Nevada Environmental Restoration Project

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Analysis of Cleanup Alternatives and Supplemental Characterization Data Amchitka Island, Alaska

Revision No.: 0

October 2000

Environmental Restoration Division

U.S. Department of Energy
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ANALYSIS OF CLEANUP ALTERNATIVES AND SUPPLEMENTAL CHARACTERIZATION DATA AMCHITKA ISLAND, ALASKA

U.S. Department of Energy, Nevada Operations Office
Las Vegas, Nevada

Revision No.: 0

October 2000

ANALYSIS OF CLEANUP ALTERNATIVES AND SUPPLEMENTAL CHARACTERIZATION DATA
AMCHITKA ISLAND, ALASKA

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List of Acronyms and Abbreviations

ADEC	Alaska Department of Environmental Conservation
AEC/NV	U.S. Atomic Energy Commission, Nevada
AEC	U.S. Atomic Energy Commission
APIA	Aleutian Pribilof Island Association
AVS	Acid volatile sulfides
BSF&W	U.S. Bureau of Sport Fisheries and Wildlife
cm/sec	Centimeter(s) per second
COC	Constituent(s) of concern
CP	Control point
cy	Cubic yard
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DRO	Diesel-range organics
EPA-R&IE	EPA's Radiation and Indoor Environments National Laboratory
ERBSC	Ecological risk-based screening concentration
FML	Flexible membrane liner
ft	Foot (feet)
GRO	Gasoline-range organics
HDEP	High density polyethylene
NCP	National Contingency Plan
NE	Northeast
NW	Northwest
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PVC	Polyvinyl chloride
Rad	Radionuclide
SEM	Simultaneously extracted metals

List of Acronyms and Abbreviations *(Continued)*

SVOC	Semivolatile organic compound(s)
TAL	Target analyte list
TOC	Total organic carbon
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USN	U.S. Navy
VOC	Volatile organic compound
WACS	White Alice Communications System
WWII	World War II

Executive Summary

This document has been prepared for surface contaminated sites on Amchitka Island, Alaska, where the U.S. Department of Energy (DOE) has environmental restoration responsibility. This document was prepared in accordance with Alaska Department of Environmental Conservation (ADEC) Regulation 18AAC75.325, *Site Cleanup Rules*. This document addresses only those surface sites that were impacted by substances found in drilling muds that were spilled or released during testing and support facility construction and operations from 1965 through 1972 at the six drill sites on Amchitka Island.

Amchitka Island is located near the far western end of the Aleutian Islands, approximately 1,340 miles west-southwest of Anchorage, Alaska. Three underground nuclear tests were conducted on Amchitka Island. Long Shot (approximately 80 kilotons) was detonated on October 29, 1965. Milrow (approximately 1,000 kilotons) was detonated on October 2, 1969. Cannikin (less than 5 megatons) was detonated on November 6, 1971. In addition to the three sites that were used for underground nuclear tests, drilling occurred at three other sites (D, E, and F) where nuclear testing was considered but not performed. These DOE environmental restoration sites are comprised of a total of 11 drilling mud pits, 8 potentially impacted streams, 4 potentially impacted lakes, and a hot mix plant located at Charlie runway that was used for the construction of the runway and support roads on the island.

The purpose of this document is to identify and provide a rationale for the selection of a recommended remedial action alternative for each of these sites.

The scope consists of the following:

- Develop remedial action objectives.
- Identify remedial action alternative evaluation criteria.
- Develop remedial action alternatives.
- Perform detailed and comparative evaluations of the remedial action alternatives in relation to the remedial action objectives and evaluation criteria.

- Recommend the preferred remedial action alternative for each site.

Site investigations were conducted by DOE in 1993, 1997, 1998, and 2000. In the 1998 investigation, the chemical analysis of the drilling mud revealed that all drilling mud pits contain concentrations of diesel-range organics (DRO), polycyclic aromatic hydrocarbons, low levels of polychlorinated biphenyls (PCBs), and chromium. Based on those results, the contaminants of concern (COCs) within each mud pit above ADEC cleanup levels is DRO. Mean concentrations of COCs in water overlying the drilling mud were well below applicable ecological criteria in all drilling mud pits. Sampling of the surface water drainages of each drill site reveal that the COCs within the sediment impacted by drilling mud are DRO and PCBs. The investigation which took place in June of 2000 gathered chemical data on the shallow groundwater downgradient of the drilling mud pits. Based on the results of this sampling, the shallow groundwater has not been impacted by the drilling mud. Therefore, the groundwater pathway has been eliminated. Table 1-1 compares the groundwater quality for COC's with the Alaska groundwater cleanup standards as listed in 18AAC75.345.

Based on potential chemical exposure pathways, the following remedial action objectives have been identified for the DOE environmental restoration sites:

- Prevent or mitigate human and ecological exposure to surface contamination.
- Meet the substantive requirements of Alaska regulations and refuge management goals of the U.S. Fish and Wildlife Service (USFWS).
- Address stakeholder concerns and the cultural beliefs and practices of native people.

Based on review of existing data and current and future land use, the following alternatives were developed for consideration at Amchitka Island:

Alternative 1 - No Further Action
Alternative 2 - Institutional Controls
Alternative 3 - Soil Cover
Alternative 4 - Geosynthetic Cap
Alternative 5 - Clean Closure by Consolidation
Alternative 6 - Clean Closure with Off-Island Disposal
Alternative 7 - Close in Place (Hot Mix Plant only)

The remedial action alternatives were evaluated based on the 9 criteria identified in the National Contingency Plan (NCP) for effectiveness, constructability, cost, and schedule:

1. Overall Protection of Human Health and the Environment
2. Compliance with Applicable, Relevant and/or Appropriate Requirements
3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost
8. Stakeholder Acceptance
9. Community Acceptance

Other factors considered were safety of construction workers, collateral damage to the surrounding ecological environs (wetlands, tundra, etc.) and long-term monitoring.

Table 4-1 provides a summary of alternatives considered and proposed for each site. Tables 4-2 through 4-9 provide an assessment of remedial action alternatives based on the NCP criteria for each site, while Table 5-1 summarizes only the proposed alternatives.

