,000 BCY and a more typical soil density of 105 pounds per cubic foot (pcf) was used rather than 100 pcf. Table 7.1-1 shows the remaining cost components that make up the RMA direct thermal desorption capital and operating costs.

The unburdened capital cost of direct thermal desorption is $43.9 million. For the 2,500,000 BCY cleanup, the unit capital cost for thermal desorption is $17.55/BCY. Depending on the soil moisture level, the operating cost of thermal desorption varies from $76.00/BCY for a dry soil (10 percent moisture) to $44.61/BCY for saturated soil (20 percent moisture). These unit costs would change as the soil treatment volume increases or decreases.

7.1.2 <u>Process Performance</u>

The applicability and effectiveness of the direct thermal desorption process are strongly dependent on soil moisture content. The energy expended in vaporizing soil moisture can be a large fraction of the total desorber heating requirement. For example, as soil moisture content increases from 5 to 20 percent of the feedstock weight, the heat load associated with vaporizing water increases from 35 to 70 percent of total fuel fired. Direct-fired desorbers have maximum firing rates; therefore, high soil moisture levels reduce the energy available to bring the soil to the required desorption temperature for the required exposure time. For any given thermal desorber, the soil processing rate decreases as the soil moisture content increases.

Three soil moisture levels were evaluated in the Weston conceptual design report (1992b). The base case assumed an average soil moisture level of 20 percent and proposed a design capacity of 74 tons/hour (52 BCY per hour [BCY/hour] at 105 pcf). This is considered a saturated soil. For a dry soil (average soil moisture content of 10 percent), the processing rate of the proposed thermal desorption facility increases to 80 tons/hour (56 BCY/hour at 105 pcf). For wet sediments (40 percent moisture), the processing rate for the two-train central desorption facility drops to 41 tons/hour (29 BCY/hour at 105 pcf).

As feed moisture levels continue to increase, handling and placement difficulties begin to limit the practicality of using direct thermal desorption as a treatment approach. The contaminated medium must contain between 20 to 30 percent solids to be processed. Sludges or dredged soil may require dewatering or blending with drier material to meet the solids content requirement.

Soil structure and gradation may also limit the application of thermal desorption. For example, a large fraction of fine silt or clay can produce dusting in the dryer and can increase particulate carryover into the off-gas treatment train. In another instance, soil that is tightly aggregated or has high clay content can result in poor processing performance because of caking. Caked material may enclose some of the contaminants and prevent their escape into the vapor phase and may also cling to or coat dryer internals and inhibit solid/vapor mixing patterns. As with soil moisture content, the caking phenomenon may reduce the soil processing rate for the desorber or actually prevent the achievement of the required DREs.

The presence of VOCs and volatile soil components can complicate the design and operation of the thermal desorber. High levels of salts expected in soil from source basins add to the generation of acid gases in the thermal desorption step. The thermal desorber and SCC need to be fabricated with materials capable of withstanding these acid gases. Gas scrubbing equipment also needs to be employed to remove the acid gases from the gas stream prior to atmospheric release. This adds to the complexity and increases the cost of the treatment system.

Thermal desorption has been demonstrated to be effective by treatability testing at bench- or pilot-scale levels for the removal of halogenated and nonhalogenated volatile organics, halogenated and nonhalogenated SVOCs, PCBs, pesticides, dioxins, and furans from soil matrices (Weston 1992a). It is potentially effective for these same organic contaminant groups in sludges, although processing problems arise with high moisture levels as described above. The technology also removes volatile metals such as mercury and lead from soil, although the technology is ineffective for most inorganic contaminants. Any volatilized metals need to be removed in the off-gas control system.

Thermal desorption is the selected remedy for one or more operable units at more than 20 Superfund sites. Canonie Environmental has extensive performance data for its LTTA system at full-scale operation (15 to 45 tons/hour) (Canonie 1992). The LTTA system is based on a transportable, direct-fired, rotary aggregate dryer and is limited by its construction materials to operating temperatures at or below 425°C. The unit has been demonstrated at full scale at the McKin (Maine), Ottati & Goss (New Hampshire), and Cannon Engineering Corp. (Massachusetts) Superfund sites on soil contaminated with VOCs and polynuclear aromatic hydrocarbons (PAHs). The LTTA system is currently remediating pesticide-contaminated soil at the Litchfield Airport Site near Phoenix, Arizona. Operating information for the Phoenix site is not yet available, but bench-scale testing indicates removal of pesticides, including dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenylethane (DDE), to be slightly above detectable levels at an operating temperature of 315°C to 340°C.

Shell Development Company conducted a laboratory-scale treatability study of thermal desorption in 1989 using static tray and tube test apparatus. The study showed that organochlorine pesticides (OCPs) present in soil from Basins A, C, and F at total concentration levels of several hundred to several thousand parts per million (ppm) were reduced to less than 50 parts per billion (ppb) at temperatures as low as 250°C (Farmayan et al. 1989).

International Technology (IT) Corporation conducted a bench-scale treatability study with Basin F soil in 1990 for Morrison-Knudson with the use of a rotary thermal apparatus. The study showed reductions of OCP concentration levels from approximately 800 ppm to below detection levels (32 ppb) at temperatures as low as 300°C. Virtually all of the mercury and between 20 to 30 percent of the arsenic were volatilized and subsequently removed by the off-gas stream (IT Corporation 1990). Other inorganics in the form of alkali chlorides and sulfates were also present in RMA soil samples. Bench-scale testing indicated that very little salt decomposition took place at the 300°C test temperature, so acid gas formation is not likely to be a major problem in the off-gas treatment train under similar conditions. A pilot-scale treatability study on several RMA soil, in which the leachability of metals from treated soil will be evaluated, will be performed in late 1995.

IT Corporation conducted an expanded bench-scale treatability study for Weston with the use of RMA soil samples representative of the South Plants, Secondary Basins, and the Undifferentiated Medium Groups. The preliminary results from the study show that all of the RMA organic contaminants of concern (COCs) can be desorbed to 10^{-4} biological worker PRGs at 250°C. To achieve 10^{-6} biological worker PRGs, the desorber operating temperature must be raised to the 300°C to 400°C range.

Because a 300°C soil discharge temperature is well above the boiling point of water, the desorber operation is analogous to commercial aggregate drying. Upon discharge, the treated soil is completely desiccated, some of the natural organic carbon is partially oxidized, the organic contaminants are desorbed to levels below their detection limits, and some volatile metal contaminants are vaporized into the sweep gas stream. Other than the loss of some humic material, the physical properties of the treated soil are essentially the same as those of the untreated material.

Based on the bench-scale testing discussed above and the full-scale performance of thermal desorbers at other sites, the concentrations of organic contaminants in RMA soil should be reduced to below their levels of detection by low-temperature thermal desorption. Based on commercial incinerator performance, the SCC can be operated at a residence time and temperature sufficient to achieve a 99.99 percent minimum DRE for all of the RMA organic COCs. Table 7.1-2 summarizes the performance information for direct thermal desorption of pesticide-contaminated soil.

7.2 INCINERATION/PYROLYSIS

Rotary kiln incineration is a high-temperature process that uses either indirect or direct heat exchange to alter or destroy organic contaminants in soil, sediment, sludge, and debris. It is used as a stand-alone treatment in Alternatives A4 and 14 Incineration/Pyrolysis (Rotary Kiln) (soil medium) and may be combined with other alternatives where Army chemical agent is encountered during remediation. Based on the DSA screening process, rotary kiln incineration was retained for evaluation during the DAA for sites in the Agent Storage and Disposal Trenches Medium Groups. Rotary kiln incineration was retained for the No Future Use, Significant Contamination History and No Future Use, Agent History Structures Medium Groups. If ongoing treatability studies indicate that thermal desorption does not achieve adequate DREs, rotary kiln incineration will be reconsidered for application to other medium groups. Rotary kiln incineration was also considered for those portions of the Basin A, Sewer Systems, Lime Basins, South Plants, and Undifferentiated Medium Groups that are found to contain agent-contaminated soil. Rotary kilns are also utilized in the on-post demilitarization of UXO, which is discussed separately in Section 9.1.

In general, the operating temperature of the incinerator (540°C to 1,000°C) is high enough to destroy the organic contaminants by oxidation or pyrolysis. Based on bench-scale treatability studies conducted with RMA soil, incineration provides temperatures high enough to reduce all of the VOCs and SVOCs of concern to less than detectable levels. The high incineration temperatures are required for unrestricted releases of agent-contaminated materials as discussed in Section 9.5. Incineration will remove, but not destroy, volatile metals such as mercury and arsenic. Mercury is almost entirely volatilized at temperatures greater than 540°C, but arsenic and lead are only partially removed.

7.2.1 <u>Process Description</u>

Except for the operating temperature of the kiln, the process flow diagram and equipment sequence for rotary kiln incineration is nearly identical to that for thermal desorption. Figure 7.2-1 presents a block diagram for rotary kiln incineration. The soil, sludges, or structural debris are first excavated and moved to the mobile incinerator unit or to a central processing area where they are prepared as feedstock. Preparation steps reduce the physical variability of the material entering the incinerator and may include drying, size reduction, scrap metal removal, and solids blending. Typically, large objects (greater than 0.5 inches) are screened from the feedstock and rejected as oversized material. Structural debris may be no larger than 1 ft by 1 ft. All reinforcing steel bars are removed from concrete. The feed material is then delivered by gravity, conveyor, or screw auger to the incinerator feed hopper.

At the central processing area, the feed pretreatment area requires a fully enclosed building with storage capacity for 3 to 5 days of feed material. The building encloses the sizing and mixing equipment and the incinerator feed hoppers and provides shelter for contaminated soil and structural debris handling activities. The incinerator feed pretreatment sequence consists of the same progression of steps as described under thermal desorption: feed hopper, magnetic separator, primary shredder, disc classifier, and final shredder.

Based on operating conditions proposed in the Task 17 conceptual design for Basin F wastes (EBASCO 1988), the incinerator is a direct-fired, inclined, rotary kiln operating under induced draft at a discharge temperature of 760°C. For ease of costing, the incinerator facility employs the same process sequence as Weston's thermal desorption facility. Soil preparation and off-gas treatment equipment are identical in size and cost, but the rotary kiln incinerator is roughly 50 percent larger in diameter than the rotary dryer for the thermal desorber. Because the soil discharges from the incinerator at a higher temperature (760°C) than from a thermal desorber (300-400°C), fuel requirements are higher per ton of soil processed. The resulting higher volume of flue gas necessitates an increase in the diameter of the rotary kiln incinerator in order to maintain the same design space velocity as that used in Weston's thermal desorber and an increase in sizing of the off-gas treatment system to maintain the same soil processing rate.

For the purposes of the DAA, Weston's conceptual design for thermal desorption was adapted to the operating temperatures required in rotary kiln incineration. The volume of gas sent to off-gas treatment is identical in both cases, so the same combustion calculations were used to establish the quantity of incinerated soil that is consistent with that volume. For the incinerator operating at 760°C, the off-gas treatment equipment in the Weston report limits the soil processing rate (at 20 percent moisture) to 56 tons/hour using two rotary kiln incinerators.

The main burner is located on the soil feed end of the kiln so that the highest flame temperatures and highest heat release occur where soil moisture levels are highest. Soil and combustion products flow in the same direction so that particulates that entrain in the flue gas are heated to the required incineration temperature before they exit the kiln. Overall soil residence time is 30 minutes.

As with thermal desorption, off gas from the incinerator passes through a cyclone separator before entering the SCC. Depending on metals content, the particulates removed by the cyclone are combined with the treated soil discharge stream or solidified to immobilize inorganics and are disposed in the on-post landfill. Residual organic contaminants in the cyclone off gas are destroyed in the SCC at the proposed operating temperature of 1,200°C and residence time of 2.5 seconds.

The off-gas treatment sequence following the SCC treatment employs a spray tower for adiabatic gas cooling, a baghouse for particulate removal, and a caustic quench procedure to remove acid gases with a venturi scrubber for additional particulate removal. The sequence can be modified to include off gas to stack gas heat recovery and spray drying of the caustic quench blowdown stream. The technology is sufficiently proven in commercial incinerator installations such that the off-gas treatment system is expected to meet air emissions standards without undertaking any extraordinary measures. Optimization of the treatment sequence will be undertaken after final engineering studies.

Direct-fired rotary kilns are also available in both transportable and fixed facility versions, and several remediation firms can provide transportable versions on a contractual basis. Compared to the bare metal construction of thermal desorbers, the higher operating temperatures of incineration require a refractory lining. A rotary kiln incinerator has no internal lifting flights for solids processing, so it is generally inclined at a steeper angle than a thermal desorber, encouraging solids movement. Depending on the moisture content of the feedstock and the volatility of the contaminants, the rated throughput for the transportable incinerators is between 5 and 44 tons/hour. Examples of current transportable unit capabilities include the following:

- Weston Transportable Incineration System (TIS)—Direct-fired rotary kiln with SCC for the final destruction of vaporized organics. Full-scale capacity is 6 tons/hour. Modular off-gas treatment consists of a spray tower, baghouse, and recirculated quench tower. The quench blowdown stream treatment is unspecified.

- Detoxco Transportable Incinerators—Direct-fired rotary kiln with SCC for the final destruction of vaporized organics. Full-scale capacity of three available models is 7, 22, or 44 tons/hour. Modular off-gas treatment consists of a quench tower, baghouse, and acid scrubber. Scrubber blowdown requires further treatment.

- Rust Remedial Services Transportable Incinerator System (PYROX 8200)—Direct-fired rotary kiln with SCC for the final destruction of vaporized organics. Full-scale capacity is 10 to 15 tons/hour. Modular off-gas treatment consists of a quench tower, baghouse, and acid scrubber. Scrubber brine stream requires further treatment.

Depending on the final volume of soil requiring incineration, transportable units may have sufficient processing capacity to be considered for part of the final RMA remedy. For the purposes of the DAA, potential soil volumes are still large enough to favor the higher throughput of a site-constructed incineration facility.

Rotary kiln incinerators are available from several heavy equipment fabricators in the United States. Combustion Engineering, Ford, Bacon, and Davis, and Allis Mineral Systems are three possible sources of detailed mechanical design and equipment fabrication technologies. These same fabricators can supply the SCC and the associated off-gas treatment equipment.

Both site-constructed and transportable incinerators require some form of off-gas treatment system. As already discussed, alternatives developed for the DAA use the same off-gas treatment sequence for thermal desorption and incineration. The off gas from the incinerator is sent to an

SCC operating at 1,200°C with a residence time of 2.5 seconds to destroy the partially oxidized organic components exiting the rotary kiln. Given the extensive experience with commercial hazardous waste incinerator off-gas treatment, proven technology is available to achieve particulate and acid gas emission requirements for stack gas standards. Depending on the sequence of off-gas treatment operations, the solids from particulates removal and the brine from acid gas neutralization may exit the off-gas treatment train as a combined stream or as separate wastes.

Particulates and metal salts recovered from the off gas exit the system from several points. The necessity of solidifying some or all of these sidestreams depends on the extent of metal partitioning between the two streams. If the soil feed is high in volatile metals, the particulate sidestream may require solidification to immobilize inorganics prior to disposal in a soil consolidation/containment area or an on-post landfill (Section 6.5).

By-product acid gases such as HCl, HBr, and HF are neutralized and scrubbed out of the desorber off-gas stream in a caustic quench step. The resulting sodium chloride brine stream is evaporated and centrifuged to a wet cake with a solids content of 80 percent. The salt cake is placed in the on-post landfill and the evaporated water recycled to the off-gas treatment system.

Incineration causes irreversible chemical and physical changes to the treated soil, generating an ash. 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. 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. Because metal oxides tend to be more soluble than the carbonates, incineration tends to increase the extractability of metal constituents over that of the untreated soil. Depending on the metal content of the contaminated soil, the particulates from the incinerator off-gas treatment system, and possibly the treated soil, may require solidification before they are placed in the on-post landfill.

The soil/ash discharged from the incinerator is cooled and rehumidified by water sprays to minimize fugitive dust emissions. Depending on the analysis of residual inorganic contaminants, the treated soil/ash is either solidified to immobilize metals and then placed in the on-post landfill or is placed in the on-post landfill without solidification. Section 10.1 presents the process of direct cement-based solidification that would be implemented.

RCRA specifies extensive siting, design, and performance requirements for treatment facilities using incineration/pyrolysis technology. Like the thermal desorber, the facility cannot be sited in a wetland area or 100-year floodplain. The unit must substantively comply with RCRA performance standards for hazardous waste incinerators (40 CFR 264, Subpart O) and achieve a minimum DRE of 99.99 percent for all organic hazardous constituents. Because RMA is in a nonattainment area, the off-gas treatment system must meet federal and Colorado primary ambient air quality standards of performance for new emissions sources. The ARARs governing the use of incineration/pyrolysis and its associated off-gas treatment train are found in Appendix A.

The capital and operating costs for the incineration/pyrolysis technology are adapted from those developed for the draft thermal desorption conceptual design proposed by Weston (1992b). The order-of-magnitude estimate includes the cost of off-gas treatment and brine concentration and excludes the cost of soil excavation, soil transport, soil backfill, and waste sidestream disposal. Table 7.2-1 shows the cost components that make up the RMA incineration capital and operating costs for a two train facility. According to the Weston model, the current capital cost for a single-train rotary kiln incinerator facility with modular feed preparation and off-gas treatment equipment is estimated to be $22.9 million, with ongoing operating and maintenance costs of $34.5 million. The volume of contaminated soil processed by this unit is 300,000 BCY over a 6-year period, resulting in unit costs of $76.00/BCY for capital and $115,00/BCY for operations.

7.2.2 Process Performance

The fuel requirement per ton of soil treated is typically more than 50 percent higher for a rotary kiln incinerator than a direct-fired thermal desorber because the soil, water vapor, and combustion gases must be raised to the higher operating temperature of the incinerator. The higher operating temperature also increases the specific volume of the off gas so that gas volume per ton of soil is almost three times higher for incineration than for thermal desorption. As a result, a rotary kiln incinerator operating at 760°C has about one-third the soil processing rate of a similarly sized thermal desorber operating at 315°C, assuming similar waste content in the feed soil.

The energy expended in vaporizing soil moisture is a lower fraction of the incineration heating requirement when compared to thermal desorption. For example, as soil moisture content increases from 5 to 20 percent of the feedstock weight, the heat load associated with vaporizing water increases from 10 to 40 percent of total fuel fired compared to an increase from 30 to 70 percent for the same moisture range in thermal desorption. Changes in moisture content have less impact on the soil processing rate.

As feedstock moisture levels increase, handling and placement difficulties begin to limit the practicality of using rotary kiln incineration as a treatment approach. The contaminated medium must contain between 20 to 30 percent solids to be processed. Sludges or dredged soil may require dewatering or blending with a drier material to meet the solids content requirement.

As with thermal desorption, a high fraction of fine silt or clay can produce dusting in the kiln and can increase particulate carryover into the off-gas treatment train. The presence of VOCs and natural organic compounds present in the soil can complicate the operation of the incinerator. High levels of salts in some soil near the basins add to the generation of acid gases in the incineration desorption step. The salts may adhere to rotary kiln refractory lining or remain as slag in the SCC. Structure debris is more abrasive than soil and will increase wear of the refractory lining and contact parts of the incinerator.

Incineration has been demonstrated to be effective at commercial facilities for the destruction of halogenated and nonhalogenated VOCs, halogenated and nonhalogenated SVOCs, PCBs, pesticides, dioxins, and furans from soil matrices. It is potentially effective for these same organic contaminant groups in sludges, but treatability study information is not as extensive for this material as it is for soil. The technology volatizes metals such as mercury from the soil and removes volatilized inorganics in the off-gas treatment system.

Transportable incinerators have been successfully used to remediate PCB-contaminated soil at several Superfund sites. Weston has extensive performance information for its TIS at full-scale operation (5 to 6 tons/hour). The TIS system consists of a transportable, direct-fired, rotary calciner operating between 650°C and 1,200°C. The associated SCC, bag house, and acid gas scrubber are also transportable. The unit has been demonstrated at full-scale operation at the Lauder Salvage Yard (Illinois) where it achieved a DRE of 99.9999 percent for PCBs. In another instance, EPA operated a transportable rotary kiln incinerator (EPA-1) at Denny Farms (Missouri) to remediate soil contaminated with chlorinated organic compounds, including aldrin, chlordane, and Silvex. Again, demonstrated DREs were 99.9999 percent.

EBASCO conducted two bench-scale incineration treatability studies on RMA soil in 1988 using a two-reactor incineration test apparatus (EBASCO 1988). The study showed that OCPs present in Basin A and F soil at total concentration levels of several hundred to several thousand ppm could be removed from the soil matrix at temperatures as low as 400°C but that overall destruction (DREs of 99.99 percent) depended on the operating temperature of the second reactor being at least 800°C.

Some of the volatile metal contaminants are also volatilized at incinerator operating temperatures. Virtually all of the mercury and more than 20 to 30 percent of the arsenic are likely to be removed with the off-gas stream. The chemical and physical characteristics of the soil are changed by incineration so that residual inorganic contaminants may be more leachable.

Other inorganics in the form of alkali chlorides and sulfates are also present in RMA soil samples. Bench-scale testing indicates that large fractions of the sodium and potassium salts may be removed from the soil matrix and contribute to the potential slagging problem in the SCC and to general corrosion problems in the off-gas treatment equipment.

Based on the performance of RCRA-permitted commercial incinerators, the concentrations of organic contaminants in RMA soil should be reduced below their detection levels by rotary kiln incineration. DREs of 99.99 percent have been demonstrated in bench-scale treatability studies of RMA soil containing a wide range of contaminants, including volatile halogenated organics (VHOs) and pesticides, and commercial units regularly achieve DREs of 99.9999 percent with PCB- and dioxin-contaminated soil. Table 7.2-2 summarizes performance information for incineration of pesticide-contaminated soil.

7.3 OFF-POST INCINERATION OF STRUCTURAL DEBRIS

Off-post incineration of structural debris involves the use of direct-fired equipment to destroy organic contaminants in the debris. Debris is loaded at RMA for rail or truck transport to an off-post facility, where it is incinerated in a rotary kiln incinerator. The off-post incineration facility is responsible for disposal of all sidestreams. Based on the DSA screening process, off-post incineration was retained for treatment of structural debris only.

7.3.1 Process Description

Off-post incineration of structural debris is performed by a facility that is responsible for incineration as well as disposal or treatment of all sidestreams generated from the debris. Section 4 discusses the transportation of structural debris to the off-post incineration facility in detail.

The feed pretreatment area at the selected facility requires a fully enclosed building, which would house the contaminated material handling, sizing, and mixing equipment and the incinerator feed hoppers. The incinerator feed pretreatment sequence could consist of the same steps described under thermal desorption: feed hopper, magnetic separator, primary shredder, disc classifier, and final shredder.

Acceptance of the structural debris is predicated on the incineration contractor's review and acceptance of the waste material data sheet, which profiles the waste and the contractor's examination of a representative sample. It was assumed that structural debris is acceptable, although subject to the following restrictions:

- Concrete may not contain reinforcing steel bars and must be small enough to be handled manually.
- Steel pieces cannot be larger than 6 inches and must be packed in 30-gallon poly drums.
- Wood must be shredded into small pieces.

Waste tracking by the contracted incineration facility is an integral part of this treatment process. Each container of waste is tracked by a bar code labeling system that organizes pertinent information about the material. Records are maintained on a computer database, which allows instant status tracking. The bar code is used to record the location of the waste when moves occur and to generate a certificate of disposal upon incineration.

Given the scale of the remediation implied by RMA structural volumes, off-post incineration requires a high processing capacity incineration facility. Examples of off-post facilities capable of treating structural debris include the following:

- Environmental Systems Company (ENSCO), El Dorado, Arkansas—Three direct-fired rotary kiln incinerators are available. Full-scale capacity is 18.2 tons/hour if the British thermal unit (BTU) content of the waste stream does not exceed 218.4 million BTU/hour.
- U.S. Pollution Control, Inc. (USPCI), Houston, Texas—Two direct-fired rotary kiln incinerators are available. Full-scale capacity is 14.6 tons/hour if the BTU content of the waste stream does not exceed 182 million BTU/hour.

All sidestreams and posttreatment requirements for incineration of structural debris are the sole responsibility of the contracted incineration facility. Once the structural debris is accepted by the contracted facility, RMA relinquishes any further responsibility.

Appendix A presents the action-specific ARARs governing the performance of incineration. Adherence to ARARs and other applicable regulations is the sole responsibility of the contracting off-post incineration facility. Section 4 discusses the ARARs related to off-post transportation.

As shown in Table 7.3-1, the capital and operating costs for off-post incineration are taken from a compilation of vendor quotations. These costs are based on the assumption that, as part of the off-post incineration technology, structural debris is shredded prior to leaving RMA. It was also assumed that the sized structural debris consists of the following proportions: 50 percent concrete, 20 percent brick/tile, 20 percent wood, and 10 percent steel. The unit cost for shredding is $0.32/CY (capital) and $13.75/CY (operations). The unit cost for a transfer facility is $0.24/CY (capital) and $1.10/CY (operations). Off-post incineration and disposal of all sidestreams costs $4,148/CY (operations) and includes the cost of transportation.

7.3.2 Process Performance

Based on specifications of the contracted incineration facility, structural debris may require pretreatment. Concrete from the structures demolition may contain reinforcing steel bars that must be removed from the concrete and sized down to pieces not to exceed 6 inches prior to treatment. The remaining concrete must be small enough to be handled manually. In addition, all wood must be shredded.

Off-post incineration of structural debris is an effective means of treating debris. Once the debris is accepted by the contracted facility, RMA relinquishes all responsibility for the debris. The contracted facility must follow all appropriate regulatory requirements for treatment and disposal of generated sidestreams from the incineration process.

Results from RMA and other sites are not applicable to this technology. Destruction efficiencies, volume reduction, and sidestream disposal information can be obtained from the contracted incineration facility. Facility specifications and operating performance standards can also be obtained from the contracted incineration facility.

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Table 7.1-1 Capital and Operating Costs for Direct Thermal Desorption

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Site Preparation	$ 857,000	Source: 1
	Soil Pretreatment	2,240,000	
	Thermal Desorption	13,200,000	Based on two thermal treatment trains with a common feed preparation building. Total soil feed rate at 20% moisture is 74 tons/hour. Onstream time is 5,700 hours per year.
	Brine Concentration	5,270,000	
	Spare Parts	2,060,000	
	Buildings	7,540,000	
	Piping	2,880,000	
	Electrical & Instrumentation	3,100,000	
	Startup, Shakedown, and Test	4,380,000	
	Field Indirects	502,000	
	Field Staff	1,810,000	
	Total Facility (74 tons/hour)	$43,900,000	
Operating Costs	Operations & Maintenance Labor	$ 5,770,000	Source: 1 for Annual Operating Cost
	Maintenance Materials	565,000	
	Analytical	599,000	
	Utilities	13,200,000	
	Chemicals	1,160,000	
	Consumables	1,290,000	
Total Annual Operating Cost		$22,600,000	

Sources:

1) Weston, Roy F., Concept Engineering Study Report for Thermal Desorption Systems for Rocky Mountain Arsenal Soils, November 1992 (Weston 1992b).

Table 7.1-2 Performance Information on Direct Thermal Desorption of Pesticide-Contaminated Soil

Year	Source	Location	Scale	Results
1989	Shell Development Company	West Hollow Research Center Houston, TX	Laboratory Scale	RMA soil from Basins A, C, and F with total OCP levels of 300 to 20,000 ppm were heated in tube and box furnaces at temperatures between 250°C and 650°C for periods of 30 to 150 minutes. Even at the lowest temperature, total OCP levels were reduced to between 1 and 50 ppb.
1990	Morrison-Knudsen Environmental Services	IT Corporation Technology Development Center Knoxville, TN	Bench Scale	Basin F soil with a total OCP level of 780 ppm was heated in a rotary thermal apparatus at temperatures between 300°C and 650°C for periods of 15 to 60 minutes. Even at the lowest temperature and shortest time, total OCP levels were reduced to below detectable levels (32 ppb).
1992	Roy F. Weston, Inc.	IT Corporation Technology Development Center Knoxville, TN	Laboratory and Bench Scale	Soil composited from Basins A, C, and F and from South Plants sites with total OCP levels were heated in a rotary thermal apparatus at temperatures between 200°C and 350°C for periods of 5 to 50 minutes.
1992	Canonie Environmental	Litchfield Airport Superfund Site Avondale, AZ	Full Scale	Underway for remediation of pesticides, including DDE and DDT.

Table 7.2-1 Capital and Operating Costs for Direct Incineration/Pyrolysis

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	Total Facility (56 tons/hour)	$45,800,000	Source: 1 Based on two incinerator trains with a common feed preparation building. Total soil feed rate at 20% moisture is 56 tons/hour. Onsteam time is 5,700 hours per year (65%).
Operating Costs	Operations & Maintenance Labor Maintenance Materials Analytical Utilities Chemicals Consumables	$11,200,000 2,560,000 1,160,000 50,000,000 1,690,000 2,500,000	Source: 1 & 2 for Annual Operating Cost Adjusted for EBASCO Task 17 operating conditions, but without the use of 40% supplemental oxygen in the kiln and the SCC. Utilities, chemicals, and brine disposal adjusted for reduced throughput.
Total Annual Operating Cost		$69,100,000	

Sources:

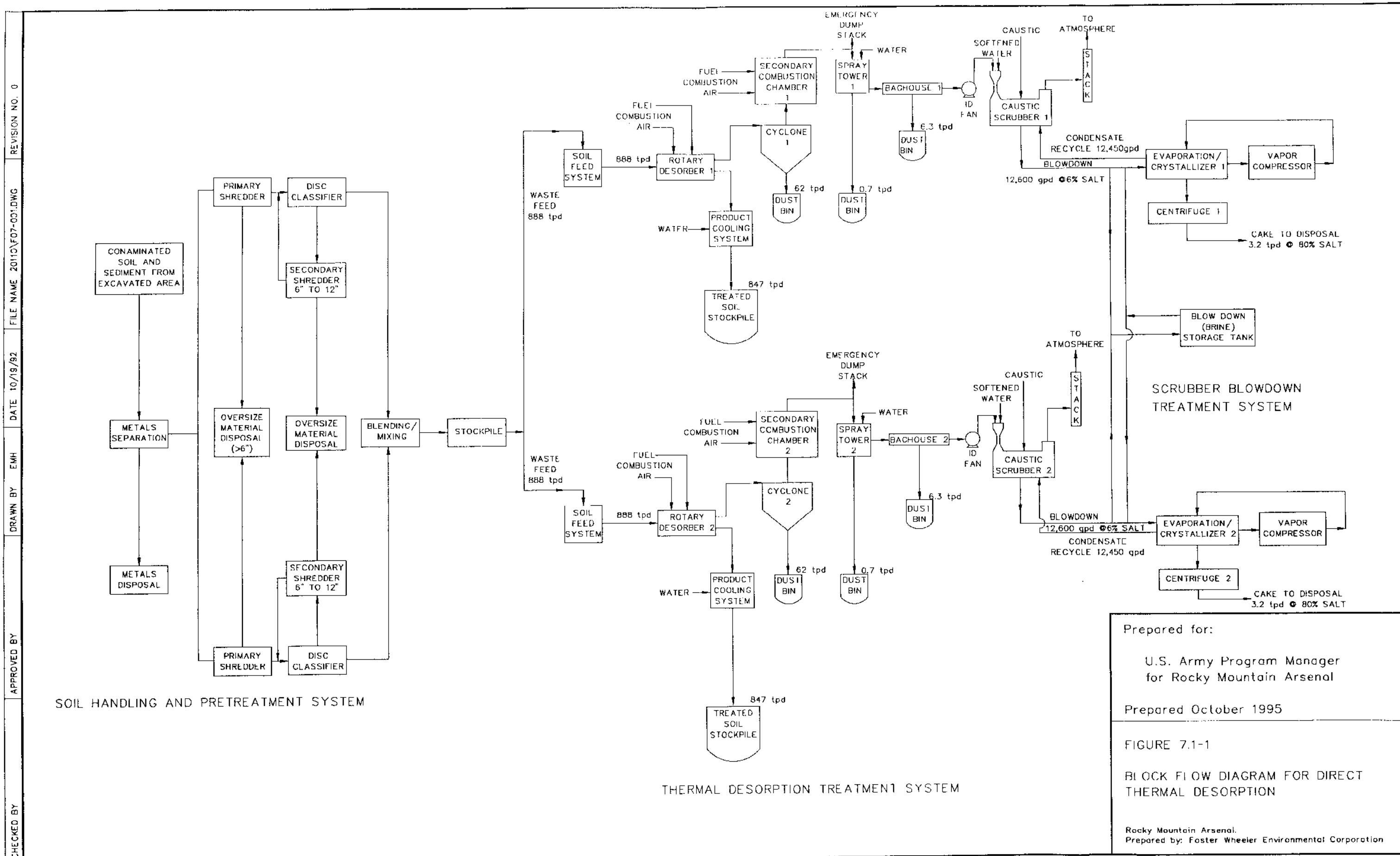
1) Weston, Roy F., Concept Engineering Study Report for Thermal Desorption Systems for Rocky Mountain Arsenal Soils, November 1992 (Weston 1992b).
2) EBASCO, Full-Scale Incineration System Conceptual Design for Basin F Wastes, Task 17, September 1988 (EBASCO 1988).

Table 7.2-2 Performance Information on the Incineration of Pesticide-Contaminated Soil

Year	Source	Location	Scale	Results
1988	EBASCO	Hittman-EBASCO Laboratory Columbia, MD	Bench Scale	RMA soil from Basin F was heated in a bench-scale incineration unit at primary reactor temperatures between 650°C and 900°C and secondary reactor temperatures between 650°C and 1,200°C. OCPs were removed from the soil at even the lowest primary operating temperature, but overall DREs of 99.99 percent required a minimum of 800°C in the SCC.
1988	EBASCO	Hittman-EBASCO Laboratory Columbia, MD	Bench Scale	RMA soil from Section 36 (Basin A) was heated in a bench-scale incineration unit at primary reactor temperatures between 450°C and 900°C and a secondary reactor temperature of 1,200°C. Results confirmed Basin F testing and suggested that low-temperature thermal desorption might be used in place of the primary incinerator. Metals partitioning results were inconclusive.

Table 7.3-1 Capital and Operating Costs for Off-Post Incineration of Structural Debris

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Transfer Facility	$0.24/CY	Vendor Quote
	Shredder	$0.32/CY	"
Operating Costs	Transfer Facility	$1.10/CY	Vendor Quote
	Shredder	$13.75/CY	"
	Total Off-Post Incineration and Disposal of All Sidestreams	$4,148/CY	"



Prepared for:

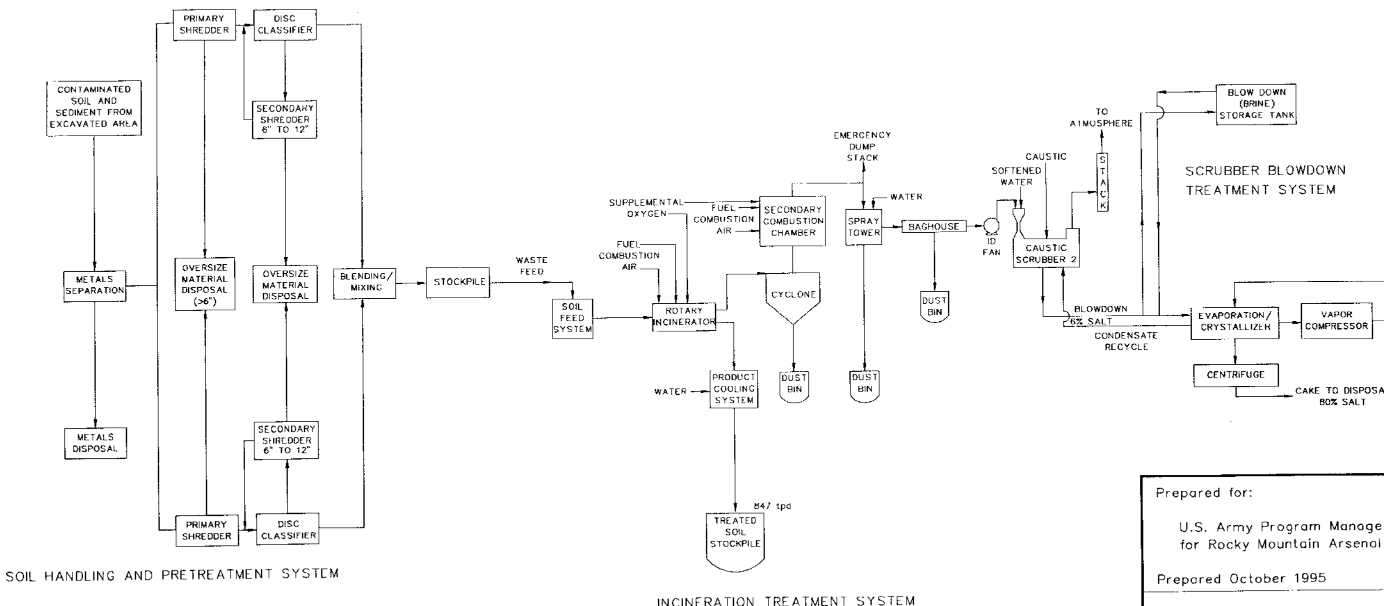
U.S. Army Program Manager for Rocky Mountain Arsenal

Prepared October 1995

FIGURE 7.1-1

BLOCK FLOW DIAGRAM FOR DIRECT THERMAL DESORPTION

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared October 1995

FIGURE 7.2-1

ROTARY KILN INCINERATION

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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Section 8

8.0 IN SITU THERMAL TREATMENT

In situ thermal treatment involves the in-place heating of contaminated soil, sediment, sludges, and structures. VOCs and SVOCs are vaporized from the solid phase and either recovered or destroyed by the off-gas treatment system. In most of these in situ processes, water vaporizes before the less volatile organic compounds, and the energy required to drive off the soil moisture may represent a sizable percentage of the total energy usage. As the operating temperature of the process is raised, more of the natural organic content of the soil is driven off with the heavy organic contaminants. Elevated treatment temperatures produce irreversible physical and chemical changes in the soil, and extreme treatment temperatures induce melting and fusion of the soil matrix.

Sections 8.1, 8.2, and 8.3 describe the surface soil heating, subsurface soil heating, and in situ vitrification process options for treating soil, respectively. Section 8.4 describes the specialized process option of hot gas decontamination of structures and debris.

8.1 SURFACE SOIL HEATING

The surface soil heating process, or enhanced surface soil vapor extraction process (ESSVEP), heats soil within 12 inches of the surface to temperatures at which the COCs are readily volatilized, collected, and treated. The process consists of a hooded grid of electrical resistance heating elements, an induced draft fan, and an off-gas treatment system and is most effective at removing surface or near-surface SVOCs such as aldrin, dieldrin, and endrin.

After the successful laboratory demonstration of thermal desorption of OCPs from RMA soil, an ESSVEP pilot-scale test module was developed for use on surficial soil contamination at RMA. The technology was demonstrated during pilot-scale testing in Basin C where ESSVEP reduced SVOC concentrations in RMA soil to levels less than 10 ppb in the top 12 inches of soil. The heating duration was 36 hours and the soil was heated to approximately 200°C to a depth of 12 inches (MKE/Shell 1995).

Based on the DSA screening process (EBASCO 1992), surface soil heating was retained for evaluation in the DAA for one of the human health medium groups (Basin A).

8.1.1 Process Description

The ESSVEP process (Figure 8.1-1) allows the concepts of traditional soil vapor extraction to be extended to SVOC contaminants and is capable of reducing their concentrations to very low levels. A heater is used to raise the soil temperature in the treatment zone to a level at which the COCs are more readily volatilized. The process consists of several different components: soil heating assembly (heater elements), heater support structure, insulation, impermeable cover, vapor collection system, vapor treatment unit, and power supply. The soil heating assembly and impermeable cover can be designed such that the entire unit can be moved quickly from one site to another. The vapor collection system ensures that the contaminants released from the soil flow into a vapor treatment system where they are collected or destroyed.

The soil heating assembly consists of separate heating modules connected mechanically and electrically. Each module contains heating elements that have the potential to be operated up to temperatures of 1,000°C with a design power rating of 70 kilowatts (kW). Power to the soil heater assembly is supplied from a 200-kW, diesel-powered generator. A rigid stainless steel hood is placed over the heater assembly. The hood is designed so that the central vent pipe is connected to a vacuum line and vapor treatment system. To ensure that the system operates under negative pressure, a flexible skirting made out of temperature-resistant silicone butyl rubber is attached to the perimeter of the hood to provide a seal between the ground surface and the hood (Figure 8.1-2).

During heating, vapors are collected from beneath the soil heating assembly to prevent vaporized contaminants from escaping into the atmosphere or moving into the surrounding soil. Several vapor treatment options are available for use in conjunction with surface soil heating, including GAC, catalytic oxidation, and incineration. GAC is widely used for vapor control because it is applicable to a wide variety of organic contaminants, concentrations, and flow rates. This technology is most cost effective where vapor concentrations and flow rates are low. For high flow rates and concentrations, carbon regeneration costs become excessive.

Surface soil heating produces three sidestreams: wastewater, treated off gas, and spent carbon. The wastewater is transferred to a nearby water treatment facility. Spent carbon from the GAC units is regenerated off post, and the treated off gas is released into the atmosphere via a stack after meeting appropriate regulatory requirements.

Surface soil heating is a site-specific technology currently being developed by Shell Oil Company (MKE/Shell 1995). The technology has progressed through pilot-scale testing, although full-scale implementation has yet to be completed. Given the scale of the remediation that is required by RMA soil volumes, several modular units will be required to achieve effective treatment in a timely manner.

Projections of full-scale implementation by Shell include construction of 50-ft by 50-ft modules capable of treating the first 12 inches of surface soil to the operating temperature of 250°C. The heating elements are similar to those demonstrated during the treatability test described above, although the type of electrical connections, heater spacing, and heater length may be altered to change the heating density where necessary. Treatment rates for surface soil heating may vary depending on the configuration of the heating assembly, capacity of the process equipment, and the geology of the treatment site, but a 50-ft by 50-ft unit can generally treat 3.5 acres annually.

Post-treatment of the soil is required, as is revegetation to restore the site to its original condition. Fertilizers and native humic material must be used to effectively maintain a vegetative cover and to supplement the organic and moisture content of the treated soil.

Because RMA is in a nonattainment area, the off-gas treatment system must meet federal and Colorado primary ambient air quality standards of performance for new emissions sources. The action-specific ARARs governing the use of surface soil heating and its associated off-gas treatment train are found in Appendix A. These action-specific ARARs primarily address discharge of untreated or treated wastewater, air emissions during operation, and worker protection during operation.

The capital and operating costs for the ESSVEP technology are taken from the draft pilot-scale field test report (MKE/Shell 1995). Projected costs are dependent upon the operating parameter assumptions used to evaluate the process. The top 12 inches of soil were remediated by using ESSVEP over a 48-hour heating period. At the end of the heating period, the soil heating assembly is allowed to remain in place for an approximate 40-hour cooling period. At the end of the cooling period, an 8-hour period is required to relocate the process equipment to the next site. The unit has a treatment rate of 17,000 SY/year. The ESSVEP apparatus was assumed to require one full-time operator on a time-averaged basis. During heating and cooling, one operator can handle several sets of equipment, but, during relocation, several operators are necessary. The current capital cost for a full-scale ESSVEP unit is estimated to be approximately $1,010,000 with ongoing operating and maintenance costs of $28.92/CY (Table 8.1-1).

8.1.2 Process Performance

As demonstrated in the pilot-scale test at RMA, uniform heating of the soil is difficult to achieve because of varying soil structure and gradation and moisture content (MKE/Shell 1995); thus the success and treatment rate of surface soil heating depends upon site-specific conditions. For example, if the area to be treated contains both sandy and dense clay layers, the tendency for baking portions of the soil greatly increases energy requirements and changes the composition of the original soil.

Surface soil heating has not been demonstrated at full scale, so no information on the operability of the units exists. The heating units are constructed of readily available materials, but commercial vendors do not currently exist.

The ESSVEP was demonstrated during a pilot-scale study on RMA soil using a 10-ft by 10-ft soil heating assembly. The primary objective was to demonstrate a reduction of SVOC contaminants in the top 6 inches of soil to potential cleanup levels by heating the topsoil to at least 250°C. The test was performed in the Shell Plot Test Area in Basin C. The soil at the test site initially contained approximately 9,000 ppb of total OCPs (i.e., aldrin, dieldrin, endrin, and isodrin) in the top 6 inches and 200 ppb in the 6- to 12-inch depth interval (Shell 1991).

The test was completed after 36 hours of operation. While the heating elements performed well, the vapor flow was lower than expected because of a partially obstructed vapor collection pipe. The 6-inch soil temperatures reached maximum values of 445°C in the middle of the plot and 338°C at the edge of the plot. The 12-inch soil temperatures reached maximum values of 206°C in the middle of the plot and 164°C at the edge of the plot.

Posttest soil sampling showed that OCPs were removed to concentrations of less than 16 ppb in the 0-inch to 6-inch and the 6-inch to 12-inch depth intervals. No significant downward movement of contaminants was indicated by the results. Only small amounts of OCPs were detected in the vapor leaving the soil and in the vapor treatment system, suggesting that OCPs may have been destroyed during soil heating or degraded into byproducts. Soil organic matter was degraded as the soil was heated, producing elevated total hydrocarbon concentrations in the vapor stream. Metals in the soil were relatively unaffected by the process as compared to the reduction of organic material. However, there was a slight reduction of mercury and arsenic, which indicates that the inorganic elements vaporized into gaseous fumes. These gaseous inorganics may have exited the system along with the volatized organic contaminants. Additional off-gas treatment is necessary to remove these inorganics from the off-gas stream.

Surface soil heating using ESSVEP has only been demonstrated in a pilot study on RMA soil. Two sets of soil samples were composited by depth for this demonstration. The first was taken from the inner 6-ft by 6-ft region called the core region. The other set was taken along a line 1 ft from the edge of the heater, the edge region. The core region was intended to be the basis of the calculation of an overall removal efficiency, whereas the edge region was intended to account for any large edge effects. Table 8.1-2 shows the OCPs analytical results of the pre- and posttest soil sampling (MKE/Shell 1995).

For both the core and edge regions of the treated area, the OCP concentrations were reduced to levels nondetectable by EPA Method 8080 in the top 6 inches and the 6-inch to 12-inch soil interval. Because the treatment temperature target was reached in the edge region, there are no significant differences in treatment effectiveness for the OCP removal between the core and edge regions. The OCP removal efficiency was greater than 99.95 percent in the top 6 inches and greater than 95.65 percent in the 6-inch to 12-inch soil interval.

8.2 SUBSURFACE SOIL HEATING

Two processes are being considered for subsurface soil heating: radio frequency (RF) heating and Shell's Enhanced Deep Soil Vapor Extraction Process (EDSVEP). RF heating converts electrical energy to an electromagnetic form that dissipates in the soil mass as heat. The soil is heated similar to the way food is heated in a microwave oven, and the heat desorbs VOCs and SVOCs from the soil mass. EDSVEP heats the soil by introducing heated air through injection vents. The hot air thermally desorbs the contaminants, which are then removed from the soil via extraction vents. Both processes employ a pattern of borings to inject heat into the soil and extract vapors from the soil mass. Both are innovative technologies and have been demonstrated in the field on RMA soil.

Subsurface soil heating is combined with cement-based solidification for the following alternatives evaluated for the soil medium: Alternative 19 (In Situ Thermal Treatment; In Situ Solidification/Stabilization) and as a sole treatment for Alternative 19a (In Situ Thermal Treatment). These in situ heating processes are designed to remove only organic contaminants; they are not intended to be effective in removing or stabilizing inorganic contaminants. Hence, in situ cement-based solidification follows the thermal treatment step to stabilize inorganic contaminants in the soil matrix, if required.

Based on pilot-scale treatability studies conducted with RMA soil, RF heating is generally effective in reducing the concentrations of VOCs and SVOCs of concern to or below PRGs although the treatment levels achieved varied widely. The vapors produced during heating are treated in a vapor treatment system that removes or destroys the VOCs and SVOCs. A treatability study was conducted on RMA soil by Shell to evaluate the effectiveness of EDSVEP. The results were not promising and Shell discontinued the study (MKC/Shell 1995).

Based on the DSA screening process (EBASCO 1992), subsurface soil heating is retained for the Basin A, Secondary Basins, Lime Basins, South Plants, Buried Sediments/Ditches, and Undifferentiated Medium Groups.

8.2.1 RF/Microwave Heating

RF heating is a process for heating large volumes of soil using electromagnetic energy. An array of electrodes is inserted into the ground in rows and the soil between the electrode rows is volumetrically heated. The mechanism of heat generation is similar to that of a microwave oven, and it does not rely on the thermal conductivity of the soil matrix. Vapors extracted from the soil are treated in a vapor treatment system.

8.2.1.1 Process Description

This process involves the desorption and collection of organic compounds through the placement of electrodes into a grid of boreholes. The soil moisture and solids absorb the electromagnetic energy produced by these electrodes and convert the energy to heat as a result of dipole rotation and molecular vibration. The organic compounds in the soil material are mobilized by vaporization or steam stripping or are thermally decomposed. The mobilized contaminants are then collected at the surface in a hood and drawn into an off-gas treatment system. The process equipment includes a radio frequency generator, a vapor collection and containment system, and a vapor treatment system.

RF heating is implemented by inserting electrodes in the ground and heating the soil to drive off organic contaminants. Power is applied to the exciter electrodes and is transmitted to the ground electrodes. The outer rows of electrodes limit the field boundary of the energy input to the system, and the depth of the electrodes defines the depth of soil to be treated. As the soil is heated, volatilized contaminants and steam are collected from the soil through perforated electrodes that serve as vacuum extraction vents.

The ground surface of the heated soil and/or area surrounding it are covered with a vapor barrier that consists of an insulated, fiberglass-reinforced, silicone rubber sheet. The barrier is secured under the soil berm surrounding the area to be treated. The vapor barrier has four functions: to help maintain a vacuum in the soil for vapor collection, to prevent fugitive emissions from the heated surface, to control infiltration of air into the heated zone and thus into the vapor treatment system, and to prevent condensation of vapors exiting the soil.

The vapor containment and collection system collects the subsurface vapors, steam, and volatilized constituents and transports them to the vapor treatment system. By applying a vacuum to the perforated electrodes under the vapor barrier, steam and vapor are drawn from the heated soil. The vapor collection manifold and pipes leading to the collection points are heat traced and covered with fiberglass insulation to prevent condensation of the vapors prior to entering the vapor treatment system (Weston 1992).

Several options are available for the vapor treatment system, including GAC, catalytic oxidation, and incineration. Based on the types of organic contaminants, concentrations, and flow rates, the thermal incinerator was selected as the vapor treatment system for the scale-up design for RMA (Weston 1992).

In the incineration process, hot gases collected from the heated blocks of soil are destroyed in the incineration chamber. Depending upon the concentration of the organic contaminants in the collected gases entering the incinerator, additional fuel may need to be added to the incinerator.

The vent gases are scrubbed to remove HCl formed during incineration and are then quenched.

RF heating produces two sidestreams: wastewater and off gas. The wastewater is transferred to a nearby water treatment facility, and the treated off gas is released into the atmosphere via a stack after meeting appropriate regulatory requirements (Weston 1992).

RF heating is a site-specific technology that has progressed through several pilot-scale tests, including several at RMA and at Volk Air National Guard Base. Given the scale of the remediation required by RMA soil volumes, RF heating will require several modular units operated simultaneously to achieve effective treatment in a timely manner (Weston 1992).

Projections of full-scale implementation at RMA include construction of a depth-dependent modular unit. The treatment system design is based on a vertical electrode placement on a rectangular grid pattern dictated by the depth of the contamination. 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 (Weston 1992).

The electrodes are made from 3-inch, schedule-40 threaded aluminum pipe. All electrodes are slotted and perforated, and the gases and vapors formed in the soil are collected by applying a vacuum to the electrodes. In addition, two horizontal, perforated gas collection lines, connected to the vacuum system, are placed on the soil surface adjacent to the two outer sheet piling ground rows. These lines are used to collect gases rising to the surface.

Posttreatment of the soil after RF 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 and moisture content need to be supplemented with fertilizers and native humic material to effectively maintain a vegetative cover.

Because RMA is in a nonattainment area, the off-gas treatment system must meet federal and Colorado primary ambient air quality standards of performance for new emissions sources. The action-specific ARARs governing the use of RF heating and its associated off-gas treatment train are found in Appendix A. These action-specific ARARs primarily address discharge of untreated or treated wastewater, air emissions during operation, and worker protection during operation.

The capital and operating costs for the RF heating technology are taken from the draft conceptual design proposed by Roy F. Weston (Weston 1992). The current capital cost for a full-scale RF unit is estimated to be approximately $7,959,000 (Table 8.2-1). Operating and maintenance costs will vary depending upon the depth of treatment and the moisture content of the soil but are estimated to be between $205.02/ton and $259.64/ton.

8.2.1.2 Process Performance

As demonstrated in the pilot-scale test at RMA (Weston 1992), uniform heating of the soil is difficult to achieve due to varying soil structure, gradation, and moisture content; therefore, the success and treatment rate of RF heating will be very site specific. For example, if the area to be treated contains both sandy and dense clay layers, the tendency for baking portions of the soil greatly increases, thus increasing energy requirements as well as changing the composition of the original soil.

The Basin F soil tested at RMA caused corrosion and destruction of the electrodes and support equipment. Based on site-specific conditions, the materials of construction could be varied to ensure the structural integrity of the unit as the composition of contaminants in the soil changes. This could lead to either construction of several different types of units to treat varying soil compositions or high costs for maintaining existing units.

Condensation of vapors under the vapor blanket also reduces the efficiency of the electrodes and increases energy requirements. The loss of energy by heat transfer through the vapor blanket and from the tent to the surrounding air proved to be a limiting factor during the pilot test at RMA.