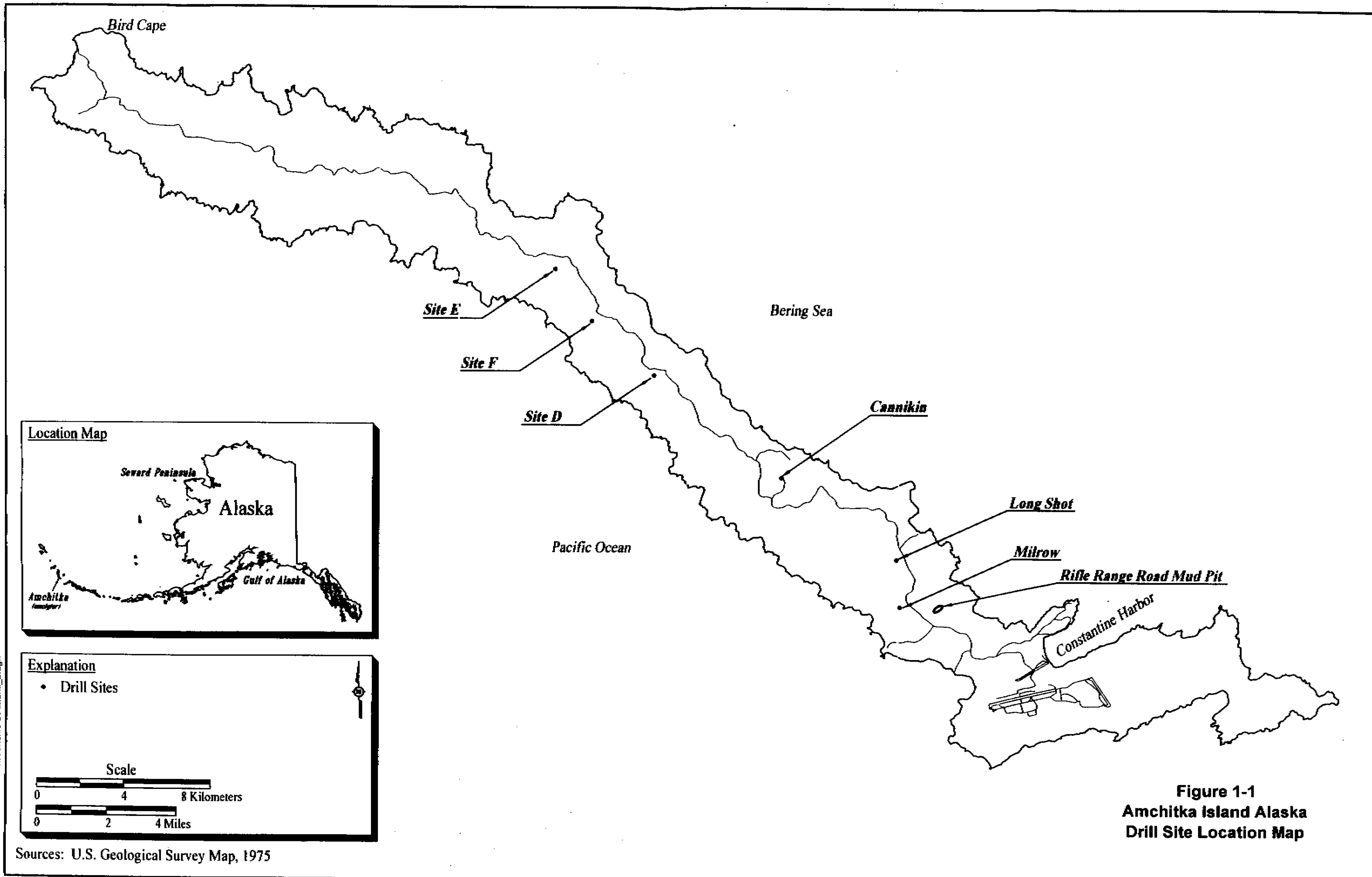
1.0 Introduction

The U.S. Department of Energy (DOE) has developed this document to identify and provide a rationale for the selection of recommended remedial actions at surface contaminated sites where DOE has environmental restoration responsibility. The DOE has assumed responsibility for the environmental restoration of these sites based on discussions and negotiations with the U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACE), U.S. Navy (USN), and Alaska Department of Environmental Conservation (ADEC). These surface sites were impacted by substances found in drilling muds that were spilled or released during testing and support facility construction and operations conducted from 1965 through 1972 on Amchitka Island, Alaska. This selection is based on site-specific characterization data collected by DOE in 1993, 1997, 1998, and 2000 and applies the evaluation criteria of: effectiveness, constructability, potential for collateral environmental damage, cost, and schedule to each alternative. This document was developed with input from the USFWS and the ADEC, and summarizes other alternatives considered and the selection process for determining the preferred remedial action at each site.

1.1 Background

Amchitka Island is located near the far western end of the Aleutian Islands, approximately 1,340 miles west-southwest of Anchorage, Alaska (see Figure 1-1). It is part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge, which is administered by the USFWS. Since World War II (WWII), Amchitka has been used by multiple U.S. government agencies for a variety of military and research activities. From 1943 to 1950, it was used as a forward air base for the U.S. Armed Forces. During the late 1960s and early 1970s, it was used by the U.S. Department of Defense (DoD) and the U.S. Atomic Energy Commission (AEC) (predecessor agency to DOE) as a site for three underground nuclear tests. Most recently, during the late 1980s and early 1990s, the USN constructed and operated a radar station on the island. Amchitka is currently uninhabited, and access is restricted. Visitors are required to obtain access authorization from either the USFWS or the USN. However, trespass by commercial fishermen is common.

Three underground nuclear tests were conducted on Amchitka Island. The DoD, in conjunction with the AEC, conducted the first nuclear test (Long Shot) in order to provide data that would improve the United States capability of detecting underground nuclear explosions. The Long Shot device



Sources: U.S. Geological Survey Map, 1975

Figure 1-1
Amchitka Island Alaska
Drill Site Location Map

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(approximately 80 kilotons) was detonated on October 29, 1965. The second nuclear test (Milrow) was conducted by the AEC as a means to study the feasibility of detonating a much larger device in the future. The Milrow device (approximately 1,000 kilotons) was detonated on October 2, 1969. The third nuclear test (Cannikin) was weapons related and detonated on November 6, 1971. The locations of the nuclear test sites and drill sites discussed in this section are shown in Figure 1-1.

In addition to the three sites that were used for nuclear tests, six other sites were considered for possible nuclear testing. The other potential sites were designated A, D, E, F, G, and H; Sites B and C were later renamed Milrow and Cannikin, respectively. Large-diameter emplacement holes were drilled at Sites D and F but were not used. An exploratory hole was drilled at Site E. Site H was graded in preparation for drilling activities that did not occur. Sites A and G were located and staked, but no further preparation was made. It was estimated that, at Sites B, C, D, E, F, and H combined, about 195 acres were disturbed by drilling or preparation for drilling. This area includes access roads and spoil-disposal areas (Fuller and Kirkwood, 1977). Drill Sites D, E, and F along with the three test sites contain mud pits which have impacted the environment.

1.1.1 History of Site Use

Amchitka Island was occupied by the U.S. Army during WWII, beginning in 1943. The island served as a forward air base between Adak Island to the east and the Japanese-held Kiska Island 69 miles to the west. During the occupation, facilities were constructed to house and support nearly 15,000 men. The Army abandoned the island in August 1950. The U.S. Air Force operated a weather station on Amchitka in the early 1950s, a White Alice Communications System site from 1959 to 1961, and a temporary radio relay site in the 1960s and 1970s.

The AEC occupancy of Amchitka, between 1967 and 1973, included use of the Base Camp area, especially around Baker Runway, and development of the Milrow and Cannikin test sites, and Drill Sites D, E, and F. A small construction camp also was installed at the northwest end of the island; it was also used as the Control Point (CP) for the Milrow and Cannikin tests. With the exception of the test sites and drill sites, facilities constructed by the AEC were located in areas disturbed by previous occupants of the island, primarily areas disturbed during WWII and areas occupied by DoD during the Long Shot project. In addition, the AEC rehabilitated and used structures built during WWII for the Long Shot project.

Available DOE records regarding AEC activities on the island focus primarily on the three test areas and three drill sites. Personnel from the U.S. Bureau of Sport Fisheries and Wildlife (BSF&W), the predecessor to the USFWS, were present on the island continuously during the AEC's occupancy, and intensive studies of the island's ecological systems were conducted throughout the AEC's stay on the island. No records from these agencies have been found regarding the release of any toxic materials into the island environment other than drilling-mud spills into various streams and lakes.

The AEC conducted an extensive restoration program prior to demobilizing from the island. The primary goals of that program were to restore areas disturbed by AEC operations to the condition they were in before AEC use, and prevent future environmental damage from areas and facilities used by the AEC (AEC/NV, 1972). The AEC identified 120 sites that required restoration based on discussions with the BSF&W (AEC/NV, 1972). Following completion of the restoration activities, BSF&W signed off on all 120 sites.

1.1.2 Current Site Status

Since 1980, Amchitka Island has been part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge which is managed by the USFWS of the U.S. Department of the Interior. Based on foreseeable human use of Amchitka, the only current users are trespassers from passing fishing vessels that visit the island on occasion and USFWS researchers who spend very limited periods on the island. Near-term occupants of Amchitka will primarily be personnel conducting wildlife research, environmental investigations, remediation, or demolition work. This occupation of the island would consist of a limited number of personnel working for tours of duty that are far shorter than the exposure duration involved in a typical residential or industrial land-use scenario. The scenario of occasional visitors is considered to be protective of transient future use. The primary concern posed by the DOE sites is ecological impacts, rather than human health issues.

1.2 Site Investigations

An extensive scientific investigation of Amchitka was conducted during the 1960s and 1970s to characterize the environment of the island before and after the AEC conducted underground nuclear testing. Much of the scientific information collected during that investigation is included in *The Environment of Amchitka Island, Alaska* (Merritt and Fuller, 1977). This publication compiled research on the geology, hydrology, climate, geomorphology, and land and marine biota of island, as well as information on environmental contaminants and the nuclear test effects.

Under DOE's environmental restoration mission, characterization efforts have been conducted to assess environmental impacts attributed to past DOE activities at their sites. These characterization efforts were conducted in 1993, 1997, 1998, and 2000 and are summarized in the following sections.

While the information contained in this volume is valuable, it generally does not include site-specific chemical analyses. Site-specific environmental investigations utilized in the development of the preferred remedial action for each site are summarized in the following subsections. Under DOE's environmental restoration mission, characterization efforts have been conducted to assess environmental impacts attributed to past DOE activities at their sites. These characterization efforts were conducted in 1993, 1997, 1998 and 2000 and are summarized in the following sections.

1.2.1 1993 Sampling

In 1993, the DOE performed investigations at the three underground nuclear test sites that included the collection of soil, surface water, and groundwater samples. The investigations were part of initial efforts to characterize possible chemical impacts at the sites. The sampling program included analysis for Target Analyte List (TAL) metals total, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). The soil samples were collected from the surface of the emplacement hole pads near ground zero at each site. Surface water samples were collected from lakes, drilling mud pits, and streams near the test sites. The groundwater samples were collected from monitoring wells installed near the test sites as part of a long-term monitoring program.