The use of RF heating could also be limited by the proximity of RMA sites to the Denver International Airport. Specific radio frequencies may be restricted to avoid interference with airport operations, although the impact of potential restrictions is unknown at this time.

RF heating has been demonstrated to reduce concentrations of VOCs and SVOCs as well as individual OCPs and organophosphorus compounds during pilot-scale tests. The proven effectiveness of RF heating for a particular site or contaminant does not ensure that the treatment efficiencies achieved can be attained at other RMA sites.

In the treatability study at RMA, the soil initially had up to 5,700 ppm of individual OCPs (Weston 1992). Although contaminant concentrations varied greatly within the test plot, which measured approximately 14 ft by 9 ft by 13 ft deep, the pilot-scale treatment unit generally reduced contaminant concentrations.

A field test performed at the Volk Air National Guard Base in Wisconsin by IIT Research Institute (IITRI) was successful in decontaminating a former fire training pit in which sandy soil had been contaminated with jet fuel to a depth of about 13 ft (Dev 1990). A vertical array of electrodes was installed in a 6-ft by 2-ft area to a depth of 7 ft. Over a 9-day treatment period, approximately 500 cubic feet of contaminated soil was heated to 160°C at an average power input of 30 kW. Results indicated contaminant removal rates in soil of 99.3 percent for volatile aliphatics, 99.6 percent for volatile aromatics, 94.3 percent for semivolatile aliphatics, and 99.1 percent for semivolatile aromatics. In addition, migration of contaminants into the heated zone from the untreated perimeter was observed through the injection of halon tracers.

The pilot-scale test demonstrated the ability of the RF heating technology to heat Basin F soil to more than 250°C and in the process to reduce the OCP concentrations to near or below PRGs (Weston 1992). Endrin was reduced to concentrations below the 10^{-6} biological worker PRG. Aldrin, dieldrin, and isodrin were removed to below the 1×10^{-4} PRGs but not the 1×10^{-6} PRGs. OCP removal efficiencies in the soil heated to 250°C or higher ranged from 97 to 99.9 percent.

Inorganic removal rates were not analyzed as part of the pilot-scale test demonstration. Upon heating, some of the mercury and arsenic may volatize into gaseous forms and exit the system with the off-gas stream.

8.3 IN SITU VITRIFICATION

In situ vitrification uses electrodes to melt contaminated soil and debris into a vitreous mass. Contaminants are either destroyed by pyrolysis (organic contaminants), bound up in the melt mass (organic and inorganic contaminants), or driven off and captured in an off-gas treatment system (organic and inorganic contaminants). This technology is used as a stand-alone treatment in Alternative 21 (In Situ Vitrification), which was developed for the soil medium.

This technology is marketed exclusively by Geosafe Corporation. A treatability test performed by Geosafe using this technology on arsenic-, mercury-, and pesticide-contaminated soil and sludge from the M-1 Settling Basins at RMA was considered successful (Geosafe 1989). Geosafe also successfully utilized this process on more than 8,500 CY of contaminated soil at the Parsons Superfund site in Michigan (EPA 1995). Based on the DSA screening process, in situ vitrification was retained for only one of the soil medium groups—the Lime Basins Medium Group—specifically for the Buried M-1 Pits Subgroup.

8.3.1 Process Description

In situ vitrification uses electrical energy to melt soil and sludge for the purpose of thermochemically treating organic and inorganic contaminants present within the treatment volume. Most in situ vitrification applications involve melting of natural soil; however, other naturally occurring or process residual chemicals may be treated. Organic and volatile inorganic contaminants that are not destroyed by 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. Figure 8.3-1 illustrates a sequential staging of in situ vitrification.

In situ vitrification is currently being utilized by Geosafe Corporation. The technology has progressed through 90 tests and demonstrations that have ranged from bench- to full-scale tests. Pilot-scale tests on soil volumes ranging from 10 to 50 tons have been performed at sites such as Hanford, Oak Ridge National Laboratory, and Idaho National Engineering Laboratory. Large-scale tests treating a soil volume of approximately 1,000 tons have also been performed at the Hanford site. These tests have indicated that organic, inorganic, and radioactive contaminants have been effectively treated and are suitable for this technology. The DREs for both arsenic and mercury from the off-gas system are expected to be 99.97 percent (Geosafe 1989). In situ vitrification has been successfully used to heat more than 8,500 CY of contaminated soil at the Parsons Superfund site in Michigan (EPA 1995).

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. The total mass of soil that can be treated by this system is estimated to range from 800 tons to 1,000 tons. During operation, the process is able to treat 4 tons to 6 tons of soil per hour and requires 0.3 to 0.5 kilowatt hours (kWh) per pound of soil. Electric power is supplied to the electrode array through flexible conductors. Because the soil typically does not have sufficient electrical conductivity to allow initiation of the process, a conductive mixture of graphite and glass frit is placed on the surface between the electrodes to serve as an initial conductive starter. As electrical potential is applied between the electrodes, current flows through the starter path, heating it and the adjacent soil to temperatures above 1,600°C. Upon melting, typical soil become electrically conductive and act as the primary conducting medium, allowing the process to continue beyond startup. The full-scale process takes place at temperatures ranging from 1,600°C to 2,000°C.

The electrodes consist of 2-inch-diameter molybdenum rods surrounded by a 12-inch-diameter graphite collar. The electrodes are placed in the soil by driving or vibrating the casings into place, placing the electrodes into the casings, and extracting the casings through vibration. The maximum spacing between electrodes is about 18 ft, which allows formation of a maximum soil melt width of about 30 ft. Electric power is supplied to the array of electrodes through a utility distribution system at typical transmission voltages of 12,500 or 13,800 volts; alternatively, the power may be generated on site by a diesel generator.

The processing area is covered by an octagonal-shaped off-gas collection hood measuring 55 ft across. The large distance between the edge of the hood and edge of the melt ensures off-gas containment. Flow of air through the hood is controlled to maintain a negative pressure relative to atmospheric pressure. Because the process occurs at temperatures well above combustion minimums, an ample supply of air is provided to ensure excess oxygen is available for combustion of pyrolysis products and organic vapors, if any exist. The off gases, combustion products, and air are drawn from the hood via an induced draft blower into the off-gas treatment system.

To ensure compliance with air emissions standards, the off-gas treatment system includes the following processes: quenching, pH-controlled scrubbing, demisting, heating (temperature and dew point control), particulate filtration, and activated carbon adsorption. A self-contained glycol cooling system cools the quenching/scrubbing solution, eliminating the need for an on-site cooling water supply.

Typically, the volume of gases evolving from the melt presents less than 1 percent of the total volume of air processed by the off-gas treatment system. The off gas contains sweep air, pyrolysis and combustion products, and some amount of particulate material. A substantial fraction of the off-gas contaminants are removed from the vapor stream at the initial quenching and scrubbing stages. The filters and carbon adsorption columns are used as polishing stages to ensure safe air emissions.

In situ vitrification produces three sidestreams: wastewater, treated off gas, and spent carbon. The wastewater is generated at a rate of approximately 1 gallon/CY of soil treated and is transferred to a nearby water treatment facility. The spent carbon from the GAC units is generated at a rate of three canisters per 1,000 CY of soil processed and is regenerated off post.

The treated off gas is released into the atmosphere via a stack after meeting the appropriate regulatory requirements. Under maximum design conditions, off-gas flow is 1,800 cfm at 260°F, with water vapor comprising approximately one-half of the gas flow.

Site preparation of the treatment site is required. Groundwater in the soil treatment zone slows the vitrification process because the process requires that this water be vaporized prior to the melt progressing downward. Therefore, a sheet pile wall may be installed to cut off groundwater flow into the area during in situ vitrification. Any vegetative growth and any surface debris also must be cleared from the site.

Site restoration includes backfilling the site with clean soil, surface grading as necessary, removal of sheet piles, and revegetation. A soil volume reduction of 28 percent is anticipated from in situ vitrification, because the original soil porosity is eliminated during melting.

Because RMA is a nonattainment area, the off-gas treatment system must meet federal and Colorado primary ambient air quality standards of performance for new emissions sources. The action-specific ARARs governing the use of in situ vitrification and its associated off-gas treatment train can be found in Appendix A. These action-specific ARARs primarily address air emissions during operation and worker protection during operation.

The capital and operating costs for in situ vitrification technology are taken from the a SITE Applications Analysis Report for the Parsons Superfund site in Michigan (EPA 1995). Projected costs are based on those determined at the Parsons site for the M1 pits exceedance volume of 26,000 BCY. The current capital cost for in situ vitrification is estimated to be approximately $763,000 or $29.34/BCY, with total operating and maintenance costs of $15.7 million or $603.49/BCY (Table 8.3-1).

8.3.2 Process Performance

In situ vitrification was tested on a sample of soil and sludge from the M-1 Settling Basins at RMA (Geosafe 1989). Processing results from the bench-scale treatability test demonstrated the feasibility of using in situ vitrification to process the subject contaminated soil/sludge into an environmentally stable and compact glass product. Approximately 81 to 86 percent of the arsenic was immobilized in the melt, and the remaining arsenic was volatilized and released as off gas. All of the mercury is anticipated to be volatilized. The vitrified material passed the Toxicity Characteristic Leaching Procedure (TCLP) requirements, with the leachate solution showing levels of 0.91 milligram per liter (mg/l) for arsenic and 0.0001 mg/l for mercury. Destruction efficiencies in the melted material were 98.3 percent for dieldrin and 96.6 percent for aldrin.

Prior to vitrification, groundwater must be driven off by system heat because a higher soil moisture content slows the vitrification process, thereby increasing cost. To dewater the soil prior to treatment, groundwater extraction wells or groundwater barriers may be used. Groundwater is present at shallow depths at the M-1 Basins. It was assumed that dewatering of the site prior to in situ vitrification treatment is required, so the current system design is based on the installation of groundwater barriers.

Buried metals greater than 5 to 15 percent of the melt weight between the electrodes can lead to a conductive path within the treatment plot that may short circuit the electrodes. Electrodes that are to be fed into the treatment plot as melting progresses may have to be designed to control this phenomenon. In addition, loosely packed rubbish or other combustible material may cause an underground fire; sheet piling or another type of subsurface barrier will help prevent this problem.

The process is potentially effective in destroying or immobilizing contaminants as a result of the melting process. However, it is suspected that during the in situ vitrification process contaminants may be driven into the surrounding soil of the inert mass causing additional contaminant migration. This technology provided effective treatment of contaminated soils at the Parsons site in Michigan (EPA 1995).

8.4 HOT GAS DECONTAMINATION OF STRUCTURES AND STRUCTURAL DEBRIS

Hot gas decontamination is a thermal process designed to release VOCs and SVOCs from structural materials. The materials are heated to temperatures of 400°C, releasing adsorbed contaminants and directing them to an off-gas treatment system. To control energy costs, standing structures are sealed and insulated and structural debris is treated in an enclosure. Based on the DSA screening process, hot gas decontamination was retained for treatment of both standing structures and structural debris.

Based on pilot-scale tests, hot gas decontamination has been proven effective in removing mustard contamination from structural materials (Battelle 1987). These results indicate that this technology is applicable to treatment of VOCs and SVOCs as well as Army chemical agent.

8.4.1 Process Description

The in situ hot gas decontamination process includes preparing the structure, heating the structure, and treating the off gases collected from the structure. It may also be applied ex situ to structure demolition debris within a suitable containment building. For in situ applications, structure preparation involves sealing and insulating the building (or portions thereof) to be treated. To ensure airtightness of the structure, all cracks are filled with high-temperature caulk or furnace cement, window glass is replaced with metal, and rubber seals are replaced with high-temperature caulk. Wooden structural members must also be removed or protected. The next step is to cover the outside of the structure with 2-inch insulation with an exterior aluminum foil seal. The aluminum both protects the insulation from the weather and helps seal the structure.

During the decontamination process, a burner with a heating capacity of 4 million BTU/hour is located outside of the structure and heats the air inside the structure to approximately 400°C. After the outside surface of the structure has reached and maintained 150°C for more than 1 hour, the treatment is considered complete. The air inside the structure is routed to an off-gas treatment system.

The gases and volatilized compounds that exit the structure can be treated using vapor-phase GAC units or by passing the gases through an afterburner. If carbon adsorption is used, the off gases must be cooled to below 90°C. Off-gas treatment is based on the modular process equipment commercially available for modular incineration units.

Hot gas decontamination is currently being developed at the pilot-scale level. Full-scale implementation of this technology has yet to be achieved. Given the scale of the structures to be treated at RMA, the use of multiple heating modules will be necessary to achieve an effective treatment in a timely manner. Projections of full-scale implementation by Battelle (1987) include the construction of a heating module with a capacity to treat 2,670 SF of structural material during a treatment cycle. The treatment cycle includes sealing the area, heating to operating temperatures, and allowing the structure to cool down. At a minimum, airflow through the structure would be 1,000 ambient cfm.

Dependent upon the selected off-gas treatment system, hot gas decontamination may produce two sidestreams: treated off gas and spent GAC. The spent carbon from the GAC units is disposed in an on-post landfill, and treated off gas is released into the atmosphere via a stack after treatment to meet appropriate regulatory requirements. Figure 8.4-1 presents a diagram of a hot gas decontamination system.

Because RMA is within an air quality nonattainment area, the off-gas treatment system must meet federal and Colorado primary ambient air quality standards of performance for new emissions sources. The action-specific ARARs governing the use of hot gas decontamination and its associated off-gas treatment train can be found in Appendix A. These action-specific ARARs primarily address air emissions and worker protection during operation.

The capital and operating costs for the hot gas decontamination technology are based on the results of a large-scale pilot test conducted at Dugway Proving Grounds on structures containing Army chemical agent (Battelle 1987). The agent of concern in the pilot-scale test was distilled mustard, and the following costs are based on decontaminating structures contaminated with mustard. For the purpose of this economic analysis, it was assumed that one decontamination module with a capacity to treat 2,670 SF of structural material during a treatment cycle is constructed. The off-gas treatment system consists of an afterburner, necessary blowers, and a stack. Use of vapor-phase GAC may result in lower costs. The current capital cost for hot gas decontamination is estimated to be $0.82/SF, with operating and maintenance costs of $12.60/SF of material surface for Significant and Other Contamination History structures and $16.10/SF for Agent History structures (Table 8.4-1).

8.4.2 Process Performance

Hot gas decontamination is only applicable to nonflammable structures contaminated with VOCs and SVOCs. Other treatment technologies would be necessary to reduce nonvolatile inorganic contaminant concentrations or to treat combustible structural materials.

Pretreatment requirements for hot gas treatment of the structure may not be achievable. Thorough sealing of the structure to be treated may be impossible to achieve because of deteriorated structure conditions. Air leakage into the structure during heating results in excessive energy requirements and significantly reduces the efficiency and effectiveness of the technology.

Structures contaminated with agent and agent degradation products must be remediated (AR 385-61 and DA PAM 385-61 [Army 1985, 1992]). Hot gas decontamination at 400°C has not yet been proven in the field as effective enough to release the structure from Army control (i.e., to decontaminate the material to the 5X level).

In pilot-scale testing, the process was effective in reducing mustard contamination from structure materials to below detection levels. These results indicate that the process could potentially be effective for other VOCs and SVOCs. Based on the pilot-scale test at Dugway Proving Grounds, a DRE of 90 to 100 percent was achieved for mustard contamination (Battelle 1987).

This technology was tested on the mustard transfer pit in Building 537 at RMA. The results are presented in a report by Battelle Pacific Northwest Laboratories (Battelle 1995). The test indicated that hot gas is an effective technology for thermal destruction of mustard chemical agent from concrete and metal structural materials. The costs for implementation of the hot gas technology are less than incineration. Currently, hot gas treatment does not meet the Army criteria for SX decontamination.

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Table 8.1-1 Capital and Operating Costs for Enhanced Surface Soil Vapor Extraction Process

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Blanket and Canopy	$670,000	Source: 1
	Power Controllers	117,000	Based on construction on one 50-ft by 50-ft heating module.
	Vapor Treatment System	163,000	
	Transformers	31,500	
	Electrical Lines	27,500	
Total Capital Cost		1,010,000	
Operating Costs	Electrical	$4.90/SY	Source: 1
	Operating Labor	5.27/SY	Based on treating 2,500 CF of soil in a 96-hour operating period or 17,000 SY annually.
	Maintenance	8.90/SY	
	Analytical	4.92/SY	
	Crane Usage	4.92/SY	
Total Operating Cost		$28.92/SY	

Sources:

1) Draft Enhanced Soil Vacuum Extraction Process Pilot Scale Field Demonstration Report (Shell 1991).

Table 8.1-2 ESSVEP Pilot Test Soil Sampling Results

Contaminants Tested	Pre-Test Sampling (ppb)	Post-Test Sampling (ppb)	Removal Efficiency %	Pre-Test Sampling (ppb)	Post-Test Sampling (ppb)	Removal Efficiency %
		Core Region			Edge Region	
0-6" Depth						
Aldrin	1,800	<8	>99.98	1,400	<8	>99.98
Dieldrin	6,100	<16	>99.95	6,300	<16	>99.95
Isodrin	ND	<8	NA	ND	<8	NA
Endrin	1,300	<16	>99.98	1,200	<16	>99.95
Total	9,200	ND	>99.96	8.900	ND	>99.95
		Core Region			Edge Region	
6-12" Depth						
Aldrin	25	<8	>98.80	21	<8	>98.10
Dieldrin	200	<16	>95.65	150	<16	>97.00
Isodrin	ND	<8	NA	ND	<8	NA
Endrin	23	<16	>98.70	ND	<16	NA
Total	248	ND	>96.13	171	ND	>96.61

Table 8.2-1 Capital and Operating Costs for RF Heating

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Electrical Substation	$670,000	Source: 1
	RF Power Source	3,553,006	Based on construction of two modules
	RF Shield	288,000	
	Matching Network	372,000	
	Dummy Load	40,000	
	Vapor Collection System	168,000	
	Engineering	893,000	
	Vapor Treatment System	1,600,000	
	Liquid Sidestream Treatment	150,000	
	Office/Safety Equip./Storage/Decon/Trailer	75,000	
	Gas Monit./Therm. Instru.	150,000	
Total Capital Cost		$7,959,000	
Operating Costs Shallow Zone	AC Power	$24.77/ton	Source: 1
	Labor	18.83/ton	Based on treatment of shallow zone only,
	Block Installation	48.25/ton	assuming 12-percent moisture content, 105-pcf soil
	Vapor Treatment System	20.06/ton	density, and treatment rate of 161 BCY/day.
	Materials	26.79/ton	
	Liquid Sidestream Treatment	2.06/ton	
	Miscellaneous	12.80/ton	
Total Operating Cost		$153.56/ton	

Source:
1) Draft Rocky Mountain Arsenal In Situ Radio Frequency Heating/Vapor Extraction Concept Engineering Report (Weston 1992).

Table 8.2-1 Capital and Operating Costs for RF Heating

Cost Category	Cost Item	Cost Estimate	Description
Operating Costs Shallow Saturated Zone	AC Power	$36.10/ton	Source: 1
	Labor	25.87/ton	Based on treatment of shallow zone only, assuming 20-percent moisture content, 105 pcf-soil density, and treatment rate of 117 BCY/day.
	Block Installation	48.25/ton	
	Vapor Treatment System	20.06/ton	
	Materials	26.79/ton	
	Liquid Sidestream Treatment	2.83/ton	
	Miscellaneous	17.59/ton	
Total Operating Cost		$177.49/ton	
Operating Costs Deep Zone	AC Power	$22.55/ton	Based on treatment of deep zone only, assuming 12-percent moisture content, 105-pcf soil density, and treatment rate of 176 BCY/day.
	Labor	17.18/ton	
	Block Installation	37.51/ton	
	Vapor Treatment System	29.65/ton	
	Materials	19.70/ton	
	Liquid Sidestream Treatment	1.88/ton	
	Miscellaneous	11.68/ton	
Total Operating Cost		$140.15/ton	
Operating Costs Deep Saturated Zone	AC Power	$32.80/ton	Based on treatment of deep zone only, assuming 20-percent moisture content, 105-pcf soil density, and treatment rate of 128 BCY/day.
	Labor	23.59/ton	
	Block Installation	37.51/ton	
	Vapor Treatment System	29.65/ton	
	Materials	19.66/ton	
	Liquid Sidestream Treatment	2.59/ton	
	Miscellaneous	16.04/ton	
Total Operating Cost		$161.84/ton	

Source:
1) Draft Rocky Mountain Arsenal In Situ Radio Frequency Heating/Vapor Extraction Concept Engineering Report (Weston 1992).

Table 8.3-1 Capital and Operating Costs for In Situ Vitrification

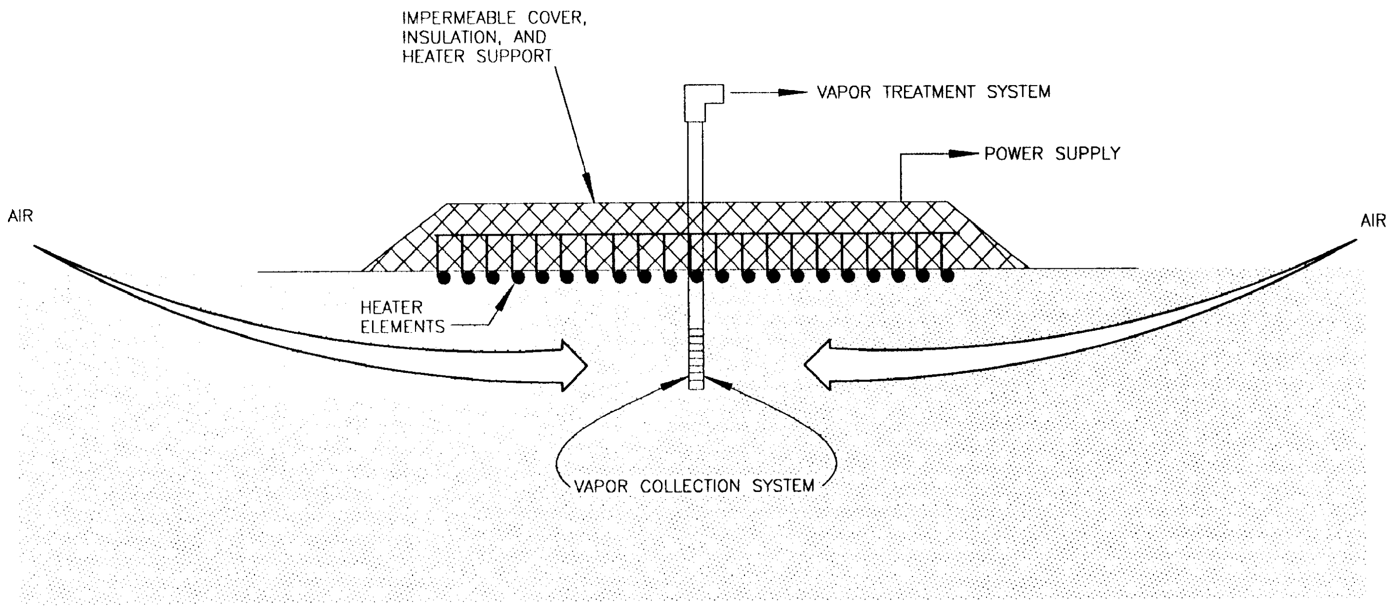
Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Site and Facility Preparation	$56,800	Source: 1
	Permitting and Regulatory Requirements	$247,000	
	Startup and Fixed	$418,000	
	Site Demobilization	$41,400	
Total Capital Cost		$763,000	
Operating Costs	Equipment Rental	$2,560,000	Source: 1
	Labor	$3,800,000	
	Consumables	$1,590,000	
	Utilities	$4,340,000	
	Waste Handling	$667,000	
	Analytical	$481,000	
	Facility Maintenance	$2,250,000	
Total Operating Cost		$15,690,000	

Source:
1) Geosafe In Situ Vitrification Process, Parsons Superfund Site, MI, SITE Applications Analysis Report (EPA 1995).

Table 8.4-1 Capital and Operating Costs for Hot Gas Decontamination

Cost Category	Cost Item	Cost Estimate	Description
		System Cost:	
Capital Costs	Burner Assembly Air Circulation Assembly Mobile Monitoring Station Total	$31,000 88,000 32,000 $151,000	Source: 1 Based on the construction of one heating system capable of treating 2,670 SF, system can be used for 75 repeated operations.
		Unit Cost:	75 repeated operations
		$151,000 $0.82/SF	
Operating Costs	Significant or Other Contamination History Structures Agent History Structures	$12.60/SF 16.10/SF	Source: 1 Based on the construction of one heating system capable of treating 2,670 SF, system can be used for repeated operations.
Total Unit Costs	Significant or Other Contamination History Structures Agent History Structures	$13.42/SF 16.92/SF	

Source:
1) Preliminary Cost Estimates for the Application of the Hot Gas Decontamination System to Field Operations (Battelle 1989).

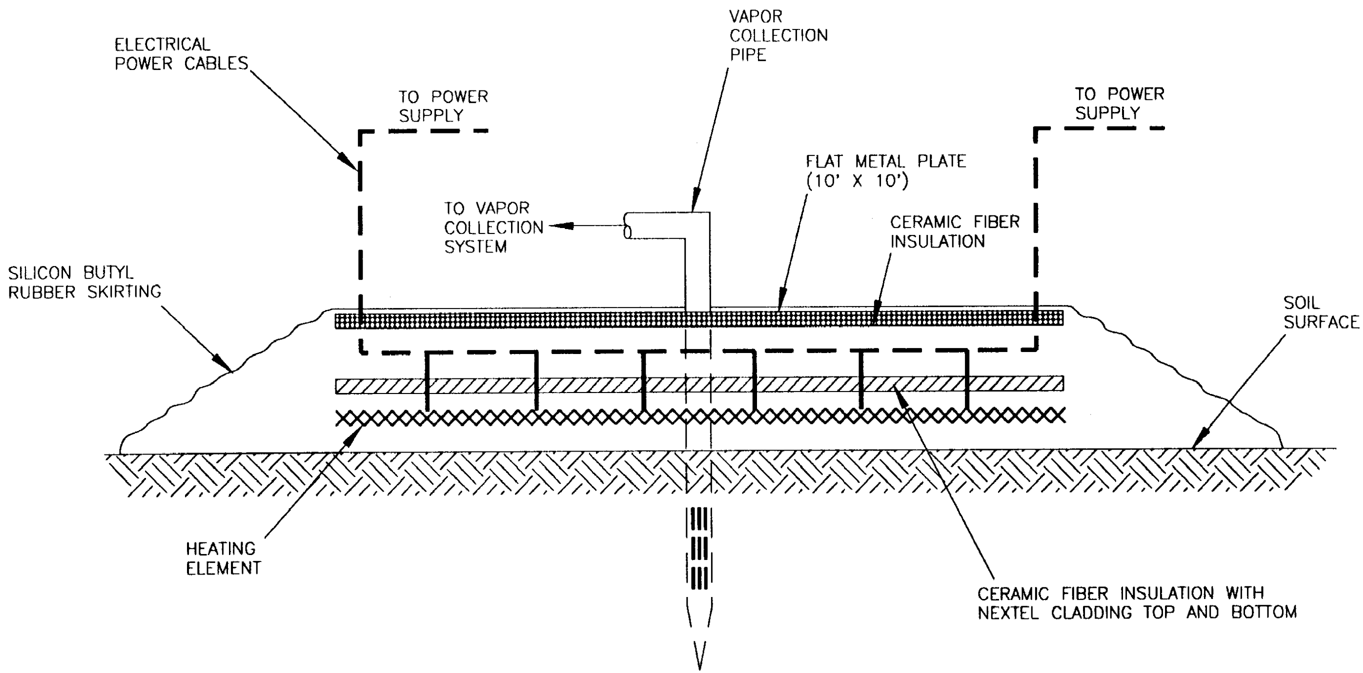


Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.1-1

Schematic of Enhanced Surface Soil Vapor Extraction Process

Prepared by:
Foster Wheeler Environmental Corporation



Prepared for:
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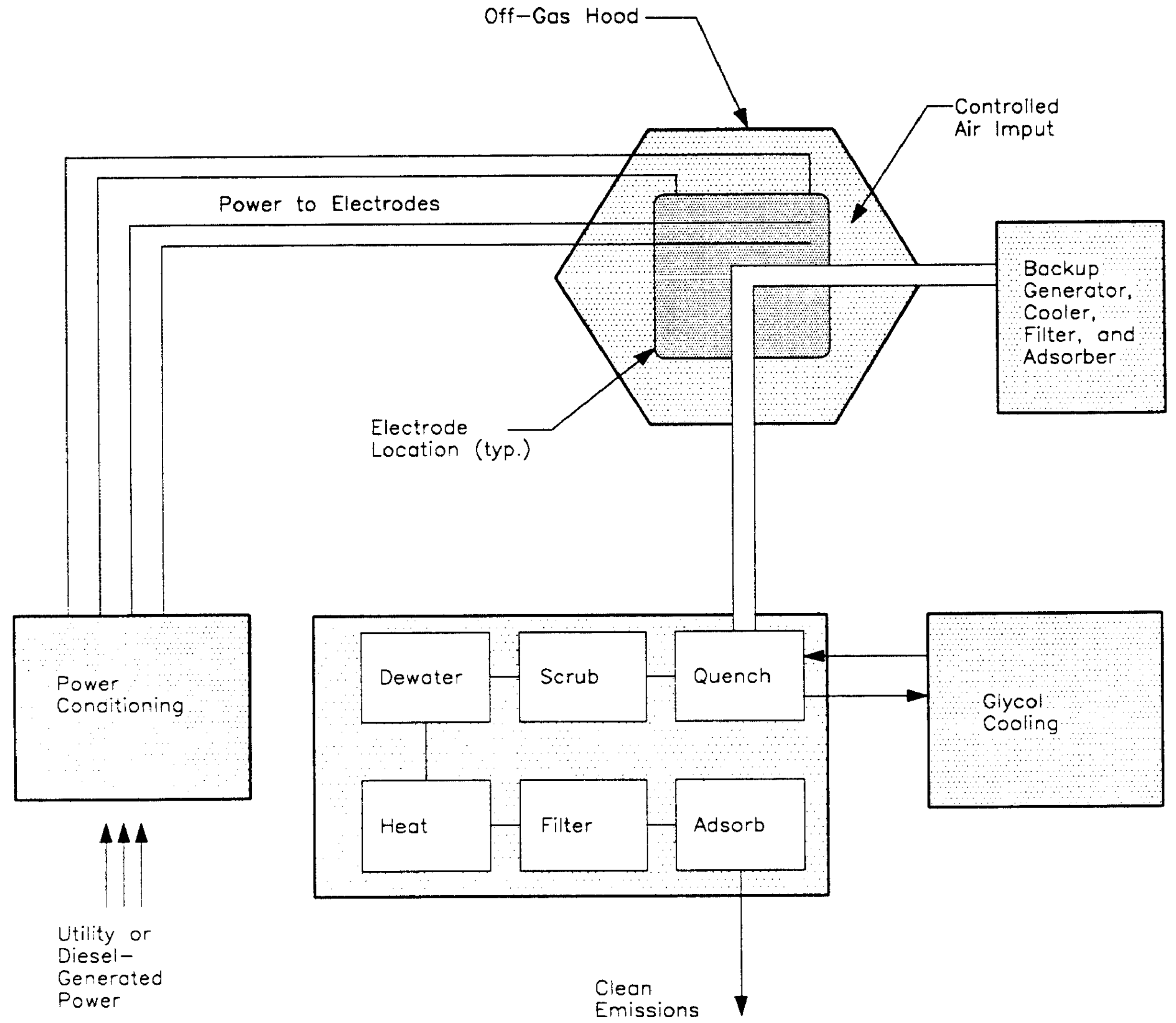
for Rocky Mountain Arsenal

FIGURE 8.1-2

ESSVEP
Soil Heating Assembly Configuration Diagram

Prepared by:
Foster Wheeler Environmental Corporation



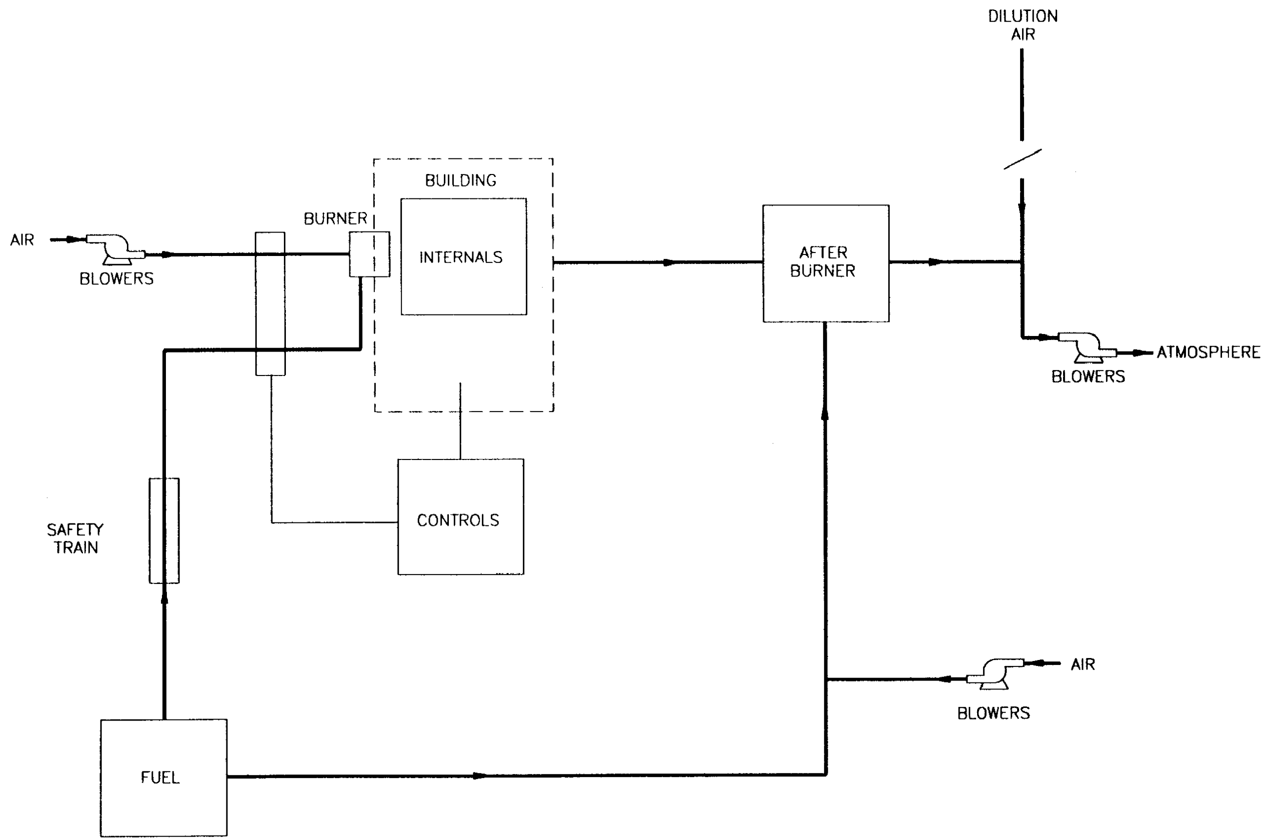
(Geosafe 1987)

Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal

FIGURE 8.3–1

In Situ Vitrification System

Prepared by:
Foster Wheeler Environmental Corporation



Source: Battelle 1989

Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 8.4-1 Hot Gas Decontamination System	Prepared by: Foster Wheeler Environmental Corporation

Section 9

9.0 AGENT/UXO TREATMENT

This section describes several processes for the demilitarization of Army chemical agent (agent) in soil and structures and UXO containing either agent or explosives. Section 9.1 presents the demilitarization of on-post UXO through detonation and incineration, Section 9.2 discusses the off-post demilitarization of UXO at other Army installations, Section 9.3 presents the neutralization of agent in soil or structure debris through caustic washing, Section 9.4 discusses the neutralization of agent through solvent extraction/caustic washing, and Section 9.5 describes the treatment of agent-contaminated soil and structure debris through rotary kiln incineration. All of these processes are governed by DOD regulations, which are referenced in the following sections.

The following methods were evaluated for the treatment of UXO: detonation and incineration using a rotary kiln and off-post demilitarization through detonation and incineration at other Army installations. UXO includes rounds or munitions that have not been detonated. UXO is typically found in test sites, soil beneath firing ranges, and munitions disposal locations, all of which describe sites within the Munitions Testing Medium Group. UXO may also occur sporadically in other medium groups (e.g., Basin A).

Munitions tested and disposed of at RMA primarily include M76 incendiary bombs that were detonated and burned on the ground surface and 4.2-inch mortars. Examples of munitions that were manufactured at RMA include M34 cluster bombs, 105-millimeter (mm) and 155-mm projectiles, and M55 rockets. Other munitions with documented history at RMA include rocket motors, rocket propellants, and miscellaneous explosives. Although only high-explosive (HE) UXO is mentioned in historical descriptions for the Munitions Testing Medium Group, there is a possibility that agent-filled UXO could be encountered during the remediation of areas within the Basin A, Disposal Trenches, and Undifferentiated Medium Groups. For that reason, provisions for dealing with both HE and agent-filled UXO are included in the discussions of on- and off-post detonation/incineration.

The Army originally established RMA to manufacture agents and agent-filled munitions. The Army manufactured Levinstein Mustard and Lewisite (L), which are classified as vesicant or blister agents. Phosgene, although not manufactured, was handled at RMA. The Army also demilitarized bombs containing cyanogen chloride. Isopropylmethylphosphonofluoridate (GB) and white phosphorous were loaded into bombs and ethyl s-dimethyl aminoethyl methylphosphonothiolate nerve agent (VX) was handled at RMA. The processes considered for treating agent-contaminated soil and structure debris are caustic washing, caustic washing/solvent extraction, and incineration using a rotary kiln.

These two processes primarily focus on treating soil from the Agent Storage Medium Group because potential presence of agent is the only exceedance for these sites. However, these processes also apply to portions of the Basin A, Sewer Systems, Disposal Trenches, Lime Basins, South Plants, and Undifferentiated Medium Groups that may contain agent. In addition, this process addresses structure debris from the structures medium groups that may potentially contain agent.

9.1 ON-POST UXO DEMILITARIZATION

On-post demilitarization consists of detonating HE-filled UXO and incinerating/detonating agent-filled UXO. This process addresses any UXO identified in the Munitions Testing Medium Group and in portions of several other soil medium groups with the potential presence of UXO.

Agent UXO includes all military lethal or incapacitating chemical agents. They can be in the form of solid, liquid, or contained gases. Agent materials must be decontaminated to the 5X level if the material is to be released from government control without precautions or restrictions in accordance with AR 385-61 and DA PAM 385-61 (Army 1985, 1992). UXO containing agent materials at RMA will be decontaminated to this level. To achieve this level, UXO containing agent must be subjected to temperatures above 540°C for at least 15 minutes. Longer times may be required if the material is unable to be disassembled.

UXO containing chemical agent material as defined in AR 50-6 (Army 1995) may be placed in one of two categories: those that pose an immediate hazard, cannot be transported, and require emergency disposal action; and those that do not pose immediate hazard and can be transported to the closest facility for demilitarization. If UXO requires emergency disposal action, options are limited to the application of the explosive ordnance disposal (EOD) render-safe procedures (detonation) by trained EOD personnel (AR 385-61, DA PAM 385-61, and AR 75-15 [Army 1985, 1992, 1978]).

9.1.1 Process Description

Following clearance procedures and UXO removal, the agent will be removed by the drill, drain, and detoxification procedures per AR 385-61 and DA PAM 385-61 (Army 1985, 1992). The burster and fuse will be removed and destroyed by demolition methods. The empty casing and fragments will be processed through a rotary kiln incinerator at 1,000°F for 15 minutes. The brine from the agent neutralization will be stopped and later injected into the secondary chamber of the rotary kiln using a liquid nozzle. The rotary kiln operates at a temperature above the 1,000°F minimum (AR 385-61 and DA PAM 385-61 [Army 1985, 1992]) required for 5X decontamination. Because appropriate air pollution control equipment (baghouse and scrubbers) is used during the incineration process. decontamination of the UXO casing with a caustic solution is not necessary prior to incineration. A complete description of the rotary kiln incineration process, including the off-gas system, is contained in Section 7.2.

Operation of the rotary kiln system for UXO demilitarization results in several residual streams:

- Debris from explosive components detonation
- Debris/slag from incineration
- Ash from agent incineration treatment
- Dust from the particulate control system
- Process and scrubber waste water

- Clean off gas

The debris from the detonation of the agent-filled UXO explosive components that have been treated to the 5X level of decontamination can be collected from the detonation site using conventional equipment and then salvaged. The metal debris/slag from the incineration process is considered clean and is released from government control without precautions or restrictions. Therefore, the metal debris/slag can be sold as salvage or be disposed at a nonhazardous waste landfill. The incinerator ash is analyzed for organic compounds and inorganics according to TCLP requirements prior to on-post disposal. If the ash does not pass TCLP requirements, it is disposed in a hazardous waste cell (Section 6.5). Dust collected from the particulate control systems is analyzed for carryover contamination (i.e., metals) and is sampled prior to on-post disposal (Section 6.5). Off gas is caustic and is scrubbed to neutralize the acid gases. The resulting brine is concentrated by evaporation and the recovered water is returned to the process. The salt cake from the concentration step is analyzed and placed in the on-post landfill. Treated off gas is monitored and released into the atmosphere.

UXO can also be of the HE type, which does not contain agent. Treatment for HE-filled UXO consists of open-air detonation. The area selected for detonation should be well-packed earth with no vegetative growth, rocks, or cracks to reduce fire hazards and lodging of the UXO in the ground. The site should be located in relation to the prevailing winds to prevent movement of any sparks generated toward explosives storage areas. Detonation should occur at the maximum practicable distance from all magazines, inhabited buildings, public traffic routes, and operating buildings. The distance should not be less than 2,400 ft unless pits or similar aids are used to limit the range of fragments and debris. When trials prove that fragments and debris are limited to lesser ranges, the appropriate inhabited building distances may be used (AMC-R 385-100 [AMC 1985]). Site ESA-4b is a bermed site that has been used for detonation and that could be used again for on-site detonation of HE-filled UXO (ESE 1988).

The quantities used to cost the UXO remedial activities were incorporated based on two assumptions: that UXO is found in 0.1 percent of the total soil area in which UXO might occur and that, assuming a 2-foot depth, there is one UXO per CY of this remaining volume (therefore 1 CY equals 1 UXO). The first step in addressing the UXO on site is to perform a clearance of the area using the two-stage geophysical survey of a metal detector sweep and a combined magnetometer and electromagnetic (EM) survey to identify their location at a cost of $0.66/SY.

The unit cost for detonation of the agent-filled UXO explosive components and incineration of the agent and agent-contaminated debris is estimated to be $225.00/BCY. One of the most complex processes associated with agent-filled UXO is handling and packaging the UXO for transportation; this was assumed to be directed by the Army's Technical Escort at a cost of $1,022.00/BCY for on-post handling of the UXO. This handling includes the removal of the explosive devices from the agent-filled UXO and the packaging and transportation of the agent-filled and explosive parts of the UXO. Table 9.1-1 presents a breakdown of the unit costs for on-post demilitarization of agent-filled UXOs. After all the UXO has been removed (both HE and agent), a 1-ft layer of soil is excavated from the ground surface at a cost of $7.14/CY. The purpose of this step is to remove the excess UXO debris remaining on the surface. The unit cost for detonation of the UXO is estimated to be $76.00/CY, which includes the collection, transportation, and detonation of the HE-filled UXO on post. It is anticipated that work would be directed by the Army's EOD personnel. Table 9.1-2 presents a breakdown of the unit costs for on-post detonation of HE-filled UXOs.

Appendix A lists action-specific ARARs related to UXO and Army agent.

9.1.2 Process Performance

The results from Supplement B 70, Project Eagle—Phase II Demilitarization and Disposal of the M34 GB Cluster at Rocky Mountain Arsenal, Final Plan (ADCM 1974) indicated that the incinerator stack emission concentrations of GB were less than 0.00003 milligrams per cubic centimeter (mg/cm^3) for all trials. The agent-filled UXO was first stripped of external hardware, drained of all agent, placed in decontaminating solution, and then thermally decontaminated in a decontaminating furnace. The UXO was then incinerated at 1,000°F for 15 minutes to achieve a 5X level of decontamination (AR 385-61 and DA PAM 385-61 [Army 1985, 1992]). Prior to incineration, the ton containers (a ton container is a heavy-duty welded-steel vessel containing an average of 1,500 pounds of GB) were washed with a caustic solution (18 percent sodium hydroxide [NaOH]) to neutralize the agent residue. However, two of the incineration trials used ton containers that had not been chemically decontaminated before being placed in the incinerator. There was no significant difference in the results from the trials using chemically decontaminated containers versus the containers that had not been nonchemically decontaminated. This indicates that caustic washing of the ton containers prior to incineration does not affect results.

9.2 OFF-POST DEMILITARIZATION OF UXO

Off-post demilitarization of UXO involves transportation of the UXO to the appropriate Army facility for demilitarization. This process, applicable to any UXO identified in the Munitions Testing Medium Group and for portions of other soil medium groups with the potential presence of UXO, involves shipping agent-filled UXO that is safe or rendered safe to an Army facility specially designed for UXO demilitarization. HE bombs are transported to an Army-approved facility such as Fort Carson Army Base in Colorado Springs, Colorado, where they are demilitarized.

The Army's current chemical weapons disposal program involves total containment, robotics, and machine disassembly of the chemical weapons as appropriate for each specific munitions. The various waste materials from disassembly are incinerated separately. There is an incinerator for the liquid chemical agent and process liquid waste; a rotary kiln furnace for the destruction of explosives and propellants, with an accompanying heated discharge conveyor to remove leftover materials; a metal parts furnace to decontaminate by incineration the empty bulk containers, shells, and bombs; and an incinerator for the combustion of waste packaging consisting of wooden pallets and crates that may be contaminated with agent (OTA 1992). Transportation requirements are outlined in AR 385-61 and DA PAM 385-61 (Army 1985, 1992) for agent-filled

UXO. UXO incineration at the specially designed off-post facility is completed to render the UXO nonhazardous. All residual streams from the incineration process are controlled and managed by the off-post facility.

9.2.1 Process Description

Agent-filled UXO that is safe or rendered safe for transport is prepared for shipment by military aircraft to the appropriate Army facility. As specified in AR 50-6 (Army 1995), military aircraft is the preferred mode for moving chemical surety material. Other modes of shipment are authorized only when they are determined to be safer, more economical, or more practical than military aircraft. HE-filled bombs safe for transport are prepared for shipment by truck, rail, or aircraft to the appropriate Army facility.

The movement of agent-filled UXO will be accomplished by using United States miliary-owned and military-operated aircraft or leased aircraft. Technical Escort personnel will accompany all military off-site movements of agent-filled UXO except as indicated for emergencies in AR 75-15 (Army 1978). Personnel will be Chemical Personnel Reliability Program (CPRP) certified and armed (AR 50-6). Category V quantities of chemical surety material will be accompanied by at least two DOD personnel knowledgeable in safety, security, custody, and accountability procedures. Costs for agent-filled UXO examinations are estimated to be $71.16/BCY and agent-filled UXO transportation is $2,222.00/BCY to an approved off-site Army facility such as Tooele Army Depot. Table 9.2-1 presents a breakdown of the costs for off-post agent-filled UXO demilitarization.

Off-post movement of HE-filled UXOs will be accomplished using United States military-owned and military-operated vehicles or leased vehicles. Trained EOD personnel will accompany all military off-site movements of HE-filled UXOs. All motor vehicle shipments of explosive materials on public highways are governed by DOT regulations and any additional state and municipal regulations. Costs for HE-filled UXO examination are estimated to be $71.16/BCY and HE-filled UXO transportation is $59.50/BCY (this cost includes collection, transportation, and detonation of the HE-filled UXO). Table 9.2-2 presents a breakdown of the costs for off-post HE-filled UXO demilitarization.

ARARs governing off-post transportation are contained in Appendix A and discussed in Section 4.0.

All agent-filled UXO shipments must be escorted in accordance with AR 50-6 and AR 740-32 (Army 1995, 1975). Shipping routes are selected to avoid congested areas and peak traffic periods. Periodic inspection of each shipment to ensure no leakage is occurring should be performed.

9.2.2 Process Performance

Off-post incineration reduces the TMV of UXO. All the UXO evaluated as safe for transport is sent off post for demilitarization and destruction. The amount of agent-filled UXO present is expected to be small; it was assumed that only 0.1 percent of the total soil volume of sites with the potential for UXO presence actually contains UXO and that there is only one UXO per BCY of this volume. Therefore, releases to the environment resulting from detonation of agent-filled UXO that are unsafe for transport are limited because the overall amount of agent-filled UXO present is small.

9.3 CAUSTIC WASHING OF AGENT-CONTAMINATED SOIL OR STRUCTURE DEBRIS

Caustic washing is a physical/chemical treatment process in which agent-contaminated soil or structure debris are excavated, mixed with caustic wash fluids in an aboveground unit to degrade agent, and then separated from the fluids. The process is carried out at ambient temperature and atmospheric pressure. The makeup of the treatment solution is based upon suspected contaminants and suspected contaminant concentrations; however, detailed laboratory and pilot-scale testing would be necessary before implementation of this alternative, as this technology has not been well demonstrated and is largely theoretical.

This process is based upon the suspected presence of GB, VX, L, and mustard. Although there are chemical treatment alternatives that more effectively treat each individual contaminant, this process has been designed to treat all aforementioned compounds and generate by-products of greatly reduced toxicity. This process could be easily refined at a later date (by alteration of the treatment solution) if analyses are performed that more accurately determine contaminants and their concentrations.

9.3.1 Process Description

The caustic washing of agent-contaminated soil or structure debris consists of contacting a caustic solution with the contaminated materials to neutralize the agent through hydrolysis. An aqueous solution of 7.5 percent NaOH and 2.5 percent hydrogen peroxide (H_2O_2) is used to neutralize the contaminants. The peroxide component is included to address the possible presence of VX. VX reacts with aqueous NaOH, but the resulting product (A1) is very toxic. Addition of H_2O_2 has been found to prevent the formation of A1. Soil is handled differently than structure debris; however, the basic approach is similar.

The soil is placed in a pugmill and mixed with the caustic solution at a ratio of 7.48 gallons of solution per cubic foot of soil. Use of the pugmill ensures contact of the caustic solution with any agent present inside the pore spaces of the soil. The pugmill will produce a slurry that will be routed to a settling tank. Structure debris will be flooded with caustic solution inside the 22-BCY rolloff box in which they are transported. After a 2-hour contact period, the liquid is drained to a settling tank. From the settling tank, the liquid portion will be decanted and recycled; the remaining sludge is removed and sent to a dewatering system. The aqueous feed to the soil pugmill will require approximately 3 gallons per minute (gpm) of fresh solution to maintain NaOH/H_2O_2 concentrations and to account for solution lost due to soil retention. Similar makeup ratios exist for structure debris treatment. The dewatering system consists of a sludge/polymer reaction, followed by a dewatering press. Because of the addition of a polymer in this step, any liquid byproducts will not be recycled back to the process for further reaction. Liquid generated from this process will be neutralized with a 50 percent sulfuric acid (H_2SO_4)

solution and evaporated to reduce disposal costs. Evaporation will be carried out with an evaporator/crystallizer. The evaporation will produce a solid sodium sulfate residue that must be landfilled. Soil exiting the press should not require any further treatment and can be landfilled. The feeder, pugmill, and the rolloff boxes will be equipped with hoods to reduce the possibility of any fugitive emissions. The hoods will be connected to a blower, with the blower exhaust passing through an activated carbon filter that will remove organics.

To identify agent contamination in soil, areas of interest are screened in the field during excavation activities and then further verified by analysis at the RMA laboratory. The cost for this screening is $0.30/BCY. The estimated capital cost for caustic washing of soil is $149.57/BCY and includes the purchase of all process equipment, electrical equipment, and an enclosed structure to house the operation. Operating costs are estimated to be $123.93/BCY for the duration of treatment. Table 9.3-1 presents a breakdown of the total capital and operating unit costs for caustic washing of agent-contaminated soil.

To detect agent contamination in structure debris, the material is monitored in rolloff boxes at a capital cost of $4.80/BCY and an operations cost of $58.44/BCY. It is assumed that 5 percent of the structure debris fail the monitoring and will require treatment at a capital cost of $121.54/CY and an operations cost of $323.48/CY. The treated debris will again be monitored to confirm that treatment was effective. Operating costs are based on 2-year operation and Level B PPE. Table 9.3-2 presents a breakdown of the capital and operating unit costs for agent caustic washing of structure debris.

The ARARs governing the performance of caustic washing are the same as those for solvent extraction, which is presented in Section 12.2. Appendix A lists these ARARs, which primarily address worker protection, air emissions during treatment, and discharge requirements for the treated solutions.

9.3.2 Process Performance

Before implementation of this technology, further testing is required to determine the effectiveness of the equipment and solutions used on agent-contaminated soil specific to the RMA. A description of a previous study's performance results is discussed below (ADCM 1974).

Project Eagle-Phase II has successfully neutralized agent using an 18 percent NaOH solution. In Project Eagle, it was shown that GB, at a temperature of 30°C and in a neutral environment (pH of 7), has a half-life of 146 hours. However, at a pH of 9, the half-life decreases to 0.4 hours. After conducting the caustic washing test the Army found that there were problems with the process: the caustics that were used to neutralize the chemical agent had to be handled safely in bulk quantities, the agent itself had to be properly handled and stored until it was neutralized, and the rate of neutralization of the chemical agent was much slower than predicted (which could be due to incomplete mixing of the organic material and the aqueous NaOH).

For the test conducted at RMA, with the use of an excess of caustic, 2.6 pounds of salt were formed to neutralize 1 pound of agent. Re-formation of GB during the spray drying of the brine solution, noted during the test, could be avoided by adjusting the pH and brine flow rate and by reducing the operating temperature of the drying process. Some difficulties were also encountered in confirming that the brine was free from agent. At RMA, the neutralization brine was considered free from agent if a 5 percent excess NaOH level was achieved. However, agent emissions during the brine spraying at RMA often exceeded the action level (0.0003 milligrams per cubic meter [mg/m^3]) and, occasionally, the shutdown level (0.003 mg/m^3) promulgated by the U.S. Department of Health and Human Services (DHHS) and the Army's Surgeon General (Project Eagle).

9.4 CAUSTIC WASHING/SOLVENT EXTRACTION OF AGENT-CONTAMINATED SOIL

Caustic 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 agent, and then separated from the wash water. The process is applicable to agent-contaminated soil sites in the soil medium groups, in particular the Agent Storage Medium Group. The process is similar to the solvent extraction process described in Section 12.2. For the agent-contaminated materials the pH is raised to 12 rather than 11 (as described for the solvent extraction). This process is preferable to simple caustic washing in that it removes organic contaminants as well as destroys Army chemical agent. The soil or structure debris is treated to a 3X decontamination level, which requires that the materials have been surface decontaminated and tested (AR 385-61 and DA PAM 385-61 [Army 1985, 1992]). As required by the Army regulation, they would have to be placed in the on-post landfill (Section 6.5).

9.4.1 Process Description

The solvent extraction process is discussed in Section 12.2. The issues of caustic destruction of Army chemical agent are discussed below. The basic principle behind caustic destruction of agent-contaminated materials is that the caustic solution neutralizes agent that is present. Neutralization may not necessarily destroy all agent present in the materials; therefore, the process is classified as a 3X decontamination level of treatment. Caustic washing is accomplished using alkaline hydrolysis, which is the reaction of water with a chemical, with the use of a base catalyst to produce compounds of greatly reduced toxicity. Alkaline hydrolysis could be a means of chemically neutralizing GB, VX, L, and mustard. GB has been successfully neutralized using a NaOH solution in a large-scale application, and both VX and mustard neutralization have been demonstrated in a small-scale application.

The process will consist of screening and crushing the feed materials to a size of less than 1/2 inch as discussed in Section 4.4. The soil size reduction steps for agent-contaminated soil are conducted under an exhaust hood so that agent releases are controlled. Exhaust air is treated with a caustic scrubber to remove agent and particulates, and the scrubber blowdown is fed forward to the slurry mixing tank. At the end of each operating day, the size reduction equipment is washed down with caustic solution to remove any agent contamination. The feed will be placed in the washer/dryer vessel and triethylamine (TEA) solvent and NaOH solution will be added to produce a slurry with a pH of 12. Subsequent extraction steps will proceed as described in

Section 12.2. If necessary, additional NaOH will be added during the subsequent extractions to keep the pH at 12.

Following extraction and pH readjustment to lower the pH, the soil will be placed in a solid waste landfill cell (Section 6.5). Soil containing elevated levels of inorganic constituents require solidification prior to disposal. Any solidification activities are to be performed in accordance with the direct cement-based solidification process described in Section 10.1.

The ARARs governing the performance of solvent extraction/caustic washing are the same as those for solvent extraction which is discussed in Section 12.2. Appendix A lists these ARARs, which primarily address worker protection, air emissions during treatment, and discharge requirements for the treated solutions.

The capital cost for caustic washing/solvent extraction of soil is similar to solvent extraction (Section 12.2). Costs are somewhat higher due to an assumed smaller volume of soil, greater PPE requirements, and increased equipment wear due to the higher pH. The estimated capital cost is $35.50/BCY. The operating cost is $214.54/BCY. Table 9.4-1 presents a breakdown of the capital and operating unit costs for agent caustic washing/solvent extraction.

9.4.2 Process Performance

Process performance in the presence of a solvent such as TEA has not been demonstrated. However, the high pH, substantial agitation, and efficient separation from the aqueous phase would suggest that the process would be effective. In addition, caustic has been used in the treatment of agent, as discussed in Section 9.3.2. Additionally, the Basic Extraction Sludge Treatment (BEST) process is isolated from the atmosphere due to the flammable nature of TEA. This would minimize atmospheric emissions, but does present a safety issue if the TEA did catch on fire prior to destruction of the agent. Treatability studies would need to be performed to confirm the effectiveness of the process.

9.5 INCINERATION OF AGENT-CONTAMINATED SOIL AND STRUCTURE DEBRIS

Rotary kiln incineration is commonly used for hazardous waste incineration, and incineration using specifically designed incinerators is the preferred method of disposal for agent-contaminated wastes (OTA 1992). The process is applicable to agent-contaminated soil from the Agent Storage Medium Group and from portions of other soil medium groups with the potential presence of agent, as well as to agent-contaminated structure debris. Rotary kiln incinerators are capable of attaining 5X decontamination levels, the required level for remediated agent materials to be released from Army control (AMC 385-131 1987). Rotary kiln incineration involves two-stage combustion of waste materials, with primary combustion occurring in the rotary kiln followed by secondary combustion of off gas in an afterburner.

9.5.1 Process Description

Rotary kiln incineration begins with pretreatment of wastes to increase the destruction efficiency of the kiln and to preserve the working life of the kiln. Pretreatment includes size reduction of soil/waste and neutralization of corrosive soil/wastes as discussed in Section 7.2. The soil/waste materials, following pretreatment, are fed into the inclined rotary kiln incinerator. Waste materials flow through the kiln as a consequence of the rotation and the angle of inclination of the kiln. Rotation of the kiln enhances mixing of the soil/waste with combustion air and provides continuously renewed contact between waste material and the hot walls of the kiln. The flow rate (residence time) of the waste in the kiln is regulated by the feed rate, angle of kiln inclination, kiln rotation (revolutions per hour), internal baffles, and kiln size. As incineration of the waste progresses, the ash flows to the bottom of the kiln and is conveyed to the ash recovery unit. Gaseous combustion by-products are exhausted to the afterburner for secondary combustion. The products from the afterburner are then passed through heat recovery and air pollution control systems. Refer to Section 7.2 for a detailed description of the rotary kiln incineration process and associated air treatment technologies.

The rotary kiln system oxidizes or volatilizes all the organic waste constituents in the soil matrix for subsequent oxidation in the afterburner. To achieve a 5X level of decontamination, the rotary kiln is operated at a temperature of at least 1,000°F with a residence time of 15 minutes to ensure complete volatilization of all agent constituents (AR 385-61 and DA PAM 385-61 [Army 1985, 1992]). The ash recovery system cools the ash in a fluidized-bed cooler; it can then be analyzed for organics and inorganics to determine the appropriate disposal methods (see Section 6.5).

Off gas from the rotary kiln is fed to the afterburner for destruction of the volatilized organics. The afterburner operates at temperatures up to 2,250°F and must be able to withstand the high corrosivity of acid gases and iron compounds (EBASCO 1988). Excess air is added to the afterburner to ensure destruction of 99.99 percent of the remaining organics present. Section 7.2 describes the off-gas control system for a rotary kiln incinerator.

Flue gas from the afterburner, which includes particulate materials and acid gases, is further processed by air pollution control equipment as discussed in Section 7.2. The incinerator by-products are handled as described in Section 7.2. The costs for rotary kiln incineration of agent-contaminated soil is presented in Table 9.5-1, and agent-contaminated structure debris is presented in Table 9.5-2.

9.5.2 <u>Process Performance</u>

The most significant screening criterion for a thermal treatment process is the operating temperature. The waste/soil being treated must be subjected to a temperature of 1,000°F for 15 minutes to achieve a 5X level of decontamination (AR 385-61 and DA PAM 385-61 [Army 1985, 1992]). Rotary kiln incineration is, therefore, an effective treatment process because temperatures above the 1,000°F range are typically achieved in the primary chamber. Moreover, because of pretreatment (e.g., size reduction and neutralization), the kiln can effectively treat a wide variety of soil with variable particle size, clay and salt content, and moisture content. Because of the abrasive nature of the waste, incineration of structure debris will require increased maintenance of the kiln. Depending on the required feed rate, a design capacity can be selected to treat the contaminated soil/waste within an appropriate time frame.

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1992 (August) Concept Engineering Study Report for Thermal Desorption Systems for Rocky Mountain Arsenal Soil. RTIC 92346R01.

Table 9.1-1 Capital and Operating Costs for Agent-Filled UXO Incineration/Pyrolysis, On Post

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	UXO Clearance	$0.66/SY	Source: 1 Based upon a complete surface sweep for UXO by geophysical survey.
	UXO Incineration	$76.00/BCY	This is the capital cost to construct the on-post rotary kiln incinerator as presented in Table 7.2-1.
Operating Costs	UXO Removal	$71.16/BCY	Source: 1 Based upon the special precautions to remove the UXO from the soil.
	UXO Transportation	$1,022.00/BCY	Source: 2 Based upon the costs for the Army's Technical Escort to handle, package, transport the UXO with appropriate safeguards to the on-post rotary kiln incinerator.
	UXO Detonation	$225.00/BCY	Source: 3 Based upon the cost to detonate the fuses prior to incinerating the UXO and agent plus the cost to incinerate the defused UXO and agent at the on-post rotary kiln incinerator.

Sources:

1) Decontamination Assessment for Land and Facilities at RMA Draft Final Report (USATHAMA 1984)
2) Phone conversations with Army's Technical Escort
3) Source 1 above and information in Section 7.2 and costing data on Table 7.2-1

Table 9.1-2 Capital and Operating Costs for HE-Filled UXO Demilitarization, On Post

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	UXO Clearance	$ 0.66/SY	Source: 1 Based upon a complete sweep for UXO by geographical survey.
Operating Costs	UXO Removal	$71.16/BCY	Sources: 1 and 2 Based upon the special precautions to remove the UXO from the soil.
	UXO Transportation and Detonation	$76.00/BCY	Sources: 3 and 4 Based on the costs for the Army's EOD to handle, package, transport the UXO with the appropriate safeguards to the on-post detonation site, then perform the UXO detonations with appropriate safeguards.

Sources:

1) Decontamination Assessment for Land and Facilities at RMA Draft Final Report (USATHAMA 1984)
2) MEANS 1993; cost for test pits plus cost factor for personal protective equipment
3) Phone conversations with Army's Technical Escort
4) Phone conversations with Fort Carson EOD

Table 9.2-1 Capital and Operating Costs for Agent-Filled UXO Demilitarization, Off Post

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	UXO Clearance	$0.66/SY	Source: 1 Based upon a complete surface sweep for UXO by geophysical survey.
Operating Costs	UXO Removal	$71.16/BCY	Source: 1 Based upon the special precautions to remove the UXO from the soil.
	UXO Transportation	$2,222.00/BCY	Source: 2 Based upon the costs for the Army's Technical Escort to handle, package, transport the UXO with appropriate safeguards to the off-post Army facility (Tooele Army Depot).

Sources:

1) Decontamination Assessment for Land and Facilities at RMA Draft Final Report (USATHAMA 1984)
2) MEANS 1993; cost for test pits plus cost factor for personal protective equipment
3) Phone conversations with Army's Technical Escort
4) Phone conversations with Fort Carson EOD

Table 9.2-2 Capital and Operating Cost Off Post for HE-Filled UXO Demilitarization, Off Post

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	UXO Clearance	$ 0.66/SY	Source: 1 Based upon a complete sweep for UXO by geophysical survey.
Operating Costs	UXO Removal	$71.16/BCY	Sources: 1 and 2 Based upon the special precautions to remove the UXO from the soil.
	UXO Transportation	$59.50/BCY	Sources: 3 and 4 Based on the costs for the Army's EOD to handle, package, transport the UXO with the appropriate safeguards to the off-post detonation site, then perform the UXO detonation with appropriate safeguards.

Sources:
1) Decontamination Assessment for Land and Facilities at RMA Draft Final Report (USATHAMA 1984)
2) MEANS 1993; cost for test pits plus cost factor for personal protective equipment
3) Phone conversations with Army's Technical Escort
4) Phone conversations with Fort Carson EOD

Table 9.3-1 Capital and Operating Costs for Agent Caustic Solution Washing for Soils

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Equipment	$136.58/BCY	Source: 1 Vendor quotes for mixing tanks, materials handling, pumps, dewatering equipment, evaporator, tanks, mixers, electrical systems, piping, and instruments
	40" x 40" Building	$12.76/BCY	Source: 1 Installed price, including concrete foundation.
	Landfill of Salts	$0.23/BCY	Source: 2
Total Capital Unit Cost		$149.57/BCY	
Operating Costs	Labor	$22.79/BCY	Based upon a 10-hour-per-day operation for 150 days.
	PPE	$22.56/BCY	Based upon Level B PPE, loss in productivity is reflected in the staffing of the operation.
	Chemicals	$76.27/BCY	Source: 1
	Waste Disposal	$0.20/BCY	Price reflects disposal of solids generated by the evaporator only.
	Utilities	$2.12/BCY	Based upon electrical and natural gas requirements, cost of water is included as a chemical cost.
Total Operating Unit Cost		$123.93/BCY	

Sources:
1) Vendor quote.
2) See Section 6.5.

Table 9.3-2 Capital and Operating Costs for Agent Caustic Solution Washing of Structure Debris

Cost Category	Cost Item	Cost Estimate		Description
Capital Costs	Agent Monitoring	$ 4.80/CY	Source: 1	Based on 2-year operation and level B PPE. Caustic treatment is assumed to be applied to 5% of the Agent Structure debris
	Caustic Treatment	$121.54/CY	Source: 1	
Operating Costs	Agent Monitoring	$58.44/CY	Source: 1	
	Caustic Treatment	$323.48/CY	Source: 1	

Source:
1) Vendor quotes

Table 9.4-1 Capital and Operating Costs for Agent Caustic Washing/Solvent Extraction

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Solvent Extraction	$35.50/BCY	See Table 12.2-1
	Total Unit Capital Cost	$35.50/BCY	
Operating Costs	Solvent Extraction Base	$148.68/BCY	See Table 12.2-1
	Adjustments		Increase of 20% from Table 12.2-1 costs
	- Labor	$29.73/BCY	Increase due to increased labor
	- PPE	$0.45/BCY	Increase of 30% from Table 12.2-1 costs, due to
	- Equipment Wear	$35.68/BCY	high pH
Total Unit Operating Cost		$214.54/BCY	

Table 9.5-1 Capital and Operating Costs for the Incineration of Agent-Contaminated Soils

Cost Category	Cost Item	Cost Estimate	Description
Total Facility Cost		$44,000,000	Based on rate of 56 tons/hour
Operating Costs	Operations & Maintenance Labor	$11,200,000	Source: 1 and 2
	Maintenance Materials	2,560,000	Adjusted for EBASCO Task 17 operating conditions
	Analytical	1,160,000	but without the use of 40% supplemental oxygen in the
	Utilities	50,000,000	rotary kiln incinerator and the SCC. Weston figures
	Chemicals	1,690,000	divided by 2 for single-train facilities.
	Consumables	2,500,000	
Total Operating Cost		$69,100,000	Annual Operating Cost

Sources:

1) Weston, Roy F., Concept Engineering Study Report for Thermal Desorption Systems for Rocky Mountain Arsenal Soils, August 1992 (Weston 1992).
2) EBASCO, Full-Scale Incineration System Conceptual Design for Basin F Wastes, Task 17, September 1988, RIC#88286R02 (EBASCO 1988).

Table 9.5-2 Capital and Operating Costs for the Incineration of Agent-Contaminated Structure Debris

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	On-Post Rotary Kiln Incinerator	$ 76.00/CY	Source: 1
Operating Cost	On-Post Rotary Kiln Incinerator	$172.50/CY	Source: 1

Source:
1) Vendor quotes

Section 10

10.0 SOLIDIFICATION/STABILIZATION

This section describes both direct and in situ solidification/stabilization processes using generic binders. The terms solidification and stabilization, generally used together because the process additives employed usually perform both functions, are also sometimes referred to as immobilization, fixation, or encapsulation. In the narrow sense, solidification changes the physical properties of the soil or waste matrix, e.g., eliminating free liquids. Stabilization changes the physical or chemical properties of the contaminants, e.g., converting metal salts to their insoluble hydroxide forms. For simplicity in the following discussion, the term solidification/stabilization is referred to as solidification.

While solidification has historically addressed inorganic contamination, the technology can be applied to media contaminated with both organic and inorganic constituents. In general, the proprietary binders and additives are aimed at incorporating organic contaminants into the soil/binder matrix or at least preventing the organic compounds from interfering with the solidification reactions. For RMA, however, direct and in situ solidification processes are evaluated for the treatment of soil, sludge, and semisolid by-product sidestreams contaminated primarily with inorganic constituents.

This section is organized as follows. Section 10.1 describes direct cement-based solidification and Section 10.2 describes in situ cement-based solidification.

10.1 DIRECT CEMENT-BASED SOLIDIFICATION

The most widely used solidification agent for hazardous wastes is Portland cement. It is widely available as a uniform product in several types, including two with moderate to high sulfate resistance. Portland cement may be used alone as the binding agent or formulated with fly ash, lime, soluble silicates, clay, or other materials to enhance processing or improve the properties of the final product. It is available in bag or bulk quantities and has a successful performance record for use in the solidification of radioactive wastes as well as other inorganic and organic contaminants (EPA 1986).

Cement-based solidification often includes the use of nonproprietary, inorganic binders that are combined with Portland cement to address specific problem interactions between the contaminants and the cement binder. For example, certain contaminants can interfere with cement hydration or solidification to disrupt the matrix or retard the setting time. In general, interference problems are more commonly caused by organic compounds than by inorganic constituents. Some common additives for cement-based binders are as follows:

- Pozzolans—Insoluble silicates in the form of fly ash, blast furnace slag, and cement kiln dust that react with the calcium hydroxide released by cement hydration to form additional cementitious compounds. Pozzolanic additives generally improve the strength and reduce the porosity of the final product if they are not consumed in competing reactions with the contaminants. Pozzolans can be added to adsorb metals, organic compounds, and excess water and generally cost less than Portland cement.

- Soluble Silicates—The liquid forms of sodium and potassium silicates that react with the calcium hydroxide released by cement hydration. Soluble silicates form a gel structure that prevents solids from settling out of aqueous wastes before the cement sets and hardens. They also encapsulate contaminants that adsorb to cement particle surfaces. The resulting solid may be weaker than Portland cement alone.

- Lime—Calcium oxide or calcium hydroxide (hydrated lime) is added to react with pozzolans and to accelerate cement hydration by providing additional calcium and hydroxide. It is also added to prevent destruction of the cement structure by acidic contaminants.

- Clay—Selected clays such as bentonite absorb free liquids and bind specific anions and cations.

Direct cement-based solidification is utilized as a treatment alternative for the Buried M-1 Pits and Burial Trenches Subgroups in Alternative 10 (Solidification/Stabilization). Direct cement-based solidification is also utilized in treating soil and process by-products (i.e., particulates from off gas) for several of the Human Health Exceedance Category medium groups that may contain excess concentrations of inorganic constituents.

10.1.1 Process Description

The solidification process starts with the mixing of the contaminated soil with Portland cement. Fresh water supplements moisture within the soil to promote the hydration reactions that bond the cement-soil-contaminant matrix together. Calcium hydroxide, cement gel, and other compounds form during the hydration process and bind the soil particles and contaminants into the crystalline lattice of the cement matrix (Figure 10.1-1). 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 and sometimes chemically bonded to the cement matrix. The overall effect is to inhibit the leaching of contaminants from the solidified/stabilized mass.

In direct solidification, the soil material is removed by conventional earth-moving equipment and conveyed or otherwise transported to the solidification equipment as discussed in Section 4. Depending on the type of mixing equipment used, the contaminated feed stream may require coarse screening as a pretreatment step. As the soil and binder are mixed with a pugmill, oversize material is "entombed" in the processed material leaving the mixer. Metering and thorough mixing of the ingredients are essential for achieving consistent solid properties, but any mechanical equipment that uniformly mixes the soil and additives is satisfactory. In general, however, a pug mill is the best choice for soil and binder mixing.

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 lime and soluble 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.

The determination of binder ratios and additive levels is site and soil specific. The soil-to-binder ratio is controlled on a weight or volume basis using weigh batchers or screw feeders available from the concrete batch plant industry. Preliminary results from the treatability studies conducted by the Waterways Experimental Station (WES) indicate that a binder-to-soil ratio of 0.2 (weight basis) is generally optimum for RMA soil (WES 1995).

For RMA soil, pretreatment consists of screening debris and metal fragments and reducing the size of clay lumps in the feed. Size reduction increases the homogeneity of the feed and improves mixing control. For thermally treated soil and sidestreams, moisture adjustment is likely to be the only pretreatment requirement.

Oversize materials, debris, and metal fragments from feed pretreatment are likely to be the only sidestream from a direct solidification process. Section 4.4 presents a discussion of materials handling systems including size classification. If contaminated, these materials are placed in the on-post landfill. If uncontaminated, the pretreatment sidestream is returned to the original excavation and embedded in the treated soil mass. Because solidification requires the handling and mixing of fine-grained soil and finely divided binder ingredients, control of volatile organic emissions and fugitive dusts is necessary during the loading, blending, and discharge operations.

Because of the interferences provided by the presence of fine soil particles and the contaminants themselves, the setting time of the cemented soil is prolonged. This slow set allows time for the transport and placement of the mixture either in the original excavation or in another location such as a landfill. Post-treatment of the processed soil is limited to backfilling in the original excavation or placing the processed soil in the on-post landfill.

In general, solidified soil are backfilled in the original excavation as a pumpable material. Solidified soil are placed in the original excavation and a soil/clay cover provides weather protection for the treated material after it has been allowed to cure, as discussed in Section 6.1. In some cases, the configuration of the site or depth of the excavation may preclude backfilling all of the processed material, so the excess soil are placed in the on-post landfill. The solidified materials are placed in forms and allowed to cure for a few days. The forms are then removed and the "monoliths" placed in the landfill.

A volume increase usually accompanies the solidification process. In most cases of cement-based solidification, the volume of the final mixture is 20 to 50 percent greater than the original in-place volume of the contaminated soil. To return the processed soil to the original area of excavation, it must accommodate the increased volume of the solidified mixture and its final protective soil cover layer.

The ARARs identified for the direct cement-based solidification process option (Appendix A) are similar to the stirring, operation, monitoring, and closure requirements for miscellaneous treatment, storage, and disposal units under RCRA (40 CFR 264, Subpart X). Although a solidification unit does not produce an off-gas sidestream, fugitive dust emissions from soil and binder mixing operations must be mitigated.

The capital and operating costs for direct cement-based solidification are developed from the SITE program applications analysis report for the Hazcon Solidification Process (RREL 1989a). Although the Hazcon process uses a proprietary binder additive, it is basically a direct cement-based technology using transportable batch plant equipment. The cost breakdown (Table 10.1-1) allows the subtraction of the proprietary binder ingredient costs from the total. The cost of the cement binder in the Hazcon economic summary is further adjusted to reflect the low binder usage observed by the WES in the preliminary solidification screening studies on RMA soil (WES 1995). The resulting order-of-magnitude estimate does not include the cost of soil excavation, transport, or backfill. The unit capital cost of cement-based solidification for 26,000 BCY of soil is \$28.43/BCY of soil solidified. The cost of the single shift operation of a transportable batch mixing plant and associated bulk storage is estimated to be \$202.53/BCY of soil solidified.

10.1.2 Process Performance

Portland cement has been used very successfully in the solidification of metal contaminants, including arsenic and mercury. The cement neutralizes excess acidity and typically converts metals to their hydroxides, which are much less soluble than other ionic species of most metals. The effectiveness of solidification depends upon the level of contamination and the oxidation state of the metal. For lead, the pH of a pure cement binder is higher than optimum for minimum hydroxide solubility. An insoluble silicate, such as fly ash, can be added to the cement binder to lower the mix pH.

Certain organic waste constituents can interfere with the cement hydration reactions. Chlorinated hydrocarbons adsorb on cement surfaces to retard hydration and interfere with cement matrix formation (Adaska et al. 1992). Portland cement has been successfully used to solidify low levels of organic contaminants, including PCBs, oils, and oily sludge, but high levels of organic contaminants require additional binder ingredients (RREL 1989b). The solidification study by WES indicates that the organic compounds present in the M-1 Pits do not interfere with the binding process (WES 1995).

Processed soil must be protected from the effects of weathering. Exposure of the matrix to the elements, particularly freeze/thaw cycles, may produce an increase in the leachability of the immobilized constituents. If the processed soil are returned to the original excavation, the backfilled mass requires a soil cover layer for freeze/thaw protection as well as successful revegetation as discussed in Section 6.1.

Direct solidification involves the excavation of the contaminated soil for treatment. Its placement after treatment may be subject to RCRA land disposal restrictions (LDRs) if the material is a characteristic hazardous waste under RCRA or is a RCRA-listed waste. In these cases, the LDRs may prohibit the disposal of the solidified mixture in anything but a RCRA-type landfill unless a waiver of LDRs is obtained. This problem is avoided by the use of in situ techniques.

Portland cement is seldom used alone for direct hazardous waste solidification because most sites contain a mix of inorganic and organic contaminants. Even metal constituents can sometimes interfere with the cement reactions, and other cementitious materials such as fly ash or lime kiln dust are blended in to increase binder effectiveness. In general, fly ash and kiln dust cost less than cement and can also be used to adjust pH. Cement has been used alone to immobilize inorganic contaminants at the Independent Nail site, and the solidified material was subsequently delisted as a RCRA hazardous waste (RREL 1989b).

Treatability studies were conducted at WES using soil from four representative RMA sites. The sites included clayey and sandy-silty soil samples from South Plants, the M-1 Pits, Basin A, and a burn site in the vicinity of Basin A. The results of the sample analyses indicated that a Portland cement/lime kiln dust binder at a loading of 20 percent of the soil mass adequately solidifies the RMA soil and immobilized the organic and inorganic contaminants such that the material passes TCLP requirements (WES 1995).

Solidification does not destroy organic or inorganic contaminants, but it does reduce their mobility by chemical reaction or physical encapsulation. The immobilization efficiency of the process is measured by comparing the leachability of the contaminants before and after solidification via the TCLP or other leach testing. Based on the WES study (WES 1995), the immobilization efficiencies are greater than 90 percent.

10.2 IN SITU CEMENT-BASED SOLIDIFICATION

Soil can be solidified/stabilized in place using conventional excavation or drilling equipment. If the contaminants are less than 2 ft deep, conventional earth-moving or land-farming equipment can be used for the mixing step. Mixing is unconfined, however, and tends to generate fugitive dust emissions. For deeper contamination, or where the contaminant volatilization or fugitive dusts must be avoided, specialized hollow-stem auger drilling equipment can deliver the binding agent to levels as deep as 150 ft. An overlapping drilling pattern is used to obtain complete contact with the contaminated soil volume.

In situ cement-based solidification is used alone in Alternative 22 or in conjunction with the in situ heating processes described in Alternative 19. This alternative was retained in the DSA for several of the Human Health Exceedance Category medium groups.

10.2.1 Process Description

The major difference between direct and in situ solidification is the absence of the excavation and backfill steps required by direct processes (Figure 10.2-1). The mixing equipment is based on powerful drilling rigs rather than cement batch plants, but the solid and liquid binder constituents still require on-site storage and handling.

The binder formulation for in situ work is the same as that used in the direct treatment method discussed above. Because of the difficulty of monitoring the binder-to-soil ratio in the in situ approach, binder consumption tends to be higher than direct treatment. Some of the increase comes from the overlapping pattern of binder application, but most is due to the necessary conservative estimate on the high side of the target formulation.

The equipment for in situ soil mixing comes from specialty foundation and cutoff wall construction. Instead of the soil being brought to the mixer, the mixing equipment is moved through the volume of soil to be remediated. The equipment takes two forms: a fully tracked modified drilling rig such as that developed by Millgard Environmental Corporation (MecTool) or Novaterra (Detoxifier) or a mobile crane-supported auger such as that developed by Geo-Con, Inc. (Deep Soil Mixer and Shallow Soil Mixer). Both types of equipment can drill as deep as 150 ft. Depending on the soil type and the depth of boring required, the size of the MecTool boring/mixing head ranges in diameter from 4 to 12 ft. The Geo-Con Deep Soil Mixer uses a pilot-scale, 3-ft-diameter single auger and a commercial-scale four-auger rig with mixing heads that can treat 27 SF at each setup. Each type of mixer 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. The MecTool and the Detoxifier are 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 but consumes more binder because of the overlapping drilling pattern.

The only pretreatment step for in situ solidification that is required is to adjust abrupt grade changes so that the mobile mixing rigs stand on a relatively flat surface. In situ solidification results in a volume expansion of the treated soil. Depending on the required binder ratio, the expansion may range between 10 and 25 percent. Post-treatment may involve recontouring of the expanded soil in place or removal of the unacceptable volume to Basin A or the on-post landfill.

Other than the fugitive dust emissions associated with bulk solids transfer, in situ cement-based solidification does not produce any sidestreams. The process involves the injection of a cement slurry into the mixed soil column, so dusting is not likely at the mixing head. Volatile organic compounds may be released from the soil as mixing proceeds, so the drill rig must be provided with a vapor collection hood if volatiles are anticipated.

In situ solidification is a miscellaneous treatment operation and falls under the siting, operation, monitoring, and closure requirements of RCRA regulations (40 CFR 264, Subpart X). The ARARs listed in Appendix A deal with fugitive dust and volatile organic compound emissions.

The operating costs for in situ cement-based solidification are developed from a quotation for a year-long program of shallow soil solidification at RMA supplied by Millgard Environmental Corp. (MEC 1992). Other than mobilization and demobilization costs, there are no capital costs associated with the process because Millgard operates and maintains the equipment as a lease (Table 10.2-1). The quotation assumed the use of one MecTool drill rig for 5 days a week and 10 hours per day as well as operating and maintenance support. Processing capacity is estimated to be 600 BCY of soil per day. Binder costs are based on $65/ton for bulk cement delivered to the site and a mix ratio of 0.2 tons of cement per ton of soil as suggested by the WES screening experiments on RMA soil (WES 1995). The Millgard quotation includes all operating and maintenance labor, including living expenses and all process utilities. As with direct solidification, a supply of clean water is required for cement slurry preparation and equipment washdown. The operating costs of in situ cement-based solidification using the proprietary MecTool process are estimated to be $60.93/BCY of soil treated. There are no capital costs.

10.2.2 Process Performance

If the cement slurry is intimately mixed with the soil, in situ cement-based solidification should be as effective in immobilizing contaminants as direct solidification methods. Uniform contact with all of the soil, however, is more difficult with in situ methods. The solution is to overlap the drilled columns to reduce the possibility of missing some of the soil section. In the overlap pattern, some of the mixed soil is remixed and additional binder is consumed.

As with direct methods, a volume increase that ranges between 10 and 25 percent takes place during the in situ processing of the soil. To protect the solidified mass from weathering, the site requires a soil cover layer for freeze/thaw protection as well as successful revegetation (Section 6.1).

In situ cement-based solidification has been used successfully to solidify soil contaminated with heavy metals but is seldom used alone when soil are also contaminated with chlorinated organic compounds such as PCBs and pesticides (RREL 1989b).

Treatability studies are not available for in situ cement-based solidification of RMA soil. However, the difference between direct and in situ solidification is in the mixing equipment rather than the binder formulation required. Because the screening tests from WES indicate that Portland cement successfully immobilizes RMA soil contaminants (WES 1995), a cement binder should prove adequate in an in situ application.

10.3 IN SITU SILICATE/PROPRIETARY ADDITIVE-BASED SOLIDIFICATION

This application of in situ solidification technology is the same as that in the previous section, except that a silicate/proprietary additive-based binder is used to reduce ammonia and VOC emissions from the soil during auger mixing. As with other solidification processes, different drilling equipment is used for various depths of soil treatment. An overlapping drilling pattern is used to obtain complete contact with the contaminated soil volume. This process is used for Former Basin F to treat principal threat volume prior to capping (Alternative 6B).

10.3.1 Process Description

This in situ solidification process is performed identically to cement-based solidification described in the previous Section 10.2. The same mobile mixing rigs are used, soil expansion will be in the range of 10 to 25 percent, and fugitive dust emissions from the mixing of the soil are not expected. A vapor collection hood is placed over the mixing area if the release of volatile organic compounds from the soil is anticipated.

The binders of silicate and proprietary additives are used instead of cement or fly-ash in order to reduce ammonia and VOC emission from the soil during mixing. According to the International Waste Technologies/Geo-Con In Situ Stabilization/Solidification SITE Applications Analysis Report (RREL 1990), the proprietary additives have been used to solidify organics and inorganics.

There are no capital costs for this in situ solidification process because the equipment is proprietary and all facets of the operation are a service of the contractor. The operating costs are based on those developed in the previous section, except for the binder costs described above (Table 10.3-1). The unit operating cost of this in situ silicate/proprietary additive-based solidification is estimated to be $123.08/BCY.

10.3.2 Process Performance

If the binders are intimately mixed with the soil, in situ silicate/proprietary additive-based solidification should be able to immobilize contaminants. The solidification technology has been shown to reduce contaminant mobility (RREL 1990). Volume increases and placement of a soil cover are also anticipated, as described in the previous section.

Treatability studies are not available for in situ silicate/proprietary additive-based solidification. However, a non-cement binder of organophillic clay and sodium silicate was used with in situ soil mixing equipment for soil contaminated with volatile and semivolatile contaminants (RREL 1990). As a result, a non-cement binder should prove adequate in an in situ application.

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Table 10.1-1 Capital and Operating Costs for Direct Cement-Based Solidification

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Equipment	$ 724,000	Source: 1 Based on single-shift operation with a 5-day week (260 days/year and 150 tpd) $3.35/BCY over a 5-year service life
	Startup and Fixed	96,400	
	Facility Modifications	9,820	
	Site Demobilization	32,600	
Total Capital Cost		$ 863,000	
Operating Costs Without Materials	Labor	$ 2,880,000	Source: 1 With variable costs adjusted for single shift operation
	Utilities	65,800	
	Analytical	231,000	
Materials Cost	Binder	$ 2,050,000	Source: 2 With 10% waste factor
Total Operating Cost		$ 5,230,000	

Sources:

1) Hazcon Solidification Process, Douglassville, PA, SITE Applications Analysis Report (RERL 1989a), with costs escalated to January 1, 1993

2) Evaluation of Solidification/Stabilization for Treating Contaminated Soils from the Rocky Mountain Arsenal (WES 1995)

Table 10.2-1 Capital and Operating Costs for In Situ Cement-Based Solidification

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	None	$ 0.00	Source: 1 Equipment is proprietary and operation is a service of the developer.
Operating Costs Without Binder	Equipment Lease, Operating and Maintenance Labor, and Utilities	$ 25.22/BCY	Source: 1 Operations are based on one 10-hour shift per day with a 5-day week.
	Cement Storage Facilities	$0.25/BCY	Source: 2 Consumables and analytical costs taken as the same as direct solidification.
	Consumables	$9.08/BCY	
	Analytical	$2.02/BCY	
	Water Truck and Driver	$0.98/BCY	
	Water	$0.14/BCY	
Binder Cost	Cement at 20 percent of soil ($65/ton)	$23.24/BCY	Source: 3
Total Operating Cost		$60.93/BCY	

Sources:

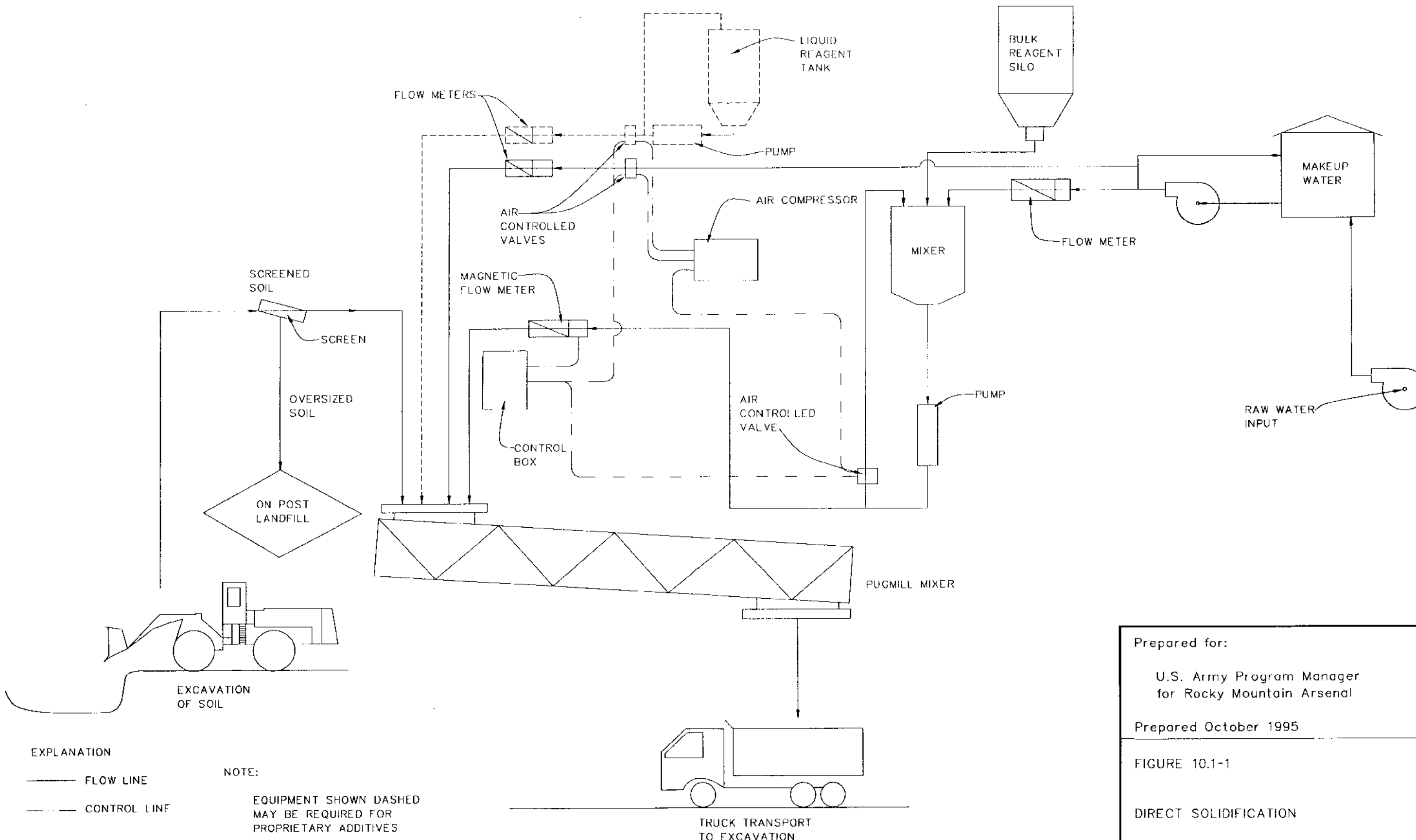
1) Millgard Environmental Corp., vendor quotation of 12/23/92, for shallow mixing (10 to 15 ft) of silty clay soils at RMA using one MecTool Remediation Delivery System for a period of 1 year
2) Hazcon Solidification Process, Douglassville, PA, SITE Applications Analysis Report (RREL 1989)
3) Evaluation of Solidification/Stabilization for Treating Contaminated Soils from the Rocky Mountain Arsenal (WES 1995)

Table 10.3-1 Capital and Operating Costs for In Situ Silicate/Proprietary Additive-Based Solidification

Cost Category	Cost Item	Cost Estimate	Description
Capital Cost	None	$ 0.00	Source: 1 Equipment is proprietary and operation is a service of the developer.
Operating Costs Without Binder	Equipment Lease, Operating and Maintenance Labor, and Utilities	$ 25.22/BCY	Source: 1 Operations are based on one 10-hour shift per day with a 5-day week.
	Cement Storage Facilities	$0.25/BCY	Source: 2 Consumables and analytical costs taken as the same as direct solidification.
	Consumables	$9.08/BCY	
	Analytical	$2.02/BCY	
	Water Truck and Driver	$0.98/BCY	
	Water	$0.14/BCY	
Binder Cost	Silicate/Proprietary Additive and Water	$85.39/BCY	Source: 3
Total Operating Cost		$123.08/BCY	

Sources:

1) Millgard Environmental Corp., vendor quotation of 12/23/92, for shallow mixing (10 to 15 ft) of silty clay soils at RMA using one MecTool Remediation Delivery System for a period of 1 year
2) Hazcon Solidification Process, Douglassville, PA, SITE Applications Analysis Report (RREL 1989)
3) International Waste Technologies/Geo-Con In Situ Stabilization/Solidification Site Applications Analysis Report (EPA 1990)



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared October 1995

FIGURE 10.1-1

DIRECT SOLIDIFICATION

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated

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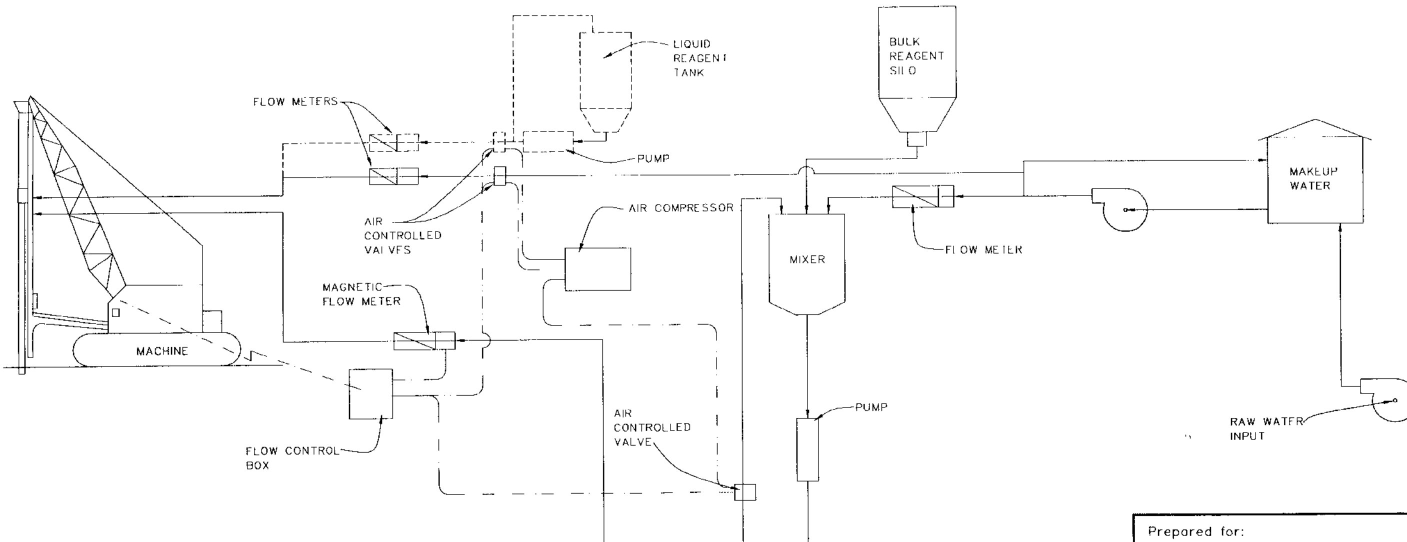

EXPLANATION

FLOW LINE

CONTROL LINE

COMMUNICATION LINE

NOTE:

EQUIPMENT SHOWN DASHED
MAY BE REQUIRED FOR
PROPRIETARY ADDITIVES

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Prepared October 1995

FIGURE 10.2-1

IN SITU CEMENT-BASED SOLIDIFICATION

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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Section 11

11.0 BIOLOGICAL TREATMENT

The technologies discussed in Section 11 consist of treating OCPs (such as dieldrin) in surface soils via agricultural practices (landfarming (Section 11.1)), treating aromatic hydrocarbons (such as benzene) in groundwater using GAC fluidized-bed biological reactors (Section 11.2), and treating OCPs in lake sediments using in situ aerobic biodegradation (Section 11.3). OCPs are found in some soil and lake sediments at RMA, and aromatic hydrocarbons are found in groundwater primarily south of the South Plants Tank Farm area.

Agricultural practices (landfarming) were considered for pesticide-contaminated soils to promote contaminant loss, to reduce the potential for the exposure of receptors to contaminants, and to reduce the potential for wind dispersion of contaminants. An associated sidestream of this process may consist of some nitrate runoff due to fertilization.

Both in situ and aboveground biological treatment were considered for treatment of the South Plants Tank Farm groundwater plume. The in situ technology produces no sidestreams, and the aboveground technology produces biomass that must be disposed.

The lake sediments were considered for in situ biological treatment to achieve aldrin and dieldrin degradation. The addition of nutrients and oxygen or other electron acceptors produces biomass and dissolved nutrient sidestreams that would remain in the lake system.

11.1 AGRICULTURAL PRACTICES (LANDFARMING)

This technology consists of using landfarming techniques either with farm machinery (V-ripper, plow, and disk) or a soil stabilizer along with seeding to facilitate stabilization and attenuation of contaminants in surface soils (0-ft to 1-ft depth interval). The concentrations of pesticides found in soil have been shown to decrease over time when subjected to agricultural practices (Shell 1982). Many studies have shown that the largest percentage of OCP losses in tilled or farmed soil occur in the first few years, although losses do continue after the first few years (Decker et al. 1965; Freeman et al. 1975; Lichtenstein and Schultz 1959; Lichtenstein et al. 1970;

Nash and Harris 1973). Other studies, however, have shown at least some loss in untilled soil (Nash and Woolson 1967). These studies postulated that there were a number of loss mechanisms involved including photolysis, oxidation, biodegradation, and volatilization. Bowman et al. (1965) and Nash (1983) have demonstrated that volatilization is an active loss mechanism, although the contribution of the other loss mechanisms is not well understood. Moreover, the rate of loss, kinetics of loss, and degradation products are not fully defined.

11.1.1 Process Description

Farm Machinery

Landfarming involves tilling soil with farm machinery and seeding it with native grass in a manner consistent with an RMA refuge management plan. Where the ground is initially too hard for a plow to penetrate, a V-ripper with 13-inch to 20-inch blades is used to open the ground surface. Once the surface is broken, a plow with 6-inch to 8-inch bottoms overturns the soil and covers the upper 2 inches of contaminated soil with uncontaminated soil from below the 0-inch to 2-inch depth interval. With the contaminated soil covered, dust dispersion and exposure of surface receptors is minimized. Finally, a 32-ft disk is used to break up soil chunks and mix the uppermost soil. To achieve uniform soil mixture, the disking is conducted in three different directions: the first pass is parallel to the plowing direction and the final two passes oppose the original plowing direction in two 45-degree angles. Fertilizer and mulch are applied and a mixture of native grasses is seeded using a pair of 15-ft seed drills. The seeding facilitates development of a stable final grass stand and aids soil conservation and prevention of dust dispersion.

Soil Stabilizer

A number of soil stabilizers that perform soil mixing are currently available. The soil stabilizers have the ability to uniformly mix an 8-ft width of soil to a depth up to 18 inches. They typically come equipped with an internal spray bar that enables water or nutrients to be added during soil mixing. The advantage of using a soil stabilizer compared to farm machinery is that the former requires only one pass to effectively mix the soil, although the results may be less predictable than with the farm machinery because soil reclamation vendors do not typically use this equipment. A typical soil stabilizer, at a working speed of 30 feet per minute (fpm), can till approximately 2.6 acres in a 10-hour day. Figure 11.1-1 presents a typical soil stabilizer.

Seeding

The RMA vegetative habitat is very complex, and it cannot be precisely determined which plants need to be seeded in particular areas without a prior assessment of remediation/mitigation goals and an RMA refuge management plan. Prairie species should be seeded in areas desirable for wildlife habitation and less desirable species should be seeded in areas requiring wildlife exclusion. For cost estimating purposes, it was assumed that crested wheat grass at 8 pounds per acre (lbs/acre) and Pubescent grass at 12 lbs/acre can be seeded for a rapidly developing stand (Hastings 1992). In more sensitive areas, native grasses at 5 to 10 lbs/acre and native forbs at 8 to 15 lbs/acre would need to be seeded. Typical costs are approximately $968 per acre.

11.1.2 Process Performance

Mixing surface contamination into the soil below is expected to promote contaminant loss and to reduce both contaminant exposure to surface receptors and migration of contaminants by surface dust dispersion. The stands of native grasses and forbs to be planted stabilize the soil and provide wildlife habitat. Native grasses and forbs are sensitive plant species, and attention to timing, soil moisture, and seeding/mulching techniques play an important role in developing the native grasses and forbs.

The landfarming technology does not provide intensive treatment of the contaminants present. It does, however, reduce contaminated dust migration and surface receptor exposure and contaminant loss is expected with time. The primary advantage of this technology is that the treated soil supports growth of native grasses and forbs that will in turn provide wildlife habitat. Other potential remediation technologies, such as thermal treatment, tend to sterilize the soil and remove the organic carbon in the soil. The soil resulting from a thermal treatment process is not a viable growth media for native grasses and forbs.

11.2 FLUIDIZED-BED BIOLOGICAL REACTOR FOR GROUNDWATER TREATMENT

This technology involves treatment of extracted groundwater in a biological reactor. A number of biotechnologies were considered in the DSA for treatment of the hydrocarbons present in the South Tank Farm groundwater plume. These technologies include trickling filters, rotating biological contactors, submerged biological contactors, and suspended-growth sequencing batch reactors. Because of the low anticipated contaminant concentrations and the results of the ongoing WES treatability studies (Zappi 1993), a GAC fluidized-bed biological reactor was selected.

11.2.1 Process Description

The biological reactor system being considered includes an oil/water separator to remove any floating product. Alternately, an in-well skimmer pump may be used to remove the floating product. Floating product removal may not be necessary if current removal efforts are successful. All influent is pumped and transported to a lined tank. This tank is sized as an equalization tank based on the anticipated amount of storage of contaminated groundwater, ensuring continuous and consistent flow to the treatment system so that sharp fluctuations in the concentration of feed water are avoided. The contaminated water is then introduced into the GAC fluidized-bed reactor (Figure 11.2-1). The fluidized-bed biological reactor consists of an expanding GAC bed to which microorganisms attach. Contaminants are quickly sorbed into the fluidized GAC. Microorganisms growing in and on the carbon subsequently degrade the contaminants, a process that regenerates the carbon. Water is continuously recycled through the reactor with oxygen from an oxygen generator added during the closed recycle loop, thereby eliminating the production of off gas in the aeration process. A lamella clarifier is used for effluent polishing and iron and manganese removal. The final treatment step consists of removing suspended solids with a sand filter. The primary sidestream consists of biomass and spent carbon from the bioreactor. The biomass is filtered in a multimedia filter and disposed in the on-post landfill. The small amounts of spent carbon are also drummed and disposed in the landfill.

11.2.2 Process Performance

The fluidized-bed biological reactor is being proposed for treatment of water extracted from the South Tank Farm Plume. The dimensions of the plume are approximately 4,000 ft long by 2,000 ft wide. The primary COC is benzene, which ranges from 75,000 to 150,000 micrograms per liter ($\mu g/l$) in the plume area where in situ biodegradation is being tested. OCPs are also present but at low levels. For the high concentrations of benzene present, it was assumed that biological treatment is combined with additional treatment to meet the target effluent criteria.

Several factors determine the implementability of biological treatment including pollutant concentration, oxygen concentration, active biomass concentration, temperature, pH, availability of inorganic nutrients, and microbial adaptation. These parameters were investigated by a WES treatability study conducted with highly concentrated water collected from the South Tank Farm Plume. This treatability study used three suspended-growth reactors to treat water extracted from the South Tank Farm Plume. Good microbial adaptation was achieved and good removal rates were maintained at higher concentrations than the estimated influent concentrations for the South Tank Farm Plume (Zappi et al. 1994).

Dissolved iron and manganese exist in the groundwater at this site and could potentially require pretreatment to prevent precipitation in the bioreactor or posttreatment to prevent clogging of the discharge system. However, during the WES treatability study, these compounds did not require special treatment. Accordingly, this system is designed without pre- or posttreatment for iron and manganese.

11.3 IN SITU AEROBIC BIODEGRADATION

In situ aerobic biodegradation consists of generating conditions within the aquifer that facilitate aerobic biodegradation of the COCs at an acceptable rate. In this system, nutrients and an oxygen source (H_2O_2) are added to the extracted groundwater, which is then reinjected into the aquifer. The nutrients and H_2O_2 enhance the in situ biodegradation process.

11.3.1 Process Description

In situ aerobic biodegradation involves the microbial degradation of organic contaminants in the aquifer. For in situ aerobic biodegradation to occur, the following materials or conditions must be present:

- Sufficient quantities of microorganisms capable of degrading the contaminants
- Sufficient oxygen concentration
- Macronutrients
- Micronutrients
- Acceptable pH for the microorganisms
- Acceptable temperature for the microorganisms

The system proposed for treatment of the contaminants present in the South Tank Farm Plume is based on an assumption that indigenous microorganisms degrade the contaminants present at the current pH and temperature under nutrient- and oxygen-enriched conditions, which is currently being evaluated in a pilot-scale testability study being performed at RMA.

Oxygen in the form of H_2O_2, along with nutrients, is expected to be a required additive. Optimum concentrations need to be determined through site-specific treatability studies. The oxygen and nutrients are introduced into the subsurface through a series of injection wells. The microorganisms, in the presence of the oxygen and nutrients, degrade the contaminants while the water moves downgradient. Extraction wells remove the treated water, and additional oxygen and nutrients are added prior to reinjection of the treated water. The purpose of reinjecting the treated water is to provide additional treatment opportunity if the water has residual concentrations of contaminants, to use the treated water to aid in flushing sorbed contaminants from the aquifer material, and to reintroduce the suspended acclimated microorganisms. During groundwater recharge, the water table is artificially elevated and contaminants trapped in pore spaces may be resolubilized. A secondary goal of this technology is to remove the contaminants in these pore spaces and subsequently treat them by in situ bioremediation. Figure 11.3-1 presents a diagram of the system.

H_2O_2 produces the highest amount of oxygen per volume of any source and also restricts biogrowth on well screens at the point of groundwater recharge. Accordingly, it will be used as the oxygen source.