1.2.2 1997 Sampling

The DOE visited Amchitka again in 1997 to conduct an investigation for radionuclides in plants and sediments collected from streams draining the three nuclear test sites, as well as from one reference stream. In addition to radionuclides, approximately half of the stream sediment samples were analyzed for a list of 32 metals total and total organic carbon (TOC). Three samples of drilling mud were also collected from the Long Shot drilling mud pits and analyzed for 32 metals and diesel-range organics (DRO).

The EPA's Radiation and Indoor Environments National Laboratory (EPA-R&IE), by interagency agreement with the U.S. Department of Energy, Nevada Operations Office (DOE/NV), conducted radiological sampling of aquatic plants and sediment on Amchitka. This work was designed to identify the presence or absence of man-made radionuclides in aquatic plants and stream sediments near the three underground nuclear test sites, and determine whether they could be attributed to cavity leakage or worldwide fallout. Samples of aquatic vegetation and sediment were collected primarily from streams within the drainage basins associated with the Cannikin, Milrow, and Long Shot test sites. Reference samples were collected from a stream located southwest of Drill Site D. Samples were also collected from standing water in the three drilling mud pits associated with the drilling of the Long Shot test hole.

1.2.3 1998 Drill Site Characterization Sampling

In 1998, DOE conducted an investigation of possible chemical impacts at the drill sites as a result of past drilling activities. The field sampling program was directed at evaluating present impacts, if any, from emplacement and exploratory hole drilling activities related to underground nuclear testing. Of particular concern was the potential for residual effects in freshwater drainages as a result of drilling mud releases and spills that occurred during the drilling operations and underground nuclear tests. Another primary objective of the investigation was to characterize the contents and integrity of the remaining drilling mud pits, to provide information for determining whether the drilling mud pits pose a significant future risk to site drainages due to the structured integrity of the drilling mud pit berms. Chemical sampling to evaluate the effects of past emplacement and exploratory drilling activities included sediment and water sampling from the 13 open drilling mud pits at the drill and test sites, several potentially impacted lakes, and 8 streams that drain the sites. Sediment and water samples were also collected from four reference streams to provide representative background conditions against which potential adverse effects could be assessed. Benthic sampling was also conducted in each of the streams to perform macroinvertebrate community assessments and bioassays to evaluate sediment toxicity (TRIAD analysis). This information, combined with the chemical results, was used in the TRIAD analysis to provide a more sensitive assessment of whether historic drilling mud releases are continuing to affect stream sediment quality and habitat. Resident fish were also collected from each of the drainages and analyzed for constituents of concern to evaluate whether bioaccumulation of drilling mud contaminants is occurring in the food web. A summary of the 1998 Drill Site sampling is presented in Table 1-1.

The results of this sampling program, which are summarized below, were utilized in the evaluation of remedial action alternatives presented in this plan.

Drilling Mud Pit Sampling - Samples were taken from 12 mud pits to determine the contaminant concentrations in the mud and the standing water in each pit. The drilling mud pits investigated are listed below:

Rifle Range Road Mud Pit (1)	Drill Site D Mud Pits (3)
Long Shot Test Site Mud Pits (2)	Drill Site E Mud Pits (2)
Cannikin Test Site Mud Pit (1)	Drill Site F Mud Pit (1)
Cannikin Drill Hole Site Mud Pits (2)	

The chemical analysis of the drilling mud revealed the COC for the drilling mud pits is DRO. Low concentration levels of PCBs were found in the main Cannikin Mud Pit and one of the Drill Site D pits, but below ADEC cleanup standards. Mean concentrations of COCs in water overlying the drilling mud were well below applicable ecological criteria in all drilling mud pits.

Visual observations made in 1998 confirmed that the drilling mud pits are in stable condition; however, the manifold system in the Drill Site D Mud Pit is corroded and leaking, which presents the potential for a release of drilling mud and water into surface drainage ways and stream(s) if the system fails.

Surface Water Sampling - Samples were collected in 1998 from the eight streams and four lakes in the vicinity of the drilling mud pits to evaluate surface water and sediment chemistry and to perform macroinvertebrate and bioassay assessments (TRIAD analysis). The surface water bodies that were investigated are listed below:

Streams

White Alice Creek	Unnamed stream at Drill Site E
Bridge Creek	Limpet Creek
Cloudberry Creek	Clevenger Creek
Rainbow Creek	Falls Creek

Lakes

Cannikin Lake	Heart Lake
Reed Pond	Lake at Drill Site D

Four reference streams, not affected by site activities, were sampled to provide background data for comparison.

Several streams were impacted by releases of large volumes of drilling mud in the 1960s and 1970s. Chemical analyses of stream water and sediment samples performed in 1998 detected sporadic, minor traces of elevated levels of hazardous substances. A TRIAD analysis, which incorporates sediment chemistry, sediment toxicity, and benthic macroinvertebrate community, was performed on the eight streams draining the sites where drilling occurred. The TRIAD analysis determined that, in most instances, the drill site and test site streams had sediment quality comparable to unimpacted reference locations. Only a few locations on Rainbow Creek, which drains the Long Shot site, and White Alice Creek, which drains the Cannikin site, showed residual effects from past releases of drilling muds.

Dolly Varden Trout were found to be abundant in the potentially impacted streams. Chemical analysis of the tissue of fish collected in affected streams showed little evidence of elevated concentrations of COCs, with the exception at several locations where PCB Arochlor 1260 was above benchmarks.

Reed Pond shows no visible evidence of mud releases and only slight chemical impacts. There were minor residual affects from mud releases shown in the sampling results of the lake at Drill Site E and Heart Lake. Drilling mud was encountered in a small portion of Cannikin Lake.

The data indicate that the contaminants contained within drilling mud in the drilling mud pits have not migrated into the streams. Because the streams are recharged from the shallow groundwater, it is a good indicator that the shallow groundwater has not been impacted; this was confirmed during the 2000 Engineering Site Investigation described below. Residual contamination present in the surface water drainages is likely a result of past spills of the drilling mud. The TRIAD analysis determined that aquatic communities impacted by drilling mud spills have been reestablished in the streams.

1.2.4 2000 Engineering Site Investigation

The DOE returned to Amchitka Island in June 2000 to obtain additional information on the physical properties of the drilling mud pits to aid in the remedial design for each of the sites and to collect supplemental characterization data based on ADEC and USFWS comments on the 1998 Drill Site Characterization Sampling Report. Geotechnical samples of the drilling mud, the drilling mud pit berms, and the proposed borrow areas were taken. A detailed topographic survey of each site and potential borrow sources was done. As a result of the ADEC review of the 1998 drill site characterization sampling results, the DOE obtained additional characterization data, specifically data on the shallow groundwater and the sediments of selected streams downgradient of the drilling mud pits. In addition, DOE, USFWS, and Aleutian Pribilof Island Association (APIA) personnel visually inspected each site to verify that the remedial action proposed for that site is, in fact, the preferred action. The inspection of each site focused on the location of each site, quantity or contaminated material (drilling mud), access to the site, and the potential for collateral environmental damage if the proposed remedial action is implemented. Table 1-2 summarizes the results of the shallow groundwater sampling directly downgradient of the drilling mud pits, while Table 1-3 summarizes the stream sediment sampling in Rainbow and Falls Creek. As shown in Table 1-2, the shallow groundwater has not been impacted by the drilling muds.

Table 1-1
Summary of 1998 Drill Site Sampling
(Page 1 of 3)

Site	Location	Media	Number of Analyses									
			GRO	DRO	VOCs	PAHs	PCBs	AVS/SEM	Metals	TOC	Rad	Lipids
Milrow	Heart Lake	Surface Water		3	3	3			3			
		Sediment		5	5	5			5			
	Clevenger Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3			1
Rifle Range Road	Drilling Mud Pit	Sediment		3	3	3			3			
Long Shot	Drilling Mud Pits	Surface Water		6	6	6			6			
		Sediment		12	12	12			12			
	Bridge Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				2	2		2			
	Rainbow Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				1	1		2			
	Cloudberry Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3		1	
	Reed Pond	Surface Water		2	2	2			2			
		Sediment		2	2	2			2			

Table 1-1
Summary of 1998 Drill Site Sampling
(Page 2 of 3)

Site	Location	Media	Number of Analyses									
			GRO	DRO	VOCs	PAHs	PCBs	AVS/SEM	Metals.	TOC	Rad	Lipids
Cannikin	Drilling Mud Pits	Surface Water		7	7	7			7			
		Sediment		10	10	10	10		10			
	Cannikin Lake	Surface Water		3	3	3	3		3			
		Sediment	3	3	3	3	3		3			
		Fish				2	2		2		6	2
	White Alice Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5	5	5	5	5		
		Fish				5	5		5		2	1
Drill Site D	Drilling Mud Pits	Surface Water		9	9	9			9			
		Sediment		24	24	24	15		24			
	Lake	Surface Water		3	3	3			3			
		Sediment		5	5	5			5			
	Falls Creek	Surface Water		5	5	5			5			
		Sediment		5	4	5		5	5	5		
		Fish				2	2		2			
Drill Site F	Drilling Mud Pits	Surface Water		3	3	3			3			
		Sediment		5	5	5			5			
	Limpet Creek	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3			1