The extraction wells proposed for the in situ aerobic biodegradation treatment option at RMA have stainless-steel slotted screens with permeable sand packs and a bentonite seal immediately above the sand pack. Grout and cement are placed above the bentonite seal. Additional aquifer and soil properties testing may indicate a need for alternative extraction methods. Trenches utilizing perforated piping could be used in low-permeability, low-flow, shallow aquifers. The injection wells proposed for this technology are designed similarly to the extraction system with the exception of increased size to enhance effluent percolation.

The nutrients and H_2O_2 are added to the water prior to reinjection. Nutrient mixing takes place in a mixing tank and oxygen concentrations are monitored to ensure desired oxygen concentrations are reached. Nutrients and H_2O_2 area added in separate cycles to prevent extensive growth on the well screens.

The in situ aerobic biodegradation technology might result in a long remediation time given the high volume of water that needs treatment and the relatively impermeable aquifer materials present in the South Tank Farm Plume area. Furthermore, the biological mass produced by these high concentrations of benzene could possibly clog the aquifer. These concerns are being evaluated in the ongoing pilot-scale treatability study.

11.3.2 Process Performance

Several factors determine the performance of the in situ aerobic biodegradation treatment process including—

- Pollutant concentration
- Microbial adaptation and activity
- Temperature

- pH
- Availability of macronutrients
- Availability of micronutrients
- Oxygen concentration
- Hydrogeologic conditions

Shell reported excellent benzene removal in an activated-sludge biological treatment pilot plant (Shell 1982). Influent concentrations ranged from 40 to 240 micrograms per liter (mg/l) and the effluent concentration was generally less than 0.020 mg/l. These removal efficiencies were achieved at 25°C with a 2-day hydraulic retention time. The unit was biologically seeded with sewage sludge, and nitrogen (N) and phosphorus (P) were added in the ratio of the 5-day biological oxygen demand (BOD_5):N:P at 100:5:1. Site-specific treatability studies are needed to demonstrate that the indigenous microorganisms are adapted to degrading the contaminants present, to establish the rate of degradation in situ, and to evaluate the impact of the system on the hydrogeologic properties of the aquifer.

Precipitation of iron and manganese is a concern because the addition of oxygen to RMA groundwater may cause the iron and manganese to precipitate either in the surface reactor or in the aquifer. The precipitates will fill the void space in the aquifer and ultimately reduce the groundwater flow to the point that the treatment system will no longer function. The magnitude of this effect was determined to be significant during the ongoing treatability study at RMA and a filter was included for iron removal.

This technology is being proposed for treatment of the South Tank Farm Plume. The main contaminant is benzene, at concentration levels of 75,000 to 150,000 μg/L in the test area. It has been reported that benzene concentrations higher than 100 mg/l are inhibitory to microbial growth and that no degradation occurs at benzene concentrations higher than 250 mg/l (Alvarez and Vogel 1991). However, the Shell study described above reported that concentrations up to 240 mg/l did not inhibit microbial growth.

The geology of the area varies from sandy siltstone to sandy claystone. The Denver formation, which dominates the South Tank Farm Plume area, has a low primary permeability. However, interconnected fractures in this area provide a much higher effective permeability. The groundwater is located in an unconfined zone of weathered bedrock with a hydraulic conductivity of 2.8×10^{-1} feet per day (ft/day). The bedrock is overlain with unsaturated alluvium with a hydraulic conductivity of 1.7×10^{2} to 2.6×10^{3} ft/day.

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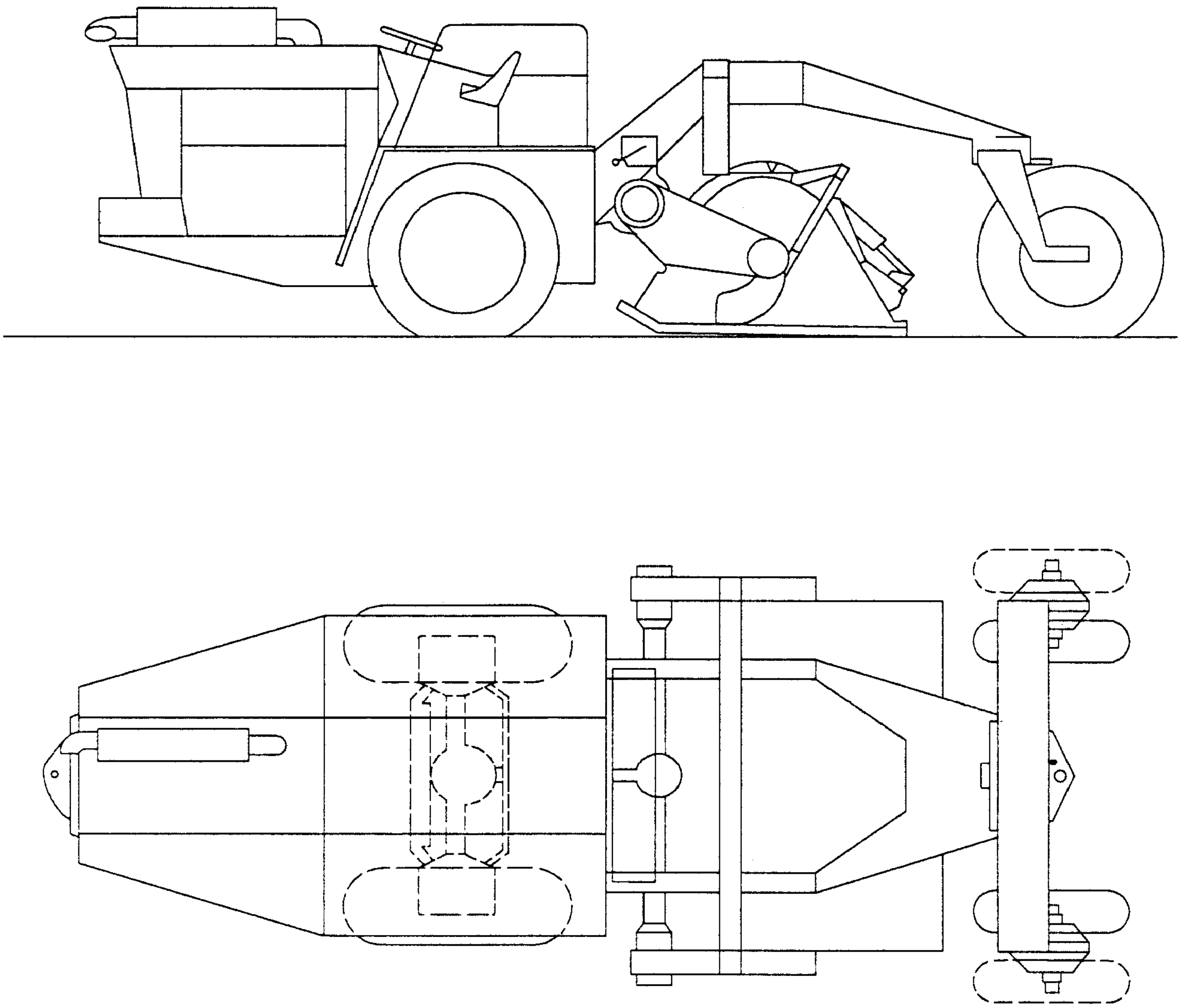
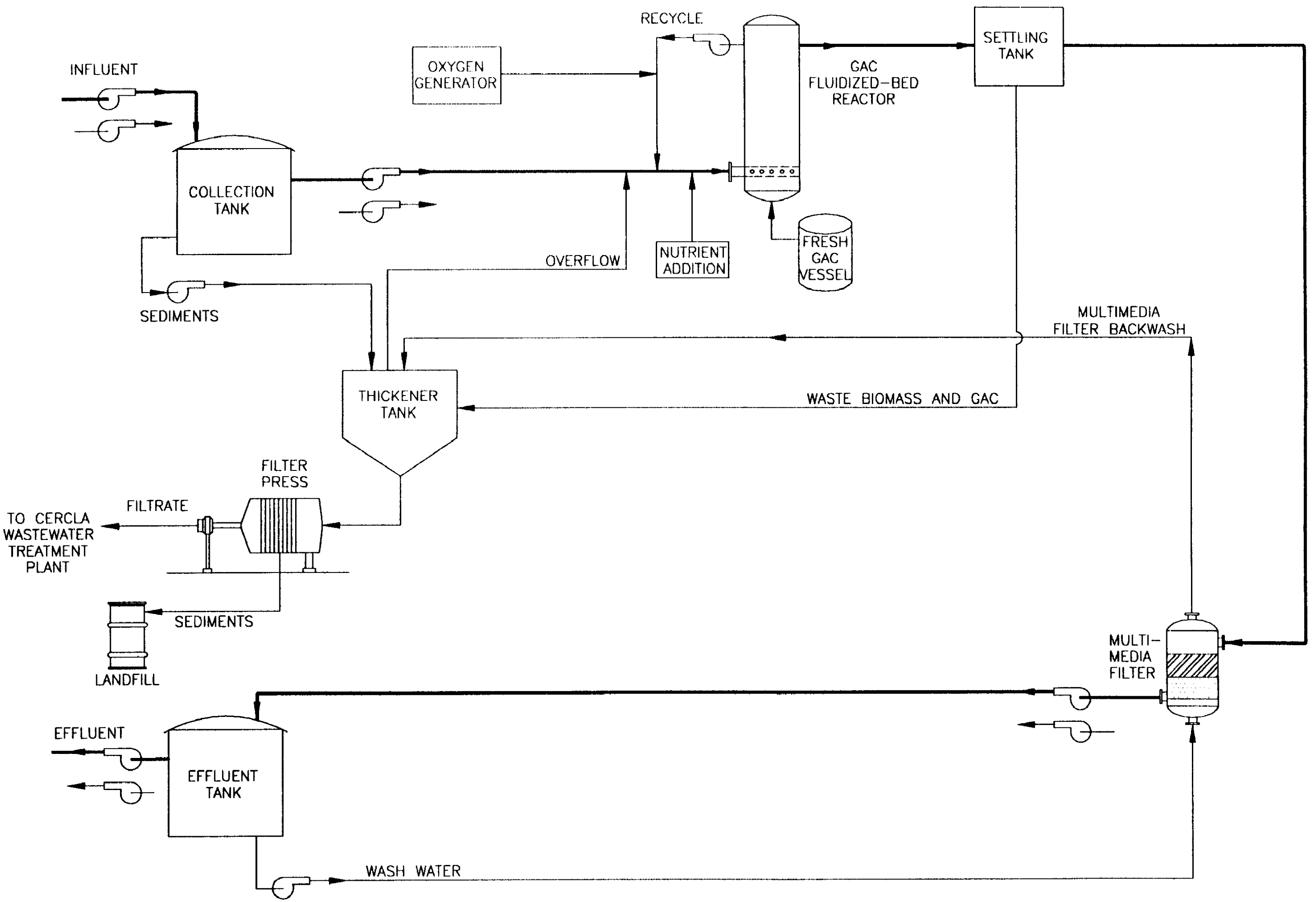


Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal

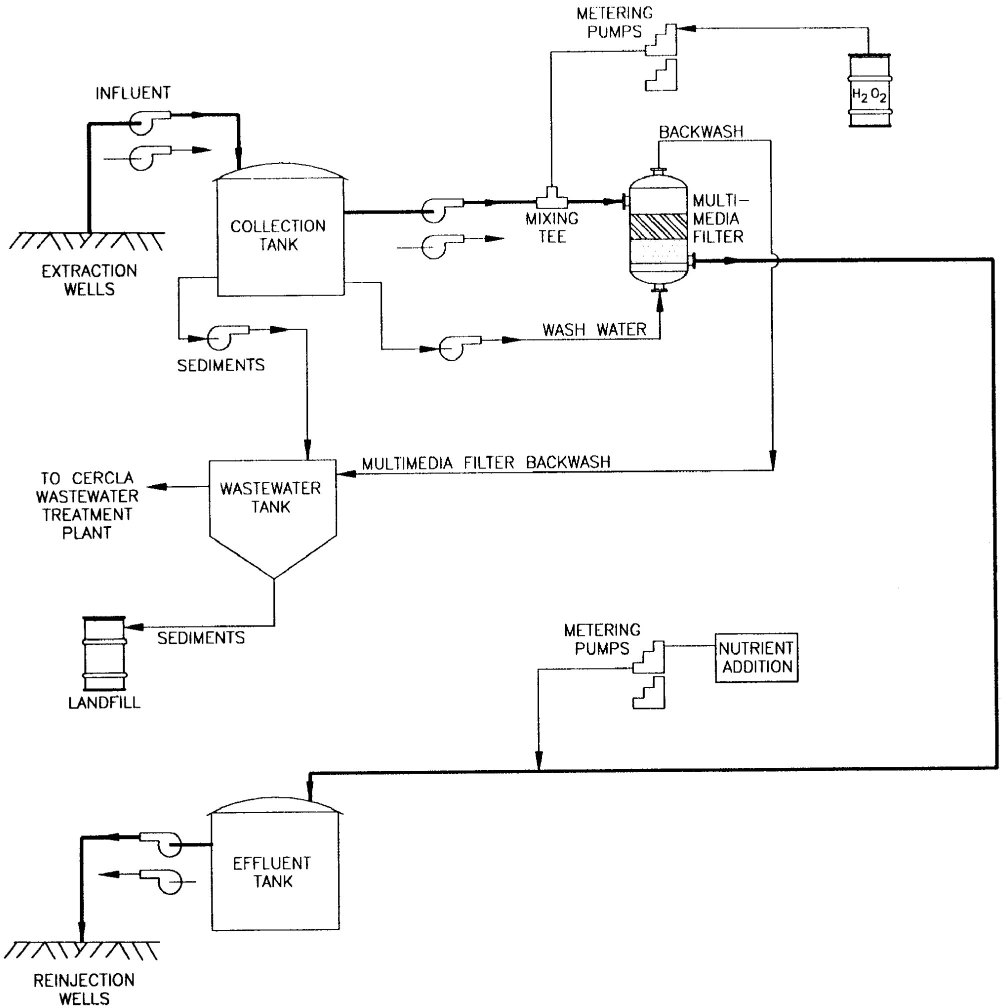
FIGURE 11.1-1

Caterpillar SS-250 Soil Stabilizer

Prepared by:
Foster Wheeler Environmental Corporation



Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 11.2-1 GAC Fluidized-Bed Biological Treatment	Prepared by: Foster Wheeler Environmental Corporation



Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 11.3-1 In Situ Aerobic Biodegradation	Prepared by: Foster Wheeler Environmental Corporation

Section 12

12.0 SOIL UNIQUE OPTIONS

Soil unique options include two process options—soil flushing and solvent extraction—developed to remediate contaminated soil by physical/chemical processes. Section 12.1 describes soil flushing, and Section 12.2 describes solvent extraction.

12.1 SOIL FLUSHING

Soil flushing is an in situ treatment option designed to remove contaminants from soil by passing extractant solutions through the soil. The process involves the creation of an active leaching field in areas of soil contamination to accelerate percolation and desorption of contaminants from the soil. The flushing solution is sprayed, flooded, or injected over and into the soil area to be treated. As the flushing solution percolates through the treatment zone, it mobilizes contaminants from the soil matrix. The flushing solution then carries the mobilized contaminants through the soil profile until it mixes with the underlying groundwater. The flushing solution and contaminants are collected in downgradient recovery wells or trenches and pumped to a treatment system. Following treatment, the captured groundwater is discharged to the leaching field, forming a closed-loop recovery system.

The effectiveness of a soil flushing system is dependent on the solubility of the contaminants in the flushing solution and the ability to move the flushing solution through the contaminated soil. Water is not sufficient to remove the COCs, and surfactants are required for removal of the OCPs. The chemical makeup of a proposed surfactant must be reviewed for toxic constituents as part of the detailed design. The effective collection of flushing solutions and contaminants mobilized is required for effective implementation. This treatment process is only effective in an appropriate hydrogeologic setting where contaminants may be collected once mobilized, which is why soil flushing was only retained for the Basin A Medium Group in the DSA (EBASCO 1992). Best removal will be achieved in highly permeable, homogeneous soil where the flushing solution is effectively distributed throughout the soil treatment zone. The process is particularly cost effective in the case where pre-existing groundwater contamination requires groundwater recovery and treatment and where the groundwater moves rapidly.

Soil flushing is a proposed technology for the Basin A Medium Group. The COCs at these sites are OCPs and metals.

12.1.1 Process Description

Figure 12.1-1 provides a schematic of a soil flushing system. For the Basin A Medium Group, the flushing solution is sprayed 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 and pumped to the Basin A Neck IRA groundwater treatment system. The Basin A Neck IRA system will require expansion if this process option is selected. Costs to expand the system were included in the estimated costs for this option. Much of the captured groundwater is discharged to the leaching field, forming a nearly closed-loop recovery system.

Soil flushing removes contaminants from the soil column by three mechanisms: preferential wetting, solubilization, and emulsification. Preferential wetting may remove residual free-phase contaminants by wetting the soil particle surfaces, thereby partially or completely displacing a residually saturated contaminant or a contaminant adsorbed to the soil organic fraction. Remaining free-phase or adsorbed contaminant removal is accomplished through solubilization (emulsification), in which the contaminant becomes dissolved or dispersed within the flushing solution.

Water can be used for flushing of relatively soluble compounds with a low affinity for soil organic carbon. To mobilize OCPs, surfactants are required; metals require weak acids, reducing agents, and chelating agents. Even with these additional agents, effectiveness for mobilizing OCPs is anticipated to be poor.

Surfactants improve the ability of an aqueous flushing solution to mobilize strongly adsorbed, low-solubility compounds. Surfactants wet the soil particles and decrease the interfacial tension between the aqueous phase and the solid phase, thereby promoting preferential wetting and solubilization due to the interaction of the surfactant molecules with the contaminant. Surfactants can also enhance the detergency of an aqueous solution by promoting the dispersion of an insoluble organic phase within the aqueous phase, creating an emulsion. Interactions between surfactants, soil media, contaminants, and microbial populations can lead to problems in implementation of soil flushing technologies 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, and biodegradation. Complete removal of surfactants from the environment may not be possible, and surfactant recovery from the waste stream can be difficult (Rixey 1990).

Surfactant requirements are dependent on the solubilization capacity of the particular compounds of interest, contaminant concentrations, desired cleanup level, and sorptive properties of the soil. Of these four parameters, surfactant requirements are most dependent on the solubility of the contaminant (Rixey 1990). OCPs have low solubilities and high organic carbon partition coefficients (i.e., attraction for soil organic carbon) and require high surfactant loadings for even partially effective remediation. Loadings of 20 to 60 pounds (lbs) of surfactant per ton of soil are commonly used for bench- and field-scale pilot tests (Rixey 1990).

The action-specific ARARs governing the design and performance of soil flushing are presented in Appendix A. These action-specific ARARs primarily address the discharge of treated wastewater, air emissions, and worker protection during process operation.

Table 12.1-1 presents costing information for soil flushing. The total capital cost for soil flushing is approximately $3,350,000; total operating and maintenance cost is $84.31/BCY. This cost was based on Alternative AC-8/AT-2 Dewatering, Stripping/sorption for soil flushing groundwater extraction from the Water DSA (EBASCO 1992).

12.1.2 Process Performance

The success of this alternative in reducing the TMV of contamination depends predominantly on the soil types in which the contaminants are distributed, the physical/chemical properties of the contaminants, and the hydrologic properties of the aquifer below. The soil types present dictate the effectiveness of the soil flushing system in distributing the flushing solution and the contact achieved between the flushing solution and the soil contaminants. Best removal efficiencies are achieved in highly permeable homogenous soil where the flushing solution is effectively distributed throughout the soil treatment zone. EPA has noted that effective remediation by soil flushing is limited to soil with a hydraulic conductivity of at least 1×10^{-4} cm/sec (SAIC 1985; HWERL 1986).

The physical/chemical properties that directly influence the applicability of soil flushing include the following:

- Contaminant solubility
- Organic carbon partition coefficient of the contaminant
- Total organic carbon (TOC) content of the soil

The solubility of a compound is a measure of its ability to enter into solution. Once a contaminant is dissolved, it moves through the soil profile and mixes with the underlying groundwater. Table 12.1-2 presents solubility data of the COCs in Basin A. The more soluble the compound, the greater the fraction of the mass present that is removed with each flushing volume.

A contaminant's partition coefficient describes its affinity to adsorb to soil organic carbon. Organic compounds are grouped by relative magnitude of their partition coefficients (K_{oc}). Values greater than 4,000 milliliters per gram (ml/g) exhibit a strong affinity for the solid phase and, therefore, a limited mobility in the aqueous phase or the flushing solution. Moderate K_{oc} values (500 to 4,000 ml/g) indicate a moderate affinity for the solid phase and moderate mobility in the aqueous phase (EBASCO 1991). Table 12.1-2 presents K_{oc} values for the COCs in the Basin A medium group.

TOC is a measure of the organic carbon content of soil. The lower the TOC value, the less carbon there is available to hold the organic contaminants in the soil; thus values lower than 1 percent are favorable to soil flushing effectiveness (SAIC 1985). The TOC content of RMA soil ranges from 2.6 percent in topsoil and root-zone layers to less than 0.01 percent in aquifer sediments.

Soil flushing experiments with surfactants were conducted with several RMA COCs. Based on physical/chemical properties, soil flushing with surfactants was found to be applicable for dieldrin at concentrations up to 1,000 milligrams per kilogram (mg/kg), aldrin up to 10 mg/kg, and dicyclopentadiene (DCPD) up to 10 mg/kg (Rixey 1990). Removal efficiencies for PAHs, which have a range of physical/chemical properties similar to dieldrin, aldrin, and DCPD, were approximately 70 percent in a field test of in situ soil flushing (Rixey 1990). Compounds that are more soluble and less strongly adsorbed to soil than aldrin, dieldrin, or DCPD are likely to be removed more efficiently under similar conditions.

Table 12.1-3 provides soil flushing performance data from other sites where it has been used. Removal efficiencies at these sites range from 60 to 95 percent. COCs removed included VOCs, PAHs, PCBs, and metals. No soil flushing applications were found for the removal of OCPs.

12.2 SOLVENT EXTRACTION

Solvent extraction is a direct physical/chemical treatment process that uses solvent solutions to leach hazardous components from contaminated material. The process described here uses organic solvents to leach organic contaminants from contaminated material. The contaminated material is placed in contact with an immiscible solvent for which the contaminants have a high affinity. The contaminants are removed from the contaminated material and concentrated in a solvent solution. The previously contaminated material is now clean, which minimizes the amount of contaminated material requiring disposal. The process involves three basic steps: feed pretreatment, solvent washing, and solvent recovery. It produces a sidestream consisting of solvent containing concentrated contaminants that must be further treated.

Solvent extraction was screened out of the selection process in the DSA (EBASCO 1992). It was removed based on the available information that it might not be able to meet PRGs, full-scale equipment was not available, and it was more expensive than other appropriate technologies such as low temperature thermal desorption. After completion of the DSA, the Army performed a pilot-scale solvent extraction treatability study using the BEST solvent extraction process. Results of this treatability study showed that PRGs could be met after multiple batch extractions. Additional recent commercial and EPA site program experience by Resources Conservation Company (RCC), the vendor that markets the BEST technology, has indicated that this technology could become viable at full-scale. Accordingly, solvent extraction using the BEST technology has been reintroduced into the screening process. The following discussion of solvent extraction is based on the BEST process.

The BEST process uses TEA as a solvent. TEA is ineffective as a solvent below a pH of 10.5. To effectively use TEA, the feed material is adjusted to a pH of 11 or greater. This requirement for a high pH makes this technology appropriate for organic-contaminated material that is also contaminated with Army chemical agent. The high pH hydrolyses the Army agent products in a manner similar to caustic washing. The other property of TEA is that it is miscible with water at temperatures below 20°C, but when heated it separates into an immiscible phase.

12.2.1 <u>Process Description</u>

Figure 12.2-1 provides a schematic of the solvent extraction process. The process starts by taking excavated soil and screening them to remove debris and oversized materials. The oversized material is fed to a size reduction unit as described in Section 4.4.1 and then back into the feed stream. Maximum size of the feed material is 1/2 inch in diameter. The feed is then mixed and agitated with refrigerated TEA solvent in a washer/dryer mixer vessel. Because TEA can be ionized at a pH of less than 10.5, the pH of the contaminated soil is tested and if necessary NaOH is added to raise the pH to 11 to prevent ionization of the TEA. In the ionic form, TEA is nonvolatile and cannot be recovered from the soil process product phase.

The washer/dryer is typically a horizontal steam-jacketed vessel with rotating paddles. For the first extraction, organic contaminants and water in the vessel dissolve in the cold TEA, creating a homogeneous single-phase mixture. As the solvent breaks the oil/water/solids bonds in the waste, the solids are released and settle to the bottom of the vessel. The solvent/water mixture is removed to a second vessel and heated. As the temperature increases, the water separates from the TEA solvent, which retains the organics, resulting in a two-phase mixture. The solvent is then decanted. Decanted TEA is sent to a stripping column where the contaminants are separated from the TEA and the TEA is recycled to the washer/dryer mixing vessel. The water is sent to another stripping column to remove any residual TEA. The product water is later added back to the treated soil to return them to their pretreatment moisture content. Subsequent extractions are conducted at elevated temperatures to keep the TEA in the nonwater soluble form, which improves the removal of organic contaminants.

Several extractions are necessary to obtain the desired contaminant removal. Once contaminant removal is achieved, product materials are adjusted back to neutral pH and sent for backfill. The BEST process does not have a residual fine soil fraction, so all fines go back with the treated soil and are used as backfill. The residual TEA with the concentrated contaminants is sent for off-site disposal.

Costs for this technology include feed preparation of screening and size reduction, pH adjustment to basic conditions, solvent extraction, solvent recycle, pH adjustment back to neutral, and product oil side stream treatment. Costs are based on the use of nine extraction steps. Costs were developed by RCC and are based on data from the RMA pilot-scale solvent extraction treatability study and full-scale systems designed by RCC (HLA 1994). These costs are based on a scenario of treating 842,000 CY of material. Total capital and operating costs are

$35.50/CY and $144.54/CY, respectively, and are shown in Table 12.2-1. Full-scale costs for solvent extraction would also include materials handling prior to treatment as discussed in Section 4.4.1.

Due to the proprietary nature of the process, RCC was reluctant to provide detailed cost backup. Results of the BEST EPA SITE Program test will be available shortly and will be used to adjust these costs if necessary.

12.2.2 Process Performance

Bench-scale and pilot-scale testing conducted at RMA (HLA 1994) evaluated solvent extraction utilizing the BEST process. Soil tested was collected from South Plants, Basin A, and Basin F. Analytical results indicate that solvent extraction is a potentially effective treatment process that can achieve the PRGs, although five to nine extraction cycles were required to achieve PRGs. Basin A soil required more cycles than Basin F and South Plants soil. The removal efficiency of the BEST process for OCPs range from 99.79 to 99.99 percent in the pilot studies (HLA 1994).

Contaminant mass balances for OCPs were calculated for the soil treated. Mass balance closure ranged from 120 to 310 percent for Basin F soil, 50 to 240 percent for South Plants soil, and 40 to 300 percent for Basin A soil. The larger deviations from 100 percent could have resulted from overall variability in influent soil as well as differences in method protocol.

Because of different characteristics, Basin A soil was processed by using a different approach than for Basin F and South Plants soil; cold solvent was used for the extraction and a solids settling time of 30 minutes, followed by centrifugation of fine solids, was required. Treatment of Basin F and South Plants soil involved an initial extraction step at 160°F and a solids settling time of 15 minutes.

The OCP concentrates produced by the solvent extraction were 14 lbs per ton, 6 lbs per ton, and 11 lbs per ton, respectively. This residual would require subsequent treatment.

Residual TEA concentrations were less than 200 mg/kg after testing and were further reduced a month later. The proposed treatment is off-site incineration.

Although not tested in the treatability study, the caustic pretreatment of the feed materials is expected to be an effective mechanism of treating agent-contaminated soil. The pH and materials retention time at that pH can be adjusted to meet Army 3X decontamination procedures. The caustic solution consisting of NaOH and water will be miscible with the TEA in the first extraction cycle. When the solution is removed from the first extraction cycle, water-soluble products of agent hydrolysis are also expected to be removed. These water-soluble products will be separated in the decanter and water stripping column and can receive further treatment if necessary. The remaining feed materials can be subjected to additional solvent extractions to remove remaining organic contaminants.

The system was designed with a step to adjust product materials pH back to neutral. However, it may be desirable to leave the materials somewhat basic if the final disposition of the materials is to be in a secure landfill and not as a growth media. Specifically, if metals are present that have a lower solubility at high pH, it may in fact be preferable to leave the product materials at a somewhat higher pH than they were originally.

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Rixey, William

1990 Soil Flushing with Surfactants, Shell Development Presentation. July 25, 1990.

RREL (Risk Reduction Engineering Laboratory, EPA)

1991 (November) Resource Conservation Company (BEST Solvent Extraction). SITE Technology Profile. EPA/540/5-91/008.

SAIC (Sciences Applications International Corporation)

1985 Treatment of Contaminated Soils with Aqueous Surfactants, EPA/600/2-85/129.

Table 12.1-1 Capital and Operating Costs for Soil Flushing

Description	Cost
Capital Cost	
Sprinkler System	$331,000
Groundwater Treatment System	$3,020,000
Total Capital	$3,350,000
Operation and Maintenance Cost	
Soil Flushing System Operation (Labor)	$1.15/BCY
Surfactant	$79.24/BCY
Effluent Treatment	$3.92/BCY
Total Operation and Maintenance	$84.31/BCY

This cost was based on Alternative AC-8/AT-2 Dewatering, Stripping/Sorption for soil flushing groundwater extraction from the water DSA (EBASCO 1992).

Table 12.1-2 Physical Properties Pertaining to Soil Flushing for Contaminants of Concern at RMA

COCs for Soil Flushing	Organic Carbon Partition Coefficient[a] Log (K_{oc})	Solubility[b] (mg/l)
Organochlorine Pesticides (OCPs)		
Aldrin	4.67 (High)	0.021 (Low)
Chlordane	5.15 (High)	0.13 (Low)
Dichlorodiphenytrichloroethane (DDT)	5.48 (High)	0.002 (Low)
Dieldrin	3.86 (High)	0.084 (Low)
Endrin	3.87 (High)	0.082 (Low)
Isodrin	4.58 (High)	0.17 (Low)
Metals		
Arsenic	–	Insoluble[c]
Chromium	–	Insoluble[c]

COCs identified for Basin A Medium Group

[a] Low = <2.4 Moderate = 2.4 to 3.6 High = >3.6

[b] Low = <50 mg/l Moderate = 50 to 10,000 mg/l High = >10,000 mg/l

[c] Some salts and compounds are soluble.

– Information not available

Data from Table E.2-1, Proposed Final Remedial Investigation Summary Report (EBASCO 1991)

Table 12.1-3 Summary of Soil Flushing Results from Other Sites

Site	Primary Contaminants	Process/Scale	Results
U.S. Aviex Michigan Superfund Site	TCA, TCE, PCE, benzene, toluene, xylenes, and diethyl ether	Record of Decision	Soil flushing of 11,500 cubic feet of soil. No DRE information currently available.
South Cavalcade Street Texas Superfund Site	VOCs, BTEX, PAHs, lead, chromium, and arsenic	Record of Decision	Soil flushing of 10,500 cubic yards of soil. No DRE information currently available.
LA Clarke and Sons Superfund Site	Benzene and creosote	Record of Decision	Flushing of subsurface soils underlying buildings. No DRE data currently available.
Goose Farm Ocean County, New Jersey Superfund Site	VOCs, SVOCs, and PCBs	Record of Decision	Flushing selected as preferred remedy. No DRE data currently available.
Texas Research Institute	Gasoline	Column and large-scale study	80% removal during column study and 60-80% removal during large-scale study.
EPA	Crude oil and PCBs	Column study	Crude oil removal of 79-94% removal. PCBs removal of 60-90%.
CH2M Hill	Creosote	Column and field tests	95% removal during the column test and 67% removal during the field test.
Volk ANG Base[A]	Jet fuel and breakdown products	Column and field tests	Column studies were promising but in situ flushing of fire training pit using surfactants was not successful because of "short-circuiting" of flushing solution.

[A] Mason. 1987. Field Studies of In Situ Soil Washing Prepared by: James H. Nash, Mason and Hanger Silas Mason Co., Inc. Prepared for: Hazardous Waste Engineering Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

Table 12.2-1 Capital and Operating Costs for Solvent Washing

Cost Category	Cost Item	Cost Estimate	Description
Capital Costs	Solvent Extraction		Source: 1
	Equipment	26.98/CY	
	Mobilization	8.52/CY	
	Total Capital Cost	$35.50/CY	
Operating Costs	Solvent Extraction	$16.22/TON	Source: 1
	—Utilities	$22.00/TON	
	—Maintenance	5.00	
	—Labor	10.00	
	—Materials	11.00	
	—Analytical	8.00	
	—Margin	10.00	
	—Miscellaneous	2.00	
	—Technology Fee	9.00	
	Sidestream Treatment	$8.57/TON	Source: Vendor quote for off-site destruction
	Total Operating Cost	$144.54/CY	

Sources: 1) Harding Lawson Associates. 1994 September. Draft Final Technical Report. Pilot Scale Solvent Extraction Treatability Study, Rocky Mountain Arsenal, Commerce City, CO.

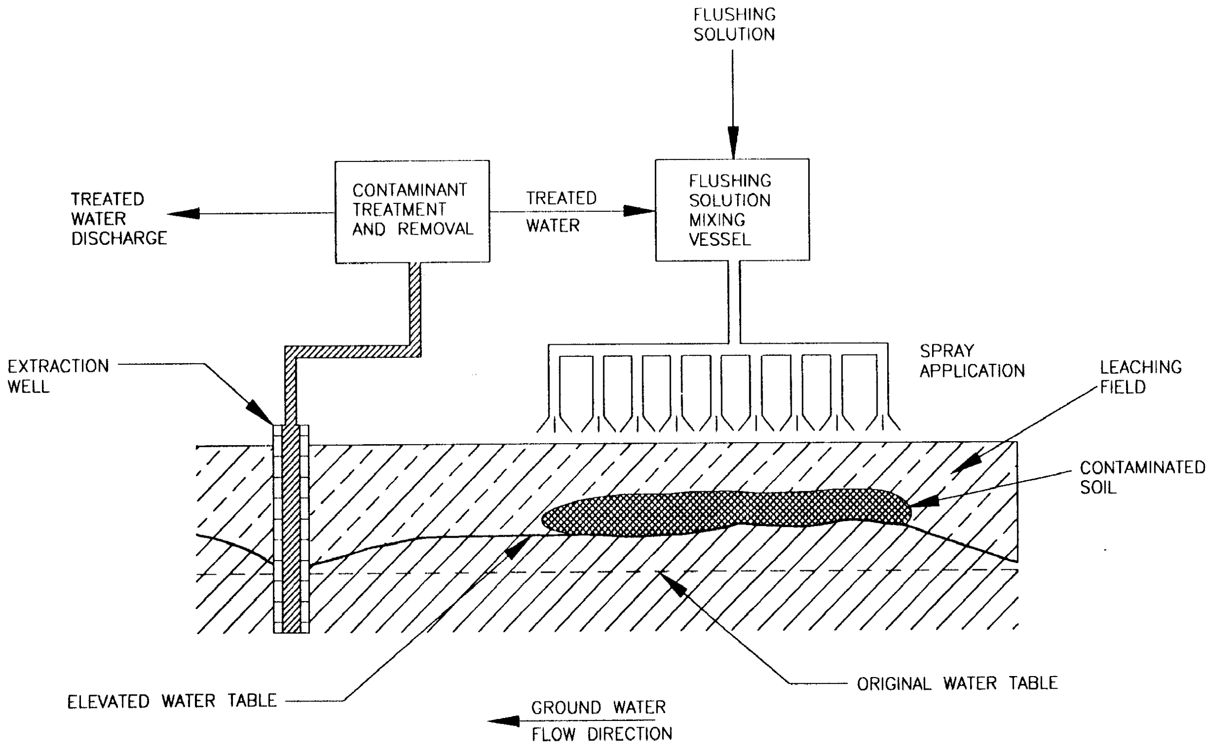

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FIGURE 12.1–1

In Situ Soil Flushing Schematic

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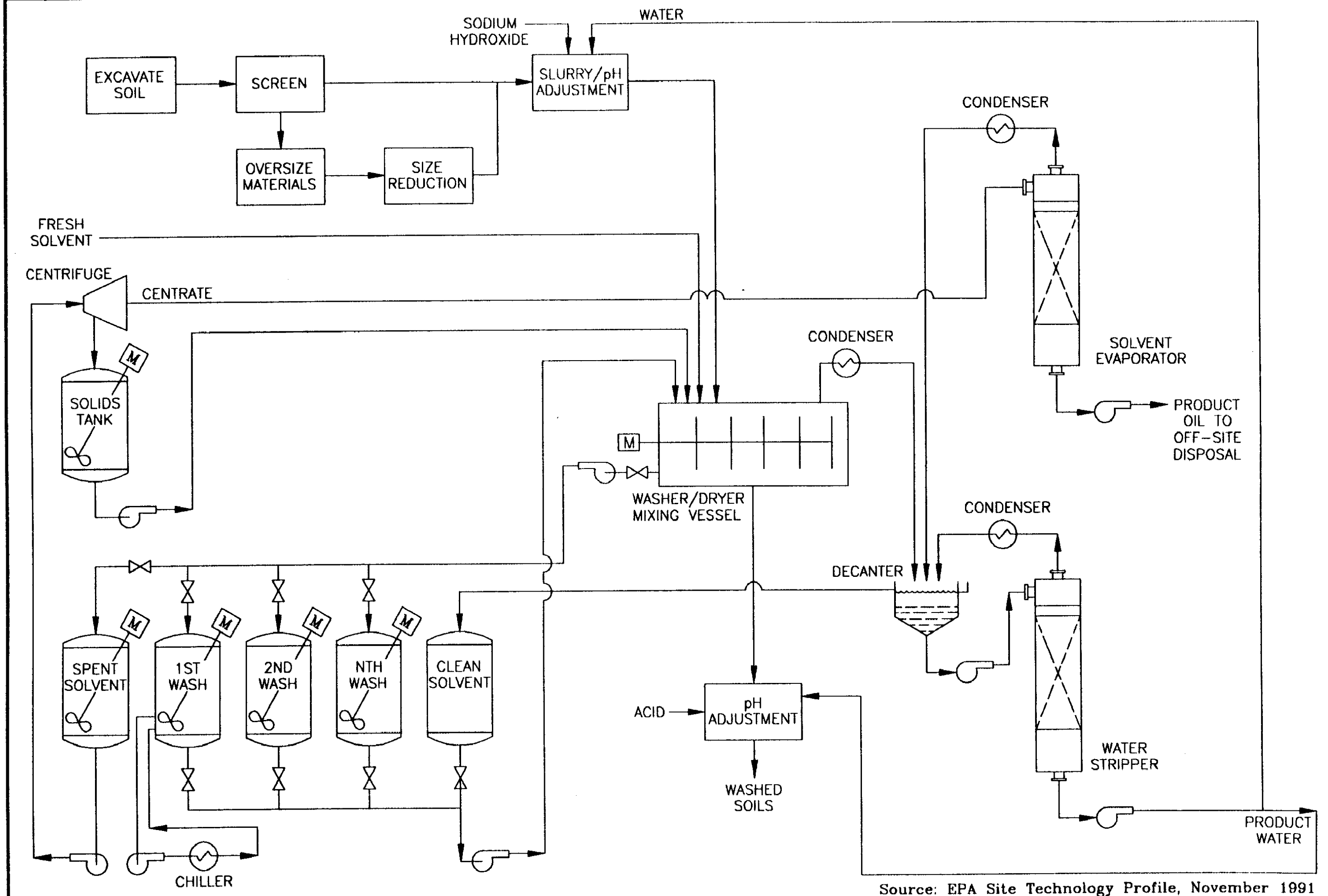

Source: EPA Site Technology Profile, November 1991

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FIGURE 12.2-1
Schematic of the TEA-Based Solvent Extraction Soil Process

Prepared by:
Foster Wheeler Environmental Corporation

Section 13

13.0 STRUCTURES-UNIQUE PROCESSES

This section details the technologies that are unique to the structures medium, which include the following:

- Pipe plugging
- Vacuum dusting
- Sand blasting
- Steam cleaning
- Salvage

All of these technologies comprise part of remedial alternatives that were retained in the DSA for further consideration in the DAA. Pipe plugging, discussed in Section 13.1, is a containment option in which pipes are filled with grout to immobilize contaminants and prevent contaminant migration. Sections 13.2 through 13.4 describe physical, in situ treatments for structure materials which include vacuum dusting, sand blasting, and steam cleaning, respectively. Section 13.5 describes different salvage options for structure materials, piping, and tanks. Salvage provides a means to minimize waste and reduce the cost of disposal. The action-specific ARARs associated with each of these processes are contained in Appendix A of this volume. Process descriptions and cost information were supplemented with vendor contacts and support materials referenced at the end of this section.

13.1 PIPE PLUGGING

This process option consists of filling the interior of pipes with grout. The purpose is to eliminate this contaminant migration pathway and immobilize contamination within the pipe, reducing its mobility. The technique involves using a mobile grout plant to mix and inject the plugging material into the pipe. The pipes to be plugged are first drained of any residual liquids, and any fittings that block the grout are cut from the pipe run. Aboveground pipe sections are cut into manageable lengths of 100 ft for diameters up to 12 inches and 50 ft for diameters up to 36 inches. The grout is pumped into the pipe run from the low end until it exits the high end, which is closed once grout starts coming out. The lower end is then closed off, and the grout is allowed to harden. Pumping grout from the low- to high-end helps to prevent the formation of voids.

The process of grouting is widely employed in a variety of construction applications. The most common use is in geotechnical applications to reduce water seepage beneath dams and to enhance the stability of foundation subgrades. Grouting has wide applications in water well construction, in which techniques similar to this process option are applied.

13.1.1 Process Description

The pipe plugging system to be used at RMA is fully portable and self-contained. It consists of a gasoline-powered portable grout plant, water tank, wastewater tank, grout hose, valves, and rubber plugs to cap the ends of the treated pipe, cutting tools, electric generator, and movable containment structures. The grout is a nonshrink Portland cement mix due to its wide applicability and availability.

The majority of the operation takes place in the vicinity of the pipe to be plugged; activities thus take place within standing buildings and under enclosed space conditions. To avoid breathing hazards, the grout plant and the electric generator are operated outside the enclosed space, and health and safety monitoring is performed during draining and placement operations to detect the presence of contaminants.

The containment system, consisting of a 55-gallon drum or larger portable tank in a secondary containment, is set up to catch any overflow from the pipe being plugged. It is sized to contain 1.5 times the pipe volume to allow for complete failure of the pipe or plug once the pipe has been filled with grout. The containment system provides a backup for the pipe draining effort, which collects and contains any residual liquids from the pipe for subsequent treatment at the CERCLA Wastewater Treatment Plant or equivalent on-post treatment.

This process was retained for the No Future Use, Significant and Other Contamination History Groups in order to isolate specific pipe runs within these structures.

13.1.2 Process Performance

The pipe runs are selected for treatment based on their potential contaminants, which could include acids, bases, pesticides, and herbicides. Pipe plugging is an effective method of reducing the mobility of residual contamination in pipes.

The process is potentially less effective on oils and greases because these substances may interfere with the chemical reaction that causes the plugging material to set or harden. Strongly alkaline or acidic environments are also likely to reduce the effectiveness of the process, although plugging material composition can be adjusted to account for some of these conditions.

The pre- and posttreatment requirements for pipe plugging are minimal. Before treatment, the condition of the structure, the pipes, and the physical hazards associated with the structure should be reviewed to ensure the safety of the workers. Also, it may be necessary to brace pipe fittings to support the additional weight of the grout and to drain residual liquids in the pipes prior to plugging operations. Following treatment, the piping runs are monitored and maintained on a regular basis.

Major waste sidestreams include residual liquids drained from pipes, the first bit of grout from the placement process, and pipe valves and other obstructions that are removed because the grout cannot pass. Minor waste sidestreams include water used to clean equipment (grout plant, grout hose, containment structure), and normal PPE and decontamination wastes. No air emissions are expected from this process.

A crew of two can operate the grout plant and prepare the pipe for plugging. With the required health and safety and foreman support, it is generally economical to operate two to four crews at once.

The grout plant used for this example was assumed to be the Chem Grout Model CG-555 with the L4 pump. This unit mixes and pumps four sacks of grout a minute at a maximum pressure of 225 pounds per square inch (psi) (Chem Grout 1992), resulting in maximum production rates. The proposed grout mixture consists of 11 pounds of water for every 50-lb sack of grout, which generates 0.45 cubic foot of pipe-plugging material (Quikcrete 1992).

The pipe plugging unit costs are entirely O&M costs, and depend on the pipe diameter. For pipes with 2-inch diameter or less, the O&M cost is $10,049.64/CY of pipe volume. Between 2 and 6-inch diameter, the O&M cost is $2,138.07/CY. Above 6-inch diameter, the O&M cost is $681.08/CY (Table 13.1-1).

13.2 VACUUM DUSTING

Vacuum dusting is the physical removal of dust from a structural surface using air suction. This process can be applied to practically any surface but only removes contaminants that are associated with the surface dust. This process does not remove any of the structural surface material. Vacuum dusting is most effective when used in conjunction with another in situ treatment process such as sand blasting, which physically loosens surface particulates.

13.2.1 Process Description

The vacuum dusting system selected for use at RMA includes a portable, self-contained vacuum-drum loading system equipped with a dual filtration system that allows three 100-ft hoses to be attached to the same vacuum. A high-efficiency particulate air (HEPA) filtration system capable of filtering particulates to a 0.3-micron size with 99.97 percent efficiency is used to remove the dust, which is loaded into drums. Fouled primary filters are cleaned using a small amount of water that is treated on post by existing systems. Vacuum dusting with reusable filtration systems has been effective in the removal of asbestos and contaminated materials from structural surfaces (Vactagon 1993).

Vacuum dusting can be an effective decontamination technique for structure material and equipment at RMA. This process was retained for the No Future Use, Significant, and Other Contamination History Groups.

13.2.2 Process Performance

Vacuum dusting provides an effective, permanent reduction of contamination associated with removable dust on structural surfaces. The major limitation of vacuum dusting is that it only removes particulates not bonded to the structural surface. In addition, contaminants can be released from the surface and escape the vacuuming system. If needed, the process can be modified through water misting as a dust control measure or by using sand blasting and steam cleaning in conjunction with this process.

A water mist may be needed as pretreatment to control dust emissions from the surface and to allow better removal of contaminants that may physically adhere to the water particles. Once the vacuum dusting is completed, the filters need to be cleaned and the extracted contaminants properly drummed and disposed.

Waste sidestreams generated by vacuum dusting are fugitive dust and spent filters. The spread of fugitive dust can be minimized by closing off the room or structure. Vacuum dusting equipment must be properly decontaminated and the filters and collected materials/contamination/debris drummed to ensure proper disposal of all collected wastes.

Capital costs for the vacuum dusting treatment include the purchase of a vacuum unit, drums, drum loader, two 50-ft-long hoses, and new HEPA filters[1], and operations and maintenance costs include labor, additional filters, additional hose, and sampling (Table 13.2-1).

[1] The recommended vacuum system has a primary filter that is easily cleaned using water; therefore, HEPA filters are changed less frequently.

13.3 SAND BLASTING

Sand blasting is an in situ treatment process consisting of the physical removal of contaminated surfaces via abrasion. This treatment is becoming more common in the hazardous waste remediation industry and is capable of reducing materials waste and operations cost through the use of a recycling system.

Sand blasting (sometimes called gritblasting) is a mechanical-scour surface removal technique in which an abrasive such as sand or steel pellets is used to uniformly remove layers of superficially contaminated structural material (Battelle 1983). Abrasive materials are propelled at sufficient velocity by a fluid stream or air pressure to scour the surface to be treated. The nature and degree of treatment are controlled by the size of the shot used, operating pressures, and exposure time.

Sand blasting is effective as a surface treatment for a wide range of materials but only at depths less than 1/8 to 1/2 inch (Battelle 1983). Minimal damage is done to the abrasive material during the process, and it may be reused after decontamination. Because the abrasive is sprayed, sand blasting is used for many hard-to-reach areas. However, corners may not be sandblasted as effectively as flat surfaces (PEI 1985). The removed surface and spent abrasive are collected immediately following impact through an integrated vacuum and recycling system. Following the collection of spent abrasive and contaminated debris, composite samples of the product need to be taken to characterize the waste for disposal.

Sand blasting is a well-known and frequently used technique. It has been used extensively throughout industry since 1870 to remove surface layers from metallic and ceramic surfaces. For example, sand blasting is commonly used to clean the surfaces of old brick and stone buildings, similar to those at RMA (PEI 1985). Sand blasting may be applied to most materials except glass, transite, and Plexiglas (PEI 1985). The method may be used for most surface contaminants except asbestos and some highly sensitive explosives.

13.3.1 Process Description

The sand blasting system proposed for RMA includes an air compressor, pressure lines, sand pot, blast gun, abrasive, a recycling system, and HEPA filters. The specific sand blasting units that are recommended for this type of treatment are equipped with a vacuum collection system and a recycling apparatus, which enables the reuse of the abrasive after separation from the contaminants within the recycling unit filtration systems. The recycling units are mounted on a trailer for full mobility between sites. A typical recycling sand blasting unit can treat 45 square feet per hour (SF/hr) (for removal of 0.6 centimeters [cm]), which requires the use of 40 lbs of abrasive per hour to replace the degenerated shot. This produces an estimated 18 cubic inches of concrete debris and abrasive per square foot treated. Used HEPA filters and debris from treatment are considered hazardous and disposed appropriately.

This process was retained for the No Future Use, Significant and Other Contamination History Groups.

13.3.2 Process Performance

Sand blasting effectively and permanently reduces surficial contamination through the removal of the top 1/8 to 1/2 inch of a surface. Residual subsurface contamination may remain if it was initially below the treatable depth limit. Sand blasting with recycling of shot has been routinely performed nationwide on structure materials (LTC 1993). Contaminants have been removed using this technology from concrete, metal, and other structure materials. Removal of hazardous substances has been demonstrated with pesticides, lead-based paints, petrochemicals, oil, and other related wastes.

Sand blasting is not applicable to wood, glass, transite, and Plexiglas surfaces. Sand blasting is only effective for surface contamination; deep contamination must be treated with a more aggressive method. In addition, the mobility and volume of particulate contaminants may be increased prior to separation/filtration, though this can be addressed using a vacuum recycling system and trained labor to accomplish the treatment task.

Pretreatment requirements for sand blasting include analysis of contamination or chemical sampling to determine contaminant types, structural material evaluation to ascertain treatability of materials (e.g., wood is untreatable), and the transport of the treatment system to the specific site. Post-treatment requirements may require sampling of the treated structure, a complete check of the sand blasting system filter for fouling, and the replacement of grit degenerated in the scouring process.

The sidestreams generated by sand blasting, which include contaminated aggregate dust and debris, are controlled primarily by a recycling system that vacuums the spent grit and debris and separates the two materials using HEPA filters (0.3 microns, 99.97 percent efficient). Sand blasting equipment that recycles grit minimizes air sidestream contamination.

Capital costs for sand blast systems consist of purchasing the sand blasting units and three 100-ft hoses and the initial cost of aluminum oxide abrasive. Seven units are required to meet schedule requirements. Operations costs other than labor are based on the materials required to replace degenerated abrasive and rental costs for a 350-cfm compressor. Unit process costs given are based on treatment of 45 SF/hr (Table 13.3-1).

13.4 STEAM CLEANING

Steam cleaning is an in situ, physical removal process that extracts contaminants from building materials, equipment surfaces, and debris using heated water applied under pressure (PEI 1985). Steam is generated using oil, gas, or electric-fired generators and is applied to the surface through either a manually operated hand-held wand or automated spraying system. The condensate containing the removed contaminants is collected in existing or temporary sumps and is either treated on site and reused or disposed.

Steam cleaning is only effective for surface decontamination (PEI 1985). Contaminants are removed from the surface by the physical action of the steam or by solubilization of the contaminants into the steam. Systems can be designed to inject sand or other abrasive materials into the water stream to enhance surface removal. In addition, solvents or cleaning solutions can be added to enhance solubilization. The materials to be treated must not have a tendency to absorb water because this causes the contamination to migrate deeper into the material. In general, metal and concrete surfaces are more amenable to steam cleaning than wood.

13.4.1 Process Description

The steam cleaning units proposed for use at RMA are fully self-contained and mobile. The pressure washer, hoses, reel, utilities, and water supply tank are all to be mounted on a trailer that may be easily moved between structures. Discharge from steam cleaning units ranges from 3.5 to 10.2 gpm. For cost and waste stream estimating purposes, it was assumed that the unit discharges approximately 5.2 gpm. Given this rate of discharge, approximately 3 gallons of wastewater is generated per square foot of material treated. Assuming 20 percent evaporates, 2.4 gallons need to be collected per square foot of surface material treated. Steam cleaning units require 200 to 600 gallons per hour of process water. The amount of raw water needed is reduced by approximately 75 percent using a water treatment and recycling system. In general, chemicals added to the steam to enhance removal typically constitute less than 2 percent of the waste stream by volume.

Condensate collection systems need to be designed for each application, although existing sumps are used to the fullest extent possible. The condensate is treated on post using a mobile, trailer-mounted water treatment system. An on-post treatment system is desirable because it minimizes the amount of water used and the volume of waste created. A typical on-post treatment system for process water consists of a multimedia filter, polyester cartridge filter (available with retention to 5 microns), and GAC. The treated water is returned to the pressure washer for reuse.

In addition to treating areas of intact structures, steam cleaning can be used for cleaning large sections of structure materials that have been segregated and positioned over a central treatment area. This is most efficient for structures that are thought to have widespread contamination;

however, for localized contamination, in situ steam cleaning prior to structural demolition is recommended.