Table 1-1
Summary of 1998 Drill Site Sampling
(Page 3 of 3)

Site	Location	Media	Number of Analyses									
			GRO	DRO	VOCs	PAHs	PCBs	AVS/SEM	Metals.	TOC	Rad	Lipids
Drill Site E	Drilling Mud Pits	Surface Water		2	2	2			2			
		Sediment		2	2	2			2			
	Unnamed Stream	Surface Water		5	5	5			5			
		Sediment		5	1	5		5	5	5		
		Fish				3	3		3			
Pumphouse Lake		Fish									2	
Reference Streams	Stream 1	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				4	4		4			
	Stream 2	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				3	3		3			
	Stream 3	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				3	3		3			
	Stream 4	Surface Water		5					5			
		Sediment		5				5	5			
		Fish				3	3		3			1
Aircraft Graveyard		Surface Water					3					
		Sediment					3					
		Groundwater					2					

GRO = Gasoline-range organics
DRO = Diesel-range organics
VOCs = Volatile Organic Compounds
PAHs = Polycyclic aromatic hydrocarbons
PCBs = Polychlorinated Biphenyls
AVS/SEM = Acid Volatile Sulfides/Simultaneously Extracted Metals
TOC = Total Organic Carbon
Rad = Radionuclide

Table 1-2
Comparison of Groundwater Data With Alaska Cleanup Standards (18AAC75.345)

Site	Sample Number	Sample Matrix/Source	Analyte	Result	AK Standard
Long Shot	LSH-GW-01	Groundwater/Boring	DRO	0.26 mg/L	1.5 mg/L
			PCBs	ND 0.54 µg/L (J)	0.5 µg/L
	LSH-GW-02		DRO	0.099 mg/L (J)	1.5 mg/L
			PCBs	ND 0.53 µg/L (J)	0.5 µg/L
Cannikin	CAN-GW-01	Groundwater/Seep	DRO	0.20 mg/L	1.5 mg/L
			PCBs	ND 0.54 µg/L (J)	0.5 µg/L
			RRO	0.25 mg/L	1.1 mg/L
			Chromium	0.022 mg/L (E)	0.1 mg/L
			Lead	0.0086 mg/L	0.015 mg/L
Drill Site D	DSD-GW-01	Groundwater/Boring	DRO	0.087 mg/L (J)	1.5 mg/L
			PCBs	ND 0.54 µg/L (J)	0.5 µg/L
	DSD-GW-02		DRO	0.24 mg/L	1.5 mg/L
			PCBs	ND 0.53 µg/L (J)	0.5 µg/L
Drill Site E	DSE-GW-01	Groundwater/Seep	DRO	0.19 mg/L	1.5 mg/L
			PCBs	ND 0.53 µg/L (J)	0.5 µg/L
Drill Site F	DSF-GW-01	Groundwater/Seep	DRO	0.15 mg/L	1.5 mg/L
			PCBs	ND 0.53 µg/L (J)	0.5 µg/L
Rifle Range Road	RRR-GW-01	Groundwater/Boring	DRO	0.10 mg/L (J)	1.5 mg/L
			PCBs	ND 0.54 µg/L (J)	0.5 µg/L
	RRR-GW-02		DRO	0.079 mg/L (J)	1.5 mg/L
			PCBs	ND 0.54 µg/L (J)	0.5 µg/L
Constantine Spring[1]	CON-GW-01	Groundwater/Spring	DRO	0.090 mg/L (J)	1.5 mg/L
			PCBs	ND 0.53 µg/L (J)	0.5 µg/L

[1]Constantine Spring is utilized as a drinking water source and included as a reference. The Spring is not in the watersheds of any of the DOE sites.

DRO = Diesel-Range Organics
RRO = Residual-Range Organics
GRO = Gasoline-Range Organics
PCB = Polychlorinated Biphenyls
mg/L = Milligrams per liter
µg/L = Micrograms per liter
ND = Not detected - value given is reporting limit.

Table 1-3
Summary of PCB Stream Sediment Sampling

Location	Sample Number	Analyte	Result
Rainbow Creek	LSH-SD-01 LSH-SD-02	PCBs PCB-1260	ND 0.056 mg/kg (J) 0.460 mg/kg
Falls Creek	DSD-SD-01 DSD-SD-02 DSD-SD-03	PCBs PCB-1260 PCB-1260	ND 0.033 mg/kg (J) 0.820 mg/kg 0.040 mg/kg

mg/kg = Milligrams per kilogram
ND = Not detected, value given is reporting limit.

2.0 Remediation Goals

The DOE's goal on Amchitka Island, Alaska, is to implement remedial actions for surface contaminated sites that are protective of human health and the environment, meet the substantive requirements of Alaska regulations, refuge management goals of the USFWS, address stakeholder concerns, and address the cultural beliefs and practices of native people.

2.1 DOE Sites

The types of sites that the DOE has responsibility for can be distinguished into three categories: historical drilling mud pits, surface water drainages, and the hot mix plant located adjacent to the Charlie runway. The following sections detail each of the DOE's site categories.

2.1.1 Drilling Mud Pits

There are 12 existing drilling mud pits on Amchitka Island which were constructed in support of the underground nuclear testing that occurred on the island. Table 2-1 presents physical dimensions and estimated quantity of drilling mud in each drilling mud pit. Chemical analyses have determined that the drilling mud contains DRO above ADEC cleanup levels. The drilling mud is composed primarily of bentonite, which when hydrated, has a permeability of 1×10^{-9} centimeters per second (cm/sec) which is highly impermeable. Based on the drill site characterization report and the results of the groundwater sampling which occurred in 2000, which did not detect DRO above ADEC cleanup criteria, the contamination is trapped within the bentonite matrix and is not mobile. The bentonite essentially has sealed the bottom and side-slopes of the drilling mud pits, which is evident because of the standing water in the drilling mud pits.

2.1.2 Surface Water Drainages

There are 12 surface water bodies that were potentially impacted during the nuclear testing activities. Table 2-2 presents summary conditions at each of the surface water bodies. The sampling activities completed in 1997 indicate that for the most part the streams have recovered from the historical drilling mud spills. The only contamination remaining in the streams is the remnants of the spilled drilling mud.

Table 2-1
Amchitka Drilling Mud Pits

Site Name	Drilling Mud Pit Name	Description
Milrow	Rifle Range Road Mud Pit	200 feet (ft) by 150 ft, 1 to 2 ft mud ~1,880 cubic yards (yd^3)
Long Shot	West Mud Pit	150 ft by 150 ft, 2 to 6.2 ft mud ~2,740 yd^3
	East Mud Pit	150 ft by 150 ft, 3 to 7.7 ft mud ~2,740 yd^3
Cannikin	Northwest Mud Pit	120 ft by 170 ft, 4.2 to 5.2 ft mud ~3,000 yd^3
	Postshot Drill Back Hole South	60 ft by 85 ft,1.5 to 3.5 ft mud ~355 yd^3
	Postshot Drill Back Hole North	42 ft by 78 ft, 1.1 to 1.5 ft mud ~133 yd^3
Drill Site D	South Mud Pit	500 ft by 130 ft, 0.1 to 2.7 ft mud ~2,350 yd^3
	Northwest Mud Pit	300 ft by 125 ft, 5.8 to 7.3 ft mud ~7,820 yd^3
	Northeast Mud Pit	300 ft by 175 ft, 1.2 to 5.1 ft mud ~4,870 yd^3
Drill Site E	Northern Mud Pit	20 ft by 40 ft, no mud found
	Southern Mud Pit	40 ft by 80 ft, ~1.5 to 8.0 ft mud ~415 yd^3
Drill Site F	Remnant of Mud Pit	East piece = 20 ft by 10 f, ~1 ft mud ~10 yd^3 West piece = 200 ft by 25 ft, 3.2 to 4.0 ft mud ~300 yd^3

2.1.3 Hot Mix Plant

The hot mix plant consists of two rail tank cars, of which one is approximately three-quarters full of liquid tar. If leaking, the tar within the tank could impact the shallow groundwater. The visual investigation of the buried tanks was not conclusive as to the condition of the tanks.