Steam cleaning is considered an effective decontamination technique for structural material at RMA. This process was retained for the No Future Use, Significant, and Other Contamination History Groups.

13.4.2 Process Performance

Steam cleaning is an effective in situ treatment for structure materials providing the materials are not porous enough to allow the steam to drive contaminants deeper into the material. In fact, steam cleaning with detergents on porous materials can reverse the decontamination process and force the contamination deeper into the surface. The use of a portable water treatment system removes contaminants from the condensate and minimizes the waste stream. Results from other sites substantiate that steam cleaning is a proven, reliable technology (Landa 1992). Equipment is readily available from many manufacturers.

Regular periodic inspections of filtration systems and materials are required in order to ensure that contamination is not spread by fouled filters. The contaminants most likely associated with structure materials at RMA are pesticide residues and metals, both of which can be removed by steam cleaning. However, an entire structure could not generally be decontaminated using steam cleaning due to the inapplicability of this process to many structure materials.

A condensate collection system must be designed for each application. The condensate is then treated on post using a mobile, trailer-mounted water treatment system. Post-treatment involves disposal of all collected materials as hazardous waste.

The capital and operating costs for steam cleaning (Table 13.4-1) are developed from vendor quotations (Landa 1992) and are compared with costs from Means (1991). Capital costs for steam cleaning systems consist of the cost for the portable treatment system and for each steam-cleaning unit. Four units are required to meet schedule goals. Operating costs for this alternative include labor, water, and treatment system costs as well as equipment maintenance and replacement filter costs.

13.5 SALVAGE

Salvage consists of recycling scrap metal, process equipment, and piping. It represents an opportunity to reduce disposal costs and minimize waste streams. Materials that are salvaged in these alternatives include metal structure materials (rebar, support beams, etc.) and process equipment and piping.

13.5.1 Process Description

On-Post Demolition/Dismantling and Salvage

On-post demolition/dismantling and salvage involves the physical demolition or dismantling, sizing, and separation of scrap metals on post. In addition, salvage includes the recycling of any metal materials that are stockpiled in "boneyards" on post. All metal materials are salvaged through the Defense Reutilization and Marketing Office (DRMO). Metal materials may either be resold to salvage companies, recycled on or off post, or redistributed to Army facilities.

The salvage option was incorporated into all of the alternatives for the No Future Use, Significant, and Other Contamination History Groups. It is assumed that all process equipment, piping, and tanks are removed from the structures, decontaminated, and stockpiled under the ongoing chemical-process-related activities. All of these stockpiled materials will be salvaged. The volume of this material was reduced by 20 percent to account for wasteage. For the Agent History Subgroup, salvage is not applicable due to the high cost of achieving 5X decontamination as required by AR 385-61 and DA PAM 385-61 (Army 1985, 1992).

13.5.2 Process Performance

Salvage of metal will minimize transportation, disposal costs, and materials waste streams at RMA, although it requires effort to size and separate the demolition/dismantled materials, which subsequently raises project costs.

Treatment requirements prior to the salvage of structures include disconnection of utilities, removal of any processing equipment, and review of chemical use history or sampling to determine the level of protection required for site workers and the most applicable decontamination treatment.

The salvage option will not generate waste streams because only noncontaminated metals or equipment from Non-Process History structures will be considered salvagable. Aggregate materials will be used as biota barriers only if they are uncontaminated.

Air sidestreams generated by this option exist as a result of demolition, sizing, separation, and transportation activities. This contamination can be addressed through the use of dust suppressants, equipment covers, and enclosure of processes from which dust has a good chance of escaping suppression methods. Air emissions need to be monitored continuously in order to ensure public and worker safety. The current price for scrap metals salvaged through DRMO is $25.00 per ton.

Capital and operations costs for salvage of metal materials at RMA are highly dependent upon the types of equipment, labor, treatment, and salvage options implemented.

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Table 13.1-1 Capital and Operating Costs for Pipe Plugging

Pipe Size	Description
≤ 2"	\$9,960/CY@5% of total volume[1]
> 2" and < 6"	\$2,119/CY@55% of total volume[1]
≥ 6"	\$678/CY@40% of total volume[1]

Sources:
1) Venor quotes

Table 13.2-1 Capital and Operating Costs for Vacuum Dusting

Item Description	Capital Cost	O&M Cost	Description
Vacuum Dusting	$0.03/SF[1]	$0.78/SF[1]	Assumed to apply to the floors and 5 ft up the interior walls of the structures.

Note: 1) Vendor quotes

Table 13.3-1 Capital and Operating Costs for Sand Blasting

Item Description	Capital Cost	O&M Cost	Description
Sand Blasting	$0.42/SF[1]	$3.61/SF[1]	Assumed to apply to floors and 5 feet up the interior walls of structures.

Note:
1) Vendor quotes

Table 13.4-1 Capital and Operating Costs for Steam Cleaning

Item Description	Capital Cost	O&M Cost	Description
Steam Cleaning	\$0.29/SF[1]	\$2.58/SF[1]	Assumed to apply to nonporous floors and 5 feet up nonporous interior walls in structure.

Note:
1) Vendor quotes

Section 14

14.0 WATER/LIQUID SIDESTREAM TREATMENT

Several treatment technologies were retained for treatment of groundwater at RMA. Treatment is needed primarily for VOCs, dibromochloropropane (DBCP), pesticides, and, potentially, inorganic constituents such as fluoride and arsenic. Technology types retained for treatment of organic compounds are phase transfer, sorption, and oxidation, and the technology type retained for inorganics treatment is sorption. This section includes descriptions of process options that were chosen to be representative of the technology types. The oxidation technology type is represented by ultraviolet (UV)/ozone/H_2O_2 oxidation, which is discussed in Section 14.1. The sorption technology type for organic compounds is GAC adsorption, which is discussed in Section 14.2. Air stripping is the process option representing the phase-transfer technology type and is discussed in Section 14.3.

14.1 CHEMICAL OXIDATION

The chemical oxidation technology type as it applies to RMA includes advanced oxidation processes (AOPs) that utilize combinations of chemical oxidizers and catalysts to destroy organic contaminants present in groundwater. Such processes can be designed to effectively treat most contaminants present in RMA water. The proper combination of oxidants depends on the chemicals to be treated. Oxidation treatability studies for groundwater from South Plants and Basin A have been conducted for the FS (Foster Wheeler Environmental 1995) at WES. Oxidation was retained in the DSA (EBASCO 1992) for alternatives in the North Boundary, Basin A, and South Plants Plume Groups.

14.1.1 Process Description

By combining UV light and/or different oxidants in AOPs, most organic chemicals, including those found at RMA, can be effectively destroyed by oxidation. The proper combination of oxidants depends on the chemical properties of the compounds to be treated; compounds with absorbance maxima in the UV range are typically treated in a process involving UV light, while other compounds may be more effectively treated with ozone and H_2O_2 (Zappi 1993).

Commercial oxidation systems are available for the UV/H_2O_2, UV/ozone, and $UV/ozone/H_2O_2$ processes. The H_2O_2/ozone process is the most recent oxidation technology on the market and commercial reactors have just recently become available.

UV/ozone oxidation is a chemical treatment process that uses ozone to oxidize organic contaminants in the presence of UV light provided by low-pressure lamps. The UV radiation converts the ozone into strongly oxidizing hydroxyl radicals. The radicals then complete the oxidation of the organic compounds. Some organic compounds are easily oxidized by ozone while other compounds require UV irradiation to create the stronger oxidizing radicals (Sundstrom et al. 1989). The chemical bonds in some organic compounds are destroyed or weakened by the UV radiation. For UV/ozone oxidation, the contaminated water is treated in a reactor containing UV lamps encased in quartz tubes where ozone is added through an air sparging system. Gaseous ozone emissions are destroyed by an ozone destruction unit prior to release. Typical reaction retention times range from 20 to 40 minutes.

The $UV/ozone/H_2O_2$ system that is commercially available is basically the same as the system described above, except that peroxide is added to further improve the oxidation. This system also uses the least powerful low-pressure UV lamps and has an ozone destruction unit for emission control.

The UV/H_2O_2 systems available utilize more powerful, medium-pressure UV lamps that more effectively catalyze the oxidization of UV-sensitive compounds such as chloroform. H_2O_2 is added to the reactor containing the UV lamps. This system has insignificant vapor emissions compared to an ozone-based system and emission control is typically not required.

The most important factor in the operation of a UV-based system is the UV lamps. These lamps are very sensitive to fouling caused by hardness-causing compounds and iron and manganese precipitation. Frequent lamp cleaning or pretreatment may be needed if the levels of such compounds are high. Examples of pretreatment include extensive filtration and preoxidation/precipitation. Most UV systems have an automated lamp wiping mechanism to prevent buildup of scale on the lamps. UV lamps are the major cause of operations problems and are the major contributor to operation costs as well as capital costs of oxidation systems. There is a cost and operational trade-off between extensive pretreatment and allowing some fouling of the UV lamps. Pretreatment processes that are based on precipitation generate large sludge volumes that have to be treated and disposed. It was assumed that extensive prefiltration provides adequate pretreatment for RMA and that further interference is dealt with through cleaning of the lamps.

Ozone/H_2O_2 oxidation (also called peroxone) provides a solution to the lamp fouling problem by eliminating the lamps. The ozone and H_2O_2 act on the organic compounds simultaneously. Catalysts such as Fenton's reagent may be added to increase the reaction rate of the ozone/H_2O_2. An ozone/H_2O_2 system consists of an ozone generator, a reactor with an ozone diffusion system, and a H_2O_2 feed unit. Ozone off gas is treated in an ozone destruction unit. Reactor retention times vary according to the required destruction levels and are determined through pilot-scale testing.

Off gas from the UV/ozone or ozone/H_2O_2 reactor is a sidestream requiring treatment in an ozone destruction unit and possibly further treatment of volatilized organic compounds. An ozone destruction unit is typically a heated molecular sieve that breaks down the ozone into oxygen before release to the atmosphere. This unit is generally included in the prefabricated oxidation systems sold by oxidation vendors. Some of the volatiles are volatilized rather than oxidized during the oxidation process. Some of the organic compounds may be destroyed thermally in the ozone destruction unit while certain compounds present at high concentrations, such as chloroform, may require further off-gas treatment.

Treatability studies are necessary to determine the applicability of this technology to particular waste streams. The post-treatment requirements that must be considered for an oxidation system are the treatment of unoxidized or partially oxidized species in the effluent gas or liquid stream.

For species that oxidize less readily, it may be more cost effective to use additional treatment such as air stripping or GAC adsorption. This is recommended for the South Tank Farm Plume and Basin A Neck Plume Group. Oxidized water must be filtered prior to reinjection.

Oxidation systems can be designed to meet groundwater and air emissions standards in addition to action-specific ARARs. The action-specific ARARs that must be considered for this technology are given in Appendix A.

UV-based oxidation systems require high UV lamp maintenance costs, which can account for 20 to 40 percent of the total operations and maintenance costs for the system. Ozone-based systems require ozone destruction units as well as other emission control for VOCs, which may account for as much as 50 percent of the costs.

14.1.2 <u>Process Performance</u>

The effectiveness and limitations of UV/ozone and ozone/H_2O_2 oxidation on the groundwater at RMA have been evaluated through recent treatability studies at WES (Zappi 1993). Several other oxidation treatability studies have been conducted at RMA over the years, a summary of which is presented in Table 14.1-1.

Oxidation, under favorable conditions, achieves DREs greater than 90 percent for most organic compounds, with some as high as 99.99 percent. Treatability studies conducted with RMA groundwater have shown that hardness, iron, and manganese can impede efficiencies by acting as oxidizer sinks and can cause scaling of the UV lamps. Oxidation is applicable to diisopropylmethyl phosphonate (DIMP), DBCP, VHOs, volatile aromatic organic compounds (VAOs) and volatile hydrocarbon compounds (VHCs), and pesticides in RMA groundwater. For complex contaminant mixtures and high concentration levels, it may be cost effective to partially remove the contaminants using oxidation and complete the treatment with other treatment technologies such as GAC adsorption or air stripping. It is known that incomplete oxidation of organic compounds may result in compounds that are more polar and consequently less adsorbable. However, if such intermediates are formed, these compounds are typically of much less concern from a health perspective and are much less likely to exceed acceptable levels.

Studies have shown that the ozone diffuser system may strip volatiles from the aqueous stream instead of oxidizing them. It may, therefore, be necessary to add an emission treatment system in addition to the ozone destruction unit. The use of H_2O_2 decreases the ozone requirement and reduces the stripping effects of the diffusion system. Also, some compounds may not be completely oxidized and their daughter products may require additional treatment.

Zappi (1993) evaluated the treatment of DIMP in RMA groundwater using UV/ozone bench-scale reactors. Treatment times of 4 hours and an ozone feed rate of 2.5 liters per minute (l/m) were required to bring DIMP concentrations down from 70 ppm to the target level of 0.5 ppm (Zappi 1993). Studies completed by Aieta et al. (1988) indicate that ozone/H_2O_2 oxidation is capable of removing recalcitrant compounds such as TCE at comparable rates to UV/chemical oxidation (Zappi 1993).

Presently, UV/H_2O_2 oxidation is being used at the RMA CERCLA Wastewater Treatment Plant. Treatability studies completed prior to design of the system showed that oxidation could be used to effectively destroy some RMA contaminants but that additional treatment would be needed for complex water matrices. Inorganics were not found to be a problem, although reductions in metal ions indicate that some metal oxidation and precipitation took place (WES 1989). Zappi et al. (1990) studied UV/H_2O_2 oxidation of groundwater from different RMA groundwater sources. Water with low concentration levels was effectively treated within 15 minutes. The UV/H_2O_2 system did not perform well for South Plants groundwater with high levels of VOCs and high iron content, which caused fouling of the UV lamps. Hydrazine fuels were effectively treated by this sytem but nitrosodimethyl amine (NDMA) was not.

In a study by Solarchem Environmental Systems (Solarchem), UV energy from proprietary UV lamps was able to effictively reduce concentrations of NDMA to very low levels (Solarchem 1994).

Treatability studies were conducted by WES as part of the groundwater FS for RMA. These studies have shown that UV/ozone and ozone/H_2O_2 oxidation are effective in destroying benzene, TCE, and chloroform in the South Plants and Basin A area plumes, although problems were encountered with the water in the Basin A Plume. The groundwater in this plume contained higher levels of metal ions that interfered with the oxidation process and retarded the oxidation of DBCP. If iron and manganese were pretreated, the organic contaminants were more easily oxidized. The results of the treatability study showed that ozone/H_2O_2 treatment without the addition of UV light was sufficient to oxidize most contaminants, leading to an operations and maintenance cost savings of up to 40 percent of the cost of oxidation based on savings in maintenance and replacement of the UV lamps and quartz tubes (Zappi 1993). However, the results also showed that 50 to 80 percent of the chloroform is volatilized rather than oxidized in ozone-based systems. Oxidation of chloroform can best be achieved by an oxidation system involving UV lamps; volatilization can be minimized by excluding ozonation. The final system selection for each alternative under consideration depends on the relative concentration and significance of each compound. It is typically more efficient to remove chloroform by air stripping than to treat it in an oxidation reactor.

Peroxone systems that utilize combinations of H_2O_2 and ozone seem to have great promise for treating a wide range of contaminants that do not require UV light for destruction. Such systems are not yet commercially available and do not have a performance history for hazardous waste applications.

The most efficient UV-based systems are designed with medium-pressure lamps that, although fairly expensive to maintain, are needed to achieve the desired UV destruction in such systems. UV radiation combined with ozone or H_2O_2 oxidation can be an effective means for completely destroying organic groundwater contamination. Several types of oxidation systems are commercially available. Oxidation effectively reduces the toxicity and volume of organic contamination in groundwater at comparable cost to air stripping with vapor-phase treatment and GAC adsorption. Most of the oxidation systems at RMA are designed as part of an alternative involving additional treatment. The optimal design, therefore, depends on which compounds are most effectively treated by each alternative at a reasonable cost.

14.2 GRANULAR-ACTIVATED CARBON ADSORPTION

GAC adsorption, as presented in this section, refers to the removal of dissolved contaminants from an aqueous stream, although it may also be applied to gaseous streams. In the GAC process, water containing dissolved organic compounds is brought into contact with GAC, onto which the organic compounds preferentially adsorb. The attraction of organic molecules in solution to the surface of the carbon is dependent on the strength of the molecular attraction between the carbon and the organic contaminant, the molecular weight of the contaminant, the type and characteristics of the carbon, the surface area of the carbon, and the pH and temperature of the solution.

The GAC process option can be used as a single treatment technology or as one of a series of treatments designed to optimally address a contaminant mixture in a treatment process train. For treatment of groundwater at RMA, GAC was retained for alternatives addressing the Basin A and South Plants Plume Groups as well as the operating North Boundary, Northwest Boundary, and Irondale systems.

14.2.1 Process Description

GAC is a well-developed technology that is widely used in the treatment of hazardous waste streams. It is well suited for the removal of a wide range of organic contaminants over broad concentration ranges. In general, the adsorbability of organic compounds is favored by high-carbon chain length, high aromaticity, low polarity, low solubility, and low degree of dissociation. Compounds that are readily adsorbed onto GAC include SVOCs such as OCPs, DBCP, and other semivolatile halogenated organics. VHOs and VHCs are not treated as efficiently as the SVOCs but can be removed by GAC adsorption at the cost of high-carbon consumption. GAC adsorption is commonly used for benzene, ethylbenzene, xylene, and toluene (BTEX) compounds that are fairly well adsorbed.

The major contaminants in RMA groundwater targeted for GAC adsorption are chloroform, benzene, methylene chloride, tetrachloroethylene, DBCP, aldrin, chlordane, dieldrin, endrin, and DDT. Of these, all but the chloroform and methylene chloride can be removed efficiently with GAC.

GAC systems are typically operated as packed beds in continuous-flow pressure vessels. The downflow, fixed-bed, in-series configuration is usually more cost-effective and produces the lowest effluent concentrations compared to other carbon adsorber configurations (e.g., downflow in parallel, moving bed, expanded upflow) although the NBCS has recently been changed to an upflow mode. In this configuration, water enters the lead vessel at the top, is collected in an internal underdrain system at the bottom, and is conveyed to the top of the second vessel. During operation, the pressure drop through the lead vessel may slowly increase as a result of trapped suspended solids or compaction of the bed. When the vessel reaches an unacceptable pressure drop (around 35 psi), it must be taken off line and backwashed to remove the clogging particles or to expand the bed. The bed is backwashed upflow for a duration of 25 to 30 minutes at a rate that is dependent on the vessel size. While one vessel is backwashed, the entire flow is diverted to the other vessel.

Eventually the lead adsorber becomes saturated with contaminants, and target effluent concentrations are exceeded. This condition is commonly referred to as "breakthrough." The lead vessel is taken offline and the spent GAC is replaced with fresh GAC (either virgin or regenerated). Spent GAC is displaced into a receiving container by pressurizing the vessel with utility water, and fresh GAC is transferred as a slurry to the empty adsorber via pressure. After the adsorber has been recharged, it is backflushed to evenly distribute the carbon within the vessel and to remove carbon fines. This vessel is then placed in the second-stage position and the former second vessel becomes the lead vessel. Spent GAC is thermally regenerated off post by the carbon vendor. The carbon is then reused.

Some pretreatment for water may be required for the following reasons: high suspended solids concentrations may lead to clogging of the carbon bed; high iron and manganese concentrations, as well as high hardness in the influent, can result in precipitation of solids on the GAC, which in turn results in clogging and fouling of the carbon surface; and precipitation may result when the equilibrium chemical conditions are changed during pumping and storage, which can happen by exposure to air. However, new GAC systems designed for the FS do not include pretreatment other than filtration. The iron content of RMA groundwater is high enough to potentially cause precipitation problems, as is the hardness, but GAC systems currently operating at RMA have not required pretreatment to remove the iron.

Post-treatment is sometimes required to remove suspended solids that can lead to clogging of reinjection wells. Precipitation of iron and manganese in the GAC effluent has caused clogging of reinjection wells at RMA, both due to precipitation onto the well screens and to biological growth associated with the iron and manganese.

14.2.2 Process Performance

GAC can be used for a wide range of water flow rates and concentrations. The size of the adsorbers and the frequency of carbon replacement is determined by the flow rate and the contaminant concentrations. The adsorber vessels must be large enough to provide a minimum hydraulic retention time for the water stream. Carbon consumption is determined by the influent contaminant concentration and the desired extent of removal. The consumption is constant, but the size of the adsorption vessels can be increased to reduce the frequency of carbon replacements.

Contacting vessels are available in sizes that range from small, drum-size units to large tanks that hold 40,000 lbs of carbon. For very large flows, multiple vessels can be connected in parallel to increase capacity.

GAC has been used extensively to treat groundwater at RMA. The NBCS, NWBCS, ICS, South Plants Treatment System, Basin A Neck IRA, and CERCLA Wastewater Treatment Plant all use GAC. Table 14.2-1 describes these treatment systems, the contaminants being removed, and the design flow rates.

All of the boundary systems were reviewed through the IRA program to ensure that they are operating efficiently and achieving treatment goals. As a result, modifications were made primarily to the extraction and injection systems, although some operational modifications were also made to the treatment systems.

Prior to the NBCS Short-Term and Long-Term Improvements IRAs, extracted water from three parts of the aquifer was kept separate so that the most highly contaminated water was treated in one adsorber, the next most contaminated water was treated in another adsorber, and the least contaminated water was treated in the remaining adsorber. After reevaluation the system was modified so that all extracted water is mixed in a single influent sump. The mixed water is then put through two of the adsorbers in series, and the remaining adsorber is available for backup. This results in more efficient use of the carbon.

In addition, the recharge wells at the NWBCS were prone to plugging so that recharge capacity was seriously reduced. It was assumed that the plugging was due to carbon fines in the effluent stream, so recharge trenches were constructed to replace the wells. Recharge was improved, but an investigation of the trenches showed that the presence of iron and manganese and associated biological growth, rather than carbon fines, was still causing some plugging of the recharge system. This demonstrated the need to consider inorganics removal for RMA water in the future.

Operation of the NWBCS was reviewed under the Short-Term Improvements IRA. This system was installed in October 1984 to remove DBCP and dieldrin from groundwater flowing to the northwest in Section 22. Two active adsorbers in parallel and one standby adsorber are used, and each of them contain 40,000 lbs of carbon. As a result of the IRA, improvements were recommended for the extraction and reinjection systems, but the treatment system remains unchanged.

The ICS was also evaluated under the IRA program. This system was originally built to remove DBCP from groundwater moving under the western boundary of RMA. The treatment system uses two adsorbers, each containing 42,000 lbs of carbon, connected in parallel, with a third adsorber available on standby. The plant capacity was increased from 1,400 gpm to 2,100 gpm by utilizing the standby adsorber. This was needed to accommodate increased flow from the Motor Pool and Rail Yard IRAs, which extract water containing TCE and DBCP, respectively. The ICS original extraction wells are currently turned off. Four newly installed extraction wells southeast of the original system (the east row) are pumping approximately 505 gpm. Five extraction wells in the Rail Classification Yard are pumping approximately 265 gpm, and two extraction wells in the Motor Pool area are pumping approximately 100 gpm. The total system flow rate is approximately 870 gpm.

All of the boundary systems have been shown to remove contaminants to acceptable concentrations through the use of GAC. GAC adsorption is the typical choice for dilute streams containing large organic molecules and for low concentrations of VOCs that are not treated as efficiently by other processes.

14.3 AIR STRIPPING

Air stripping is an effective and proven method for removal of VOCs from water. The process involves the removal of volatile contaminants from an aqueous stream by mass transfer through countercurrent contact of the stream with air. Air stripping is a means for transferring the contamination from the liquid phase to the gas (vapor), which requires additional treatment. Air stripping was retained as an alternative in the DSA for the groundwater in the North Boundary, Basin A, and South Plants Plume Groups.

14.3.1 Process Description

The most effective and most economical air stripping system that is being considered for RMA is the shallow tray stripper. The stripper consists of a series of up to four perforated trays stacked on top of one another. Water is introduced at the top of the stripper and flows down from tray to tray while air is introduced at the bottom of the stripper and blown up through the perforations. Each tray includes baffles that channel the water back and forth across the tray, assuring an extended contact time with the air stream on each tray. By maintaining a high air flow rate and by retarding the downward flow of the water, efficient mass transfer can be achieved without the use of the more traditional, tall, and awkward packed tower. The air containing the removed contaminants is emitted from the top and is treated in a vapor-phase treatment system, if necessary, to meet air emissions standards. The liquid effluent leaves through the bottom of the stripper and is further treated or discharged.

Pretreatment requirements for air stripping typically include filtration or water softening to remove hardness-causing compounds. Filtration is required to remove any suspended solids. The pH of the water may also increase during air stripping as carbon dioxide is removed from the water along with the contaminants. The increase in pH may cause dissolved metals in the water to precipitate although this does not generally present a problem because turbulence on the trays discourages precipitation and scale buildup on the tray surfaces. In the event that scale does form, the trays are easily cleaned. This problem can be addressed by mixing carbon dioxide with the air entering the column, thereby reducing the amount of carbon dioxide removed from the water or by periodically rinsing the column packing with an acid or caustic solution to remove the scale buildup. Alternatively, a scaling inhibitor that keeps the scaling-causing compounds in solution may be added to the water upstream of the air stripper.

Air stripping transfers the VOCs in a liquid waste stream into a gaseous stream. If the gaseous stream meets emissions standards, it may be released without further treatment. However, at RMA further treatment is often included. The vapor-phase treatment technologies under consideration are vapor-phase GAC adsorption, thermal oxidation, and catalytic oxidation. Vapor-phase GAC adsorption consists of transferring the contaminants to activated carbon by way of adsorption. Catalytic oxidation involves the conversion of the contaminants in the air stream to carbon dioxide and water by oxidation in the presence of a catalyst, which allows the reaction to take place more quickly at lower temperatures than thermal oxidation. Thermal oxidation is the thermal destruction of organic contaminants in the air stream. Possible post-treatment technologies for gaseous emissions are discussed in detail in Section 15.0 Air Treatment.

Air stripping systems can be designed to meet groundwater and air emissions standards. Action-specific ARARs related to this process are listed Appendix A.

14.3.2 Process Performance

Air stripping is commonly used, easily implemented, and widely accepted for removing low levels of VOCs from wastewater and groundwater. It is highly effective for the types of volatile contaminants found in RMA groundwater and is currently being used to treat groundwater from Basin F at Basin A Neck and at the CERCLA Wastewater Treatment Plant. In addition, it has been successfully used to treat most of the volatile contaminants found at RMA.

The removal efficiencies for organic compounds by air stripping are controlled by the ability of contaminants in the water to migrate to the air/water interface and then by the tendency for the contaminants to transfer into the air from the water phase once they reach the interface. Conveying the contaminants to the interface is determined by the configuration of the contact system, which has been chosen to be a shallow tray stripper in this case, and by the air-to-water flow ratio. The tendency of a contaminant to transfer from the water phase into the air phase is dependent on the specific system under consideration. A relation that is used to evaluate the affinity of a contaminant for the vapor over the liquid phase is the Henry's Law constant, which is defined as the partial pressure of a contaminant in air over its mole fraction in water when the system is in equilibrium (Kavanaugh and Trussel 1981). Compounds with high Henry's Law constants have a high affinity for the air phase and thus are good candidates for stripping. In general, compounds with dimensionless Henry's Law constants greater than 0.0003 are strippable (EPA 1982). Removal efficiencies range from 90 to 99.9 percent for most volatile compounds. However, the contamination found in much of the water at RMA contains nonvolatiles as well as volatiles. In these cases, it would be necessary to add an additional treatment system to remove the unstrippable compounds. Table 14.3-1 presents the Henry's Law constants for contaminants of concern at RMA.

The South Plants groundwater treatment pilot plant included an air stripper that provided 96 to 100 percent removal rates for VOCs except for methylisobutyl ketone and carbon tetrachloride (S-R 1983). Testing completed on this unit showed that no advantage was gained from softening the water prior to treatment and that increasing the air-to-water ratio increased the removal of all VOCs (EBASCO 1988).

Air stripping is currently being used as a treatment step at the CERCLA Wastewater Treatment Plant and the Basin A Neck treatment system. The Basin F groundwater treatment system has had problems with calcium carbonate scaling in the stripper. Air stripping at these RMA sites has been effective at removing the VOCs from the influent water streams. Both systems use vapor-phase GAC adsorption to meet vapor-phase emissions requirements.

This technology typically requires that concentrations of iron and manganese be reduced to less than 0.2 ppm and 0.1 ppm, respectively, in the influent water stream. Typically, manganese and iron are present at low ppm levels in RMA groundwater, indicating that pretreatment for removal of iron, manganese, and hardness-causing compounds may be required.

The iron, manganese, and hardness-causing compounds present in the RMA groundwater may require additional pretreatment or process modifications, such as inhibitor additions, depending on the specific levels in each water to be treated.

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Table 14.1-1 Past Chemical Oxidation Research Efforts Using RMA Waters

Year	Researcher	Main Concern	Operation Units	Results
1977	Thompson et al.	DIMP, groundwater from Well PW-3.	Ultrox (pilot scale)	1. 99.9 percent removal rate. 2. TOC removal increased with increased UV dosage.
1978	WES	Intermediate products of DIMP, $CMPSO_2$, aldrin, dieldrin, DCPD.	UV/ozone	1. Organic acids formed as intermediate products of incomplete oxidation. 2. Organic compounds converted to inorganic phosphates, sulfurs, and carbon dioxide.
1978	Khan and Thompson	Groundwater contaminated with DIMP	UV/ozone (bench scale)	1. Iron and manganese were removed by caustic/lime. 2. High-intensity lamps proved more effective. 3. Four hours were required to achieve target levels (from 70 mg/l to 0.5 mg/l).
1990	Zappi et al.	Contaminated waters; groundwater from NBCS and South Plants Area, wastewater from the hydrazine storage facility, and influent to the South Plants Treatment System.	UV/H_2O_2	1. Low levels of contaminants could be treated in 15 min or less (North Boundary groundwater and NBCS influent). 2. DIMP very reactive to both UV and peroxide. 3. Chlorinated aliphatics difficult to oxidize. 4. Process not effective for VOC removal from the South Plants groundwater. 5. Oxidized iron posed serious fouling problems for the UV lamps. 6. Hydrazine fuels treated effectively, but not effective for NDMA. 7. Longer treatment time required for NDMA.
1990	Jelinek et al.	Wastewater from the hydrazine storage facility.	UV/chemical oxidation (Batch, pilot scale).	1. Hydrazine fuels oxidized with the use of tungsten catalyst within 16 hours at pH less than 3.0. 2. NDMA required 80 hours for destruction.

Year	Researcher	Main Concern	Operation Units	Results
1991	USAE WES	DIMP, North Boundary groundwater.	Chemical oxidation system (bench scale).	1. Hydrogen peroxide alone was not very reactive. 2. Catalysts, $FeCl_2$ or WO_3, caused appreciable oxidation. 3. With UV, complete removal of DIMP occurred within 10 minutes. 4. Cooxidation treatment kinetics were similar to UV. DIMP was removed without UV.
1991	USAE WES	Chloroform and benzene (distilled water solution and North Boundary groundwater).	UV/H_2O_2.	1. Benzene and chloroform in groundwater effectively treated.
1993	USAE WES	Basin A and South Plants groundwater.	UV/H_2O_2, UV/ozone and H_2O_2 ozone.	1. DBCP and OCPs effectively treated by H_2O_2/ozone. 2. Chloroform most effectively destroyed in presence of UV light. Significant fraction of chloroform stripped in ozone system.

Table 14.2-1 GAC Treatment Systems Using RMA Waters

Year	Operator	Operation Units	Main Concern	Design Flow Rate
1981	PMRMA/Shell	North Boundary Containment System	DIMP/$CHCl_3$	450 gpm
1981	PMRMA/Shell	Irondale Containment System	DBCP/TCE	2,100 gpm
	PMRMA/Shell	South Plants Treatment System	Miscellaneous Contaminated Waters	10 gpm
1984	PMRMA/Shell	Northwest Boundary Containment System	DBCP/Dieldrin	1,500 gpm
1990	PMRMA/Shell	Basin A Neck Interim Response Action	VHOs, VAOs, OCPs	15 gpm
1992	PMRMA/Shell	CERCLA Wastewater Treatment System	Miscellaneous Contaminated Waters	20 gpm

Table 14.3-1 Henry's Law Constants for Contaminants of Concern at RMA

Contaminant	Henry's Law Constant (atm m^3/mol)	Reference Temperature (°C)	Reference
Aldrin	4.96E-04	25	EPA 1981
Benzene	5.55E-03	25	EPA 1981
Carbon tetrachloride	3.02E-02	25	EPA 1981
Chlordane	4.80E-05	25	EPA 1981
Chlorobenzene	3.93E-03	25	EPA 1981
Chloroform	3.39E-03	25	EPA 1981
Dibromochloropropane	1.47E-04	25	SCR 1988
1,2-Dichloroethane	1.31E-03	25	Nirmalakhandan & Speece, 1988
1,2-Dichloroethylene	1.50E-02	25	EPA 1981
Dieldrin	5.80E-05	25	EPA 1981
Endrin	5.00E-07	25	EPA 1981
Methylene chloride	3.19E-03	25	EPA 1981
Tetrachloroethylene	2.87E-02	25	EPA 1981
Trichloroethylene	1.17E-02	25	EPA 1981

Section 15

15.0 AIR TREATMENT

The air treatment processes evaluated in the FS are all secondary treatments associated with emissions generated by remediation technologies used for other media. In most cases, the emission controls are integral parts of the equipment or action implemented under the primary technologies and are, therefore, discussed as part of the technologies with which they are associated. This section summarizes those DAA technologies that emit off gases.

For those technologies that do not include air controls in the equipment package, a number of competitively priced options are available. Air stripping is a good example of a technology that typically does not include integrated air control. Section 15.1 summarizes emission treatment technologies and Section 15.2 analyzes the preferred air treatment technologies for the flow and concentration ranges being considered.

15.1 EMISSION TREATMENT SUMMARY

The technologies that were identified as generating potential air sidestreams (Table 15.1-1) were reviewed during the DAA to determine whether air-related issues were identified and addressed to the extent necessary. Some of these air-related issues included the type and quantity of emissions anticipated, proposed air treatment technology, treatment effectiveness, air ARARs, and costs associated with air treatment.

In most cases, the treatment technologies identify the specific air treatment processes that are included as part of the technology package. In general, the equipment vendors provide a treatment package that specifies compatible air treatment equipment as part of their overall treatment train in order to address the anticipated emissions generated by the primary treatment equipment. In these cases, the air portion of the technology package was reviewed to ensure that all of the anticipated air emissions could be addressed by the specified air treatment, that the air treatment technology could efficiently treat the compounds to satisfy ARARs, and that air treatment costs were included in the overall technology costs.

In cases where air treatment was not built in to the technologies, the potential air emissions were reviewed, and proposed air treatment was evaluated to determine whether it could effectively address these emissions and satisfy ARARs. Overall treatment costs were also reviewed to ensure that costs associated with air treatment or air emission control were included.

15.2 EVALUATION OF TREATMENT TECHNOLOGIES FOR AIR STRIPPER OFF GAS

Five groundwater alternatives in the DAA include the use of an air stripper whose emissions may exceed ARARs. Several technologies are available for the treatment of organic compounds in the off-gas emissions. These technologies, GAC adsorption, biofiltration, thermal oxidation, and catalytic oxidation, are described below.

Vapor-phase GAC adsorption is the most common method for removing VOCs from vapor emissions generated by water treatment systems. Unfortunately, some compounds encountered at RMA, such as chloroform and methylene chloride, are relatively poorly adsorbed and, consequently, require large quantities of GAC. For low flow rates, GAC may be the most practical option; but for the cases presented here, at flow rates greater than 200 standard cubic feet per minute (scfm), GAC usage increases dramatically. Concentrations and flow rates of air emissions are presented in Table 15.2-1. Furthermore, the contaminants are not destroyed but are transferred to GAC, which requires thermal regeneration or disposal off post. In-place regeneration units are also available. These typically use steam or hot nitrogen to desorb the contaminants from the GAC bed. Hot nitrogen applications are generally cost prohibitive and, therefore, limited to highly concentrated industrial streams. Steam regeneration units, on the other hand, could potentially be used for regenerating the GAC at RMA. Success of the technology depends on how effectively the contaminants removed by the steam can be separated from the condensate. It is not expected that the removed contaminants have any resale value, but it might be possible to use contaminants such as benzene as supplemental fuel for thermal treatment of soil.

Catalytic oxidation is a less frequently applied technology that offers two advantages over GAC—near complete destruction of contaminants and, generally, lower costs. For the alternatives under evaluation at RMA, catalytic oxidation is also preferred over thermal oxidation because of the lower required operating temperature of the reactor. Recent innovations in catalyst development have led to catalysts that can handle the decomposition of chlorinated compounds. Even tetrachloroethylene, a compound normally requiring very high oxidation temperatures, can be destroyed in the presence of a catalyst. Previous to these developments, the generation of monatomic chlorine during thermal decomposition created a masking effect over the catalyst. The new catalysts require a moist environment, which is provided by the emissions from the air stripper (as compared with GAC adsorption, where the emission stream would have to be dried first and the resulting condensate would need further treatment). Over the period of 3 to 5 years, the catalyst approaches deactivation and must be replaced. The vendor supplying the new catalyst often buys the old catalyst bed and recovers its platinum.

Thermal oxidation and biofiltration are two other technologies that are applied to air streams. For the waste streams to be treated at RMA, however, they are not as effective as catalytic oxidation or GAC. Thermal oxidation tends to be most cost effective when used at sites where high hydrocarbon levels (greater than 50 percent lower explosive limit) can be sustained. At lower levels, fuel consumption becomes significant, and catalytic oxidation or GAC adsorption should be evaluated as control technologies. Although modern heat recovery equipment has significantly reduced the cost of fuel consumption, other factors such as public acceptance, byproduct formation, and treatment of criteria pollutants (i.e., carbon monoxide and nitrogen oxides) are distinct disadvantages of thermal oxidation units. As previously mentioned, the destruction of tetrachloroethylene found in the off gas requires a very high temperature; as a result, additional treatment such as GAC may be required if levels surpass those mandated by the ARARs.

The use of biofiltration (a distribution system of perforated pipe buried in a soil bed) is precluded because of the difficulty in treating a variable loading of contaminants. The mass of organic compounds in the air stream is expected to vary widely over time. There may potentially be periods where the mass of organic compounds is insufficient to continually sustain the microorganisms. On other occasions, a spike of contaminants may be concentrated enough to pass through the bed and be released to the atmosphere. The primary maintenance problem with biofilters is controlling the moisture of the bed. The bed typically requires 99 percent relative humidity of the air in the soil pores; however, this percentage should not be difficult to obtain considering the air coming off the air stripper is saturated.

A comparison of the cost of using catalytic oxidation for 10 to 30 years versus using GAC without and with steam regeneration shows catalytic oxidation to be the most cost-effective option. It is recommended that catalytic oxidation be given serious consideration as the primary treatment for off gas from groundwater treatment systems because more than 98 percent conversion may be achieved. For those scenarios where the quantity of contaminants still exceed air ARARs, a vapor-phase GAC unit could be used as a polishing unit.

Table 15.1-1 List of Technologies with Air Sidestreams

Technology	Anticipated Emissions	Air Treatment Technology	ARARs Considered (Y/N)	Part of Treatment Package (Y/N)	Costs
*Rotary Kiln Incineration	Particulates Acid Gas	Spray Tower Bag House Venturi Scrubber Caustic Quench	Y	Y	Included in Technology Package
In Situ/Microwave Heating	Volatile Organic Emissions	Emissions Captured in Hood	Y	Y	Included in Technology Package
Thermal Desorption	Particulates Acid Gas	Spray Tower Bag House Venturi Scrubber Caustic Quench	Y	Y	Included in Technology Package
Vacuum Extraction	Vapor Emissions	Catalytic Oxidation GAC Adsorption	Y	N	Incorporated in Alternative Costing
Excavation	Particulates	Water Sprayer Surfactants	Y	Y	Included in Technology Package
In Situ Surface Soil Heating	Vapor Emissions	Emissions Captured and Treated	Y	Y	Included in Technology Package
In Situ Vitrification	Vapor Emissions	Emissions Captured and Treated	Y	Y	Included in Technology Package
In Situ Steam Cleaning	Vapor Emissions	Emissions Captured and Treated	Y	Y	Included in Technology Package
Vacuum Dusting	Particulates	—	—	—	

* Reviewed to ensure that anticipated air emissions addressed by specified air treatment.

Table 15.1-1 List of Technologies with Air Sidestreams

Technology	Anticipated Emissions	Air Treatment Technology	ARARs Considered (Y/N)	Part of Treatment Package (Y/N)	Costs
Sand Blasting	Particulates/Dust Emissions	Building Containment	Y	Y	Included in Technology Package
Excavation/Odor Control Basin F	Ammonia	Acidified Scrubber	Y	N	Incorporated in Alternative Costing
Hot Gas Treatment	Vapor Emissions	After Burner or Activated Carbon	Y	Y	Included in Technology Package
Transportation	Visible Dust Emission-Particulates Organic Vapor Emissions	Lining, Covering, Packaging, Material, Dust Suppression (including water spraying)	Y	N	Incorporated in Alternative Costing
*Demolition	Dust Emission	Spray or Misting Water	Y	N	Included in Technology Package
Air Stripping	Volatile Organic Emissions	Activated Carbon	Y	N	Incorporated in Alternative Costing

* Reviewed to ensure that anticipated air emissions addressed by specified air treatment.

Table 15.2-1 Concentrations and Flow Rates of Air Emissions from Air Stripping and Oxidation Units

Process Option	Contaminant of Concern	Water Concentration (µg/l)	Water Rate (gpm)	Treatment Unit	% Stripped*	Air Flow (scfm)	Mass in Emissions (g/hr)	Gaseous Effluent Concentration (µg/l)
1	1,2 DCA	7	10	Stripping	99.9%	70	0.02	0.13
	Chlorobenzene	130			99.9%		0.29	2.48
	Chloroform	3100			99.9%		7.03	59
	Methylene chloride	72			99.9%		0.16	1.37
	Tetrachloroethylene	98			99.9%		0.22	1.87
	TCE	20			99.9%		0.05	0.38
	Benzene	390			99.9%		0.88	7.44

* Air stream was assumed to be nearly saturated and approximately 40 to 60°F. The percentage stripped was based on designed efficiencies and Henry's Law constant.

APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND INFORMATION TO-BE-CONSIDERED

APPENDIX A

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LIST OF ACRONYMS AND ABBREVIATIONS

$\mu g/m^3$	micrograms per cubic meter
$\mu g/l$	micrograms per liter
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing material
ACOE	Army Corps of Engineers
AIR	automobile inspection and readjustment
ALARA	as low as reasonably achievable
AMC	Army Materiel Command
AOC	area of contamination
AR	Army regulations
ARAR	applicable or relevant and appropriate requirement
Army	U.S. Army
BCY	bank cubic yards
BDAT	best demonstrated available technology
BGEPA	Bald and Golden Eagle Protection Act
$CaCo_3$	calcium carbonate
CAMU	Corrective Action Management Unit
cc	cubic centimeters
CCR	Code of Colorado Regulations
CCW	constituent concentration in waste
CCWE	constituent concentration in waste extract
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeters
CMP	comprehensive monitoring program
CO	carbon monoxide
CO_2	carbon dioxide
COC	contaminant of concern
Cr	chromium
CRS	Colorado Revised Statute
CWA	Clean Water Act
CY	cubic yards
DAA	Detailed Analysis of Alternatives
db(A)	decibels
DCPD	dicyclopentadiene
DDE	2,2-Bis(para-chlorophany 1)-1,1-dichlorethene
DDT	2,2-Bis(para-chlorophenyl)-1,1,1-trichloroethane
DOD	Department of Defense
DOT	Department of Transportation
DRE	destruction and removal efficiency

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

DRMO	Defense Reutilization Management Office
DSA	Development and Screening of Alternatives
EA	endangerment assessment
EPA	U.S. Environmental Protection Agency
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
f/m^3	fibers per cubic meter
FAA	Federal Aviation Administration
FFA	Federal Facilities Agreement
FM	field manual
FR	Federal Register
FS	feasibility study
ft	feet
ft^2	square feet
FWQC	Federal Water Quality Criteria
GAA	granular activated alumina
GAC	granular activated carbon
GB	isopropylmethyl phosphonofluoridate
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
HCL	hydrogen chloride
HE	high explosive
HEPA	high-efficiency particulate
HSWA	Hazardous and Solid Waste Amendments of 1984
ICP	inductively coupled plasma
IRA	interim remedial action
IRIS	Integrated Risk Information System
kg	kilogram
kg/mo	kilograms per month
L	Lewisite
LDR	land disposal restriction
LEL	lower exposure limit
MAX	maximum peak above the ceiling
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/m^3	milligrams per cubic meter
mg/l	milligrams per liter
mm	millimeter

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

mppcf	million particles per cubic foot
MTR	minimum technology requirements
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
OCP	organochlorine pesticides
°F	degrees fahrenheit
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
Pb	lead
PC	corrected concentration of particulate matter
PCB	polychlorinated biphenyl
PCM	phase contrast microscopy
PEL	permissible exposure limit
PL	public law
PM_{10}	particulate matter with diameter less than or equal to 10 micrometers
POHC(s)	principal organic hazardous constituent(s)
ppm	parts per million
PQL	practical quantitation limit
PRG	preliminary remediation goal
RA	regional administrator (EPA)
RACT	reasonably available control technology
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
REL	recommended exposure limit
RI	remedial investigation
RISR	Remedial Investigation Summary Report
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
s/mm^2	asbestos structures per square millimeter
SDWA	Safe Drinking Water Act
SF	square feet
SHO	semivolatile halogenated organic
STEL	short-term exposure limit
TBC	to-be-considered guidance
TCLP	toxicity characteristic leaching procedure
TEC	target effluent concentration

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

TEGD	Technical Enforcement Guidance Document
TEM	transmission electron microscopy
TLV	ACGIH threshold limit value
TM	technical manual
TMV	toxicity, mobility, or volume
TPCRAC	tolerances for pesticide chemicals on or in raw agricultural commodites
TPES	toxic pollutant effluent standards
TPF	tolerances for pesticides in food
TSCA	Toxic Substances Control Act
TU	temporary units
TWA	time weighted average
UIC	underground injection control
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USC	United States Code
UFS	unconfined flow system
USFWS	U.S. Fish and Wildlife Service
UTS	universal treatment standards
UV	ultraviolet
UXO	unexploded ordnance
VAO	volatile aromatic organic
VHO	volatile halogenated organic
VOC	volatile organic compound
VX	ethyl S-dimethylaminoethyl methylphosphonothiolate

A.1.0 INTRODUCTION

Appendix A is a compilation of chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBCs) criteria that are pertinent to potential remediation alternatives at the Rocky Mountain Arsenal (RMA). This Appendix identifies ARARs and TBCs for water, soils, and structures media.

The ARARs and TBCs identified in this appendix have been compiled to comply with Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Pursuant to this section, an ARAR is defined as "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 citing 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.

ARARs were identified according to the procedures outlined in the most recent U.S. Environmental Protection Agency (EPA) guidance (EPA 1988; OERR 1988; OSWER 1989b) and the National Contingency Plan (NCP) (40 CFR 300) (EPA 1990). The Record of Decision (ROD) will identify the ARARs that will be attained by the selected remedies and any federal or state ARARs that the selected remedies will not meet. In circumstances in which specific ARARs will not be attained, the ROD will also identify any waivers that will be invoked and the justification for invoking each waiver.

Federal and state regulations and guidance that were reviewed fall into one of the following three categories: applicable requirements; relevant and appropriate requirements; and other criteria, advisories, or guidance TBC. These requirements are defined in the NCP (40 CFR 300) as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site and fulfill all jurisdictional prerequisites. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable (40 CFR Section 300.5).

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate (40 CFR 300.5).

- In addition to applicable or relevant and appropriate requirements, the lead and support agencies may, as appropriate, identify TBC for a particular release. The TBC category consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies [40 CFR 300.400(g)(3)].

The NCP (40 CFR 300) establishes the basic criteria for applicability of a federal or state regulation as specifically addressing the contaminants, actions, or location of a CERCLA site. If a regulation is determined to be applicable or relevant and appropriate, only the substantive portions of the regulation are considered to be applicable. Substantive portions of a requirement refer to those portions of an ARAR that pertain directly to actions or conditions in the environment. They generally involve a quantitative limitation or performance objective. Administrative requirements are those mechanisms that facilitate implementation of the substantive requirements, and typically include record keeping and reporting, documentation, issuance of permits, and approval of or consultation with administrative bodies. On the other hand, monitoring requirements, including recording of the monitoring results in some form, are generally considered substantive because they are usually necessary to document attainment of cleanup levels and compliance with emission and discharge limitations.

Many regulations are not directly "applicable" to potential remediation alternatives at the RMA, but may be considered "relevant and appropriate." As defined by the EPA in the NCP (40 CFR 300), regulations which are relevant and appropriate must address situations sufficiently similar to those encountered at the CERCLA site that their usage is well suited to the particular site. Only those "relevant and appropriate" requirements that are determined to be <u>both</u> relevant <u>and</u> appropriate must be complied with. The NCP (40 CFR 300) requires that the following comparisons be made to determine relevance and appropriateness:

- The purpose of the requirement and the purpose of the CERCLA action
- The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site
- The substances regulated by the requirement and the substances found at the CERCLA site
- The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site
- The type of place regulated and the type of place affected by the release or CERCLA action
- The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action
- Any consideration of use or potential use of the affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site [40 CFR 300.400(g)(2)]

Requirements that are judged both relevant and appropriate must be compiled with to the same degree as if they were applicable, unless the ARAR meets the CERCLA criteria for a waiver under Section 121(d)(4) of CERCLA. Other regulations, advisories, or guidance may be useful in developing protectiveness criteria for contaminants for which there are no ARARs. These regulations fall into the TBC category. TBCs are not enforceable, but may be useful in developing remedies. The U.S. Army (Army) will conduct a review of the remedial actions selected for RMA every five years.

A.2.0 CHEMICAL-SPECIFIC REQUIREMENTS

Chemical-specific ARARs set concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Such ARARs either set protective cleanup levels for the chemicals of concern in the designated media or indicate an appropriate level of discharge based on health- and risk-based analyses and technological considerations. This section discusses the rationale for chemical-specific requirements for water, soil, and structures media.

A.2.1 Groundwater and Surface Water Requirements

The CERCLA Compliance with Other Laws Manual (OERR 1988) identifies federal standards developed under the Resource Conservation and Recovery Act (RCRA), the Safe Drinking Water Act (SDWA), and the Clean Water Act (CWA) as ARARs. These ARARs include the following:

- SDWA Maximum Contaminant Levels (MCLs): 40 CFR 141 Subparts B and G, 40 CFR 143.3
- SDWA Maximum Contaminant Level Goals (MCLGs): 40 CFR 141 Subpart F
- CWA Water Quality Criteria (FWQC): 33 USC Section 1313
- RCRA Maximum Contaminant Levels (RCRA MCLs): 40 CFR Section 264.94

With respect to state standards, ARARs include the following when these provisions are equivalent to or more stringent than federal requirements:

- Colorado Rules and Regulations Pertaining to Hazardous Waste
- Colorado Basic Standards for Groundwater (CBSG)

- Colorado Primary Drinking Water Regulations
- Colorado Basic Standards and Methodologies for Surface Water (CBSM)

The SDWA establishes standards for public drinking water systems (40 CFR Parts 141 and 143). These standards have been established as part of the National Primary and Secondary Drinking Water Regulations. SDWA MCLs apply to "public water systems," which are systems that provide piped water for human consumption to at least 15 service connections or an average of at least 25 persons daily for at least 60 days of the year (40 CFR Section 141.2).

EPA has also promulgated MCLGs in 40 CFR Sections 141.50 through 141.51. Although MCLGs are nonenforceable health goals for public water supply systems and, therefore, cannot be applicable to RMA, Section 121 of CERCLA provides that remedial actions will at least attain MCLGs where such goals are relevant and appropriate under the circumstances of the release or threatened release (42 United States Code (USC) Section 9621(d)(2)(A)). EPA has nonetheless stated that, disregarding special circumstances, "MCLs ... are the appropriate standard because they represent the level of quality for the nation's drinking water supplies" (53 FR 51441, December 21, 1988). EPA further states that MCLGs are not relevant at most CERCLA sites because "they would impose a more restrictive requirement than exists for the drinking water consumed by most households in the country." Therefore, EPA (53 FR 51441, December 21, 1988) believes that MCLs are sufficiently protective to achieve CERCLA's goal of protecting human health and the environment. However, according to the NCP (EPA 1990), MCLGs set at levels above zero shall be attained by remedial actions for groundwater and surface waters that are current or potential sources of drinking water. Therefore, the Army has determined that non-zero MCLGs are ARARs. Where MCLGs are set at zero, the MCL will generally be the ARAR.

In those cases where no federal or state ARAR exists for a chemical, the Army sometimes selected EPA Integrated Risk Information system (IRIS) (EPA 1989) drinking water concentrations at 10^{-6} cancer risk level as TBCs.

FWQC are nonpromulgated surface water guidelines developed under Section 304 of the CWA that are used by Colorado, in conjunction with designated uses for a stream segment, to establish water quality standards under Section 303 of the CWA (33 USC §1313). Although FWQC are nonenforceable, and thus cannot be applicable, Section 121 of CERCLA states that remedial actions must attain FWQC where they are relevant and appropriate under the circumstances of a release or threatened release (42 USC §9621(d)(2)(a)).

In determining if FWQC are relevant, the primary factors to consider are the designated or potential uses of the water, the media affected, and the purposes for which the potential requirements are intended. FWQC have been established for protection of human health and for protection of aquatic life. FWQC for protection of human health address both consumption of water and fish and consumption of fish only. FWQC for protection of aquatic life consider both acute and chronic effects (33 USC §1313). A review of the site circumstances regarding any release or threatened release indicates that the relevant and appropriate FWQC applicable and protective to this site are the water criteria for the protection of aquatic life. Since Colorado has a promulgated numeric water quality standard the state standard is relevant and appropriate.

ARARs and TBCs for groundwater and surface water were identified by evaluating the current lists of target contaminants addressed by the groundwater (Table A-1) and surface water (Table A-2) monitoring programs and identifying corresponding standards, regulations, or requirements. Tables A-1 and A-2 provide a comprehensive list of contaminants of concern at the site to use as a basis to identify ARARs and TBCs. This list is updated annually to ensure that all contaminants of concern are monitored for on a regular basis.

This is the same approach that was taken to identify constituent ARARs in the Development and Screening of Alternatives (DSA) (EBASCO 1992a). In the DSA, the target contaminants list consisted of parameters monitored for in Task 44 of the remedial investigation (EBASCO 1989); groundwater and surface water analytes monitored as part of the comprehensive monitoring program (R.L. Stoller & Associates Incorporated 1989a, b); other target United States Army

Toxic and Hazardous Materials Agency (USATHAMA) compounds (USATHAMA 1988); and non-target compounds detected in groundwater that were added to the Chemical Index (EBASCO et al. 1988).

Over the years the target analyte list has changed slightly due to addition of contaminants of concern or deletion of contaminants that were not detected, detected well below existing standards, detected only one time over a number of years, detected using a gas chromatograph/mass spectrometer (GC/MS) method for quality assurance and quality control, or are of no concern. Therefore, the ARARs and TBCs for groundwater and surface water have changed. Contaminants have been added and deleted from the potential ARARs and TBCs identified in the DSA (EBASCO 1992a).

Tables A-3 through A-6 contain ARARs and TBCs identified for groundwater at each treatment system. ARARs and TBCs for surface water are identified in Tables A-8 and A-9.

Each ARAR was reviewed to determine whether it was applicable or relevant and appropriate. This was done in accordance with the CERCLA Compliance with Other Laws Manual (OSWER 1989b). Where there was more than one ARAR for a contaminant, the most stringent was selected. If no ARAR existed for a contaminant, the most stringent TBC appropriate under the circumstances was selected. Finally, if the numerical values of the ARARs or TBCs are a function of the hardness of the surface water or groundwater, the hardness value corresponding to each requirement is given in the HRD column of the table.

A.2.2 Chemical-Specific Requirements for Soils

The proposed RCRA Corrective Action Rule example action levels (55 FR 30798, July 27, 1990), LDR Universal Treatment Standard (UTS) and TSCA PCB Spill Cleanup Policy (40 CFR Part 761 Subpart G), are TBC values for soils and sediments at RMA. Land Disposal Restriction (LDR) Best Demonstrated Available Technology (BDAT) levels (40 CFR Part 268) are ARARs if placement occurs.

The proposed RCRA Corrective Action Rule (55 FR 30798, July 27, 1990) is a potential TBC for determining cleanup levels for soils and groundwater at RMA. The proposed rule was developed using risk-based information to identify action levels needed at facilities that are contaminated as a result of inadequate management of hazardous waste. Some of the contaminants of concern in this proposed rule are also contaminants found at RMA in the groundwater and soil. The types of cleanup activities contemplated by the proposed rule may be similar to some of the types of cleanup activities now being considered for RMA. Table A-10 lists the specific RCRA Corrective Action Rule levels to be considered for soils remedial actions if listed hazardous waste(s) are determined to be present.

There are several other Colorado and federal laws and regulations that set specific values for certain contaminants in specific media, but no laws other than RCRA, TSCA, and asbestos that set specific values that are likely ARARs or TBCs for RMA soils and sediments. EPA proposed soil treatment standards in the Universal Treatment Standards (UTS) rule on September 14, 1993, but deferred action on soil LDRs when that rule was finalized, consequently UTSs are TBCs with respect to soils at RMA. EPA plans to establish risk-based levels for soil in the future. In addition, there are no levels set by the SDWA or CWA or their state equivalents for soils and sediments. The Toxic Substances Control Act (TSCA) establish guidance on action levels for polychlorinated biphenyls (PCBs) in soils. CWA has a standard for asbestos, that could be applied to any soils and sediments contaminated with asbestos.

A.2.3 Chemical-Specific Requirements for Structures

TSCA-PCB cleanup levels established for spills occurring after May 4, 1987 in addition to PCB cleanup standards contained in EPAs "Guidance on Remedial Actions for Superfund Sites with PCB Contamination" may serve as TBC for PCB contaminated structure surfaces and debris. The LDR BDAT levels are ARARs values for structural debris if placement occurs.

A.2.4 Chemical-Specific Requirements for Air

The CERCLA Compliance with Other Laws Manual Part II (EPA 1989) identifies federal standards developed under the Clean Air Act (CAA). These ARARs include the following:

- National Ambient Air Quality Standards (NAAQS): 40 CFR 61
- National Emission Standards for Hazardous Air Pollutants (NESHAPs): 40 CFR 50

State standards that are equivalent or more stringent than federal requirements are also considered ARARs and these include:

- Colorado Ambient Air Standards: 5 CCR 1001-5 Regulation 3, 5 CCR 1001-14
- Control of Hazardous Air Pollutants: 5 CCR 1001-8

A.3.0 LOCATION-SPECIFIC REQUIREMENTS

Location-specific ARARS are those requirements that set restrictions on remedial activities or limitations on contaminant levels, depending upon the characteristics of the site or the immediate environment. Alternative remedial actions may be restricted or precluded by location-specific ARARs that are contingent upon the location or characteristics of the site and the requirements that apply to it. Examples of such regulations include citing laws for hazardous waste facilities, laws regarding development or other activities in wetlands or floodplains, and laws for preservation of historic or cultural sites. Location-specific ARARs are displayed in Table A-8.

In determining location-specific ARARs, the following characteristics of RMA must be taken into account:

- Absence of karst topography underlying RMA
- Absence of faults underlying RMA that have had displacement in Holocene time
- Potential presence of areas designated as National Historic Landmarks or National Preservation Areas
- Presence of wetlands as shown in the Remedial Investigation Summary Report (RISR) (EBASCO 1992b)

- Presence of 100-year floodplains associated with most drainages at RMA, as shown in the RISR (EBASCO 1992b)

All requirements pertaining to the protection and management of floodplains and wetlands are considered potentially applicable to the on-post Feasibility Study (FS). Location-specific ARARs pertaining to floodplains are contained in Executive Order 11988 [44 Federal Register (FR) 43239, July 7, 1979, procedures codified in regulations under the National Environmental Policy Act (NEPA), 40 CFR Part 6, and 40 CFR Section 257.3-1(a)]. The provisions of 40 CFR Section 257.3-1(a) are applicable only in units regulated under RCRA, but are considered relevant and appropriate requirements concerning the construction of facilities and conduct of remedial actions in floodplain zones. Location-specific ARARs pertaining to wetlands are contained in Executive Order 11990 and 40 CFR Part 6. Excerpts from these requirements are provided below:

Floodplains

- "Evaluate the potential effects of actions ...[that would be taken] in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain." [40 CFR Section 6.302 (b)].
- "Ensure that ...[the federal agency's] planning programs and budget requests reflect consideration of flood hazards and floodplain management, including the restoration and preservation of such land areas as natural undeveloped floodplains ..." [40 CFR Part 6, Appendix A, Section 1(a)].
- "Executive Order 11988 ...requires Federal agencies to ...prescribe procedures to implement the policies and procedures of [the] Executive Order." [40 CFR Part 6, Appendix A, Section 1(a)].
- "Where there is no practical alternative to locating in a floodplain, minimize the impact of floods on human safety, health and ... the natural environment." [40 CFR Part 6, Appendix A, Section 3(b)(2)].
- "Restore and preserve natural and beneficial values served by floodplains." [40 CFR Part 6, Appendix A, Section 3(b)(3)].
- "Identify floodplains which require restoration and preservation and recommend management programs necessary to protect these floodplains and to include such

considerations as part of on-going planning programs." [40 CFR Part 6, Appendix A, Section 3(b)(5)].

- "Facilities or practices in floodplains shall not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a threat to human life, wildlife, or land or water resources." [40 CFR Section 257.3-1(a)].

Wetlands

- "Requires Federal agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands." [40 CFR Section 6.302(a)].
- "The responsible official shall either avoid adverse impacts or minimize them if no practicable alternative to the action exists." [40 CFR Section 6.302(a)].

Floodplains and Wetlands

- "Before undertaking an Agency action, each program office must determine whether or not the action will be located in or affect a floodplain or wetlands." [40 CFR Part 6, Appendix A, Section 6(a)(1)].
- "The Agency shall utilize maps prepared by the Federal Insurance Administration of the Federal Emergency Management Agency ..., Fish and Wildlife Service ..., and other appropriate agencies to determine whether a proposed action is located in or will likely affect a floodplain or wetlands." [40 CFR Part 6, Appendix A, Section 6(a)(1)].
- If an action "is likely to impact a floodplain or wetlands, the public should be informed through appropriate public notice procedures." [40 CFR Part 6, Appendix A, Section 6(a)(2)].
- "If the Agency determines a proposed action is located in or affects a floodplain or wetlands, a floodplain/wetlands assessment shall be undertaken ... [that] shall consist of a description of the proposed action, a discussion of its effect on the floodplain/wetlands, and shall also describe the alternatives considered." [40 CFR Part 6, Appendix A, Section 6(a)(3)].

- "A public notice of the floodplain/wetlands assessment shall be made consistent with the public involvement requirements of the applicable program." [40 CFR Part 6, Appendix A, Section 6(a)(4)].
- "For all Agency actions proposed to be in or affecting a floodplain/wetlands, the Agency shall provide further public notice announcing this decision. This decision shall be accompanied by a Statement of Findings, not to exceed three pages. This statement should include" all items outlined in the statute. [40 CFR Part 6, Appendix A, Section 6(a)(6)].

Requirements adopted as part of RCRA are applicable or relevant and appropriate to remedial actions conducted at CERCLA sites. Location-specific ARARs that may be relevant and appropriate for on-post remediation are contained in 40 CFR Section 257.3-1, which applies directly to floodplain management, and 40 CFR 264 Subpart B, which contains EPA regulations for owners and operators of RCRA-permitted hazardous waste facilities.

The Army is in the process of conducting an archeological, architectural, historical, and prehistorical cultural resource survey. This survey could identify structures that may be protected under the National Historic Preservation Act (36 CFR Part 800) or the Archeological Resources Protection Act (16 USC Section 469a-1). Location-specific ARARs would be triggered if culturally significant structures are identified at RMA.

Regulations promulgated pursuant to RCRA are location-specific ARARs for some remedial actions conducted at CERCLA sites. RCRA location-specific ARARs that may be relevant and appropriate for on-post remediation are contained in 40 CFR Section 257.3-1, which applies directly to solid waste landfills in floodplains, and 40 CFR 264 Subpart B, which contains EPA regulations for owners and operators of RCRA-permitted hazardous waste facilities.

A.4.0 ACTION-SPECIFIC REQUIREMENTS

Action-specific ARARs and TBCs are standards that establish restrictions or controls on particular kinds of remedial activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities, as opposed to the specific chemicals present or the location of the remediation activity. For example, if a particular remedial action could result in emissions of regulated air pollutants, then certain air regulations could be ARARs for that particular remedial action. Tables A-12 through A-45 contain ARARs and TBCs for the technologies that are part of any of the alternatives considered in the DAA for water, soil, and structures. Each table contains ARARs and TBCs for a specific technology that may represent only one part of a complete alternative that consists of several technologies. Therefore several ARAR tables will be applied to each alternative. These action-specific ARARs do not in themselves determine the appropriate remedial alternative, but indicate the performance levels to be achieved by an alternative.

A.5.0 OTHER POTENTIAL REQUIREMENTS

In addition to the chemical-, location-, and action-specific ARARs and TBCs, there are a number of other requirements and potential requirements that could constrain and direct remedial actions at RMA. These additional items are addressed below.

Federal Facility Agreement

Provisions of the Federal Facility Agreement (FFA) regarding use restrictions, federal ownership, and access restrictions are not ARARs or TBCs; however, they must be complied with.

Asbestos-Containing Materials

Asbestos-containing materials (ACM) that may be found in structures or soil during remediation will be managed in accordance with potential ARARs identified in the Interim Remedial Action (IRA) for Asbestos removal. ACM generated during remedial activities will be disposed in a landfill that is designed and managed in accordance with ARARs specified in appropriate ARAR tables.

Polychlorinated Biphenyls

The Army has undertaken several programs to identify, inventory, and dispose of its PCB contamination in structures, equipment, and soil as described below. The methodology for PCB-contaminated materials is regulated under 40 CFR Part 761 and described in the Guidance on Remedial Actions for Superfund Sites with PCB Contamination, EPA/540/G-90/007 (OERR 1990b).

- The PCB IRA program identifies and inventories PCB-contaminated materials in non-agent and non-Shell structures. Contaminated equipment is disposed of in a landfill meeting TSCA requirements. Some large pieces of contaminated equipment, which have proven difficult to remove, are left in place, to be disposed as part of the final structures cleanup. PCB-contaminated structure materials or soil are also left in place for the final cleanup under this program. The one exception is a soil removal action at the Building 621B salvage yard. PCB-contaminated materials that are handled in the final cleanup will be treated and disposed of in landfills meeting TSCA requirements.

- The Chemical Process-Related Activities IRA decontaminates and removes equipment that is potentially agent contaminated. Decontaminated agent equipment that is also PCB contaminated is currently stored on post, and will be disposed of in a landfill meeting TSCA requirements.

- The electrical substation and transformer maintenance activities have removed and properly disposed all PCB-contaminated equipment.

Equipment, structures, and soil for which the Army has a responsibility will be handled as follows:

- Equipment: PCB fluids will be drained and sent offpost for disposal in compliance with applicable TSCA regulations. PCB-contaminated equipment will be disposed of in a landfill meeting TSCA requirements. Action levels to classify a piece of equipment as PCB contaminated will be taken from 40 CFR Part 761. The equipment will be disposed under one of three possible scenarios:

  — Identified and disposed as part of the ongoing PCB IRA.

  — Identified under the PCB IRA, but disposed under the final structures cleanup.

  — Agent-decontaminated materials that will be disposed under the final structures cleanup.

- Structure Materials: The PCB contamination in No Future Use structure materials will be identified in the PCB IRA completion report. Based on a 50 ppm action level, structure material will be addressed in one of two ways:

— Structure materials with PCB concentrations of 50 ppm or above which exist above the ground elevation, as well as contaminated parts of ground floor slabs and foundations that will be removed, will be identified prior to demolition, segregated during demolition, and disposed of in a landfill meeting TSCA requirements. Similar materials with PCB concentrations below 50 ppm will not require disposal in a TSCA landfill.

— PCB-contaminated sections of ground floor slabs or foundations that are not required to be demolished as part of the remediation, and which have PCB concentrations of less than 50 ppm, will be left in place. However, if such slab or foundation material has PCB concentrations of 50 ppm or greater, it will be removed during demolition and disposed of in a landfill that meets TSCA design requirements.

- Soil: Action on PCB-contaminated soil is 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 from 50 ppm to below 250 ppm. These areas will receive a minimum 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.

Army Future Use structures have been managed for occupancy under current environmental and worker protection regulations. There is no evidence of PCB contamination in this medium group.

Structures and equipment for which Shell has responsibility will be handled as follows:

- All Shell buildings to be demolished during the final remedy will be inspected for equipment containing fluids potentially contaminated with PCBs prior to demolition. Suspected fluids will be drained and sent offpost for disposal in compliance with applicable TSCA regulations. Equipment that contained these fluids as well as all other equipment will be disposed of in a landfill meeting TSCA requirements. Significant Contamination History structures will be demolished and the resulting debris will be placed in a landfill meeting TSCA requirements. Other Contamination History structures will be evaluated by Shell and EPA for any visual evidence of leaks or spills. If observed in areas where potential PCB releases may reasonably have been expected to occur, the affected structure debris will be disposed of in a landfill meeting TSCA requirements. Examples of this type of visual evidence would include stains near equipment potentially containing PCB fluids or stains in buildings where there are numerous instances of equipment potentially containing PCB-contaminated fluids. Further details of this work will be addressed at the remedial design stage.

- All fluorescent light ballasts will be disposed at an offpost disposal facility in accordance with applicable TSCA regulations.

Shell does not have responsibility for any structures within the Future Use or Agent History Medium Groups.

Protection of Wildlife

The provisions of the FFA for RMA (EPA et al. 1989), that call for the preservation and management of wildlife at RMA, are not ARARs, but must be complied with. Sections 44.2(e) and (f) of the FFA specifically address activities at RMA and provide for the following:

> (e) Wildlife habitat(s) shall be preserved and managed as necessary to protect endangered species of wildlife to the extent required by the Endangered Species Act, 16 USC Section 1531 et seq., migratory birds to the extent required by the Migratory Bird Treaty Act, 16 USC Section 703 et seq., and bald eagles to the extent required by the Bald Eagle Protection Act, 16 USC Section 668 et seq.
>
> (f) Other than as may be necessary in connection with a Response Action or as necessary to construct or operate a Response Action Structure, no major alteration shall be permitted in the geophysical characteristics of the Arsenal if such alteration may likely have an adverse effect on the natural drainage of the Arsenal for floodplain management, recharge of groundwater, operation and maintenance of Response Action Structures, and protection of wildlife habitat(s).

The provisions of the Endangered Species Act, (ESA) [16 USC Sections 1531 et seq; 50 CFR Section 424.02(d)(2); 50 CFR Part 402] the Migratory Bird Treaty Act, (MBTA) (16 USC

Section 703 et seq.) and the Bald and Golden Eagle Protection Act (BGEPA) (16 USC Section 668 et seq.) apply to RMA. The Army will establish remediation goals for site contaminants to maintain and enhance healthy populations of the species subject to the ESA, MBTA and BGEPA and their habitats at RMA. Remediation goals for soils and sediments that are consistent with the ESA, MBTA, and BGEPA will be established using a methodology agreed to by the Army, Shell, and EPA in consultation with the U.S. Fish and Wildlife Service (USFWS). The Army will also consult with the USFWS to determine whether any of the CERCLA activities or remedial alternatives might have a short term impact on a subject species or its habitat. If a determination is made that the Army's activities or remedial alternatives could impact a subject species or its habitat, the Army will consult with the USFWS to determine whether the activity should proceed and what, if any mitigation measures are necessary, in light of any long term benefits to protection of populations of the subject species.

Wastewater from Remedial Actions

Remedial actions at RMA could potentially generate wastewaters from structures and soils. Some of the wastewater generated will be directed to the RMA wastewater treatment plant and treated in accordance with the CERCLA Wastewater Treatment System IRA and the ARARs found therein.

Land Disposal Restrictions

LDRs are not TBCs, except when applied to contaminated soils, but are applicable requirements for prohibited substances in the event that placement occurs. For subject materials that are managed within a Corrective Action Management Unit (CAMU), or moved from outside to within the CAMU for disposal, as may be established at RMA in the selected remedy, LDRs are not required to be met because placement is not by definition occurring. Similarly, for restricted wastes consolidated (and not otherwise managed) within an Area of Contamination (AOC), as may be established at RMA in the selected remedy, LDRs are not required to be met because placement is not occurring. Except for restricted wastes consolidated within, or moved into a CAMU, and restricted wastes consolidated within an AOC, LDRs are applicable and require, among other things. treatment of listed or characteristic hazardous wastes to BDAT levels prior to placement in land disposal units.

Treatment standards for debris contaminated with listed hazardous waste or debris that exhibits hazardous waste characteristics were finalized by EPA on August 18, 1992 and incorporated by reference by the State of Colorado on October 19, 1993. The alternative debris BDAT standards were intended to make land disposal of hazardous debris more feasible. The rule requires that debris contaminated with listed hazardous waste must be handled as if it were hazardous until the listed waste is removed and then the debris can be placed in a non-hazardous waste landfill. Debris that exhibits a characteristic of a hazardous waste must be treated according to BDAT and may be land disposed as non-hazardous once the characteristic is removed. EPA's LDRs for waste debris do not apply to contaminated soils, except for soils mixed with man-made debris (57 FR 958, January 9, 1992.)

LDRs will be considered action-specific ARARs if the soils, sediments, or debris is shown to be RCRA characteristic or to contain RCRA-listed wastes, and the remedial alternatives involve "placement" of these RCRA hazardous wastes.

The CAMU regulations allow for exceptions from the LDRs for remediation wastes managed at CAMUs or temporary units. The Colorado Hazardous Waste Commission adopted state regulations with the intention that the state regulations be interpreted in a manner consistent with the Federal CAMU rule. The CAMU regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.

Agent Management and Disposal

DOD/Army Regulations addressing UXO and agent management and disposal are ARARs for any of the possible remedial actions proposed for RMA. These include but are not limited to:

- Draft Army (DA) Pamphlet 50-6, Chapter 7 for suspected (or known) chemical munitions. Army Regulation (AR) 50-6-Chemical Surety Program

- AR 75-15 – Emergency Disposal of Munitions (both explosive and chemical munitions) – gives Explosive Ordnance Disposal (EOD) or Army Technical Escort Unit the authority to explosively dispose of munitions too hazardous to move.

- Draft AR 385-61 – Army Toxic Chemical Agent Safety Program

- Draft AR 385-64 – Ammunition and Explosives

- AR 385-131 – Chemical Agent Safety.

State RCRA Authority

Colorado has been authorized by EPA to implement most Federal RCRA statutory and regulatory requirements and as such, State regulations are ARARs.

Worker Protection Standards

Table A-46 presents chemical-specific worker exposure guidelines established by the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Institute for Occupational Safety and Health (NIOSH). OSHA does not apply to federal employees; however, Department of Defense (DOD) employees are covered by OSHA under Executive Order No. 12196, which addresses employee health and safety standards.

The worker protection standards presented in Table A-49 address exposure standards for chemicals detected and potentially associated with water, soil, and structures at RMA. Because ACGIH and NIOSH are not governmental agencies, their Threshold Limit Values (TLVs) and Recommended Exposure Limits (RELs) are presented here as TBCs. OSHA values are presented as ARARs for protection of workers during remediation. OSHA regulations for worker health and safety, which are codified at 29 CFR 1910, are independently applicable to the remedial actions at RMA.

Air Emission Standards

Air emission standards that may pertain to remedial actions at RMA are identified in Table A-47. The substantive requirements necessary to control particulate emissions from off-site transport will be addressed in the remedial design phase of the project.

Chemical Weapons Convention

The Draft Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on their Destruction (CWC) provides for a declaration of the possession of any chemical weapons production facilities and the ultimate destruction of such. The CWC was signed by 130 nations, including the United States, in January 1993. Each nation must submit a declaration as to whether it owns or possesses any chemical weapons or whether any chemical weapons are located in its jurisdiction or control. Chemical weapons are defined as toxic chemicals and their precursors, munitions, and devices specifically designed to cause death or harm through the toxic properties of the chemicals, which would be released by employment of munitions or devices.

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A.6.0 REFERENCES

Army (U.S. Army)

1995 (February 1) AR [Army Regulation] 50-6, Nuclear and Chemical Weapons and Material.

1991 (May 17) DA PAM [Department of the Army Pamphlet] 50-6, Chemical Accident or Incident Response Assistance (CAIRA) Operations.

1987 (May 22) AR 385-64, Ammunition and Explosives Safety Standards.

1985 (August 27) AR 385-61, Safety Studies and Reviews of Chemical Agents and Associated Weapon Systems.

1978 (November 1) AR 75-15, Responsibilities and Procedures for Explosive Ordnance Disposal.

AMC (Army Materiel Command)

1987 (October 9) AMC [Army Materiel Command Regulation] 385-131, Safety Regulation for Chemical Agents, H, HD, HT, GB, and VX.

EBASCO (Ebasco Services Incorporated)

1992a (December) Final On-Post Feasibility Study, Development and Screening of Alternatives. Prepared for the Program Manager for Rocky Mountain Arsenal. Version 4.1, 7 v. RTIC 92363R01.

1992b (January) Final Remedial Investigation Summary Report, Version 3.2, RTIC 92017R01.

1989 (July) Water Remedial Investigation Report, Final, Version 3.3; Volume II, Appendix C. RTIC 89186R01.

EBASCO et al.

1988 (May) Rocky Mountain Arsenal Chemical Index; Appendix C. Table C-3, Volumes I-III.

EPA (U.S. Environmental Protection Agency)

1990 (March 8) National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300 (Federal Register 55(46): 8666-8865). (NCP).

1989 Integrated Risk Information System (IRIS). (Note: This is an EPA computerized database.)

1988 Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final (EPA/540/G-89/004).

1986 TGST Methods for Evaluating Solid Wastes: Physical/Chemical Methods, Third ed.

EPA et al.

1989 (February) Federal Facility Agreement for Rocky Mountain Arsenal. RTIC 89068R01. (FFA)

OERR-EPA (Office of Emergency and Remedial Response, U.S. Environmental Protection Agency)

1990a (September) Superfund LDR Guide No. 6A. (2nd ed.) Obtaining a Soil and Debris Treatability Variance for Remedial Actions. Fact Sheet OSWER/9347.3-06FS.

1990b (August) Guidance on Remedial Actions for Superfund Sites with PCB Contamination EPA/540/G-90/007.

1989 (July) Superfund LDR Guide No. 5: Determining When Land Disposal Restrictions (LDRs) Are Applicable to CERCLA Response Actions. (Fact Sheet [Final]). EPA/9347.3-05/FS.

1988 (August 8) CERCLA Compliance with Other Laws Manual. Part 1. Interim Final (Draft Report) (EPA 540/G-89/006); OSWER/9234.1-01.

OSWER (Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency)

1989a (December) Superfund LDR Guide No. 7. Determining When Land Disposal Restrictions (LDRs) Are Relevant and Appropriate to CERCLA Response Actions (Fact Sheet). OSWER/9347.3-08FS.

1989b (August) CERCLA Compliance with Other Laws Manual, Interim Final OSWER Directive 9234.1-02. EPA/540/G-89/009.

R.L. Stollar & Associates Incorporated

1989a (October) Comprehensive Monitoring Program, Surface Water Final Technical Plan, Version 3.1.1. RTIC 90110R01.

1989b (June) Comprehensive Monitoring Program, Groundwater Final Technical Plan, Version 3.2 RTIC 89213R02.

USATHAMA (U.S. Army Toxic and Hazardous Materials Agency)
1988 (September) U.S. Army Toxic and Hazardous Materials Agency Analyte Summary. Version 4.

A.7.0 TABLES

Table A-1 List of Rocky Mountain Arsenal Target Constituents Addressed by the Groundwater Monitoring Program[1]

Group name/constituent	Group name/constituent
Agent degradation products	**Volatile aromatic organic compounds**
thiodiglycol	benzene
isopropyl methylphosphonic acid	ethylbenzene
	toluene
Metals	m-xylene
cadmium	o- and p-xylene
chromium	
copper	**Organophosporous compounds**
lead	diisopropyl methylphosphonate
zinc	
	Organophosphorous pesticides
Organochlorine pesticides	atrazine
2,2'bis(p-chlorophenyl)-1,1-dichloroethylene	malathion
2,2'bis(p-chlorophenyl)-1,1,1-trichloroethane	parathion
aldrin	supona
chlordane	vapona
dieldrin	
endrin	**Volatile halogenated organic compounds**
hexachlorocyclopentadiene	1,1-dichloroethane
isodrin	1,2-dichloroethane
	1,1-dichloroethylene
Organosulfur compounds	1,2-dichloroethylene (cis and trans isomers)
1,4-oxathiane	1,1,1-trichloroethane
Benzothiazole	1,1,2-trichlorethane
p-chlorophenylmethyl sulfide	carbon tetrachloride
p-chlorophenylmethyl sulfone	chlorobenzene
p-chlorophenylmethyl sulfoxide	chloroform
dimethyl disulfide	methylene chloride
dithiane	tetrachloroethylene
	trichloroethylene

Table A-1 List of Rocky Mountain Arsenal Target Constituents Addressed by the Groundwater Monitoring Program[1]

Group name constituent	**Group name**/constituent
Volatile hydrocarbon compounds	**Anions**
bicyclo[2,2,1]hepta-2,5-diene	chloride
dicyclopentadiene	sulfate
methylisobutyl ketone	fluoride
arsenic	**Cations**
mercury	calcium
cyanide	magnesium
	sodium
dibromochloropropane	potassium
N-Nitrosodimethylamine	**nitrite/nitrate**

[1] This list does not include the GC/MS analyses that are performed on 10 percent of the samples for quality assurance and quality control purposes.

Table A-2 List of Rocky Mountain Arsenal Target Constituents Addressed by the Surface Water Monitoring Program[1]

Group name/constituent	**Group name**/constituent
Agent degradation products	**Volatile aromatic organic compounds**
thiodiglycol	benzene
isopropyl methylphosphonic acid	ethylbenzene
	toluene
Metals	m-xylene
cadmium	o- and p-xylene
chromium	
copper	**Organophosphorous compounds**
lead	diisopropyl methylphosphonate
zinc	
	Organophosphorous pesticides
Organochlorine pesticides	atrazine
2,2'bis(p-chlorophenyl)-1,1-dichloroethylene	malathion
2,2'bis(p-chlorophenyl)-1,1,1-trichloroethane	parathion
aldrin	supona
dieldrin	vapona
endrin	
hexachlorocyclopentadiene	**Volatile halogenated organic compounds**
isodrin	1,1-dichloroethane
	1,2-dichloroethane
Organosulfur compounds	1,1-dichloroethylene
1,4-oxathiane	1,2-dichloroethylene (cis and trans isomers)
Benzothiazole	1,1,1-trichloroethane
p-chlorophenylmethyl sulfide	1,1,2-trichlorethane
p-chlorophenylmethyl sulfone	carbon tetrachloride
p-chlorophenylmethyl sulfoxide	chlorobenzene
dimethyl disulfide	chloroform
dithiane	methylene chloride
	tetrachloroethylene
	trichloroethylene

Table A-2 List of Rocky Mountain Arsenal Target Constituents Addressed by the Surface Water Monitoring Program[1]

Group name/constituent	**Group name**/constituent
Volatile hydrocarbon compounds	**Anions**
bicyclo[2,2,1]hepta-2,5-diene	chloride
dicyclopentadiene	sulfate
methylisobutyl ketone	fluoride
arsenic	**Cations**
mercury	calcium
cyanide	magnesium
	sodium
dibromochloropropane	potassium
	nitrite/nitrate

[1] This list does not include the GC/MS analyses that are performed on 10 percent of the samples for quality assurance and quality control purposes.

Table A-3 ARARs for Groundwater for Northwest Boundary Containment System

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Arsenic (total)	AsTOT	50	N	Y	Y	μg/l		40 CFR 141.11, Federal primary MCL
		50	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
Benzene	C6H6	5	N	Y	Y	μg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
Chloroform	CHCL3	6	N	Y	Y	μg/l		see trihalomethanes
		6	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
Dibromochloropropane		0.2	N	Y	Y	μg/l		40 CFR 141.61, Federal primary MCL
	DBCP	0.2*	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
Dieldrin	DLDRN	0.002	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
		0.1**	N	Y	Y	μg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)
Diisopropylmethyl phosphonate	DIMP	8	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
Endrin	ENDRN	2	N	Y	Y	μg/l		40 CFR 141.61, Federal primary MCL
		0.2	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard
Trichloroethylene	TRCLE	5	N	Y	Y	μg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	μg/l		5 CCR 1002-8, Colorado Groundwater Standard

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit

** PQL Detection levels for Gas Chromatography/Mass Spectrometry

μg/l Indicates micrograms per liter.

Table A-4 ARARs for Groundwater for Irondale Containment System

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Dibromochloropropane	DBCP	0.2*	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		0.2	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Trichloroethylene	TRCLE	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit

µg/l Indicates micrograms per liter.

Table A-5 ARARs for Groundwater for North Boundary of Rocky Mountain Arsenal

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
1,2-Dichloroethane	12DCLE	5*	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		0.4	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		1**	N	Y	Y	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)
1,2-Dichloroethylene	12DCE	70	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		70	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Aldrin	ALDRN	0.002	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		0.1**	N	Y	Y	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)
Arsenic (total)	AsTOT	50	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		50	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Atrazine	ATZ	3*	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCLG
		3	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Benzene	C6H6	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Carbon Tetrachloride	CCL4	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		0.3	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		1**	N	Y	Y	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit.

** PQL Detection levels for Gas Chromatography/Mass Spectrometry

µg/l Indicates micrograms per liter.

Table A-5 ARARs for Groundwater for North Boundary of Rocky Mountain Arsenal

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Chloride	Cl	250,000	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Chloroform	CHCL3	6	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		6	N	Y	Y	µg/l		see trihalomethanes (total)
Dibromochloropropane	DBCP	0.2*	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		0.2	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Dieldrin	DLDRN	0.002	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		0.1**	N	Y	Y	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)
Diisopropylmethyl phosphonate	DIMP	8	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Endrin	ENDRN	2	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCLG
		0.2	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Fluoride	F	4,000	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCLG
		2,000	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Methylene Chloride	CH2CL2	5*	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Sulfate	SO4	250,000	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Tetrachloroethylene	TCLEE	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit.
** PQL Detection levels for Gas Chromatography/Mass Spectrometry
µg/l Indicates micrograms per liter.

Table A-5 ARARs for Groundwater for North Boundary of Rocky Mountain Arsenal

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Trichloroethylene	TRCLE	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Toluene	MEC6H5	1,000	N	Y	Y	µg/l		40 CFR 141.50, Federal primary MCLG
		1,000	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit.
** PQL Detection levels for Gas Chromatography/Mass Spectrometry
µg/l Indicates micrograms per liter.

Table A-6 ARARs for Groundwater at Basin A Neck IRA Treatment System

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
1,2-Dichloroethane	12DCLE	*5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		0.4	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		1**	N	Y	Y	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)
1,1-Dichloroethylene	11DCE	*7	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCLG
		7	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
1,1,1-Trichloroethane	111TCE	200	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCLG
		200	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Arsenic (Total)	AsTOT	50	N	Y	Y	µg/l		40 CFR 141.11, Federal primary MCL
		50	N	Y	Y	µg/l		5 CCR 1003-1, Colorado Groundwater Standard
Atrazine	ATZ	*3	N	Y	Y	µg/l		40 CFR 141.50, Federal primary MCLG
		3	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Benzene	C6H6	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Carbon Tetrachloride	CCL4	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		0.3	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
		1**	N	Y	Y	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in CBSG Table A)
Chlorobenzene	CLC6H5	100	N	Y	Y	µg/l		40 CFR 141.50, Federal primary MCLG
		100	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Chloroform	CHCL3	6	N	Y	Y	µg/l		See trihalomethanes (Total)
		6	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Dieldrin	DLDRN	0.1**	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit.
** PQL Detection levels for Gas Chromatography/Mass Spectrometry
µg/l Indicates micrograms per liter.

Table A-6 ARARs for Groundwater at Basin A Neck IRA Treatment System

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Endrin	ENDRN	2	N	Y	Y	µg/l		40 CFR 141.50, Federal primary MCLG
		0.2	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Hexachlorocyclopentadiene	CL6CP	*50	N	Y	Y	µg/l		40 CFR 141.50, Federal primary MCLG
		50	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Mercury	Hg	2	N	Y	Y	µg/l		40 CFR 141.51, Federal primary MCLG
		2	N	Y	Y	µg/l		5 CCR 1003-1, Colorado primary drinking water standard
Tetrachloroethylene	TCLEE	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard
Trichloroethylene	TRCLE	5	N	Y	Y	µg/l		40 CFR 141.61, Federal primary MCL
		5	N	Y	Y	µg/l		5 CCR 1002-8, Colorado Groundwater Standard

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit.
** PQL Detection levels for Gas Chromatography/Mass Spectrometry
µg/l Indicates micrograms per liter.

Table A-7 TBCs for Groundwater

Parameter	Abbrev	Conc	Units	Hrd	Source
Diisopropylmethyl Phosphonate	DIMP	600	µg/l		EPA Lifetime Health Advisory, December 1989
Isopropyl Methylphosphonic acid	IMPA	700	µg/l		EPA Lifetime Health Advisory, 1992
Methylisobutyl Ketone	MIBK	2000	µg/l		Proposed Corrective Action Rule, 55 FR 30798, Appendix A, July 27, 1990
Parathion	PRTHN	200	µg/l		Proposed Corrective Action Rule, 55 FR 30798, Appendix A, July 27, 1990

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit.
µg/l Indicates micrograms per liter.

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
1,1,1-Trichloroethane	111TCE	18400	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
1,1,2-Trichloroethane	112TCE	9400	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
1,1,2-Trichloroethane	112TCE	18000	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		9400	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
1,2-Dichloroethane	12DCLE	20000	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
Dichloroethylenes	DCE	11600	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
Aldrin	ALDRN	*3	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		1.5	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Arsenic (V)	AsV	48	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		150	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Arsenic (V)	AsV	850	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		360	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Benzene	C6H6	5300	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		5300	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Cadmium	Cd	1.1	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		1.1	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Carbon Tetrachloride	CCL4	35200	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		35200	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Chloroform	CHCL3	1240	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		1240	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Chloroform	CHCL3	28900	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		28900	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit
µg/l Indicates micrograms per liter.

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Chromium (III)	CrIII	210	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		207	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Chromium (III)	CrIII	1,700	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		1,700	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Chromium (VI)	CrVI	11	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		11	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Chromium (VI)	CrVI	16	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		16	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Copper	Cu	12	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		12	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Copper	Cu	18	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		18	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Cyanide (Free)	CYNF	5.2	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
Cyanide (Free)	CYFN	22	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
DDT (Total)	PPDDT	*0.001	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		0.001	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
		0.1	N	Y	Y	µg/l		State Discharge Permit System PQLs (referenced in surface water tables)
DDT (Total)	PPDDT	*1.1	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		0.55	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
DDE	PPDDE	1050	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		1050	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit
µg/l Indicates micrograms per liter.

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Dieldrin	DLDRN	*0.0019	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		0.0019	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
		0.1	N	Y	Y	µg/l		State Discharge Permit System PQLs (referenced in surface water tables)
Dieldrin	DLDRN	*2.5	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		1.3	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Endrin	ENDRN	*0.0023	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		0.0023	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
		0.1	N	Y	Y	µg/l		State Discharge Permit System PQLs (referenced in surface water tables)
Endrin	ENDRN	*0.18	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		0.09	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Hexachlorocyclopentadiene	CL6CP	*5.2	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		5	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Hexachlorocyclopentadiene	CL6CP	*7	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		7	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Lead	Pb	3.2	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		3.9	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Lead	Pb	82	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		96	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Malathion	MLTHN	*0.1	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		0.1	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
		0.2	N	Y	Y	µg/l		State Discharge Permit System PQLs (referenced in surface water tables)
Mercury	Hg	0.012	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		0.1	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit
µg/l Indicates micrograms per liter.

Parameter	Abbrev	Conc	App	Rel	Apr	Units	Hrd	Source
Mercury	Hg	2.4	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		2.4	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Parathion	PRTHN	*0.013	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
Parathion	PRTHN	*0.065	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
Tetrachloroethylene	TCLEE	840	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		840	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Tetrachloroethylene	TCLEE	5280	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		5280	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Toluene	MEC6H5	17500	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		17500	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Trichloroethylene	TRCLE	21900	N	Y	Y	µg/l		Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		21900	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Trichloroethylene	TRCLE	45000	N	Y	Y	µg/l		Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		45000	N	Y	Y	µg/l		State Surface Water Standard, acute toxicity to freshwater aquatic life
Zinc	Zn	110	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, chronic toxicity to freshwater aquatic life
		106	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life
Zinc	Zn	120	N	Y	Y	µg/l	100 mg/l	Federal Water Quality Criteria, acute toxicity to freshwater aquatic life
		117	N	Y	Y	µg/l	100 mg/l	State Surface Water Standard, acute toxicity to freshwater aquatic life

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit

µg/l Indicates micrograms per liter.

Table A-9 TBCs for Surface Water

Parameter	Abbrev	Conc	App	Hrd	Source
Diisopropylmethyl phosphonate	DIMP	600	µg/l		EPA Health Advisory, December 1988
		1.0	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in surface water tables)
Ethylbenzene	ETC6H5	4000	µg/l		Proposed Corrective Action Rule, 55 FR 30798, Appendix A, July 27, 1990
		680	µg/l		EPA Integrated Risk Information System
Fluoride	F	2000	µg/l		40 CFR 143.3, Federal secondary MCL
Methylene chloride	CH2CL2	*5	µg/l		Proposed Corrective Action Rule, 55 FR 30798, Appendix A, July 27, 1990
Methylisobutyl ketone	MIBK	2000	µg/l		Proposed Corrective Action Rule, 55 FR 30798, Appendix A, July 27, 1990
n-Nitrosodimethylamine	NNDMEA	0.007	µg/l		EPA Integrated Risk Information System
		10.0	µg/l		5 CCR 1002-2, State Discharge Permit System PQLs (referenced in surface water tables)
Xylenes (Total)	XYLEN	70000	µg/l		Proposed Corrective Action Rule, 55 FR 30798, Appendix A, July 27, 1990

* Asterisk indicates concentration below the highest USATHAMA Certified Reporting Limit
µg/l Indicates micrograms per liter.

Table A-10 TBCs for Soils and Sediments

Chemical Compound	RCRA Proposed Corrective Action Rule Levels (ppm)[2]
VHOs	
1,2-Dichloroethane	8
1,1-Dichloroethylene	10
1,1,2,2-Tetrachloroethane	40
Carbon tetrachloride	5
Chlorobenzene	2,000
Chloroform	100
Methylene chloride	90
Tetrachloroethylene	10
Trichloroethylene	60
Toluene	
SHOs	
Hexachlorocyclopentadiene	600
OCPs	
Aldrin	0.04
Chlrodane	0.5
DDE	2
DDT	2
Dieldrin	0.04
Endrin	20
Arsenic	80
Mercury	20
PCB	50*
ICP Metals	
Cadmium	40
Chromium (VI)	400

1 The following Contaminants of Concern (COCs) currently do not have proposed RCRA Corrective Action Rule Levels:

Benzene
Chloroacetic acid
Dibromochloropropane
Dicyclopentadiene
Isodrin
Lead

2 Source: EPA proposed Corrective Action Rule for solid waste management units (55 FR 30798; July 1990)

* Based on TSCA regulatory threshold value and not RCRA Subpart 5 standards

Location	Citation	Requirements
Areas prone to surface movement	40 CFR 264.18(a) 6 CCR 1007-3, 264.18(a)	New treatment facilities, storage facilities, or hazardous waste disposal facilities should not be within 200 feet (ft) of a fault. Facilities should not be located in areas prone to earthquakes, floods, fire, or other disasters that could cause a breakdown of the public water system.
Within 100-year floodplain	40 CFR 257.3-1(a) 40 CFR 264.18(b) 6 CCR 1007-3, 264.18(b) Executive Order 11988 40 CFR 6.302 (b) 40 CFR 6, Appendix A, Section 3(a), 3(b)(1), & 3(b)(4) 44 FR 43239 (proposed July 24, 1979)	Facilities should be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. Floodplain management requirements exist to avoid adverse impacts associated with the occupancy and modification of floodplains.
Wetlands	Clean Water Act Section 404 40 CFR Parts 230, Subpart H Substantive (but not permit) 33 CFR 320-330 Executive Order 11990 40 CFR 6.302 (a) 40 CFR 6, Appendix A, Section 3(a) & 3(c)	The discharge of dredged or fill material into the waters of the United States is prohibited without a permit. Protection of wetlands is required to avoid adverse impacts associated with the destruction and modification of wetlands.
Area affecting stream or river	16 USC Part 661-663 40 CFR 6.302 (e) and (g) 16 USC 1274 et. seq.	Fish or wildlife resources that may be affected by actions resulting in control or structural modification of any natural stream or body of water should be protected. Federal agencies taking such actions must consult with the U.S. Fish and Wildlife Service. The Wild and Scenic Rivers Act established requirements for water resource projects affecting wild, scenic or recreational rivers in the National Wild and Scenic Rivers system.
Historically or culturally significant properties owned or controlled by a federal agency	16 USC 470 aa et. seq. 36 CFR 800 44 FR 6068	The National Historic Preservation Act identifies procedures for protection of Historically and Culturally Significant Properties, including Colorado's delegated responsibilities under the act.
Prehistoric, historic, or archaeological sites owned or controlled by a federal agency	36 CFR 60 36 CFR 63 Proposed 36 CFR 66	Department of Interior regulations for determining site eligibility for the National Register of Historic Places and standards for data recovery should be complied with.

Location	Citation	Requirements
Historical, prehistorical and archaeological resources and State Register of Historic Places Act	CRS § 24-80-401 et. seq. CRS §24-80.1-101 et. seq.	Consultation with the Colorado Historic Society, the State Archaeologist, and State Register of Historic Places is required before an action is taken.
Cultural resource owned or controlled by a federal agency	35 FR 8921	Executive Order 11593: Any federal agency controlling culturally significant resources is the designated leader in the preservation of those resources. This order ensures that all culturally significant resources located on an agency's property are protected. The federal agencies are responsible for identifying, evaluating, and nominating (where appropriate) to the National Register of Historic Places all culturally significant resources found on their land.
Archeological or historic site owned or controlled by a federal agency	16 USC 469 et. seq.	The Archeological and Historic Preservation Act of 1974 requires that a federal agency notifies the Secretary of Interior of any agency project that will destroy a significant archaeological site. The Secretary of the notifying agency may support data recovery programs to preserve the resource.
Historically significant property owned and managed by the U.S. Army	Army Regulation 420 32 CFR 650.181 to 193 Technical Manual 5-801-1 Technical Note 78-17 32 CFR 229	U.S. Department of the Army has procedures and standards for preserving historically significant properties and procedures for implementing the Archeological Resources Protection Act. Department of the Army Regulations 420 prescribe Army policy procedures and responsibilities for compliance with the National Historic Preservation Act of 1966, as amended, for maintaining the preservation of historically significant sites, the hiring of qualified personnel to manage the sites, and the conduct of state-of-the-art standards for preservation, personnel, and projects for accomplishment of the historic preservation program. This regulation also requires that each installation prepare a historic preservation plan or have documentation on file indicating that no resources appropriate for such management planning exist.
Archeological resources on U.S. Department of the Army installations	16 USC 470 aa et. seq.	The Archeological Resources Protection Act of 1979 establishes criminal and civil penalties for anyone damaging archaeological resources. This act also allows the Secretary of the Army to issue excavation permits for archaeological resources.
Prehistoric, historic, or archaeological sites owned or controlled by the U.S. Army	16 USC 470a 36 CFR 800	The National Historic Preservation Act of 1966 requires the Secretary of the Interior to inventory, evaluate, and nominate (where appropriate) significant properties to the National Register of Historic Places.

Location	Citation	Requirements
Prehistoric, historic, or archaeological sites owned or controlled by the U.S. Army (continued)	Executive Order No. 11593, May 13, 1971, 36 FR 8921, Section 2(b).	According to Executive Order No. 11593, each federal agency shall exercise caution to ensure that any such property that might qualify for inclusion is not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate significantly.
	16 USC 470 aa et. seq. 36 CFR 60.6	Based on the historical and field inventory information, the significance of all identified sites should be evaluated following criteria set forth in 36 CFR 60.6 and in accordance with the Preservation Office before conducting any ground-altering activity with guidelines from the Colorado State Historic Preservation Office. The act also requires the Army agency to consult with the Advisory Council on Historic issues that may affect those significant properties. A federal agency should take into account the effect of the project on any National Register-listed or eligible property and is directed to complete an appropriate data recovery program before such a site is damaged or destroyed.
National Historic Landmark Program	36 CFR 65	The National Historic Landmark Program was established to identify and designate National Historic Landmarks and encourage the long range preservation of nationally significant properties that illustrate or commemorate the history and prehistory of the United States.
General location requirements	6 CCR 1007-2, Part 2	State siting requirements control the location, design, and design performance of hazardous waste disposal sites. Such disposal sites must be located and designed in a manner that ensures long-term protection of human health and the environment. Disposal sites must be designed to prevent adverse effects on: • Groundwater • Surface water • Air quality • Public health and the environment

Location	Citation	Requirements
National Wildlife Refuge System Administration Act	16 USC 668dd et. seq.	The National Wildlife Refuge Administration Act prohibits the taking or possessing any fish, bird, mammal, or other wild vertebrate or invertebrate animals or part or nest or egg thereof within any such area; or enter, use, or otherwise occupy any such area for any purpose; unless such activities are performed by persons authorized to manage such area or unless such activities are permitted.

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
	29 CFR 1926 Subpart P	29 CFR 1926 Subpart P provides guidelines for workers engaged in activities related to construction and utilization of trenches and ditches.

Action	Citation	Requirements
	AR-385-10 AR 385-64 AMC-R 395-100 DAA Pam 40-8 [TBC] FM 3-21 [TBC] TM 10-277 [TBC] ACOE Guidance on Safety Concepts for UXO [TBC]	If unexploded ordnance (UXO) is encountered during excavation, workers must comply with the substantive requirements of AMCR 385-100, AR 385-10, AR 385-64, as well as guidance provided in DA Pam 40-8, FM 3-21, TM 10-277 and ACOE guidance for UXO regarding health and safety of workers associated with ammunition, explosives, and chemical agents.
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, excavation at Basin F is expected to encounter ammonia. The ammonia fumes will be neutralized using an acidified scrubber that utilizes hydrochloric acid. Worker exposure standards for these chemicals are as follows: Ammonia: ACGIH-TWA = 25 ppm, 17 mg/m^3; STEL = 35 ppm, 24 mg/m^3; NIOSH-REL = 25 ppm, 18 mg/m^3; STEL = 35 ppm, 27 mg/m^3; OSHA-PEL = 50 ppm, 35 mg/m^3 Hydrogen Chloride: ACGIH-ceiling = 5 ppm, 7.5 mg/m3; NIOSH-ceiling = 5 ppm, 7 mg/m3; OSHA-ceiling = 5 ppm, 7 mg/m3 If chemical agent is encountered during excavation, workers must comply with the chemical-specific exposure guidelines for chemical agents and breakdown products outlined in Table A-28 of this document. (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air Emission Control		
Particulate emissions during excavation and backfill	5 CCR 1001–3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. In addition, no off-site transport of particulate matter is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Excavation and backfill of soils could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air

Action	Citation	Requirements
Air emissions from diesel-powered vehicles associated with excavation and backfill operations	5 CCR 1001-15, Regulation 12	Colorado Diesel-Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows: 1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Excavation and backfilling of soils must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.

Action	Citation	Requirements
	5 CCR 1001-14 CRS Section 42-4-307(8)	The colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
<u>Smoke and opacity</u>	5 CCR 1001-3, Regulation 1, Sect II.A	Excavation and backfilling of soils must be conducted in a manner that will not allow or cause the emission into the atmosphere of any air pollutant that is in excess of 20% opacity.
<u>Waste Characterization</u>		
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.

Action	Citation	Requirements
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandanced, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Wastes generated during soil excavation activities must be characterized and evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods or by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes.

Action	Citation	Requirements
		2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore non-putrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, commercial, and special wastes are expected from soil excavation at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
Waste Management		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	If soil excavation at RMA generates hazardous wastes, the wastes must be treated, stored or disposed in accordance with RCRA regulations, including LDRs-UTS (if placement occurs).

Action	Citation	Requirements
	6 CCR 1007-3 Parts detailed below	Some of the Colorado standards for owners and operators of hazardous waste treatment, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. The standards that are more stringent are detailed below.
	Part 264.13 6 CCR 1007-3 Sect 264.13	General waste analysis requirements
	Part 264.97 (g)(3) 6 CCR 1007-3 Sect 264.97(g)(3)	General groundwater monitoring requirements
	Part 264.98 (c) 6 CCR 1007-3 Sect 264.98(c)	Groundwater detection monitoring program
	Part 264.99 (C)(3)(i)(iii) 6 CCR 1007-3 Sect 264.99(C)(3)(i)(iii)	Groundwater compliance monitoring program
	Part 264.100 (e)(2) 6 CCR 1007-3 Sect 264.100(e)(2)	Corrective action program
	Part 264.171-173 6 CCR 1007-3 Sect 264.171-173	Applicability of the requirements of containers
	Part 264.101 (c)(1) 6 CCR 1007-3 Sect 264.101(c)(1)	Corrective action for solid waste management units
	Part 264.190 (c) 6 CCR 1007-3 Sect 264.190(c)	Applicability of the requirements for tanks or tank systems
	Part 264.251 (c) & (d) 6 CCR 1007-3 Sect 264.251(c) & (d)	Design and operating requirements for waste piles
	Part 264.273 (c) & (d) 6 CCR 1007-3 Sect 264.273(c) & (d)	Design and operating requirements for land treatment
	Part 264.312 (b) 6 CCR 1007-3 Sect 264.312(b)	Special requirements for ignitable and reactive wastes in landfills

Action	Citation	Requirements
	Part 264.314 (a) 6 CCR 1007-3 Sect 264.314(a)	Special requirements for bulk and containerized liquids in landfills
	Part 264.340 (a)(1) & (2) 6 CCR 1007-3 Sect 264.340(a)(1) & (2)	Applicability of incinerator requirements
	Part 264.16 (a)(1) 6 CCR 1007-3 Sect 264.16(a)(1)	Personnel training
	Part 264.31 (a) 6 CCR 1007-3 Sect 264.31(a)	Facility design and operation requirements
	Part 264.51 (a) 6 CCR 1007-3 Sect 264.51(a)	Purpose and implementation of contingency plans
	Part 264.52 (a) 6 CCR 1007-3 Sect 264.52(a)	Content of contingency plans
	Part 264 Subpart cc 6 CCR 1007-3 Part 264 Subpart cc	Air emission standards for tanks
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris generated during soil excavation activities must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris if placement occurs. In certain cases, after treatment the debris may no longer be subject to RCRA Subtitle C regulation.
<u>Management of Remediation Wastes</u>	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.