Table 2-2
Amchitka Ponds and Streams

Pond/Stream Name	Description
Heart Lake (Milrow)	300 ft from Milrow Emplacement Hole, Wet portion of lakebed = 1/3 total lake area, 4.5 ft max water depth; no mud presently impacts lake
Clevenger Creek (Milrow)	Connected to Heart Lake by a small tributary that drains the lake, flows southwest to Pacific Ocean. Studied section was 6,500 ft long; no mud found
Rainbow Creek (Long Shot)	~4,500 ft long, drainage channel running from Long Shot drilling mud pits, east under Infantry Road, then northeast to Square Bay on the Bering Sea: deposits of mud found
Cloudberry Creek (Long Shot)	Begins upstream of Infantry Road, flows northeast beneath road through a culvert and empties into Cyril Cove on the Bering Sea, ~7,200 ft long
Bridge Creek (Long Shot)	Tributary that exits Long Shot Pond and flows north into a larger channel about 800 ft upstream of Infantry Road, studied portion = ~ 3,900 ft
Reed Pond (Long Shot)	~180 by 150 ft, 0.8 to 1.5 ft water; no mud found
Cannikin Lake (Cannikin)	Interrupts White Alice Creek, resulted from nuclear detonation ground subsidence; 0.5 to 0.8 ft mud in southwest margin of lake; quantity of mud remaining on lake bottom is unknown
White Alice Creek (Cannikin)	Begins west of Cannikin surface ground zero, flows to the Bering Sea, studied portion = 8,000 ft
Falls Creek (Drill Site D)	Primary drainage stream of Drill Site D watershed, ~ 6,000 ft long, located south of site and flows to Pacific Ocean, only one sampling location showed signs of impact from drilling mud pits -- evidence of diesel at Station 1 found when stream sediment was disturbed and high DRO concentrations found
Unnamed Lake (Drill Site D)	Southeast of drilling mud pits at Drill Site D, visual inspection along shoreline revealed no drilling mud
Limpet Creek (Drill Site F)	Primary stream of Drill Site F watershed, 10,000 ft long; headwaters located northeast of drill site, water quality and sediment quality generally do not appear to be adversely impacted from past drilling mud releases
Unnamed Drill Site E Stream	Primary drainage of Drill Site E watershed, flows adjacent to concrete drilling pad, flows south past drill site to Pacific Ocean, ~8,200 ft long, DRO only detected in sediment at one station

3.0 Remedial Alternatives Considered

The alternatives evaluated for the DOE sites are described in the following sections. They were selected from a wide variety of established technologies based on the type of contaminant, the capability of the technology to achieve the desired results, and the logistical conditions associated with the remoteness of the island. The alternatives include:

1. No Further Action
2. Institutional Controls
3. Soil Cover
4. Geosynthetic Cap
5. Clean Closure by Consolidation
6. Clean Closure with Off-Island Disposal
7. Close in Place (Hot Mix Plant only)

3.1 Alternative 1 - No Further Action (Administrative Closure)

Under this alternative, no further action will be taken to remediate the site; contaminants will remain in place, untouched, and the site will be administratively closed. This alternative is appropriate at sites where one or more of the following criteria is met:

- Contamination is confined to a small area.
- Contaminant migration to an ecologically sensitive area is unlikely.
- No significant impact is expected.
- No unacceptable human health risk and minimal ecological risk is expected under present or future use scenarios.
- Site characterization study indicates no downgradient impacts detected.
- Site constitutes a small percentage of overall terrestrial habitat for affected species.
- Residual contamination appears to be biodegrading.
- Evidence indicates past migration of contaminants has ceased because the source of contamination has been depleted and/or eliminated.

- Remedial action, on-site or accessing the site, will cause extensive damage to sensitive ecological areas such as tundra and wetlands (i.e., ecological damage caused by remediation exceeds any benefits of remedial action).

- Excavation of contaminated soils may accelerate migration of contaminants to bedrock, making the problem worse (as in wetland areas).

- Remedial measures would be costly to implement with questionable benefits.

- Remedial measures would exceed schedule constraints to be completed in a single season.

This alternative will require periodic inspection and maintenance. Because of the remoteness of the island, the required monitoring will not be scheduled on a regular basis, but at opportunistic times when other activity is scheduled on the island by other government agencies such as the USFWS.

3.2 Alternative 2 - Institutional Controls

This alternative prevents any future human intrusion by erecting a physical barrier around the site or by applying some other administrative obstacle (i.e., land record entry isolating the site from human use in the case where a physical object may only serve to attract vandalism). This may be a feasible alternative in some instances involving small quantities of contaminants or where gaining access to the site to perform remedial/removal activities would cause more environmental damage (disturb/destroy tundra and/or wetlands) than if the site was untouched. In these instances contaminants will remain in place. This alternative will require periodic inspection and maintenance. Because of the remoteness of the island, the required monitoring will not be scheduled on a regular basis, but at opportunistic times when other activity is scheduled on the island by other government agencies such as the USFWS.

3.3 Alternative 3 - Soil Cover

This option essentially isolates the drilling mud from the environment and eliminates risk pathways by placing a layer of soil on it. The standing water on the drilling mud pits will be pumped off and native soil will be excavated from one or more soil borrow areas on the island, processed to a usable particle size using a vibratory screen, and hauled to the drilling mud pit. The processed soil will be dumped adjacent to the drilling mud pit and the drilling mud will be stabilized with those soils by mixing with a backhoe bucket. An additional soil layer (1-ft thick, minimum) will be placed and graded in such a way as to promote surface water runoff and then revegetated with a native seed mix to stabilize the cover and minimize erosion. This alternative will significantly reduce the possibility of contaminant exposure, but will not reduce the volume of the drilling mud or the contaminants. This alternative will require periodic inspection and maintenance. Because of the remoteness of the island, the required inspection will not be scheduled on a regular basis, but will occur at opportunistic times when other activity is scheduled on the island by other government agencies such as the USFWS. This alternative is appropriate at sites where there is a significant volume of contamination present and one or more of the following criteria is met:

- On-site soils of low permeability are available to be used for the cap.
- There is a moderate to high potential for migration of contaminants toward ecologically sensitive areas.
- Structural stability of present confining berms or structures appear unstable or show signs of erosion.
- In-flow/out-flow of surface waters may transport contaminants from the site.
- Poses a potential health or safety risk to human intruders.
- Contaminant concentrations exceed regulatory response levels.
- Ecological receptors frequent the site.

3.4 Alternative 4 - Geosynthetic Cap

This alternative provides a geosynthetic barrier in accordance with 18 AAC 60.430 to isolate the contaminants from the environment and eliminates risk pathways. The standing water on the drilling mud pits will be pumped off, soil (from on-island borrow area) will be brought to the drilling mud pit and mixed with the drilling mud to create a stable, competent mixture capable of supporting the cap. Additional soil will be placed directly on the mud/soil mixture with a low ground pressure bulldozer and graded to promote surface water runoff. A geosynthetic cap constructed of a flexible membrane liner (FML) will then be installed on top of the soil. The FML can be constructed of high-density polyethylene (HDPE), polyvinyl chloride (PVC), or other approved material. Finally, a layer of soil will be placed over the FML with a low ground pressure bulldozer, to act as a frost protection graded to promote surface water runoff, and seeded with a native seed mix to stabilize the soil and minimize erosion. This alternative will isolate the contaminants from the environment with a highly impermeable cap (permeability $\leq 1 \times 10^{-9}$ cm/sec) which will prevent surface water infiltration from contacting the contaminated drilling mud, thus preventing the potential migration of contaminants from the drilling mud pit. It will not reduce the volume of the drilling mud or the contaminants present. This alternative will require periodic inspection and maintenance. Because of the remoteness of the island, the required inspection will not be scheduled on a regular basis, but will occur at opportunistic times when other activity is scheduled on the island by other government agencies such as the USFWS. This alternative is appropriate at sites where there is a significant volume of contamination present and one or more of the following criteria is met:

- There is a moderate to high potential for migration of contaminants toward ecologically sensitive areas.
- Structural stability of the present confining berms or structures appear unstable or show signs of erosion.
- In-flow/out-flow of surface waters may transport contaminants from the site.
- The exposed mud poses a potential health or safety risk to human intruders.
- Contaminant concentrations exceed regulatory response levels.

3.5 Alternative 5 - Clean Closure by Consolidation

In this alternative, the drilling mud will be excavated from a site and transported to another contaminated site, where a larger volume of drilling mud is present and is designated to be remediated by Alternative 3 or 4. After the drilling mud is removed, confirmatory samples will be taken to verify that the underlying *in situ* soils are below applicable clean-up levels. The excavated area will then be backfilled with native soils and graded to promote surface water drainage and minimize ponding. This method will effectively remove the contaminant from the site and reduce the future requirements by obtaining clean closure. This alternative is appropriate at sites where the following criteria is met:

- A relatively small quantity of drilling mud exists that is accessible without causing extensive collateral environmental damage or posing undue risk to construction workers.
- The site is in close proximity to another site slated for remediation by Alternative 4.

3.6 Alternative 6 - Clean Closure with Off-Island Disposal

This alternative will require the excavation and transport of all contaminants from the island and shipment to a permitted facility on the mainland for disposal. After all standing water is removed, processed soil from the on-site borrow areas will be mixed with the mud to create a transportable material with no free liquids (a regulatory requirement for disposal). If the addition of on-site soils does not bind the free liquids, then a reagent such as Portland cement will be added to stabilize the mud. The stabilized mud will be transported to the dock and loaded onto barges for transport to the mainland for disposal. At the port of Anchorage (or Seattle), the drilling mud will be off-loaded and transferred onto permitted commercial vehicles for transport to a licensed disposal facility. After the drilling mud is removed, *in situ* soils at each drilling mud pit will be sampled to confirm that all of the material has been removed. The drilling mud pits will then be backfilled with native soils, graded to promote surface water runoff, and revegetated with a native seed mix. This alternative removes the contaminant from the site, therefore eliminating future inspection requirements.

3.7 Alternative 7 - Close in Place

This alternative addresses the hot mix plant only. The liquid tar in the tank will be pumped out, containerized, and transported to the mainland for proper disposal. The tank will then be filled with native soils to prevent the future collapse of the tank.

4.0 Selection of Alternatives

Remedial alternatives were selected for consideration at each site based on the established concentration of the COCs (DRO that exceed ADEC requirements), the physical properties and volume of contaminated material, and, in the case of the drilling mud pits, the physical condition of the drilling mud pit itself.

4.1 Selection Criteria

These alternatives were evaluated and compared on their ability to meet the following criteria based on the National Contingency Plan (NCP) requirements.

4.1.1 Effectiveness

The effectiveness of the remedial action depends on the alternative's ability to isolate the hazardous substances from the pathways through which they could impact human health and the environment. The potential pathways may include groundwater, surface water, air, vegetation, dermal contact, and ingestion. Based on the results of the 1998 sampling and analysis field event and the 2000 field investigation, several of these potential pathways were eliminated from consideration. Surface water sampling in 1998 and shallow groundwater sampling in 2000 verify that COCs are below ADEC cleanup standards; therefore, the two pathways are eliminated. In June 2000, the DOE verified this by collecting groundwater samples downgradient of the drilling mud pits using direct-push methodology and via surface seeps. The results of this sampling as shown in Table 1-2 indicate that shallow groundwater is below ADEC clean-up levels.

4.1.2 Constructability

Constructability is the measure of the difficulty to construct the remedial action alternative; a less complex alternative is favored over one that is difficult to construct or maintain, if all other factors are equivalent.

Potential for Collateral Environmental Damage

The location of a contaminated site may be such that considerable temporary, long-term, and/or permanent damage to sensitive environments such as tundra, wetlands, or stream channels, and impacts to populations of benthic invertebrates and fish may occur in the process of accessing the site to either remove, or place a cover on the contaminants found there. In these instances, the more prudent choice may be to take no further action.

4.1.3 Cost

The relative cost of each remedial action alternative is compared with the others, as necessary, and is presented in Section 4.3.

4.1.4 Schedule

The anticipated time to complete construction and project-related logistics are taken into account when selecting a remedial action alternative.

4.2 Comparative Analysis

The following sections summarize the considerations in evaluating and selecting proposed remedial alternatives for each of the affected sites. Table 4-1 identifies the proposed alternative and other alternatives considered for each site.

4.2.1 Rifle Range Road Mud Pit (Milrow Site)

During the site characterization, one drilling mud pit along Rifle Range Road was located and sampled. This drilling mud pit is approximately 200 by 150 ft and contains approximately 1,880 cubic yards (yd^3) of drilling mud with a thickness of 1 to 2 ft. Based on the 1998 characterization sampling, DRO within the drilling mud ranges from 60 parts per million (ppm) to 2,620 ppm, but shallow groundwater is not impacted (see Table 1-2). There is a small risk for ecological receptors in the immediate area of the drilling mud pit because the drilling mud is exposed to the environment with no overlying water. The following alternatives have been considered for the remediation of this site:

- No further action
- Institutional controls
- Soil cover
- Clean closure by consolidation
- Clean closure with off-island disposal

The following paragraphs detail each of the alternatives considered:

No further action was considered but was determined to be unacceptable because of the significant volume of mud, the drilling mud pit's location within a previously disturbed soil borrow area and the close proximity to Rifle Range Road. This site is easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Institutional controls in the form of fencing was considered but was also determined to be unacceptable because it would not prevent access by birds and water fowl which are plentiful on the island.

Placing a **soil cover** over the drilling mud pit was considered as an alternative to eliminate exposure pathways at this site. This method would isolate the drilling mud from the environment and direct precipitation off of the cover by placing a layer of soil over the drilling mud. The relatively thin layer of drilling mud within the drilling mud pit (1 foot on average) would allow the drilling mud pit to be placed with a low ground pressure bulldozer. The soil cover would be blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit minimizing infiltration into the underlying drilling mud and minimizing potential erosion of the cover material. The matrix of the drilling mud itself (bentonite) would prevent seepage of COCs from the drilling mud pit; therefore, the soil cover alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

The construction of a **geosynthetic cap** over each of the drilling mud pits would create a highly impermeable barrier ($\leq 1 \times 10^{-9}$ cm/sec) between the drilling mud and the surface. The cap would be constructed to allow surface water to runoff without ponding on the drilling mud pit. After placement of the geosynthetic cap, a soil layer would be placed and blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit, while minimizing the potential for erosion. The matrix of the drilling mud itself (bentonite) would prevent seepage of COCs from the drilling mud pit; therefore, the geosynthetic cap alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

Clean closure by consolidation of the drilling mud with another drilling mud pit was considered as a way to remove the source and eliminate exposure at this site. This alternative has been excluded as a viable option because of the distance that the excavated mud would have to be transported to be consolidated into another drilling mud pit. The next closest drilling mud pit is at the Long Shot site, which is over three miles away. Transporting the drilling mud over Rifle Range Road and Infantry Road would increase the potential for spills along the route as well as increase the duration of the construction schedule for site remediation.

Clean closure with off-island disposal through excavation and transportation of the drilling mud off the island for disposal in a permitted facility on the mainland was considered as a remedial alternative. Even though this alternative would be effective in removing the contamination from the island, execution would be difficult and extremely expensive to accomplish because of logistical considerations associated with this remote island. There would be a high risk of spilling the drilling mud at the drilling mud pit, while loading the containers at the drilling mud pit, while loading the barge at the dock, and at the port while offloading the barge. The highest potential for environmental damage would occur during the loading of the barge at the dock. The drilling mud would be viscous and difficult to control resulting in a likelihood for spillage. Even with good housekeeping practices, and careful loading, some drilling mud could be spilled into the Constantine Harbor. This alternative would also be logistically difficult to complete. Barge transport in the Bering Sea has a small window of safe travel. The loaded barges would need to depart Amchitka Island in August to arrive in Anchorage prior to the bad weather associated with the Aleutians during the latter months of the year. This method would also be cost prohibitive. A huge transportation cost would be incurred in transporting the drilling mud over 1,300 miles by barge to Anchorage, then by vehicle over the road to the disposal facility. The effectiveness of the method is not substantially greater than isolating the drilling mud from the environment while leaving it on site. Due to the potential for environmental damage, logistical complexity, as well as high cost, this alternative has been eliminated as a potential remediation method.

Table 4-2 provides an assessment of the above remedial action alternatives based on the NCP Criteria.

Alternative 4 - Geosynthetic Cap is the proposed approach for this site. It will isolate the drilling mud from the environment, provide adequate protection to potential receptors, and can be accomplished within the allotted construction season without substantial impact to the surrounding environment.

4.2.2 Long Shot Mud Pits

There are two drilling mud pits associated with the drilling activities at the Long Shot site located on the drilling pad approximately 100 ft north of surface ground zero. Each drilling mud pit is approximately 150 by 150 ft and contains approximately 2,740 yd^3 of drilling mud ranging from 2 to 7 ft in thickness. There is approximately 1.5 ft of standing water in each of the drilling mud pits. Water samples from the mud pits taken in 1997 had tritium concentrations of 2,000 picocuries/liter. For comparison, the federal drinking water standards allow tritium in concentrations up to 20,000 picocuries/liter.

Based on the 1998 characterization sampling, DRO within the drilling mud ranges from 296 ppm to 58,800 ppm. However, sampling that occurred in June 2000 shows that the shallow groundwater has not been impacted (Table 1-2). There is a small risk for ecological receptors in the immediate area of the drilling mud pit because the drilling mud is exposed to the environment. The following alternatives have been considered for the remediation of this site:

- No further action
- Institutional controls
- Soil cover
- Geosynthetic cap

The following paragraphs detail each of the alternatives considered.

No further action was considered but was determined to be unacceptable because of the significant volume of mud and the drilling mud pit's close proximity to Infantry Road allowing easy access to this site by personnel. Additionally, this site is located on the drilling pad used for the emplacement hole, making it easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Institutional controls in the form of fencing was considered but was also determined to be unacceptable because the standing water on the drilling mud pits is flowing into Rainbow Creek.