Action	Citation	Requirements
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
<u>Groundwater Injection</u>		
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed in compliance with the requirements of 40 CFR 124, 144, 146, 147 (Subpart G), and 148.
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
<u>Dredged Material Management</u>		
Discharge of Dredged Materials	40 CFR 230 Subpart B	Dredging operations in wetland areas must be managed in accordance with the applicable requirements based on the impacts resulting from specific dredged material discharges associated with sediment removal activities.
Certification of Federal Licenses and Permits (401 Certification)	33 USC Section 1341 Section 401 of Clean Water Act	Provides for state review of facility operations for the purposes of assuring that applicable effluent limitations or other limitations or other applicable water quality requirements will not be violated.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Waste Characterization		
Solid waste determination		Drums, debris, and equipment from structures that stockpiled must be evaluated to determine whether it may be recycled or reused or whether it is a solid waste.
	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 (a) 6 CCR 1007-3 Sect 261.4(a) 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31	A solid waste is any discarded material that is not excluded by 40 CFR 261.4 (a) or that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Solid wastes including drums, debris, and equipment from structures that are temporarily stored in stockpiles must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods or by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used

Action	Citation	Requirements
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes are expected from sstockpiles at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
Waste Management		
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater)
		Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements.
		Containers must be dated when they are placed in storage.
		All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
PCB decontamination standards	40 CFR 761.79	PCB containers to be contaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.
Treatment, storage, or disposal of hazardous wastes in waste piles	40 CFR Part 264.251 6 CCR 1007-3 Sect 264.251 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes stored in stockpiles that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.

Action	Citation	Requirements
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases after treatment, the debris may no longer be subject to RCRA Subtitle C Regulation. [Refer to Table A-20 for citations and requirements relevant to both on-post and off-post solid waste landfills.]
Design and operating requirements for waste piles that contain hazardous wastes	40 CFR 264.251 6 CCR 1007-3 Sect 264.251	Waste piles that contain hazardous wastes must: • Have a liner that is designed, constructed, and installed to prevent migration of wastes out of the pile into adjacent soil, groundwater, or surface water. • Be constructed with materials to prevent failure, physical contact with the waste, and that will endure stress of installation and daily operation. • Be placed on a foundation that provides support to prevent failure of the liner. • Be installed to cover all surrounding earth likely to be in contact with the waste or leachate. • Have a leachate collection system. • Have a run-on control system capable of preventing flow onto the active portion of the pile during peak discharge from at least a 25-year storm. • Have a run-off management system to collect and control at least the water volume resulting from a 24-hour, 25-year storm. • Be covered or managed properly if the pile contains any particulate matter which may be subject to wind dispersal.
	6 CCR 1007-3	Colorado regulations are more stringent than federal requirements by requiring that run-on and run-off control systems are designed and operated to collect and control the water volume resulting from a 24-hour, 100-year storm.
Incompatible wastes in waste piles	40 CFR 264.257 6 CCR 1007-3 Sect 264.257 40 CFR 264.17 (b) 6 CCR 1007-3 Sect 264.17(b)	Incompatible wastes must not be placed in the same pile unless 40 CFR 264.17 (b) is complied with. Incompatible wastes must be separated from other materials.

Action	Citation	Requirements
Closure and post-closure care of waste piles	40 CFR 264.258 6 CCR 1007-3 Sect 264.258	At closure, the owner or operator must remove or decontaminate all waste residues and manage them as hazardous wastes.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis

Action	Citation	Requirements
		• Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
<u>Air Emissions</u>		
<u>Standard for asbestos waste disposal</u>	40 CFR 61 Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing waste; deposit asbestos-containing waste as soon as possible at disposal site; mark transport vehicles appropriately during loading and unloading operations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120(b) to (j)	29 CFR 1910.120(b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under the RCRA and the CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, the ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Demolition		
Air emissions during demolition	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. In addition, no off-site transport of particulate emissions is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Standard for asbestos waste disposal	40 CFR 61 Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as soon as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
Emission control for opacity	5 CCR 1001-3 Regulation 1, Section II	Demolition of structures shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Demolition of structures could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits:

Action	Citation	Requirements
		1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel–powered vehicles associated with demolition	5 CCR 1001-15, Regulation 12	Colorado Diesel–Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows: 1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.

Action	Citation	Requirements
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Demolition of structures must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Waste Characterization		
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR 261 6 CCR 1007-3 Part 261	Wastes generated during the demolition of structures must be characterized. Solid wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-3, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes.

Action	Citation	Requirements
		2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor mounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes are expected from slurry wall installation at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.

Action	Citation	Requirements
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater)
		Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements.
		Containers must be dated when they are placed in storage.
		All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
PCB decontamination standards	40 CFR 761.79	PCB containers to be contaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.
Treatment, storage, or disposal of hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264	If structure demolition at RMA generates hazardous wastes, the wastes must be treated and stores in accordance with RCRA regulations.
	40 CFR Part 264.250 6 CCR 1007-3 Sect 264.250 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes stored in stockpiles that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
	40 CFR Part 264.171-173 6 CCR 1007-3 Sect 264.171-173	Applicability of the requirements for containers.

Action	Citation	Requirements
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed in Appendix A, Table A-12.
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3 Sect 268.45	Hazardous debris encountered during slurry wall installation must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases after treatment, the debris may no longer be subject to RCRA Subtitle C regulation.
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
On-post land disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264 EPA/540/G-89/006 [TBC]	Based upon a determination of whether the disposal technique constitutes placement, LDRs-UTS may be applicable. If placement occurs, the on-site disposal facility must comply with the substantive requirements of 40 CFR 264.

Action	Citation	Requirements
Stormwater Management Discharge of stormwater to on-post surface water	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone — 7:00 a.m. to next 7:00 p.m. — 7:00 p.m. to next 7:00 a.m. Residential — 55 db(A) — 50 db(A) Commercial — 60 db(A) — 55 db(A) Light Industrial — 70 db(A) — 65 db(A) Industrial — 80 db(A) — 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

Action	Citation	Requirements
		e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
	29 CFR 1926 Subpart P	29 CFR 1926 Subpart P provides guidelines for workers engaged in activities related to construction and utilization of trenches and ditches.
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are presented as guidelines.)

Action	Citation	Requirements
Air Emissions		
Air emissions during trench construction	5 CCR 1001–3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3 Regulation 1, Section II	Trench construction shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Trench construction could cause volatization of some organic and metal contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air

Action	Citation	Requirements
		2) For all other land use area—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel-powered vehicles associated with trench construction	5 CCR 1001-15, Regulation 12	Colorado Diesel-Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows: 1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.

Action	Citation	Requirements
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Trench construction must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone / 7:00 a.m. to next 7:00 p.m. / 7:00 p.m. to next 7:00 a.m. Residential / 55 db(A) / 50 db(A) Commercial / 60 db(A) / 55 db(A) Light Industrial / 70 db(A) / 65 db(A) Industrial / 80 db(A) / 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
<u>Siting</u>		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	The following requirements must be considered for cap cover installation over unlined land disposal sites: 1. They must not be located within 200 ft of a Holocene-age fault. 2. They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain).
<u>Worker Protection</u>		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
		Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are presented as guidelines.)
Construction of Caps/Covers		
Design/installation of caps/covers	EPA/530/SW-89/047 [TBC]	Caps and covers must be designed and installed to prevent wind dispersal of hazardous wastes. They should be designed, constructed, and installed as specified in EPA/530/SW-89/047.
Air Emission Control		
Particulate emissions during cap/cover installation	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Excavation and backfilling of soils conducted in a manner that will not allow or cause the emission into thxcess of 20% opacity. In addition, no off-site transport of particulate matter is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1; Section II	Installation of caps/covers shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Installation of caps/covers could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.

Action	Citation	Requirements
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Odor emissions	5 CCR 1001-4, Regulation 2 [TBC]	Colorado odor emission regulations require that no person shassion of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial reas—odors detece odorous air has been diluted with seven more volumes of dor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel-powered vehicles associated with installation of caps/covers	5 CCR 1001-15, Regulation 12	Colorado Diesel-Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows: 1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity.

Action	Citation	Requirements
		4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Installation of caps/covers must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
Visibility protection (continued)	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

Action	Citation	Requirements
		b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations land emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
	29 CFR 1926 Subpart P	29 CFR 1926 Subpart P provides guidelines for workers engaged in activities related to construction and utilization of trenches and ditches.
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, workers installing the concrete liners will be exposed to Portland cement dust. Worker exposure standards for Portland cement are the following:

Action	Citation	Requirements
		Portland cement ACGIH-TWA = 10 mg/m^3* NIOSH-REL = 10 mg/m^3 (total), 5 mg/m^3 (resp) OSHA-TWA = 15 mg/m^3 (total), 5 mg/m^3 (resp) * value is for total dust containing no asbestos land less than 1% crystalline silica (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are presented as guidelines.)
<u>Air Emission Control</u>		
Particulate emissions during installation of concrete liners	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Mixing of concrete material must be conducted in a manner that will not allow or reuse emissions into the atmosphere of any air pollutant in excess of 20% opacity. In addition, no off-site transport of particulate matter is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Construction of concrete liners shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Concrete liner installation could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.

Action	Citation	Requirements
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Concrete liner installation must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
	29 CFR 1926 Subpart P	29 CFR 1926 Subpart P provides guidelines for workers engaged in activities related to construction and utilization of trenches and ditches.
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air Emissions		
Air emissions during slurry wall construction	5 CCR 1001–3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Slurry wall construction must be conducted in such a manner that will not allow or cause emissions into the atmosphere of any air pollutants in excess of 20% opacity. In addition, no off-site transport of particulate matter is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Slurry walls shall not cause the emission into the atmosphere of any air pollutant which is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Slurry wall construction could cause volatization of some organic and/or metal contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits:

Action	Citation	Requirements
		1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel-powered vehicles associated with slurry wall construction	5 CCR 1001-15, Regulation 12	Colorado Diesel-Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows: 1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.

Action	Citation	Requirements
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Slurry wall construction must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike

Waste Characterization

Action	Citation	Requirements
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 CCR 1007-3 Part 261	Wastes generated during slurry wall construction must be characterized. Solid wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes.

Action	Citation	Requirements
		5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes are expected from slurry wall installation at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
Waste Management		
Treatment, storage, or disposal of hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264	If slurry wall construction at RMA generates hazardous wastes, the wastes must be treated and stored in accordance with RCRA regulations.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed in Appendix A, Table A-9.
On-post land disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268 EPA/540/G-89/006 [TBC]	Based upon a determination of whether the disposal technique constitutes placement, LDRs-UTS may be applicable. If placement occurs, the on-site disposal facility must comply with the substantive requirements of 40 CFR 264.

Action	Citation	Requirements
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris encountered during slurry wall installation must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases after treatment, the debris may no longer be subject to RCRA Subtitle C regulation.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of on-post hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed on-post to treat, store, or dispose must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain).
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are provided as guidelines.)
Landfill Design/Operation		
On-post hazardous waste landfill design/operation	40 CFR 264 Subpart N 6 CCR 1007-3 Part 264 Subpart N 40 CFR 268 6 CCR 1007-3 Part 268	On-post hazardous waste landfills shall be designed and operated in compliance with the applicable substantive requirements of 40 CFR 264, including Subparts A, B, C, D, F, G, I, J, and N. If the landfill is located outside the AOC from which the hazardous waste was derived or is not in a designated CAMU, placement has occurred and the landfill must comply with LDRs-UTS in 40 CFR 268.
Off-post hazardous waste landfill operation	40 CFR 264 6 CCR 1007-3 Part 264 OSWER Directive 9834.11	Off-post hazardous waste landfills shall be RCRA-permitted facilities and shall operate in compliance with all requirements of 40 CFR 264. The facilities shall also be in compliance with OSWER Directive 9834.11 regarding off-site disposal of hazardous waste from CERCLA sites. All RCRA requirements such as manifesting and LDRs-UTS will apply to all off-site shipments of hazardous waste, including any hazardous waste debris.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
TCSA-PCB design standards	40 CFR 761 Subpart D	On-post hazardous waste landfills shall be designed and operated in compliance with applicable substantive requirements of 40 CFR 761 Subpart D.
Waste Management		
Asbestos waste disposal management	6 CCR 1007-2, Part B, Section 5.0	On-Post hazardous waste landfill shall be designed and operated in compliance with applicable substantive requirements for asbestos waste disposal sites.

Action	Citation	Requirements
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
PCB chemical waste landfilling standards	40 CFR 761.75	Landfill must be located in thick, relatively impermeable soil formation or on soil with high clay and silt content, synthetic membranes must be used when these conditions cannot be met. In addition, other structural requirements include avoidance of location in a floodplain; required run-on/run-off structures if below the 100 year floodplain, and ground/surface water monitoring for specified parameters. The landfill must include a leachate monitoring system. PCB wastes must be segregated from wastes not chemically compatible with PCBs.

Action	Citation	Requirements
PCB decontamination standards	40 CFR 761.79	PCB containers to be contaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.
Treatment, storage, or disposal of hazardous wastes in containers and tanks	40 CFR 264.171-173 6 CCR 1007-3 Part 264.171-173	Applicability of the requirements for containers.
	40 CFR 264.190(c) 6 CCR 1007-3 Part 264.190(c)	Applicability of the requirement for tanks or tank systems.
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Air Emission Control		
Emission of particulates	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. No off-site tranport of particulate matter is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements will be necessary.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	On-post landfilling shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. On-post landfilling may cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO Emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

Action	Citation	Requirements
Air Emissions		
Standard for asbestos waste disposal	40 CFR 61 Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing waste; deposit asbestos-containing waste as soon as possible at disposal site; mark transport vehicles appropriately during loading and unloading operations.
Odor emissions	5 CCR 1001-4, Regulations	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	On-post landfilling must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain).
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b)-(j)	29 CFR 1910.120 (b) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table 1 in Appendix A1 of the DSA. In addition to the compounds listed in Table 1, off gases from the rotary kiln incinerators may contain gaseous hydrogen chloride, hydrogen bromide, and hydrogen fluoride. These gases will be removed during further treatment of the off gases, including a caustic quench system using sodium hydroxide. The worker exposure standards for these compounds are as follows: Hydrogen bromide: ACGIH-Ceiling = 3 ppm, 9.9 mg/m^3; NIOSH- Ceiling = 3 ppm, 10 mg/m^3; OSHA- PEL = 3 ppm, 10 mg/m^3 Hydrogen chloride: ACGIH- Ceiling = 5 ppm, 7.5 mg/m^3; NIOSH- Ceiling = 5 ppm, 7 mg/m^3; OSHA- Ceiling = 5 ppm, 7 mg/m^3 Hydrogen fluoride: ACGIH- Ceiling = 3 ppm, 2.6 mg/m^3; NIOSH-REL = 3 ppm, 2.5 mg/m^3 15-min ceiling = 6 ppm, 5 mg/m^3; OSHA-PEL = 3 ppm Sodium hydroxide: ACGIH- Ceiling = 2 mg/m^3; NIOSH- Ceiling = 2 mg/m^3; OSHA-PEL = 2 mg/m^3 (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are presented as guidelines.)

Action	Citation	Requirements
Thermal Desorption Unit Operation		
Determination of operational readiness	40 CFR 270.19 [TBC] 6 CCR 1007-3 Sect 270.19 [TBC] 40 CFR 270.62 (b)[TBC] 6 CCR 1007-3 Sect 270.62(b) [TBC]	Although permit applications are not necessary for RMA remedial actions, the operational readiness information will be provided in CERCLA documents leading to incineration alternatives.
Operation of thermal desorption unit	40 CFR 264 Subpart 0 6 CCR 1007-3 Part 264 Subpart O	The thermal desorption unit shall be operated to comply with substantive requirements of the incinerator regulations in 40 CFR 264 Subpart 0, including, but not limited to the following: • Stack emission • Monitoring • Inspections • Testing of the emergency waste feed cutoff system
	6 CCR 1007-3	Colorado incinerator regulations are broader in scope than the federal regulations. The Colorado regulations include boilers and industrial furnaces as regulated units under Subpart O.
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned mateiral may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike

Action	Citation	Requirements
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Thermal desorption of soils will generate salt cake, metal fines, and other solids. These wastes and all others generated must be characterized and evaluated according to the following methods to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Part 1, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain the following five solid waste categories: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes.

Action	Citation	Requirements
		5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, commercial, and special wastes are expected from thermal desorption of soils at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
PCB incineration standards	40 CFR 761.70	Incineration requirements for non-liquid PCB apply to PCB concentrations >50 ppm and include specified dwell times; combustion efficiency of 99.9999 percent; process record/monitoring requirements; automatic shut-off standards; a maximum mass air emission of 0.001 g PCB per kg of PCB entering the incinerator.

Action	Citation	Requirements
PCB decontamination standards	40 CFR 761.79	PCB containers to be contaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.
Treatment, storage, or disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264	Wastes that are determined to be RCRA hazardous wastes must be stored and treated, in compliance with RCRA regulations.
On-post land disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264 EPA/540/G-89/005 [TBC]	Based upon a determination of whether the disposal technique constitutes placement, LDRs-UTS may be applicable. If placement does occur, the disposal facility must comply with the substantive requirements of 40 CFR Part 264.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Air Emissions		
Emission of Particulates	40 CFR 60 Subpart E 5 CCR 1001-8, Regulation 6, Part B (VII)	The thermal desorption unit shall operate in compliance with substantive requirements of 40 CFR 60 Subpart E and the corresponding state requirements. In addition, no off-site transport of particulate matter is allowed.
	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
	5 CCR 1001-3, Regulation 1, Section III.B	Performance standards regarding particulate matter (<.10 gram of particulate matter per standard cubic foot) and performance testing in accordance with Appendix A of Air Quality Control Commission Regulation 6.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Thermal desorption of soils shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Thermal desorption will cause volatization of some contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

Action	Citation	Requirements
		Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
PM/CO Emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Thermal desorption of soils must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
<u>Siting</u>		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007.3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain).
<u>Worker Protection</u>		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46.

Action	Citation	Requirements

In addition to the compounds listed in Table A-46 will be removed during further treatment of the off gases, including a caustic quench system using sodium hydroxide. The worker exposure standards for these compounds are as follows:

Hydrogen bromide

ACGIH-Ceiling	=	3 ppm, 9.9 mg/m^3
NIOSH- Ceiling	=	3 ppm, 10 mg/m^3
OSHA-PEL	=	3 ppm, 10 mg/m^3

Hydrogen chloride

ACGIH- Ceiling	=	5 ppm, 7.5 mg/m^3
NIOSH- Ceiling	=	5 ppm, 7 mg/m^3
OSHA- Ceiling	=	5 ppm, 7 mg/m^3

Hydrogen fluoride

ACGIH- Ceiling	=	3 ppm, 2.6 mg/m^3
NIOSH-REL	=	3 ppm, 2.5 mg/m^3 15-min ceiling = 6 ppm, 5 mg/m^3
OSHA-PEL	=	3 ppm

Sodium hydroxide

ACGIH- Ceiling	=	2 mg/m^3
NIOSH- Ceiling	=	2 mg/m^3
OSHA-PEL	=	2 mg/m^3

If chemical agent is incinerated on post, the agent must be managed to comply with the exposure standards shown in Table A-28 of this document.

OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.

Action	Citation	Requirements
Operation of Incinerators		
Determination of operation readiness	40 CFR 270.19 [TBC] 6 CCR 1007.3 Sect 270.19 40 CFR 270.62 (b) [TBC] 6 CCR 1007-3 Sect 270.62(b)	Although permit applications are not necessary for RMA remedial actions, operational readiness information will be provided in CERCLA documents leading to incineration alternatives.
Incinerator operations	40 CFR 264 Subpart 0 6 CCR 1007-3 Part 264 Subpart O	On-post rotary-kiln incinerators must be operated in compliance with the substantive requirements of 40 CFR 264 Subpart 0, including, but not limited to the following: • Waste-specific performance standards • Stack emission standards • Monitoring Off-post incinerators must be RCRA-permitted and comply with all requirements of 40 CFR 264 Subpart 0.
	6 CCR 1007-3	Colorado incinerator regulations are broader in scope than the federal regulations. The Colorado regulations include boilers and industrial furnaces as regulated units under Subpart 0.
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned mateiral may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike

Action	Citation	Requirements
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Incineration/pyrolysis of soils will generate oversize soil, debris, metallic waste, ash, and salt cake. These wastes and all others generated must be characterized and evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain the following five solid waste categories: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes means all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes," which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes.

Action	Citation	Requirements
		5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, commercial, and special wastes are expected from incineration/pyrolysis of soils at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
Waste Management		
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
PCB incineration standards	40 CFR 761.70	Incineration requirements for non-liquid PCB apply to PCB concentrations >50 ppm and include specified dwell times; combustion efficiency of 99.9999 percent; process record/monitoring requirements; automatic shut-off standards; a maximum mass air emission of 0.001 g PCB per kg of PCB entering the incinerator.

Action	Citation	Requirements
PCB decontamination standards	40 CFR 761.79	PCB containers to be contaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 EPA/540/G-89/006 [TBC]	Wastes that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations. If the soil is treated in a central incineration/pyrolysis facility at RMA that is outside the AOC from which the soil came, any waste returned to the AOC after treatment will be subject to LDRs-UTS since placement of the waste will have occurred.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Treatment of UXO containing chemical agent	AMC-R 385-131	UXO shall be incinerated as described in AMC-R 385-131 to a 5X level of docontamination so that it can be released from DOD control.
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris generated during incineration/pyrolysis activities must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris if placement occurs. In certain cases, after treatment the debris may no longer be subject to RCRA Subtitle C regulation.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.

Action	Citation	Requirements
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
<u>Air Emissions</u>		
Emission of particulates	40 CFR 60 Subpart E 5 CCR 1001-8, Regulation 6, Part B (VII)	Incineration/pyrolysis activities must operate in compliance with the particulate emission standards for incinerators in 40 CFR 60 Subpart E and the corresponding state requirements. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Incineration/pyrolysis operations shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Incineration/pyrolysis will cause volatization of some contaminants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air

Action	Citation	Requirements
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Incineration /pyrolysis operations must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Emission of particulates	5 CCR 1001-3, Regulation 1, Sect III.B	Performance standards regarding particulate matter (<0.1 grams of particulate matter per dry standard cubic foot) and performance testing in accordance with Appendix A or Air Quality Control Commission Regulation No. 6.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone / 7:00 a.m. to next 7:00 p.m. / 7:00 p.m. to next 7:00 a.m. Residential / 55 db(A) / 50 db(A) Commercial / 60 db(A) / 55 db(A) Light Industrial / 70 db(A) / 65 db(A) Industrial / 80 db(A) / 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

Action	Citation	Requirements
		e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Off-Post Incinerator		
Incinerator facility operations	40 CFR 264 Subpart 0 6 CCR 1007-3 Part 264 Subpart O OSWER Directive 9834.11 [TBC]	The off-post facility must have a RCRA permit to operate under the requirements of 40 CFR 264 Subpart 0. The facility should also be approved under the conditions of OSWER Directive 9834.11 for off-site disposal of hazardous wastes from a CERCLA site.
	6 CCR 1007-3	Colorado incinerator regulations are broader in scope than the federal regulations. The Colorado regulations include boilers and industrial furnaces as regulated units under Subpart 0.
Air Emissions		
Emission of Particulates	5 CCR 1001-3, Regulation 1, Sect III.B	Performance standards regarding particulate matter (<0.1 gram of particulate matter per dry standard cubic foot) and performance testing in accordance with Appendix A of Air Quality Control Commission Regulation No. 6.
Waste Management		
Off-site disposal of hazardous waste	40 CFR Part 268 6 CCR 1007-3 Part 268	All off-site shipments of hazardous waste to approved TSDF must be accompanied by required LDR certifications and analysis.
Off-site shipment of hazardous waste	40 CFR Part 262 6 CCR 1007-3 Part 262	Any shipments of hazardous waste off-site must be in compliance with generator standards such as manifests, packaging/labeling, and placarding requirements.

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, the Enhanced Surface Soil Vacuum Extraction Process (ESSVEP) generates hydrochloric acid vapors in the off gases. Worker exposure standards for hydrogen chloride are as follows:

Action	Citation	Requirements
		Hydrogen chloride (ceiling) ACGIH-TWA = 5 ppm, 7.5 mg/m^3 NIOSH-REL = 5 ppm, 7 mg/m^3 (ceiling) OSHA-PEL = 5 ppm, 7 mg/m^3 (ceiling) (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Waste Characterization</u>		
Solid Waste Determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Soil heating will generate wastewater, off gases, and possibly spent carbon. These wastes and all others generated must be characterized and evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261

Action	Citation	Requirements
		• Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes," which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation.

Action	Citation	Requirements
		If present, only small quantities of industrial, community, and commercial wastes are expected from soil heating operations at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement has occurred.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Wastewater	40 CFR Part 122 40 CFR Part 125 40 CFR Part 129	Any wastewater generated during soil heating will be routed to the on-post RMA wastewater treatment plant if it is not hazardous waste and will not interrupt the existing treatment system. If wastewater is routed to the on-post treatment plant, it must be treated in accordance with NPDES requirements.

Action	Citation	Requirements
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Air Emissions		
Emission of particulates	5 CCR 1001--3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Soil heating operations shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.

Action	Citation	Requirements
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Soil heating will cause volatization of some contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

Action	Citation	Requirements
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Soil heating must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

Action	Citation	Requirements
		b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, ethylene glycol will be used as a coolant in the vitrification process. Worker exposure standards for this chemical are as follows: Ethylene glycol ACGIH-TWA = 50 ppm, 127 mg/m^3 (ceiling) (OSHA regulations and other safety and health requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air Emissions		
Emission of particulates	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	In situ vitrification of soils shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. In-situ vitrification of soils may cause volatilization of some contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

Action	Citation	Requirements
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	In situ vitrification must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel-powered vehicles associated with in-situ vitrification	5 CCR 1001-15, Regulation 12	Colorado Diesel–Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows: 1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C".

Action	Citation	Requirements
		3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike.
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	In situ vitrification will generate grubbed vegetation and debris. These wastes and all others generated must be characterized and evaluated according to the following method to determine whether the waste is hazardous:

Action	Citation	Requirements
		• Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation.

Action	Citation	Requirements
		If present, only small quantities of industrial, community, commercial, and special wastes are expected from in situ vitrification at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
Waste Management		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268 EPA/540/G-89/006 [TBC]	Wastes that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris generated during in situ vitrification activities must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases after treatment, the debris may no longer be subject to RCRA Subtitle C regulation.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.

<table>
<tr><th>Action</th><th>Citation</th><th>Requirements</th></tr>
<tr><td>Temporary Units</td><td>6 CCR 1007-3 Sect 264.553
40 CFR 264.533</td><td>Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.</td></tr>
<tr><td><u>Stormwater Management</u></td><td></td><td></td></tr>
<tr><td>Discharge of stormwater to on-post surface waters</td><td>40 CFR Parts 122-125</td><td>Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.</td></tr>
<tr><td><u>Noise abatement</u></td><td>Colorado Revised Statute, Section 25-12-103</td><td>The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:
<table>
<tr><th>Zone</th><th>7:00 a.m. to next 7:00 p.m.</th><th>7:00 p.m. to next 7:00 a.m.</th></tr>
<tr><td>Residential</td><td>55 db(A)</td><td>50 db(A)</td></tr>
<tr><td>Commercial</td><td>60 db(A)</td><td>55 db(A)</td></tr>
<tr><td>Light Industrial</td><td>70 db(A)</td><td>65 db(A)</td></tr>
<tr><td>Industrial</td><td>80 db(A)</td><td>75 db(A)</td></tr>
</table>
b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).</td></tr>
</table>

Action	Citation	Requirements
		d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120(b) to (j)	29 CFR 1910.120(b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 CR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike.
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Wastes generated during structure decontamination activities must be characterized. Solid wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain the following five solid waste categories:

Action	Citation	Requirements
		1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes are expected from hot gas decontamination at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
Waste Management		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264	Wastes that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
Treatment, storage, or disposal of RCRA hazardous waste (continued)	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Wastewater	40 CFR Part 122 40 CFR Part 125 40 CFR part 129	Any wastewater generated during hot gas decontamination of structures will be routed to the on-post RMA wastewater treatment plant if it is not hazardous waste and will not interrupt the existing treatment system. If wastewater is routed to the on-post treatment plant, it must be treated in accordance with NPDES requirements.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Air Emission Control		
Particulate emissions	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions Estimated emissions from the proposed remedial activity per Colorado APEN requirements will be necessary.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Hot gas decontamination operations shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emissions regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Decontamination of structures could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements.

Action	Citation	Requirements
		Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	42 USC 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Hot gas decontamination of structures must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

<table>
<tr><th>Action</th><th>Citation</th><th>Requirements</th></tr>
<tr><td>Noise abatement</td><td>Colorado Revised Statute, Section 25-12-103</td><td>The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone / 7:00 a.m. to next 7:00 p.m. / 7:00 p.m. to next 7:00 a.m.
Residential / 55 db(A) / 50 db(A)
Commercial / 60 db(A) / 55 db(A)
Light Industrial / 70 db(A) / 65 db(A)
Industrial / 80 db(A) / 75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."</td></tr>
</table>

Action	Citation	Requirements
Detonation of UXO Containing High Explosives		
UXO detonation	AMC-R 755-B	High explosives will be detonated in compliance with the substantive requirements of AMC-R 755-B regarding demilitarization of class V materials.
On-post detonation of UXO	40 CFR 264.601 and .602 6 CCR 1007-3 Sect 264.601-602	On-post detonation of UXO must comply with the substantive requirements of the environmental performance standards described in 40 CFR 264.601 and substantive portions of the monitoring, analysis, reporting, and corrective action requirements of 40 CFR 264.602.
Off-post detonation of UXO	40 CFR 264 Subpart X 6 CCR 1007-3 Part 264 Subpart X	Off-post facilities used for detonation of UXO must be RCRA-permitted units that have been permitted under 40 CFR 264 Subpart X.
Chemical Agent Decontamination		
Agent decontamination	AMC-R 385-131	Decontamination of chemical agent-contaminated material will comply with the requirements of AMC-R 385-131
Worker Protection		
Health and safety protection	AR 385-10 AR 385-61 AR 385-64 AMC-R 385-100 DA PAM 40-8 [TBC] DA PAM 385-61 FM3-21 [TBC] TM 10-277 [TBC] ACOE Guidance on Safety Concepts for UXO [TBC]	Workers shall comply with the substantive requirements of AMC-R 385-100, AR 385-10, AR 385-61, AR 385-64, as well as guidance provided in DA PAM 40-8, DA PAM 385-61, FM 3-21, TM 10-277 and ACOE guidance for UXO regarding health and safety of workers associated with ammunition, explosives, and chemical agents.
	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA.

Action	Citation	Requirements
		Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, workers involved in the demilitarization of HE- or agent-filled UXO will be exposed to several unique chemicals. Worker exposure standards for explosives are as follows: Aluminum (Pyro powder) ACGIH-TWA = 5 mg/m^3 (Pyro-powder) OSHA-PEL = 15 mg/m^3 total, 5 mg/m^3 resp (ASAL) Lead Azide (Colloidal - as Pb)* Nitroglycerin ACGIH-TWA = 0.05 ppm, 0.46 mg/m^3 (skin) NIOSH-REL = 0.1 ppm (skin) OSHA-Ceiling = 0.2 ppm, 2 mg/m^3 (15 min ceiling) * Source: Hazardous Component Safety Data Sheet (ARRADCOM Form 29)

Action	Citation	Requirements
		Picric Acid ACGIH-TWA = 0.1 mg/m^3 NIOSH-REL = 0.1 mg/m^3, STEL = 0.3 mg/m^3 (skin) OSHA-PEL = 0.1 mg/m^3 (8 hr TWA - skin) RDX (Cyclonite) ACGIH-TWA = 1.5 mg/m^3 (skin) Tetryl ACGIH-TWA = 1.5 mg/m^3 NIOSH-REL = 1.5 mg/m^3 (skin) OSHA - PEL = 1.5 mg/m^3 (8 hr TWA - skin) 2,4,6-Trinitrotoluene (TNT) ACGIH-TWA = 0.5 mg/m^3 (skin) NIOSH-REL = 0.5 mg/m^3 (skin) OSHA-PEL = 1.5 mg/m^3 * Source: Hazardous Component Safety Data Sheet (ARRAD COM Form 29) Worker exposure standards for chemical agents and their breakdown products are found in Table A-28 of this document. (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Emission of particulates	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.

Action	Citation	Requirements
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. UXO demilitarization could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Demilitarization of UXO must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.

Action	Citation	Requirements
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulatoins require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone — 7:00 a.m. to next 7:00 p.m. — 7:00 p.m. to next 7:00 a.m. Residential — 55 db(A) — 50 db(A) Commercial — 60 db(A) — 55 db(A) Light Industrial — 70 db(A) — 65 db(A) Industrial — 80 db(A) — 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

Action	Citation	Requirements
		c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Chemical Name	Exposure Standards		Source	Associated Agent
Acetic Acid	ACGIH-TWA	= 10 ppm, 25 mg/m^3	SDP	GB
	ACGIH-STEL	= 15 ppm, 37 mg/m^3		
	NIOSH-REL	= 10 ppm, 25 mg/m^3		
	NIOSH-STEL	= 15 ppm, 37 mg/m^3		
	OSHA-PEL	= 10 ppm, 25 mg/m^3 (8 hr TWA)		
Acetylene	ACGIH -TWA	= simple asphyxiant	HP, ICP	L
Acetylene chloride [acetylene monochloride]	Animal toxicity data only[3]		ICP	L
Acetylene Dichloride** [1,2-dichloroethylene]	ACGIH-TWA	= 200 ppm, 793 mg/m^3	ICP	HL, L
	NIOSH-REL	= 200 ppm, 790 mg/m^3		
	OSHA-PEL	= 200 ppm, 790 mg/m^3		
Adamsite (DM) [10 chloro-5,10-dihydrophenarsazine]	LCt_{50}[1]	= 11000-44000 mg-min/m^3 (inhal)	A	DM
	ICt_{50}[1]	= 370 mg-min/m^3 (inhal)		
Ammonia	ACGIH-TWA	= 25 ppm, 17 mg/m^3	SDP	GB
	ACGIH-STEL	= 35 ppm, 24 mg/m^3		
	NIOSH-REL	= 25 ppm, 18 mg/m^3		
	NIOSH-STEL	= 35 ppm, 27 mg/m^3		
	OSHA-PEL	= 50 ppm, 35 mg/m^3		
Arsenic (Inorganic Compounds as As - including arsenous oxide, arsenic oxychloride, arsenic trichloride, arsenic trioxide, sodium arsenite)	ACGIH-TWA	= 0.01 mg/m^3	HP, CP, ICP	HL, L
	NIOSH-Ceiling	= 0.002 mg/m^3 (15 min ceiling)		
	OSHA-PEL	= 10 µg/m^3 (8 hr TWA)		
Bis(2-chlorovinyl)chloroarsine	Animal toxicity data only[3]		–	L
Calcium Chloride	Animal toxicity data only[3]		DP	HD
Calcium Sulfate	ACGIH-TWA	= 10 mg/m^3***	DP	HD
	OSHA-PEL	= 15 mg/m^3 (8 hr TWA - total dust)		
		= 5 mg/m^3 (8 hrs TWA - rf)		

Chemical Name	Exposure Standards		Source	Associated Agent
Carbon Dioxide	ACGIH-TWA	= 5000 ppm, 9000 mg/m^3	CP, DP	CG, GB, HD, HL
	ACGIH-STEL	= 30000 ppm, 54000 mg/m^3		
	NIOSH-REL	= 5000 ppm, 9000 mg/m^3		
	NIOSH-STEL	= 30000 ppm, 54000 mg/m^3		
	OSHA-PEL	= 5000 ppm, 9000 mg/m^3 (8 hr TWA)		
Chlorine	ACGIH-TWA	= 0.5 ppm, 1.5 mg/m^3	CP	HL, L
	ACGIH-STEL	= 1 ppm, 2.9 mg/m^3		
	NIOSH-REL	= 0.5 ppm, 1.5 mg/m^3		
	NIOSH-STEL	= 1 ppm, 3 mg/m^3		
	OSHA-Ceiling	= 1 ppm, 3 mg/m^3		
Chloroacetic Acid	Animal toxicity data only[3]		–	HD
Chloroform**	ACGIH-TWA	= 10 ppm, 49 mg/m^3	DP, ICP, SDP	GB, HD
	NIOSH-STEL	= 2 ppm, 9.78 mg/m^3 (60 min)		
	OSHA-Ceiling	= 50 ppm, 240 mg/m^3		
1,2-Dichloroethane** {ethylene dichloride]	ACGIH-TWA	=10 ppm, 40 mg/m^3	ICP	HD
	OSHA-PEL	= 50 ppm (8 hr TWA); 100 ppm (ceiling); 200 ppm (5 mins/3 hr)		
	NIOSH-REL	=1 ppm, 4 mg/m^3		
	NIOSH-STEL	= 2 ppm, 8 mg/m^3		
	MPC	= 200 ppm		
Diethyldisulfide	Animal toxicity data only[3]		ICP	HD
Diisopropylcarbodiimide (DIPC)	Animal toxicity data only[3]		AS	GB
Distilled Mustard (HD) [2,2-dichloro-diethyl sulfide; bis(2-chloro-ethyl) sulfide]	LCt_{50}[1]	= 1500 mg-min/m^3 (inhal)	A	HD
		= 10000 mg-min/m^3 (s/m-vapor)		
		= 7.0 gm/70 kg man (s/m-liquid)		
	ICt_{50}[1]	= 200 mg-min/m^3 (eye injury)		
		= 2000 mg-min/m^3 (s/m @ 70°-80°F)****		

Chemical Name	Exposure Standards		Source	Associated Agent
	MPC	= 2 mg-min/m^3 (eye)		
		= 5 mg min/m^3 (s/m)		
Distilled Mustard (continued)	PEL[2]	= 0.003 mg/m^3 uw (8 hr TWA)		
	Ceiling[2]	= 0.003 mg/m^3 (uw)		
		= 0.003 mg/m^3 (naw/gp)		
	SEL[2]	= 0.003 mg/m^3 (1 hr TWA)		
	AEL[4]	= 0.003 mg/m^3		
Ethanethiol [ethyl mercaptan]	ACGIH-TWA	= 0.5 ppm, 1.3 mg/m^3	ICP	HD
	NIOSH-Ceiling	= 0.5 ppm, 1.3 mg/m^3 (15 min ceiling)		
	OSHA- Ceiling	= 10 ppm, 25 mg/m^3		
Ethyl Chloride [chloroethane]	ACGIH-TWA	= 1000 ppm, 2640 mg/m^3	ICP	HD
	OSHA-PEL	= 1000 ppm, 2600 mg/m^3 (8 hr TWA)		
Fluoride (Inorganic Compounds - including calcium fluoride and sodium fluoride)	ACGIH-TWA	= 2.5 mg/m^3	DP	GB
	NIOSH-REL	= 2.5 mg/m^3		
	OSHA-PEL	= 2.5 mg/m^3 (8 hr TWA)		
GB	AEL[4]	= 0.0001 mg/m^3 (8hr TWA)		
	AEL[4]	= 0.2 mg/m^3 (any period)		
H	AEL[4]	= 0.003 mg/m^3		
HT	AEL[4]	= 0.003 mg/m^3		
Hydrogen Chloride	ACGIH- Ceiling	= 5 ppm, 7.5 mg/m^3	HP, CP	CG, HD, HL, L
	NIOSH- Ceiling	= 5 ppm, 7 mg/m^3		
	OSHA- Ceiling	= 5 ppm, 7 mg/m^3		
Hydrogen Fluoride	ACGIH- Ceiling	= 3 ppm, 2.6 mg/m^3	CP, HP	GB
	NIOSH-REL	= 3 ppm, 2.5 mg/m^3		
	NIOSH-Ceiling	= 6 ppm, 5 mg/m^3 (15 min)		
	OSHA-PEL	= 3 ppm, (8 hr TWA)		

Chemical Name	Exposure Standards	Source	Associated Agent
Hydrogen Sulfide	ACGIH-TWA = 10 ppm, 14 mg/m^3 ACGIH-STEL = 15 ppm, 21 mg/m^3 NIOSH- Ceiling = 10 ppm, 15 mg/m^3 (10 min) OSHA- Ceiling = 20 ppm OSHA-MPC = 50 ppm (10 min OT)	ICP	HD
Isopropyl Alcohol	ACGIH-TWA = 400 ppm, 983 mg/m^3 ACGIH-STEL = 500 ppm, 1230 mg/m^3 NIOSH-REL = 400 ppm, 980 mg/m^3 NIOSH-STEL = 500 ppm, 1225 mg/m^3 OSHA-PEL = 400 ppm, 980 mg/m^3 (8 hr TWA)	HP	GB
Lewisite (L) [dichloro(2-chlorovinyl)arsine]	LCt_{50}[1] = 1200-1500 mg-min/m^3 (inhal) = 100000 mg-min/m^3 (s/m) ICt_{50}[1] < 300 mg-min/m^3 (eye injury-vapor) > 1500 mg-min/m^3 (s/m) Ceiling[2] = 0.0001 mg/m^3 (uw) = 0.0001 mg/m^3 (naw/gp) SEL[2] = 0.0001 mg/m3 (1 hr TWA)	A	HL, L
Mercury Alkyl Compounds (including dimethyl mercury and methyl mercury salts)	ACGIH-TWA = 0.01 mg/m^3 ACGIH-STEL = 0.03 mg/m^3 NIOSH-REL = 0.01 mg/m^3 (skin) NIOSH-STEL = 0.03 mg/m^3 (skin) OSHA- Ceiling = 0.01 mg/m^3	–	HL, L
Methyl Chloride [chloromethane]	ACGIH-TWA = 50 ppm, 103 mg/m^3 (skin) ACGIH-STEL = 100 ppm, 207 mg/m^3 (skin) NIOSH-REL = reduce to lowest feasible concentration OSHA-PEL = 100 ppm (8 hr TWA) OSHA-Ceiling = 200 ppm OSHA-MPC = 300 ppm (5 min/3 hr)	ICP	L

Chemical Name	Exposure Standards		Source	Associated Agent
Methylene Chloride**	ACGIH-TWA	= 50 ppm, 174 mg/m^3	ICP	HD
	NIOSH-REL	= reduce to lowest feasible concentration		
	OSHA-PEL	= 500 ppm, 1765 mg/m^3 (8 hr TWA)		
	OSHA-Ceiling	= 1000 ppm, 3530 mg/m^3		
	OSHA-MPC	= 2000 ppm, 7060 mg/m^3 (5 min/2 hrs)		
Mustard-Lewisite Mixture	LCt_{50}[1]	= 1500 mg-min/m^3 (inhal)	A	HL
		> 10000 mg-min/m^3 (s/m)		
	ICt_{50}[1]	= 200 mg-min/m^3 (eye injury)		
		= 1500-2000 mg-min/m^3 (s/m)		
Phosphoric Acid [orthophosphoric acid]	ACGIH-TWA	= 1 mg/m^3	ICP	GB
	ACGIH-STEL	= 3 mg/m^3		
	NIOSH-REL	= 1 mg/m^3		
	NIOSH-STEL	= 3 mg/m^3		
	OSHA-PEL	= 1 mg/m^3 (8 hr TWA)		
Phosphorus Pentoxide [POX, phosphoric anhydride]	Animal toxicity data only[3]		CP	GB
Sarin (GB) [isopropyl methylphosphono fluoridate; methyisopropo oxyfluoro-phosphine oxide]	LCt_{50}[1] (resp)	= 100 mg-min/m^3 (resting)	A	GB
		= 70 mg-min/m^3 (mild activity)		
	ICt_{50}[1] (resp)	= 75 mg-min/m^3 (resting)		
		= 35 mg-min/m^3 (mild activity)		
	TWA[2]	= 0.0001 mg/m^3 (uw - 8 hr TWA)		
		= 0.000003 mg/m^3 (naw/gw - 72 hr TWA)		
	Ceiling[2]	= 0.0001 mg/m^3 (naw/gw)		
	SEL[2]	= 0.0003 mg/m^3 (1 hr TWA)		
Sulfur	Eye irritation[3]	= 6 ppm	ICP	HD

Chemical Name	Exposure Standards		Source	Associated Agent
Sulfur Dioxide	ACGIH-TWA	= 2 ppm, 5.2 mg/m^3	CP	HD
	ACGIH-STEL	= 5 ppm, 13 mg/m^3		
	NIOSH-REL	= 2 ppm, 5 mg/m^3		
	NIOSH-STEL	= 5 ppm, 10 mg/m^3		
	OSHA-PEL	= 5 ppm, 13 mg/m^3 (8 hr TWA)		
1,1,1,2-Tetrachloroethane	Animal toxicity data only[3]		ICP	HD
1,1,2,2-Tetrachloroethane** [acetylene tetrachloride]	ACGIH-TWA	= 1 ppm, 6.9 mg/m^3	ICP	HD
	NIOSH-REL	= 1 ppm, 7 mg/m^3 (skin)		
	OSHA-PEL	= 5 ppm, 35 mg/m^3 (8 hr TWA - skin)		
beta-Thiodiglycol [thiodiethylene glycol]	Animal toxicity data only[3]		DP, HP	HD, HL
Tributylamine (TBA)	Animal toxicity data only[3]		AS	GB
1,1,1-Trichloroethane** [methyl chloroform]	ACGIH-TWA	= 350 ppm, 1910 mg/m^3	ICP	HD
	ACGIH-STEL	= 450 ppm, 2460 mg/m^3		
	OSHA-PEL	= 350 ppm, 1900 mg/m^3 (8 hr TWA)		
	NIOSH-Ceiling	= 350 ppm, 1900 mg/m^3 - 15 min		
1,1,2-Trichloroethane*	ACGIH-TWA	= 10 ppm, 55 mg/m^3 (skin)	ICP	HD
	OSHA-PEL	= 10 ppm, 45 mg/m^3 (8 hr TWA - skin)		
Vinyl Chloride* [chloroethylene; ethylene monochloride]	ACGIH-TWA	= 5 ppm, 13 mg/m^3	ACP	L
	NIOSH-REL	= Lowest reliably detectable concentration		
	OSHA-PEL	= 1 ppm, 2.6 mg/m^3 (8 hr TWA)		
	OSHA-Ceiling	= 5 ppm, 13 mg/m^3 (15 min)		
VX	AEL	= 0.00001 mg/m^3 (TWA)		
	AEL	= 0.02 mg/m^3 (any period)		

Note: Also follow all monitoring and detection and other standards in AMC-R 385-131, Safety Regulation for Chemical Agents H, HD, HT, GB, and VX.

Chemical Name	Exposure Standards	Source	Associated Agent

*	The values presented in this table are commonly considered chemical-specific ARARs or independently applicable requirements. They are provided for completeness and the convenience of the reader.
**	Exposure information appears in DSA
***	Value is for total dust containing no asbestos and less than 1 percent silica
****	Skin absorption increases above 80°F (e.g., ICt_{50} = 1000 mg-min/m^3 at 90°F)
1	Reference: Chemical Agent Data Sheets, Volume 1, Edgewood Arsenal Special Report EO-SR-74001, December 1974 [TBC]
2	Reference: AR 385-64 [ARAR] and DA Pamphlet 40-8 [TBC]
3	Reference: N.I. Sax, Dangerous Properties of Industrial Materials, 6th Ed., 1984
4	Reference: AMC-R 385-131, Safety Regulation for Chemical Agent, H, HD, HT, GB, and VX

A	Agent
ACGIH	American Conference of Governmental Industrial Hygienists
AEL	Airborne Exposure Limit
AS	Agent stabilizer
CG	Phosgene
CP	Combustion product
DM	Adamsite
DP	Decontamination product
GB	Sarin
H	Mustard
HD	Distilled mustard
HL	Mustard-Lewisite mixture
HP	Hydrolysis product
hr	Hour
HT	Mustard
ICP	Incomplete combustion product
ICt_{50}	Median incapacitating dose
L	Lewisite
LCt_{50}	Median lethal dose
MAX	Maximum peak above the ceiling
VX	Nerve Agent
mg-min/m^3	Milligrams per minute per cubic meter
mg/m^3	Milligrams per cubic meter
min	Minutes
MPC	Maximum peak concentration
naw/gp	Non-agent worker/general population
NIOSH	National Institute for Occupational Safety and Health (NIOSH-TWA is the time-weighted concentration for a 10-hour day and a 40-hour work week)
OSHA	Occupational Safety and Health Administration
OT	One time exposure if no other measurable exposure occurs
PEL	Permissible exposure limit
ppm	Parts per million
REL	Recommended exposure limit
resp	Respirable
rf	Respirable fraction
s/m	Skin exposure/masked worker
SDP	Stabilizer decontamination product
SEL	Source emission limit
STEL	Short-term exposure limit
TWA	Time weighted average
uw	Unmasked worker

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain).
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, soil solidification/stabilization will use Portland cement and possibly calcium silicate, calcium hydroxide, and calcium oxide. Worker exposure limits for these compounds are provided below: Calcium hydroxide ACGIH-TWA = 5 mg/m^3 OSHA-TWA = 15 mg/m^3 (total dust), 5 mg/m^3 (resp) Calcium oxide ACGIH-TWA = 2 mg/m^3 NIOSH-REL = 2 mg/m^3 OSHA-PEL = 5 mg/m^3 Calcium silicate ACGIH-TWA = 10 mg/m^3* OSHA-PEL = 15 mg/m^3 (total dust), 5 mg/m^3 (resp) Portland cement* ACGIH-TWA = 10 mg/m^3 NIOSH-REL = 10 mg/m^3 (total), 5 mg/m^3 (resp) OSHA-TWA = 15 mg/m^3 (total), 5 mg/m^3 (resp) * values are for total dust containing no asbestos and less than 1% crystalline silica (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 CCR 1007-3 Part 261	Direct soil solidification/stabilization will generate oversize soil debris and metallic wastes. These wastes and all others generated must be characterized and evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded form regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories, which include the following:

Action	Citation	Requirements
		1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, commercial, and special wastes are expected from direct solidification/stabilization at RMA. No special testing requirements are specified for solid wastes. The management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment and storage of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264	Wastes that are determined to be RCRA hazardous wastes must be stored and treated in compliance with RCRA regulations, including the tank requirements in 40 CFR 264 Subpart J.

Action	Citation	Requirements
On-post land disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264 EPA/540/G-89/006 [TBC] 40 CFR Part 268 6 CCR 1007-3 Part 268	Based upon a determination of whether the disposal technique constitutes placement, the LDRs-UTS may be applicable. If placement does occur, the disposal facility must comply with the substantive requirements of 40 CFR Part 264.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
<u>Air Emissions</u>		
Emission of Particulates	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions.
		Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Direct solidification/stabilization of soils shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.

Action	Citation	Requirements
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Direct solidification/stabilization of soils could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Direct soil solidification/stabilization must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

Action	Citation	Requirements
		e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	Due to the necessity to reduce exposure once contaminated soil has been solidified/stabilized, in situ solidification/stabilization of soil must not occur in the following situations: • Within 200 ft of a Holocene-age fault • Within a 100-year floodplain where washout of the soil may occur during a 100-year flood
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46.

Action	Citation	Requirements
		In addition to the chemicals listed in Table A-46, soil solidification/stabilization will use Portland cement and possibly calcium silicate, calcium hydroxide, and calcium oxide. Worker exposure limits for these compounds are provided below: Calcium hydroxide — ACGIH-TWA = 5 mg/m^3; OSHA-TWA = 15 mg/m^3 (total dust), 5 mg/m^3 (resp) Calcium oxide — ACGIH-TWA = 2 mg/m^3; NIOSH-REL = 2 mg/m^3; OSHA-PEL = 5 mg/m^3 Calcium silicate* — ACGIH-TWA = 10 mg/m^3; OSHA-PEL = 15 mg/m^3 (total dust), 5 mg/m^3 (resp) Portland cement* — ACGIH-TWA = 10 mg/m^3; NIOSH-REL = 10 mg/m^3 (total), 5 mg/m^3 (resp); OSHA-TWA = 15 mg/m^3 (total), 5 mg/m^3 (resp) * values are for total dust containing no asbestos and less than 1% crystalline silica (OSHA regulations and other health and safety requirements are actually independently applicable requirements, not ARARs and TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air Emissions		
Emission Particulates	5 CCR 1001-3, Regulation 1 Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	In situ solidification/stabilization of soils shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Direct solidification/stabilization of soils could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	In situ soil solidification/stabilization must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.

Action	Citation	Requirements
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
<u>Odor emission</u>	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use ares—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the folowing requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of any hazardous waste by a 100-year flood (if the facility is located within the 100-year floodplain).
Worker Protection		(These regulations are commonly considered location-specific ARARs, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	20 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirments. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits:

Action	Citation	Requirements
		1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
<u>Waste Characterization</u>		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Biological reactor treatment of groundwater at RMA will create wastes consisting of spent biomass, iron and manganese precipitates, suspended solids, and recovered DCPD. These and all other wastes generated in this process must be evaluated according to the following method to determine if the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used

Action	Citation	Requirements
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. Only small quantities of industrial, community, and commercial wastes, along with inert material, are expected to be generated during biological reactor treatment of groundwater at RMA.