The construction of a **soil cover** was considered as an alternative to close these drilling mud pits. Although a soil cover would isolate the drilling mud from the environment, given the large quantity of the mud and the close proximity of the Rainbow Creek drainage (the standing water in the drilling mud pits actually helps form the headwaters of the stream), a more impervious cover would be necessary for the Long Shot mud pits to effectively reduce potential future impact to Rainbow Creek. Therefore, this alternative has been eliminated as a potential remediation method.

The construction of a **geosynthetic cap** over each of the drilling mud pits would create a highly impermeable barrier ($\leq 1 \times 10^{-9}$ cm/sec) between the drilling mud and the surface. The cap would be constructed to allow surface water to runoff without ponding on the drilling mud pit. After placement of the geosynthetic cap, a soil layer would be placed and blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit, while minimizing the potential for erosion. The matrix of the drilling mud itself (bentonite) would prevent seepage of COCs from the drilling mud pit; therefore, the geosynthetic cap alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

Table 4-3 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 4 - Geosynthetic cap is the proposed approach for the two drilling mud pits at Long Shot. The cap will isolate the drilling mud from the environment, provide adequate protection to potential receptors, and can be constructed within the allotted construction season without excessive impact to the surrounding environment.

4.2.3 Cannikin Mud Pits

There are three drilling mud pits associated with the drilling activities at the Cannikin site. One of the drilling mud pits is located just off of the drilling pad approximately 200 ft west of surface ground zero. The drilling mud pit at the drilling pad (Northwest Pit) is approximately 120 by 170 ft and contains approximately 3,000 yd^3 of drilling mud ranging from 4 to 6 ft in thickness. There is approximately 3 ft of standing water in the drilling mud pit. Two smaller exploratory hole mud pits (a northern drilling mud pit and a southern drilling mud pit) are located approximately 2,000 ft to the south of the drilling pad. The northern drilling mud pit is approximately 45 by 80 ft and contains approximately 135 yd^3 of drilling mud ranging from 1 to 2 ft in thickness. There is approximately 1 foot of standing water on the drilling mud pit. The southern drilling mud pit is approximately 60 by 85 ft and contains approximately 355 yd^3 of drilling mud ranging from 1 to 4 ft in thickness. This drilling mud pit also has approximately 1 foot of standing water.

Based on the 1998 characterization sampling, DRO within the drilling mud of the larger drilling mud pit ranges from 1,980 ppm to 14,000 ppm. The DRO within the drilling mud of the two smaller drilling mud pits range from 273 ppm to 7,940 ppm. There is a small risk for ecological receptors in the immediate area of the drilling mud pits due to the fact that the drilling mud is exposed to the environment. The following alternatives have been considered:

- No further action
- Soil cover
- Geosynthetic cap
- Clean closure by consolidation
- Clean closure with off-island disposal

The following paragraphs detail each of the alternatives considered.

4.2.3.1 Northwest Pit (Located at the Drilling Pad)

No further action was considered but was determined to be unacceptable because of the significant volume of mud and the drilling mud pit's close proximity to Infantry Road allowing easy access to this site by personnel. Additionally, this site is located on the drilling pad used for the emplacement hole, making it easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Placing a **soil cover** over the mud pit was considered as an alternative to eliminate exposure pathways at this site. This method would isolate the drilling mud from the environment and direct precipitation off of the cover by placing a layer of soil over the drilling mud. The soil cover would be blended into the surrounding topography in such a way to allow surface water to runoff of the soil cover minimizing infiltration into the underlying drilling mud. The soil cover would be seeded with native grass to minimizing potential erosion of the cover material. The matrix of the drilling mud itself (bentonite) would help prevent seepage of DRO from the drilling mud pit; therefore, the soil cover alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

The construction of a **geosynthetic cap** over the drilling mud pit would create a highly impermeable barrier ($\leq 1 \times 10^{-9}$ cm/sec) between the drilling mud and the surface. The cap would be constructed to allow surface water to runoff without ponding on the drilling mud pit. After placement of the geosynthetic cap, a soil layer would be placed and blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit while minimizing the potential for erosion. The matrix of the drilling mud itself (bentonite) would prevent seepage of DRO from the drilling mud pit; therefore, the geosynthetic cap alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants. Although viable, this alternative is significantly more costly than the soil cover.

Table 4-4 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 4 - Geosynthetic cap is the proposed approach for the Northwest Pit at this site. It will isolate the drilling mud from the environment, provide adequate protection to potential receptors, and can be accomplished within the allotted construction season without substantial impact to the surrounding environment.

4.2.3.2 Postshot Drill Back Hole Mud Pits (Northern Pit and Southern Pit)

No further action was considered but was determined to be unacceptable because of the significant volume of mud and the drilling mud pit's close proximity to Infantry Road allowing easy access to this site by personnel. Additionally, this site is located on the drilling pad used for the emplacement hole, making it easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Clean closure by consolidation was considered for the southernmost of the two smaller drilling mud pits based on their close proximity to each other. The quantity of mud in the southern drilling mud pit can easily be transported and consolidated into the northern drilling mud pit. After the drilling mud is removed from the Southern Pit, the *in situ* soils will be sampled and, if below cleanup levels, the area will be backfilled and revegetated.

Clean closure with off-island disposal through excavation and transportation of the drilling mud off the island for disposal in a permitted facility on the mainland was considered as a remedial alternative. Even though this alternative would be effective in removing the contamination from the island, execution would be difficult and extremely expensive to accomplish because of logistical considerations associated with this remote island. There would be a high risk of spilling the drilling mud at the drilling mud pit; while loading the trucks at the drilling mud pit, while loading the barge at the dock, and at the port while offloading the barge. The highest potential for environmental damage would occur during the loading of the barge at the dock. The drilling mud would be viscous and difficult to control resulting in a likelihood for spillage. Even with good housekeeping practices, and careful loading, some drilling mud could be spilled into the Constantine Harbor. This alternative would also be logistically difficult to complete. Barge transport in the Bering Sea has a small window of safe travel. The loaded barges would need to depart Amchitka prior to August in order to arrive in Anchorage prior to the bad weather associated with the latter months of the year. This method would also be cost prohibitive. A huge transportation cost would be incurred in transporting the drilling mud over 1,300 miles by barge to Anchorage, and then by vehicle over the road to the disposal facility. The effectiveness of the method is not substantially greater than isolating the drilling mud from the environment while leaving it on site. Due to the potential for environmental damage, logistical complexity, as well as high cost, this alternative has been eliminated as a potential remediation method.

Table 4-4 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 5 - Clean Closure by Consolidation is the proposed approach for the southern drilling mud pit at this site; the drilling mud will be consolidated into the northern drilling mud pit, which will then be covered with a **geosynthetic cap**.

4.2.4 Drill Site D Mud Pits

There are three drilling mud pits associated with the drilling activities at Drill Site D. One of the drilling mud pits (Northwest Mud Pit) located adjacent to and south of the emplacement hole pad is approximately 300 by 125 ft and contains approximately 7,820 yd^3 of drilling mud ranging from 6 to 7 ft in thickness. There is approximately 3 ft of standing water in this drilling mud pit. Located east of the Northwest Mud Pit is another drilling mud pit (Northeast Mud Pit) adjacent to the emplacement hole pad. This drilling mud pit, which is connected to the Northwest Mud Pit by culverts, is approximately 300 by 175 ft and contains approximately 4,870 yd^3 of drilling mud ranging from 1 to 5 ft in thickness. There is approximately 6 ft of standing water in this drilling mud pit. A third drilling mud pit (South Mud Pit) is located adjacent to and south of the first two. This drilling mud pit, which is connected to the Northwest Mud Pit by a trench, is approximately 500 by 130 ft and contains approximately 2,350 yd^3 of drilling mud ranging from 0 to 3 ft in thickness. This drilling mud pit is also connected to a nearby pond by a 5-foot deep trench on the east end of the drilling mud pit.

Based on the 1998 characterization sampling, DRO within the drilling mud ranges from 46 ppm to 2,400 ppm. However, groundwater sampling in June 2000 showed no impact to the shallow groundwater. There is a small risk for ecological receptors in the immediate area of the drilling mud pit because the drilling mud is exposed to the environment. The following alternatives have been considered for the remediation of this site:

- No further action
- Soil cover
- Geosynthetic cap

The following paragraphs detail each of the alternatives considered.