Action	Citation	Requirements
		No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes from biological reactor treatment of groundwater that are determined to be RCRA hazardous wastes must be treated, stored, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed according to the requirements of 40 CFR 124, 144, 146, 147 (Subpart G) and 148.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

Action	Citation	Requirements
		d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR Part 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	20 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals in Table A-46, the UV/ozone treatment will potentially utilize hydrogen peroxide and ozone. The worker exposure standards for these compounds are given below: Hydrogen peroxide ACGIH-TWA = 1 ppm, 1.4 mg/m^3 NIOSH-REL = 1 ppm, 1.4 mg/m^3 OSHA-PEL = 1 ppm, 1.4 mg/m^3

Action	Citation	Requirements
		Ozone ACGIH-Ceiling = 0.1 ppm, 0.20 mg/m^3 NIOSH-Ceiling = 0.1 ppm, 0.20 mg/m^3 OSHA-PEL = 0.1 ppm, 0.2 mg/m^3 (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
Air Emissions		
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirments. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits:

Action	Citation	Requirements
		1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
<u>Waste Characterization</u>		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	UV/ozone treatment of groundwater will create wastes consisting primarily of inorganic sludges. These and all other wastes generated in this process must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used

Action	Citation	Requirements
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes," which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. Only small quantities of industrial, community, and commercial wastes, along with inert material, are expected to be generated during UV/ozone treatment of groundwater. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
Waste Management		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes from UV/ozone treatment that are determined to be RCRA hazardous wastes must be treated, stored, and disposed in compliance with RCRA regulations, including land disposal restrictions LDRs-UTS if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed according to the requirements of 40 CFR 124, 144, 146, 147 (Subpart G), and 148.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone / 7:00 a.m. to next 7:00 p.m. / 7:00 p.m. to next 7:00 a.m. Residential / 55 db(A) / 50 db(A) Commercial / 60 db(A) / 55 db(A) Light Industrial / 70 db(A) / 65 db(A) Industrial / 80 db(A) / 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

Action	Citation	Requirements
		d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting of Solvent Extraction Facility		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain). (These regulations are commonly considered location-specific ARARs, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46.
<u>Air Emissions</u>		
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Solvent extraction could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
PM/CO emissions	40 CFR 51.300-307 40 CFR 52.26-29	Solvent extraction must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Solvent extraction must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.

Action	Citation	Requirements
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Emission of Particulates	5 CCR 1001-3, Regulation 1, Section III(D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Odor Emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use ares—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Management of Remediation Wastes		
Correction action management units	40 CFR 264 Subpart 5 6 CCR 1007-3 Subpart 5	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.

Action	Citation	Requirements
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Wastewater		
Discharge of liquid wastes	40 CFR Part 122 40 CFR Part 125 40 CFR Part 129	Any wastewater generated during solvent extraction will be routed to the on-post RMA wastewater treatment plant if it is not hazardous waste and will not interrupt the existing treatment system. If wastewater is routed to the on-post treatment plant, it must be treated in accordance with NPDES requirements.
	40 CFR Part 262 6 CCR 1007-3 Part 262 40 CFR Part 264 6 CCR 1007-3 Part 264	Wastewater that is determined to be hazardous must be treated in accordance with provisions of the RCRA.
Waste Management		
Treatment, storage, or disposal of hazardous wastes	40 CFR Part 264, Subpart aa, bb, and cc 6 CCR 1007-3 Part 264, Subpart aa, bb, and cc	Wastes that are determined to be RCRA hazardous wastes must be stored and treated, in compliance with RCRA air emission regulations.
	40 CFR 264.190(c) 6 CCR 1007-3 Sect 264.190 (c)	Applicability of all requiremens for tanks or tank systems.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone — 7:00 a.m. to next 7:00 p.m. — 7:00 p.m. to next 7:00 a.m. Residential — 55 db(A) — 50 db(A) Commercial — 60 db(A) — 55 db(A) Light Industrial — 70 db(A) — 65 db(A) Industrial — 80 db(A) — 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air Emissions		
Emissions of particulates	5 CCR 1001-3, Regulation 1, Sect III.D 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use ares—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Emission control for opacity	5 CCR 1001-3, Regulation 1, Sect II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8	Emission of listed hazardous air pollutants is controlled by NESHAPs. Vacuum dusting could potentially cause emission of hazardous air polutants.
Waste Characterization		

Action	Citation	Requirements
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Wastes generated during pipe plugging activities must be characterized. Solid wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes.

Action	Citation	Requirements
		2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, special, and commercial wastes are expected from pipe plugging activities at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	If pipe plugging in structures at RMA generates hazardous wastes, the wastes must be treated, stored or disposed in accordance with RCRA regulations, including LDRs-UTS if placement occurs.

Action	Citation	Requirements
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris generated during pipe plugging activities may be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases, after treatment the debris may no longer be subject to RCRA Subtitle C regulation.

Action	Citation	Requirements
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone — 7:00 a.m. to next 7:00 p.m. — 7:00 p.m. to next 7:00 a.m. Residential — 55 db(A) — 50 db(A) Commercial — 60 db(A) — 55 db(A) Light Industrial — 70 db(A) — 65 db(A) Industrial — 80 db(A) — 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120(b) to (j)	29 CFR 1910.120(b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
<u>Air Emissions</u>		
Emission of Particulates	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Vacuum dusting shall not cause the emission into the atmosphere of any air pollutant which is in excess of 20 percent opacity.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Vacuum dusting must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Vacuum dusting could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.

Action	Citation	Requirements
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Waste Management		
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.

Action	Citation	Requirements
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 160.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 161.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Vacuum dusting of structures at RMA will create wastes consisting of filters with dust particles and debris. These wastes and all other solid wastes generated in this process must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following:

Action	Citation	Requirements
		1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes are expected from vacuum dusting of structures at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264	Vacuum dusting wastes that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including land disposal restrictions LDRs if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone — 7:00 a.m. to next 7:00 p.m. — 7:00 p.m. to next 7:00 a.m. Residential — 55 db(A) — 50 db(A) Commercial — 60 db(A) — 55 db(A) Light Industrial — 70 db(A) — 65 db(A) Industrial — 80 db(A) — 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

Action	Citation	Requirements
		e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines)

Action	Citation	Requirements
Air Emissions		
Emission of Particulates	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Steam cleaning of structures shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Steam cleaning may cause volatization of some contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado Odor Emission Regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel–powered vehicles associated with construction or demolition	5 CCR 1001-15, Regulation 12	Colorado Diesel–Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows:

Action	Citation	Requirements
		1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Steam cleaning must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of Federal Class I areas.

Action	Citation	Requirements
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements.
	42 USC 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control disposal of VOCs by evaporation or spilling unless reasonably available control technologies are utilized.
<u>Waste Management</u>		
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.

Action	Citation	Requirements
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Steam cleaning will generate wastewater from condensate and potential spent filter media. These wastes and all others generated must be characterized. The wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following:

Action	Citation	Requirements
		1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes",which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes, along with inert material are expected from steam cleaning of structures at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
Wastewater	40 CFR Part 122 40 CFR Part 125 40 CFR Part 129	Any wastewater generated during steam cleaning will be routed to the on-post RMA wastewater treatment plant if it is not hazardous waste and will not interrupt the existing treatment system. If wastewater is routed to the on-post treatment plant, it must be treated in accordance with NPDES requirements.
	40 CFR Part 262 6 CCR 1007-3 Part 262 40 CFR Part 264 6 CCR 1007-3 Part 264	Wastewater that is determined to be hazardous must be treated in accordance with provisions of the RCRA.
Treatment, storage or disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264	Wastes that are determined to be RCRA hazardous wastes, such as spent filter media from steam cleaning, must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.

Action	Citation	Requirements
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone / 7:00 a.m. to next 7:00 p.m. / 7:00 p.m. to next 7:00 a.m. Residential / 55 db(A) / 50 db(A) Commercial / 60 db(A) / 55 db(A) Light Industrial / 70 db(A) / 65 db(A) Industrial / 80 db(A) / 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

Action	Citation	Requirements
		d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air Emissions		
Emission of particulates	5 CCR 1001-3, Regulation 1, Section III (D)(2)(j) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Sand blasting shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Sand blasting could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Sand blasting must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.

Action	Citation	Requirements
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standards for the AIR Program area is a standard visual range of 32 miles. The averaging time is four hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
<u>Waste Management</u>		
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.

Action	Citation	Requirements
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
Solid waste determination citations	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently waste-like
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Sand blasting structures at RMA will create wastes that consist of dust, abrasives such as sand or pellets, debris, and possibly used filters. These wastes and all other solid wastes generated in this process must be evaluated according to the following process to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261

Action	Citation	Requirements
		• Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation.

Action	Citation	Requirements
		If present, only small quantities of industrial, community, and commercial wastes are expected from sand blasting of structures at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
Treatment, storage, or disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264	Wastes that are determined to be RCRA hazardous wastes, such as spent filter media, abrasives and debris, must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

Action	Citation	Requirements
		e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)

Action	Citation	Requirements
Air emissions during salvage	5 CCR 1001–3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2 Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Salvage of structures shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs. Salvage of structures could potentially cause emission of hazardous air pollutants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air emissions from diesel–powered vehicles associated with salvage	5 CCR 1001-15, Regulation 12	Colorado Diesel–Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state as follows:

Action	Citation	Requirements
		1) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing 7,500 pounds and less, empty weight, any air contaminant, for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 2) No person shall emit or cause to be emitted into the atmosphere from any diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, any air contaminant, for a period greater than (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 35% opacity, with the exception of subpart "C". 3) No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated (non-turbocharged) diesel-powered motor vehicle weighing more than 7,500 pounds, empty weight, operated above 7,000 feet (mean sea level) any air contaminant for a period greater than five (5) consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity. 4) Any diesel-powered motor vehicle exceeding these requirements shall be exempt for a period of 10 minutes if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position. 5) These standards shall apply to motor vehicles intended, designed, and manufactured primarily for travel or use in transporting persons, property, auxiliary equipment, and/or cargo over roads, streets, and highways.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Salvage of structures must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.

Action	Citation	Requirements
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

Action	Citation	Requirements
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 107-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Wastes generated during structure salvage activities must be characterized. Solid wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following:

Action	Citation	Requirements
		1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes are expected from structure salvage activities at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.

Action	Citation	Requirements
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater)
		Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements.
		Containers must be dated when they are placed in storage.
		All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	If demolition of structures at RMA generates hazardous wastes, the wastes must be treated, stored, or disposed in accordance with RCRA regulations, including LDRs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris generated during structure salvage activities must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases, after treatment the debris may no longer be subject to RCRA Subtitle C regulation.

Action	Citation	Requirements
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Tanks and Containers		
Residues of hazardous waste in empty containers	40 CFR 261.7 6 CCR 1007-3 Sect 261.7	A container or inner liner removed from a container that has held any hazardous waste is empty if: 1) All wastes have been removed that can be removed using the practices commonly employed to remove materials from that type of container (e.g., pouring, pumping, and aspirating), and 2) No more than one inch of residue remains on the bottom of the container or inner liner, or 3) a) No more than 3 percent by weight of the total capacity of the container remains in the container or inner liner if the container is less than or equal to 110 gallons in size, or b) No more than 0.3 percent by weight of the total capacity of the container remains in the container or inner liner if the container is greater than 110 gallons in size.

Action	Citation	Requirements
		A container that has held a hazardous waste that is a compressed gas is empty when the pressure in the container approaches atmospheric. A container or an inner liner removed from a container that has held an acute hazardous waste listed in 40 CFR 261.31, 261.32, or 261.33(e) is empty if: 1) The container or inner liner has been triple rinsed using a solvent capable of removing the commercial chemical product or manufacturing chemical intermediate, or 2) The container or inner liner has been cleaned by another method that has been shown in the scientific literature, or by tests conducted by the generator, to achieve equivalent removal, or 3) In the case of a lined container, the inner liner that prevented contact of the commercial chemical product or manufacturing chemical intermediate with the container, has been removed. Any hazardous waste remaining in an empty container or an inner liner removed from an empty container is not considered a hazardous waste and is not subject to the RCRA regulations. Any hazardous waste in a container or inner liner removed from a container that is not empty is subject to RCRA hazardous waste regulations.
Closure of tanks and tank systems	40 CFR 264.197(a) 6 CCR 1007-3 Sect 264.197(a) 40 CFR 261.3(d) 6 CCR 1007-3 Sect 261.3(d) 40 CFR 264.310 6 CCR 1007-3 Sect 264.310	At closure of a tank system, all waste residues, contaminated containment system components, contaminated soils, and structures and equipment contaminated with wastes must be removed, decontaminated, and managed as hazardous wastes unless 40 CFR 261.3(d) applies (i.e., unless residues and contaminated materials are not hazardous wastes). If the owner or operator demonstrates that not all soils can be practically removed or decontaminated as required, then the tank system must be closed in accordance with requirements that apply to landfills.

Action	Citation	Requirements
	40 CFR 264.198(a) 6 CCR 1007-3 Sect 264.198(a) 40 CFR 264.176 6 CCR 1007-3 Sect 264.176	Ignitable or reactive waste should not be placed in tank systems unless the waste is treated, rendered, or mixed before or immediately after placement in the tank system, or unless the waste is stored or treated in such a way that it is protected from any material or condition that may cause the waste to ignite or react.
	40 CFR 264.198(b) 6 CCR 1007-3 Sect 264.198(b) NFPA Flammable and Combustible Liquids Code 1990 [TBC]	Facilities where ignitable or reactive waste is stored or treated in a tank should comply with requirements for the maintenance of protective distances between the waste management area and any public ways, streets, alleys, or an adjoining property line that can be built upon as provided in Tables 2–1 through 2–6 of the 1990 NFPA Flammable and Combustible Liquids Code.
	40 CFR 264.199 6 CCR 1007-3 Sect 264.199 40 CFR 264.17 6 CCR 1007-3 Sect 264.17	Incompatible wastes, or incompatible wastes and materials, must not be placed in the same tank system unless 40 CFR 264.17 is complied with.
		Hazardous waste must not be placed in a tank system that has not been decontaminated and that previously held an incompatible waste or material unless 40 CFR 264.17 is complied with.
	40 CFR 265.201(d) 6 CCR 1007-3 Sect 265.201(d)	Generators that accumulate between 100 and 1,000 kg/mo of hazardous waste in tanks must, upon closure, remove all hazardous wastes from tanks, control equipment, and discharge confinement structures.
	40 CFR 265.201(e) (1) 6 CCR 1007-3 Sect 265.201(e)(1)	Generators of between 100 and 1,000 kg/mo of hazardous waste must not place ignitable or reactive waste in tanks unless the waste is treated before or immediately after placement in a tank or the waste is stored or treated in such a way that it is protected from any material or condition that may cause the waste to ignite or react. Ignitable or reactive waste must not be placed in the tank unless the tank is used solely for emergencies.
	40 CFR 265.201(e) (2) 6 CCR 1007-3 Sect 265.201(e)(2) NFPA Flammable and Combustible Liquids Code 1990 [TBC]	Facilities where ignitable or reactive wastes are treated or stored in covered tanks are required to comply with the buffer zone requirements for tanks contained in Tables 2–1 through 2–6 of the 1990 NFPA Flammable and Combustible Liquids Code.

Action	Citation	Requirements
	40 CFR 264.111(a) and (b) 6 CCR 1007-3 Sect 264.111(a),(b)	A facility must be closed in a manner that minimizes the need for further maintenance and controls, minimizes, or eliminates to the extent necessary to protect human health and the environment post closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the groundwater or surface waters or to the atmosphere.
	40 CFR 264.197 6 CCR 1007-3 Sect 264.197 40 CFR 264 Subpart G 6 CCR 1007-3 Part 264 Subpart G	The closure plan and closure activities for tank systems must meet all of the substantive requirements provided in 40 CFR 264 Subpart G and 40 CFR 264.197.
<u>Wastewater Treatment/Disposal</u>		
Discharge of wastewater to the treatment plant	40 CFR Part 122 40 CFR Part 125 40 CFR Part 129	Any wastewater generated during cleanup or remedial actions will be directed to the on-post RMA wastewater treatment plant and treated in accordance with NPDES requirements.
	40 CFR Part 262 6 CCR 1007-3 Part 262 40 CFR Part 264 6 CCR 1007-3 Part 264	Wastewater that is determined to be a hazardous waste must be treated in accordance with the provisions of RCRA.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with stormwater management requirements.
<u>Decontamination and Disposal Standards for Chemical Agents</u>	AMC-R 385-131 [TBC]	Army regulations provide standards for decontamination of items exposed to chemical agents. Material, equipment, and clothing that has been decontaminated to the 3X level may be landfilled in a RCRA-approved hazardous waste landfill.

Action	Citation	Requirements
		Items may not be released from government control until they have been decontaminated to the 5X level.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

Action	Citation	Requirements
		f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of any hazardous waste by a 100-year flood (if the facility is located within the 100-year floodplain). (These regulations are commonly considered location-specific ARARS, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	20 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirments. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air

Action	Citation	Requirements
		2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Air stripper emissions	OSWER Directive 9355.0-28 June 15, 1989	"Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites"
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Air stripping of VOCs from groundwater shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Visibility protection	40 CFR 51.300-307	Air stripping from groundwater must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307 (8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
<u>Waste Characterization</u>		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be – disposed of – burned or incinerated – accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated

Action	Citation	Requirements
		• Recycled materials which is – used in a manner constituting disposal – burned for energy recovery – reclaimed – speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Air stripping of VOCs from groundwater will create wastes consisting of sludges and spent filters. These and all other wastes generated in this process must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories, which include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes.

Action	Citation	Requirements
		4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes, and inert material are expected from air stripping treatment of groundwater at RMA. No special testing requirements are specified for solid wastes. The management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes from air stripping treatment of groundwater that are determined to be RCRA hazardous wastes must be treated, stored, and disposed in compliance with RCRA regulations, including LDRs if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.

Action	Citation	Requirements
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
<u>Stormwater Management</u>		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed according to the requirements of 40 CFR 124, 144, 146, 147 (Subpart G), and 148.

Action	Citation	Requirements
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: • They must not be located within 200 ft of a Holocene-age fault. • They must be designed, constructed, and operated to prevent washout of any hazardous waste by a 100-year flood if the facility is located within the 100-year floodplain. (These regulations are commonly considered location-specific ARARs, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	20 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation

Action	Citation	Requirements
		• Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and the NIOSH are outlined in Table A-46. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirments. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air

Action	Citation	Requirements
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be – disposed of – burned or incinerated – accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Abandoned material may be – disposed of – burned or incinerated – accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled materials which is – used in a manner constituting disposal – burned for energy recovery – reclaimed – speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Groundwater treatment at RMA using GAC adsorption will create wastes consisting of spent carbon and carbon fines. These and all other wastes generated in this process must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used

Action	Citation	Requirements
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes, resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes and inert material are expected from GAC treatment of groundwater at RMA. No special testing requirements are specified for solid waste. The management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirmements.

Action	Citation	Requirements
Waste Management		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes from GAC water treatment that are determined to be RCRA hazardous wastes must be treated, stored, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.

Action	Citation	Requirements
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed according to the requirements of 40 CFR 124, 144, 146, 147 (Subpart G) and 148.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that: a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones: Zone — 7:00 a.m. to next 7:00 p.m. — 7:00 p.m. to next 7:00 a.m. Residential — 55 db(A) — 50 db(A) Commercial — 60 db(A) — 55 db(A) Light Industrial — 70 db(A) — 65 db(A) Industrial — 80 db(A) — 75 db(A) b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period. c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above). d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

Action	Citation	Requirements
		f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1063-3 Sect 264.18	New facilities constructed to treat, store, and dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of any hazardous waste by a 100-year flood (if the facility is located within the 100-year floodplain). (These regulations are commonly considered location-specific ARARs, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	20 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation

Action	Citation	Requirements
		• Air monitoring
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and the NIOSH are outlined in Table A-46. Chemical oxidation treatment of groundwater uses ozone and may use hydrogen peroxide to oxidize organic contaminants. The worker exposure standards for these compounds are given below. Hydrogen peroxide ACGIH-TWA = 1 ppm, 1.4 mg/m^3 NIOSH-REL = 1 ppm, 1.4 mg/m^3 OSHA-PEL = 1 ppm, 1.4 mg/m^3 Ozone ACGIH-Ceiling = 0.1 ppm , 0.20 mg/m^3 NIOSH-Ceiling = 0.1 ppm , 0.20 mg/m^3 OSHA-PEL = 0.1 ppm, 0.2 mg/m^3 (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

Action	Citation	Requirements
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61 42 USCS Section 7412	Emission of certain hazardous air pollutants is controlled by NESHAPs. National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Chemical oxidation of organic compounds from groundwater shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Visibility protection	40 CFR 51.300-307	Chemical oxidation of organic compounds from a groundwater must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307 (8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.

Action	Citation	Requirements
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be – disposed of – burned or incinerated – accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled materials which is – used in a manner constituting disposal – burned for energy recovery – reclaimed – speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.4 40 CFR Part 261 6 CCR 1007-3 Part 261	Chemical oxidation of organic compounds will create wastes consisting primarily of sludges. This and all other wastes generated in this process must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories, which include the following:

Action	Citation	Requirements
		1) "Industrial wastes," which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes," which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes, and inert material are expected from chemical oxidation treatment of groundwater at RMA. No special testing requirements are specified for solid wastes. The management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
<u>Waste Management</u>		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes from chemical oxidation of organic compounds in groundwater that are determined to be RCRA hazardous wastes must be treated, stored, and disposed in compliance with RCRA regulations, including LDRs if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed according to the requirements of 40 CFR 124, 144, 146, 147 (Subpart G) and 148.

Action	Citation	Requirements
<u>Siting</u>		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, and dispose of hazardous waste must adhere to the following: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of any hazardous waste by a 100-year flood (if the facility is located within the 100-year floodplain). (These regulations are commonly considered location-specific ARARs, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
<u>Worker Protection</u>		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites. A key concern in GAA adsorption treatment of groundwater is the handling of corrosives (acids and caustics) used in GAA treatment and regeneration.
	29 CFR 1910.120 (b) to (j)	20 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on–site workers • Site characterization and analysis • Site control • On–site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 29 CFR 1910.1000	Chemical–specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. A key concern in GAA treatment is the handling of corrosives used for pH adjustment in GAA treatment and regeneration. The principal corrosives used in GAA process are sulfuric acid and sodium hydroxide. In addition, calcium hydroxide may be used to precipitate iron and hardness prior to treatment. The worker exposure standards for these compounds are given below: Sodium hydroxide ACGIH-Ceiling = 2 mg/m^3 NIOSH-Ceiling = 2 mg/m^3 (15-min) OSHA-Ceiling = 2 mg/m^3 = 2 mg/m^3 Sulfuric acid ACGIH-TWA = 1 mg/m^3; STEL = 3 mg/m^3 NIOSH-REL = 1 mg/m^3 OSHA-PEL = 1 mg/m^3 Calcium hydroxide ACGIH-TWA = 5 mg/m^3 OSHA-TWA = 15 mg/m^3 (total dust), 5 mg/m^3 (resp) (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirments.

Action	Citation	Requirements
		Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of certain hazardous air pollutants is controlled by NESHAPs.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
<u>Waste Characterization</u>		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be – disposed of – burned or incinerated – accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned or incinerated

Action	Citation	Requirements
		• Recycled materials which is – used in a manner constituting disposal – burned for energy recovery – reclaimed – speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	GAA adsorption will create wastes consisting primarily of regeneration sludge. This and all other wastes generated in this process must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories, which include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes.

Action	Citation	Requirements
		4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, and commercial wastes, and inert material are expected from GAA treatment of groundwater at RMA. No special testing requirements are specified for solid wastes. The management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes from GAA adsorption that are determined to be RCRA hazardous wastes must be treated, stored, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.

Action	Citation	Requirements
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Reinjection of treated groundwater	RCRA Section 3020 (b) OSWER Directive 9234.1-06 [TBC]	Reinjection of treated groundwater must be managed in accordance with the guidelines in OSWER Directive 9234.1-06. Wells should be constructed and installed and managed according to the requirements of 40 CFR 124, 144, 146, 147 (Subpart G) and 148.

Action	Citation	Requirements
Transportation of Hazardous Waste		
On-post transportation		All on-post shipments of hazardous waste may be required to meet the provisions of 5 CCR 1001, 40 CFR Parts 52 and 81, and AR 50-6 including, but not limited to the following:
	5 CCR 1001-15, Regulation 12	1) Transportation of wastes in diesel-powered vehicles may be subject to state opacity and visibility standards.
	5 CCR 1001-4, Regulation 2	2) Loading, unloading, or transportation of wastes may cause odors or emissions from contaminants that exceed state odor limitations.
	5 CCR 1001-3, Regulation 1 Section III (D) (2) 5 CCR 1001-5, Regulation 3	3) Transportation on unpaved roadways may be subject to state requirements to reduce particulate emissions resulting from the use of the roadway.
	AR 50-6 Chapter 4 [TBC]	5) This regulation describes procedures to be followed during the transportation of Chemical Surety Materials.
Air Emissions		
Emission of hazardous pollutants	5 CCR 1001-10, Regulation 8	Emission of listed hazardous air pollutants is controlled by NESHAPs. Soil flushing will cause volatilization of some contaminants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.

Action	Citation	Requirements
Waste Management		
Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.
Asbestos waste handling management	40 CFR 61, Subpart M	Prevent discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; deposit asbestos-containing waste as possible at disposal site; mark transport vehicle appropriately during loading and unloading operations.
	5 CCR 10001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.
PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs, walls; have impervious floors with curbs (no floor drains expansion joints or other openings); be located above 100 year floodplain (applies to PCBs at concentrations of 50 ppm or greater) Temporary storage (<30 days) of PCB containers containing non-liquid PCBs, such as contaminated soil, rags, debris need not comply with above requirements. Containers must be dated when they are placed in storage. All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
PCB incineration standards	40 CFR 761.70	Incineration requirements for non-liquid PCB apply to PCB concentrations >50 ppm and include specified dwell times; combustion efficiency of 99.9999 percent; process record/monitoring requirements; automatic shut-off standards; a maximum mass air emission of 0.001 g PCB per kg of PCB entering the incinerator.

Action	Citation	Requirements
PCB chemical waste landfilling standards	40 CFR 761.75	Landfill must be located in thick, relatively impermeable soil formation or on soil with high clay and silt content, synthetic membranes must be used when these conditions cannot be met. In addition, other structural requirements include avoidance of location in a floodplain; required run-on/run-off structures if below the 100 year floodplain, and ground/surface water monitoring for specified parameters. The landfill must include a leachate monitoring system. PCB wastes must be segregated from wastes not chemically compatible with PCBs.
PCB decontamination standards	40 CFR 761.79	PCB containers to be contaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.

Action	Citation	Requirements
Access Restrictions		
Access controls	40 CFR 264.14 6 CCR 1007-3 Sect 264.14	Access controls will be provided that will prevent unknowing entry and minimize unauthorized entry of persons or livestock onto active portions of RMA. These may include 24-hour surveillance or a barrier (either natural or artificial) and a means of controlling access.
Land Use/Deed Restrictions		
Land use and deed restrictions for former hazardous waste disposal units	40 CFR 264.119 6 CCR 1007-3 Sect 264.119	If RMA ceases to be federal government property, a notation on the deed must indicate that ht eland was previously used to manage hazardous wastes and its use is restricted under 40 CFR 264 Subpart G regulations. A record of the type, location, and quantity of hazardous waste managed at each disposal unit must also be supplied to the local zoning authority or through authority over local land use.
Monitoring		
Groundwater monitoring	40 CFR 264 Subpart F 6 CCR 1007-3 Part 264 Subpart F 2 CCR 402-2, Rule 10RCRA Groundwater Monitoring TEGD [TBC]	Groundwater monitoring will be conducted for the presence of hazardous constituents in the groundwater downgradient from solid water management units. Monitoring wells should be constructed and installed according to the requirements of 2 CCR 402-2, Rule 10 and the guidance in t he RCRA Groundwater Monitoring TEGD.
	6 CCR 1007-3	Colorado groundwater regulations specify requirements for determining background groundwater quality.
Air Emissions		
Emission of particulates	5 CCR 1001-3, Regulation 1, Sect III(D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions.

Action	Citation	Requirements
Odor emissions	5 CCR 1001-4, Regulation 4	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use ares—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air

Action	Citation	Requirements
Monitoring		
Groundwater monitoring	40 CFR 264 Subpart F 6 CCR 1007-3 Part 264 Subpart F 2 CCR 402-2, Rule 10 RCRA Groundwater Monitoring TEGD [TBC]	Groundwater monitoring will be conducted for the presence of hazardous constituents in the groundwater downgradient from solid waste management units. Monitoring wells should be constructed and installed according to the requirements of 2 CCR 402-2, Rule 10 and the guidance in the RCRA Groundwater Monitoring TEGD.
	6 CCR 1007-3	Colorado groundwater regulations specify requirements for determining background groundwater quality.
Air Emissions		
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use ares—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Emissions of hazardous air pollutants	5 CCR 1001-10, Regulation 8	Emission of listed hazardous air pollutants is controlled by NESHAPs. Soil flushing will cause volatization of some contaminants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.

Action	Citation	Requirements
Siting of Peroxide/Hypochlorite Treatment Facility		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood, (if the facility is located within the 100-year flood plain). (These regulations are commonly considered location-specific ARARs, but may impact the remedial actions taken. They are included in this table for the convenience of the reader.)
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table A-46. In addition to the chemicals listed in Table A-46, peroxide/hypochlorite treatment involves the use of hydrogen peroxide and sodium hypochlorite. Hypochlorite the treatment is neutralized using hydrochloric acid. Worker exposure standards for these chemicals are: Hydrogen peroxide ACGIH-TWA = 1 ppm, 1.4 mg/m^3 NIOSH-REL = 1 ppm, 1.4 mg/m^3 OSHA-PEL = 1 ppm 1.4 mg/m^3 Sodium hypochlorite ACGIH-TWA = 0.1 ppm (ceiling), 0.20 mg/m^3 (ceiling) NIOSH-REL = 0.1 ppm (ceiling), 0.20 mg/m^3 (ceiling) OSHA-PEL = 0.1 ppm, 0.2 mg/m^3 STEL = 0.3 ppm, 0.6 mg/m^3 (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGHI and NIOSH values are provided as guidelines.)
<u>Air Emissions</u>		
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Soil flushing will cause volatization of some contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements.

Action	Citation	Requirements
		Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
Waste Characterization		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be – disposed of – burned or incinerated – accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled materials which is – used in a manner constituting disposal – burned for energy recovery – reclaimed – speculatively accumulated • Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Wastes generated during soil excavation activities must be characterized. Solid wastes must be evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used

Action	Citation	Requirements
Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories. The waste categories include the following: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes. 5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation. If present, only small quantities of industrial, community, commercial, and special wastes are expected from peroxide/hypochlorite treatment of debris at RMA. No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.

Action	Citation	Requirements
Waste Management		
Treatment, storage, or disposal of RCRA hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268	If peroxide/hypochlorite treatment at RMA generates hazardous wastes, the wastes must be treated, stored, or disposed in accordance with RCRA regulations, including LDRs.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268	Hazardous debris treated with peroxide or hypochlorite must be treated to extract, destroy, or immobilize hazardous constituents on or in the debris. In certain cases after treatment, the debris may no longer be subject to RCRA Subtitle C regulation.
Management of Remediation Wastes		
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.

Action	Citation	Requirements
Stormwater Management		
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.
Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that:

a. "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sould levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the following time periods and zones:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in Requirement a (above) may be increased by ten decibels for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five decibels less than those listed in Requirement a (above).

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

Action	Citation	Requirements
		e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour. f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements."

Chemical Name	Exposure Standards
Aldrin	ACGIH-TWA= 0.25 mg/m^3 (skin) NIOSH-REL=0.25 mg/m^3 (skin) OSHA-PEL=0.25 mg/m^3 (8 hr TWA) (skin)
Arsenic (organic)	ACGIH-TWA=0.1 mg/m^3 OSHA-PEL=10.0 $\mu g/m^3$ (8 hr TWA)
Asbestos	ACGIH-TLV Amosite=0.5 $fibers/cm^3$ Chrysolite=2 $fibers/cm^3$ Crosidolite-0.2 $fibers/cm^3$ Other Forms=2 $fibers/cm^3$ NIOSH-REL=0.1 $fibers/cm^3$ OSHA-REL=0.2 $fibers/cm^3$ (8 hr TWA) OSHA action level=0.1 $fibers/cm^3$
Atrazine	ACGIH-TWA=5 mg/m^3
Benzene	ACGIH-TWA=10 ppm, 32 mg/m^3, Suspected human carcinogen NIOSH-REL=0.1 ppm, STEL=1 ppm (15 min) OSHA-PEL=10 ppm (8 hr TWA, 25 ppm (15 min ceiling); 50 ppm (peak concentration, maximum duration 10 min/8 hr)
Cadmium	ACGIH-TWA*=0.01 mg/m^3 (total), 0.002 mg/m^3 (resp), Suspected human carcinogen NIOSH-REL-Reduce exposure to lowest feasible concentration OSHA-PEL fume=0.1 mg/m^3 (8 hr TWA), 0.3 mg/m^3 (ceiling) OSHA-PEL dust=0.2 mg/m^3 (8 hr TWA), 0.6 mg/m^3 (ceiling)
Caprolactam (vapor)	ACGIH-TWA*=5 ppm, 23 mg/m^3; STEL=10 ppm, 46 mg/m^3
Carbon Tetrachloride	ACGIH-TWA=5 ppm, 31 mg/m^3 (skin); STEL=10 ppm, 63 mg/m^3, Suspected human carcinogen NIOSH-STEL=2 ppm (60 min), 12.6 mg/m^3 OSHA-PEL=10 ppm, 8 hr TWA; 25 ppm (ceiling); 200 ppm (peak concentration, max duration 5 min/in any 4 hrs.)

Chemical Name	Exposure Standards
Chlordane	ACGIH-TWA=0.5 mg/m^3 (skin) NIOSH-REL=0.5 mg/m^3 (skin) OSHA-PEL=0.5 mg/m^3 (8 hr TWA) (skin)
Chlorobenzene	ACGIH-TWA=10 ppm, 46 mg/m^3 OSHA-PEL=75 ppm, 350 mg/m^3, (8 hr TWA)
Chloroform	ACGIH-TWA=10 ppm, 49 mg/m^3, Suspected human carcinogen NIOSH-STEL=2 ppm, 9.78 mg/m^3 (60 min) OSHA-Ceiling=50 ppm, 240 mg/m^3
Chromium (Cr-metal; compounds)	ACGIH-TWA=0.5 mg/m^3 [metal, Cr(II) and Cr (III) compounds] 0.01 mg/m^3 [CrVI compounds] Insoluble, NOC 0.05 mg/m^3 [Cr(VI) compounds], Human carcinogen for water-insoluble compounds NIOSH-REL= 1 $\mu g/m^3$ (10 hr TWA) [carcinogenic Cr(VI) compounds]; 0.5 mg/m^3 [metal, Cr(II) and Cr(III) compounds] OSHA-PEL= 1 mg/m^3 (8 hr TWA) [metal and insoluble salts]; 0.5 mg/m^3 (8 hr TWA) [soluble salts];
Copper	ACGIH-TWA fume=0.2 mg/m^3 ACGIH-TWA dust =1 mg/m^3 NIOSH-REL fume 0.1 mg/m^3 (10 hr TWA) NIOSH-REL dust=1 mg/m^3 (10 hr TWA) OSHA-PEL fume=0.1 mg/m^3 (8 hr TWA) OSHA-PEL dust =1 mg/m^3 (8 hr TWA)
Cyanides (as CN)	ACGIH-Ceiling=5 mg/m^3 (skin); TWA=4.7 mg/m^3 NIOSH-Ceiling=4.7 ppm, 5 mg/m^3 (10 min) OSHA-PEL=5 mg/m^3 (8 hr TWA)
Dibutyl Phthalate	ACGIH-TWA=5 mg/m^3 NIOSH-REL=5 mg/m^3 (10 hr TWA) OSHA-PEL=5 mg/m^3 (8 hr TWA)

Chemical Name	Exposure Standards
1, 2-Dibromo-3-chloropropane (DBCP)	OSHA-PEL=1ppb (8 hr TWA)
1,1-Dichloroethane	ACGIH-TWA*= 100 ppm, 405 mg/m^3 NIOSH-REL=100 ppm, 400 mg/m^3 OSHA-PEL=100 ppm, 400 mg/m^3 (8 hr TWA)
1,2-Dichloroethane	ACGIH-TWA=10 ppm, 40 mg/m^3 OSHA-PEL=50 ppm (8 hr TWA); 100 ppm (ceiling); 200 ppm (maximum concentration)
1,1-Dichloroethylene	ACGIH-TWA=5 ppm, 20 mg/m^3; STEL=20 ppm, 79 mg/m^3
1,2-Dichloroethylene (Trans)	ACGIH-TWA=200 ppm, 793 mg/m^3 NIOSH-REL=200 ppm, 740 mg/m^3 (10 hr TWA) OSHA-PEL=200 ppm, 790 mg/m^3 (8 hr TWA)
Dichlorvos (Vapona) DDVP	ACGIH-TWA=0.1 ppm, 0.90 mg/m^3 (skin) NIOSH-REL=1 mg/m^3 (10 hr TWA) (skin) OSHA-PEL=1 mg/m^3 (8 hr TWA) (skin)
DDT	ACGIH-TWA=1 mg/m^3 NIOSH-REL=0.5 mg/m^3 OSHA-PEL=1 mg/m^3 (8 hr TWA) (skin)
Dicyclopentadiene	ACGIH-TWA=5 ppm, 27 mg/m^3 OSHA-TWA=5 ppm, 30 mg/m^3 (8 hr TWA)
Dieldrin	ACGIH-TWA=0.25 mg/m^3 (skin) NIOSH-REL=0.25 mg/m^3 OSHA-PEL=0.25 mg/m^3 (skin)
Diethyl Phthalate	ACGIH-TWA=5 mg/m^3
1,1-Dimethylhydrazine	ACGIH-TWA=0.01 ppm, 0.025 mg/m^3(skin)Suspected human carcinogen NIOSH-Ceiling=0.06 ppm, 0.15 mg/m^3 (120 min) OSHA-PEL=0.5 ppm, 1 mg/m^3

Chemical Name	Exposure Standards
Endrin	ACGIH-TWA=0.1 mg/m^3 (skin) NISOH-REL=0.1 mg/m^3 (10 hr TWA) (skin) OSHA-PEL=0.1 mg/m^3 (8 hr TWA) (skin)
Ethyl Benzene	ACGIH-TWA=100 ppm, 434 mg/m^3; STEL=125 ppm, 543 mg/m^3 NISOH-REL=100 ppm, 435 mg/m^3 (10 hr TWA); STEL-125 ppm, 545 mg/m^3 OSHA-PEL=100 ppm, 435 mg/m^3 (8 hr TWA)
Fluoride (as F)	ACGIH-TWA=2.5 mg/m^3 NIOSH-REL=2.5 mg/m^3 (10 hr TWA) OSHA-PEL=2.5 mg/m^3 (8 hr TWA)
Hexachlorobutadiene	ACGIH-TWA=0.02 ppm 0.21 mg/m^3, Suspected human carcinogen
Hexachlorocyclopentadiene	ACGIH-TWA=0.01 ppm, 0.11 mg/m^3 OSHA PEL=0.01 ppm, 0.1 mg/m^3 NIOSH-REL=0.01 ppm, 0.013 mg/m^3
Hydrazine	ACGIH-TWA*=0.1 ppm, 0.13 mg/m^3 (skin), Suspected human carcinogen NIOSH-Ceiling=0.03 ppm, 0.04 mg/m^3 (120 min ceiling) OSHA-PEL=1 ppm, 1.3 mg/m^3 (8-hr TWA)
4-Hydroxy-4-methyl-2-pentanone	ACGIH-TWA=50 ppm, 238 mg/m^3
Lead (dust & fumes)	ACGIH-TWA=0.05 mg/m^3 NIOSH-REL (inorganic) 0.1 mg /m^3 (10 hr TWA); OSHA-PEL=50 $\mu g/m^3$
Magnesium (as Mg Oxide fumes)	ACGIH-TWA=10 mg/m^3 OSHA-PEL= 15 mg/m^3 (8 hr TWA) (resp)
Malathion	ACGIH-TWA=10 mg/m^3 (skin) NIOSH-REL=10 mg/m^3 (10 hr TWA) OSHA-PEL=15 mg/m^3 (8 hr TWA)

Chemical Name	Exposure Standards
Mercury (as Hg) (inorganic)	ACGIH- TWA vapor=0.025 mg/m^3 (skin) NIOSH-REL vapor=0.05 mg/m^3 (10 hour TWA) (skin) OSHA-Ceiling=0.1mg/m^3 (skin)
Methylene Chloride	ACGIH-TWA=50 ppm, 174 mg/m^3, Suspected human carcinogen NIOSH-REL=Reduce exposure to lowest feasible limit OSHA-PEL=500 ppm (8 hr TWA); 1000 ppm (ceiling); 2000 ppm, (peak concentration, maximum duration 5 min/2 hr)
Methylisobutyl Ketone (Hexone)	ACGIH-TWA=50 ppm, 205 mg/m^3; STEL=75 ppm, 307 mg/m^3 NIOSH-REL=50 ppm, 205 mg/m^3, (10 hr TWA); STEL=75 ppm, 300 mg/m^3 OSHA-PEL=100 ppm, 410 mg/m^3 (8 hr TWA)
Parathion	ACGIH-TWA=0.1 mg/m^3 (skin) NIOSH-REL=0.05 mg/m^3 (10 hr TWA) (skin) OSHA-PEL=0.1 mg/m^3 (8 hr TWA) (skin)
PCB (42% chlorine)	ACGIH=1.0 mg/m^3 (skin) NIOSH=0.001 mg/m^3 OSHA=1 mg/m^3 (skin)
PCB (54% chlorine)	ACGIH=0.5 mg/m^3 (skin) NIOSH=0.001 mg/m^3 OSHA=0.5 mg/m^3 (skin)
Pentachlorophenol	ACGIH-TWA=0.5 mg/m^3 (skin) NIOSH-REL=0.5 mg/m^3 (10 hr TWA) (skin) OSHA-PEL=0.5 mg/m^3, (8 hr TWA) (skin)
Phenol	ACGIH-TWA=5 ppm, 19 mg/m^3 (skin) NIOSH-REL=5 ppm, 19 mg/m^3 (10 hr TWA); Ceiling=15.6 ppm, 60 mg/m^3 (15 min) (skin) OSHA-PEL=5 ppm, 19 mg/m^3 (8 hr TWA) (skin)

Chemical Name	Exposure Standards
1,1,2,2-Tetrachloroethane	ACGIH-TWA=1 ppm, 6.9 mg/m^3 (skin) NIOSH-REL=1 ppm, 7mg/m^3 (10 hr TWA) (skin) OSHA-PEL=5 ppm, 35 mg/m^3 (8 hr TWA) (skin)
Tetrachloroethylene (Perchloroethylene)	ACGIH-TWA=25 ppm, 170 mg/m^3; STEL=100 ppm, 685 mg/m^3 NIOSH-REL=Minimize workplace exposure concentrations; limit number of workers exposed OSHA-PEL=100 ppm (8 hr TWA); 200 ppm (ceiling); 300 ppm (peak concentration, maximum duration 5 min/2 hrs)
Toluene	ACGIH-TWA*=50 ppm, 188 mg/m^3 NIOSH-REL=100 ppm, 375 mg/m^3 (10 hr TWA); STEL=150 ppm, 560 mg/m^3 (15 min) OSHA-PEL=200 ppm (8 hr TWA); 300 ppm (ceiling); 500 ppm (peak concentration-for 10 minutes)
1,2,4-Trichlorobenzene	ACGIH-Ceiling=5 ppm, 37 mg/m^3
1,1,1-Trichloroethane (Methyl chloroform)	ACGIH-TWA=350 ppm, 1910 mg/m^3; STEL=450 ppm, 2460 mg/m^3 NISOH-Ceiling-350 ppm, 1900 mg/m^3 (15 min ceiling) OSHA-PEL=350 ppm, 1900 mg/m^3 (8 hr TWA)
1, 1, 2-Trichloroethane	ACGIH-TWA=10 ppm, 55 mg/m^3 (skin) OSHA-PEL=10 ppm, 45 mg/m^3 (8 hr TWA) (skin)
Trichloroethylene	ACGIH-TWA=50 ppm, 269 mg/m^3; STEL=100 ppm, 537 mg/m^3 NIOSH-REL=25 ppm (10 hr TWA) OSHA-PEL=100 ppm (8 hr TWA); 200 (ceiling); 300 ppm (peak concentration, maximum duration 5 min/2 hrs)
Trimethyl Benzene	ACGIH-TWA=25 ppm, 123 mg/m^3
Xylene - o,m,p	ACGIH-TWA=100 ppm, 434 mg/m^3; STEL=150 ppm, 651 mg/m^3 NIOSH-REL=100 ppm, 434 mg/m^3 (10 hr TWA); STEL-150 ppm, 655 mg/m^3 (15 min ceiling) OSHA-PEL=100 ppm, 435 mg/m^3
Xylene - M (α,α diamine)	ACGIH-Ceiling=0.1 mg/m^3 (skin)

Chemical Name	Exposure Standards
Zinc (as zinc oxide)	ACGIH-TWA dust=10 mg/m^3 - containing no asbestos and <1% crystalline silica ACGIH-TWA fume=5 mg/m^3; STEL=10 mg/m^3 NIOSH-REL fume=5 mg/m^3 (10 hr TWA), STEL=10 mg/m^3 (15 min ceiling) OSHA-PEL dust=15 mg/m^3; 5 mg/m^3 (resp) OSHA-PEL fume=5 mg/m^3 (8 hr TWA)

ACGIH	American Conference of Governmental Industrial Hygienists
OSHA	Occupational Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health (NIOSH-TWA is the time-weighted concentration for a 10-hour day and a 40-hour work week)
STEL	Short-Term Exposure Limit
TWA	Time Weighted Average
PEL	Permissible Exposure Limit
MAX	Maximum Peak Above the Ceiling
REL	Recommended Exposure Limit
resp	respirable
hr	hour(s)
min	minute(s)

ppm	parts per million
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
$\mu g/m^3$	micrograms per cubic meter
*	proposed change
**	change is proposed, not quantified
+	all forms except alkyl vapor

Parameter	Concentration	Units	Standard	Citation
Asbestos	NA	NA	No visible emissions allowed unless specified alternative waste management procedures followed.	40 CFR 61 Subpart M
Benzene (Fugitive Emission)	10,000	ppm	Machine reading indicates leak; Readings of less than 500 ppm above background are not considered action events; Colorado Air Pollution Control Regulations; National Emission Standard.	5 CCR 1001 Regulation 8, Section VIII 40 CFR 61.110
Beryllium	10	grams	Over a 24 hour period; National Emission Standard; Colorado Air Pollution Control Regulations	40 CFR 61.32 5 CCR 1001 Regulation 8, Section III
Beryllium	.01	$\mu g/m^3$	30 day average, at least 3 years of data available; National Emission Standard; Colorado Air Pollution Control Regulations	40 CFR 61.32 5 CCR 1001 Regulation 8, Section III
Hydrogen Sulfide	142	$\mu g/m^3$	1 hour average; Colorado Air Pollution Control Regulations.	5 CCR 1001 Regulation 8, Section VII
Lead	1.5	$\mu g/m^3$	Average over one month period; Colorado Air Pollution Control Regulations.	5 CCR 1001 Regulation 8, Section VI
Mercury (from Sludge Incineration)	1,600	grams/day	Monitor emissions at least once a year by EPA Method 105; Below Federal limit of 3,200 grams/day; Colorado Air Pollution Control Regulations; National Emission Standard.	5 CCR 1001 Regulation 8, Section VI 40 CFR 61.52
Odor	7	Volume	Residential commercial areas, dilution with volumes of odor-free air; Colorado Air Pollution Regulations.	5 CCR 1001 Regulation 2
Odor	15	Volume	All other land use areas, dilution with volumes of odor-free air; Colorado Air Pollution Control Regulations.	5 CCR 1001 Regulation 2
Opacity	20%	—	No operation with emissions exceeding 20% opacity; Colorado Air Pollution Control Regulations.	5 CCR 1001 Regulation 1, Section II

Parameter	Concentration	Units	Standard	Citation
Ambient Air Quality Standards	Lead - 1.5	μg/m³ (max. arithmetic mean average over a calendar quarter)	Sources cannot cause or contribute to an exceedance of a national or Colorado Ambient Air Quality Standard.	5 CCR 1001-5, Regulation 3 5 CCR 1001-14
	PM - 150 & 50	μg/m³ (24 hr average concentration & annual arithmetic mean, respectively)		

ppm parts per million
$\mu g/m^3$ micrograms per cubic meter
mg/m^3 milligrams per cubic meter

Action	Citation	Requirements
Siting		
Siting of hazardous waste facilities	40 CFR 264.18 6 CCR 1007-3 Sect 264.18	New facilities constructed to treat, store, or dispose of hazardous waste must adhere to the following requirements: 1) They must not be located within 200 ft of a Holocene-age fault. 2) They must be designed, constructed, and operated to prevent washout of hazardous waste by a 100-year flood (if the facility is located within the 100-year flood plain).
Worker Protection		
Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites.
	29 CFR 1910.120 (b)-(j)	29 CFR 1910.120 (b) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA. Specific provisions include the following: • Health and safety program participation required by all on-site workers • Site characterization and analysis • Site control • On-site training • Medical surveillance • Engineering controls • Work practices • Personal protective equipment • Emergency response plan • Drum handling • Sanitation • Air monitoring

Action	Citation	Requirements
Worker exposure	ACGIH 1991-1992 [TBC] NIOSH 1990 [TBC] 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH are outlined in Table 1 in Appendix A1 of the DSA. (OSHA regulations and other health and safety requirements are actually independently applicable regulatory requirements, not ARARs or TBCs. ACGIH and NIOSH values are presented as guidelines.)
<u>Soil Dryer Unit Operation</u>		
Determination of operational readiness	40 CFR 270.19 [TBC] 6 CCR 1007-3 Sect 270.19 40 CFR 270.62 (b)[TBC] 6 CCR 1007-3 Sect 270.62(b)	Although permit applications are not necessary for RMA remedial actions, the operational readiness information will be provided in CERCLA documents leading to incineration alternatives.
<u>Operation of Miscellaneous Unit</u>	40 CFR 264 Subpart x 6 CCR 1007-3 Part 264 Subpart x	The soil drying unit shall be operated to comply with the substantive requirements of the miscellaneous regulation in 40 CFR 264 Subpart x environmental performance standards.
<u>Waste Characterization</u>		
Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Sect 260.30-31 40 CFR 261.2 6 CCR 1007-3 Sect 261.2 40 CFR 261.4 6 CCR 1007-3 Sect 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned mateiral may be - disposed of - burned or incinerated - accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material which is - used in a manner constituting disposal - burned for energy recovery - reclaimed - speculatively accumulated

Action	Citation	Requirements
		• Waste-like material is material that is considered inherently wastelike
Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Sect 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Soil-generated waste must be characterized and evaluated according to the following methods to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR Part 261 • Determine whether the waste is identified in 40 CFR Part 261 by testing the waste according to specified test methods and by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used
Solid waste classification	6 CCR 1007-2, Part 1, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain the following five solid waste categories: 1) "Industrial wastes", which includes all solid wastes resulting from the manufacture of products or goods by mechanical or chemical processes. 2) "Community wastes", which includes all solid wastes generated by the noncommercial and nonindustrial activities of private individuals of the community including solid wastes from streets, sidewalks, and alleys. 3) "Commercial wastes", which includes all solid wastes generated by stores, hotels, markets, offices, restaurants, and other nonmanufacturing activities, with the exclusion of community and industrial wastes. 4) "Special wastes", which includes any solid waste that requires special handling or disposal procedures. Special wastes may include, but are not limited to, asbestos, bulk tires, or other bulk materials, sludges, and biomedical wastes.

Action	Citation	Requirements
		5) "Inert material", which includes solids that are not soluble in water and therefore nonputrescible, together with such minor amounts and types of other materials that do not significantly affect the inert nature of such solids. The term includes, but is not limited to, earth, sand, gravel, rock, concrete that has been in a hardened state for at least 60 days, masonry, asphalt-paving fragments, and other inert solids, including those that the Colorado Department of Health may identify by regulation.
		If present, only small quantities of industrial, community, commercial, and special wastes are expected from thermal desorption of soils at RMA.
		No special testing requirements are specified for solid wastes; the management and disposal rules are strictly oriented toward imposing minimum engineering and technology requirements.
<u>Waste Management</u>		
Treatment, storage, or disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264	Wastes that are determined to be RCRA hazardous wastes must be stored and treated, in compliance with RCRA regulations.
On-post land disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264 EPA/540/G-89/005 [TBC]	Based upon a determination of whether the disposal technique constitutes placement, LDRs-UTS may be applicable. If placement does occur, the disposal facility must comply with the substantive requirements of 40 CFR Part 264.
	6 CCR 1007-3	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations and should therefore be considered ARARs. These standards are detailed on Appendix A, Table A-12.
<u>Management of Remediation Wastes</u>		

Action	Citation	Requirements
Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Subpart S	The corrective action management (CAMU) regulations allow for exceptions from otherwise generally applicable LDRs and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs are not triggered.
Temporary Units	6 CCR 1007-3 Sect 264.553 40 CFR 264.533	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
Air Emissions		
Emission of Particulates		
	5 CCR 1001-3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. In addition no off-site transport of particulate matter is allowed. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.
Emission control for opacity	5 CCR 1001-3, Regulation 1, Section II	Thermal desorption of soils shall not cause the emission into the atmosphere of any air pollutant that is in excess of 20 percent opacity.
Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61	Emission of listed hazardous air pollutants is controlled by NESHAPs. Thermal desorption will cause volatization of some contaminants.
	42 USCS Section 7412	National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.

Action	Citation	Requirements
Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment of ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements.
	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.
		Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Soil drying must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
	5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as appropriate). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the following limits: 1) For residential and commercial areas—odors detected after the odorous air has been diluted with seven more volumes of odor-free air 2) For all other land use areas—odors detected after the odorous air has been diluted with 15 more volumes of odor-free air
Stormwater Management		

Action	Citation	Requirements
Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters shall be conducted in compliance with the stormwater management regulations.