No further action was considered but was determined to be unacceptable because of the significant volume of mud and the drilling mud pits' close proximity to Infantry Road, allowing easy access to this site by personnel. Additionally, this site is located adjacent to the drilling pad used for the emplacement hole, making it easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Soil cover - Placing a soil cover over the Drill Site D mud pits was considered as an alternative to eliminate exposure pathways at this site. This method would isolate the drilling mud from the environment and direct precipitation off of the cover by placing a layer of soil over the drilling mud. The soil cover would be blended into the surrounding topography in such a way to allow surface water to run off of the soil cover, minimizing infiltration into the underlying drilling mud. The soil cover would be seeded with native grass to minimize potential erosion of the cover material. The matrix of the drilling mud itself (bentonite) would help prevent seepage of DRO from the drilling mud pit; therefore, the soil cover alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

The construction of a **geosynthetic cap** over the drilling mud pits would create a highly impermeable barrier ($\leq 1 \times 10^{-9}$ cm/sec) between the drilling mud and the surface. The cap would be constructed to allow surface water to run off without ponding on the drilling mud pit. After placement of the geosynthetic cap, a soil layer would be placed and blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit, while minimizing the potential for erosion. The matrix of the drilling mud itself (bentonite) would prevent seepage of DRO from the drilling mud pit; therefore, the geosynthetic cap alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants. Although viable, this alternative is significantly more costly than the soil cover.

Table 4-5 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 4 - Geosynthetic cap is the proposed approach for the drilling mud pits at this site. It will isolate the drilling mud from the environment, provide adequate protection to potential receptors, and can be accomplished within the allotted construction season without substantial impact to the surrounding environment.

4.2.5 Drill Site E

There are two drilling mud pits associated with the drilling activities at Drill Site E located 400 to 500 ft southwest (downhill) of the emplacement hole. The southern drilling mud pit is approximately 40 by 80 ft and contains approximately 415 yd^3 of drilling mud ranging from 1 to 8 ft in thickness. The northern drilling mud pit is approximately 20 by 40 ft and contains less than 4 yd^3 of drilling mud. However, no mud was found in the northern drilling mud pit during the June 2000 investigations. There is approximately 1 foot of standing water in each of the drilling mud pits.

Based on the 1998 characterization sampling, DRO within the drilling mud at the north drilling mud pit was 214 ppm. The DRO within the drilling mud at the south drilling mud pit was 10,600 ppm. However, sampling in June of 2000 showed DRO concentrations well below ADEC clean-up criterion impact to the shallow groundwater. There is a small risk for ecological receptors in the immediate area of the south drilling mud pit due to the fact that the drilling mud is exposed to the environment. The following alternatives have been considered for the remediation of this site:

- No further action
- Soil cover
- Geosynthetic cap
- Clean closure by consolidation

The following paragraphs detail each of the alternatives considered.

4.2.5.1 Northern Mud Pit

No further action was considered as a viable alternative for this drilling mud pit due to the small quantity of drilling mud, low level of contamination, and observed recovery of affected stream.

Clean closure by consolidation was considered for the northern drilling mud pit based on the close proximity to the larger southern drilling mud pit. As stated in the 1998 Characterization Report, the quantity of mud in this drilling mud pit is extremely small (< 4 yd^3) and concentration of DRO is very low (214 ppm). This pit was investigated during June 2000 and no drilling mud was found. Removal and consolidation of this drilling mud is not warranted because the quantity and COC concentrations indicate negligible potential for future impacts to the stream.

Table 4-6 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative - No Further Action is the proposed approach for the northern drilling mud pit at this site. The contamination is confined to a small area, COC concentrations are very low, no unacceptable human health or ecological risk is expected under present or future use scenarios, and evidence indicates that the affected stream has undergone significant recovery since mud releases that occurred three decades ago.

4.2.5.2 Southern Mud Pit

No further action was considered but was determined to be unacceptable because of the significant volume of mud and the drilling mud pit's close proximity to Infantry Road allowing easy access to this site by personnel. Additionally, this site is easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Placing a **soil cover** over the southern drilling mud pit was considered as an alternative to eliminate exposure pathways at this site. This method would isolate the drilling mud from the environment and direct precipitation off of the cover by placing a layer of soil over the drilling mud. The soil cover would be blended into the surrounding topography in such a way to allow surface water to run off of the soil cover, minimizing infiltration into the underlying drilling mud. The soil cover would be seeded with native grass to minimizing potential erosion of the cover material. The matrix of the drilling mud itself (bentonite) would help prevent seepage of DRO from the drilling mud pit; therefore, the soil cover alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

The construction of a **geosynthetic cap** over the drilling mud pit would create a highly impermeable barrier ($\leq 1 \times 10^{9}$ cm/sec) between the drilling mud and the surface. The cap would be constructed to allow surface water to run off without ponding on the drilling mud pit. After placement of the geosynthetic cap, a soil layer would be placed and blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit, while minimizing the potential for erosion. The matrix of the drilling mud itself (bentonite) would prevent seepage of DRO from the drilling mud pit; therefore, the geosynthetic cap alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants. Although viable, this alternative is significantly more costly than the soil cover.

Table 4-6 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 4 - Geosynthetic cap is the proposed approach for the southern drill drilling mud pit at this site. It will isolate the drilling mud from the environment, provide adequate protection to potential receptors, and can be accomplished within the allotted construction season without substantial impact to the surrounding environment.

4.2.6 Drill Site F

Drill site F contains one drilling mud pit that has been partially backfilled, leaving two segments that contain drilling mud and water. The larger portion on the west end of the original drilling mud pit is approximately 200 by 25 ft and contains approximately 300 yd^3 of drilling mud ranging from 1 to 6 ft in thickness. The smaller portion on the east end is approximately 20 by 10 ft and contains approximately 10 yd^3 of drilling mud approximately 1-foot thick. There is approximately 1 foot of standing water in both sections of the drilling mud pit.

Based on the 1998 characterization sampling, DRO within the drilling mud at this site ranged from 975 ppm to 12,800 ppm. There is a slight risk to ecological receptors in the immediate area due to the fact that the drilling mud is exposed to the environment. The following alternatives have been considered for the remediation of this site:

- No further action
- Soil cover
- Geosynthetic cap
- Clean closure by consolidation

The following paragraphs detail each of the alternatives considered.

No further action was considered but was determined to be unacceptable because of the significant volume of mud and the drilling mud pit's close proximity to Infantry Road allowing easy access to this site by personnel. Additionally, this site is easily accessible for remedial action with minimal collateral damage to the surrounding tundra.

Placing a **soil cover** over the Drill Site F drilling mud pit was considered as an alternative to eliminate exposure pathways at this site. This method would isolate the drilling mud from the environment and direct precipitation off of the cover by placing a layer of soil over the drilling mud. The soil cover would be blended into the surrounding topography in such a way to allow surface water to run off of the soil cover, minimizing infiltration into the underlying drilling mud. The soil cover would be seeded with native grass to minimize potential erosion of the cover material. The matrix of the drilling mud itself (bentonite) would help prevent seepage of DRO from the drilling mud pit; therefore, the soil cover alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants.

The construction of a **geosynthetic cap** over the drilling mud pit would create a highly impermeable barrier ($\leq 1 \times 10^{-9}$ cm/sec) between the drilling mud and the surface. The cap would be constructed to allow surface water to run off without ponding on the drilling mud pit. After placement of the geosynthetic cap, a soil layer would be placed and blended into surrounding topography in such a way to allow surface water runoff to travel off of the drilling mud pit, while minimizing the potential for erosion. The matrix of the drilling mud itself (bentonite) would prevent seepage of DRO from the drilling mud pit; therefore, the geosynthetic cap alternative would effectively isolate the contamination from the environment and prevent migration of the contaminants. Although viable, this alternative is significantly more costly than the soil cover.

Clean closure by consolidation was considered for the eastern portion of the drilling mud pit at this site. By excavating and moving the small quantity of drilling mud (approximately 10 yd^3) from the east end of the drilling mud pit to the larger western portion, the size of soil cover required would be reduced, as would the area to be inspected and maintained.

Table 4-7 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 4 - Geosynthetic cap is the proposed approach for the drilling mud pit at this site.

4.2.7 Surface Water

Surface waters were investigated at eight streams and four lakes in the vicinity of the drilling mud pits. The affected bodies of water were:

Streams

White Alice Creek	Unnamed stream at Drill Site E
Bridge Creek	Limpet Creek
Cloudberry Creek	Clevenger Creek
Rainbow Creek	Falls Creek

Lakes

Cannikin Lake	Heart Lake
Reed Pond	Lake at Drill Site D

Several streams were impacted by releases of large volumes of drilling mud in the 1960s and 1970s. The chemical analyses of stream water and sediment performed in 1998 detected no elevated COCs in surface waters, and only a few locations where sediment concentrations of a small number of COCs exceeded background levels. A TRIAD analysis, which incorporates sediment chemistry, sediment toxicity and benthic macroinvertibrate community analysis, was performed on the eight streams draining the sites where drilling occurred. The TRIAD analysis determined that, in most instances, the drill site and test site streams had sediment quality comparable to unimpacted reference locations. Only a few locations on Rainbow Creek, which drains the Long Shot site, and White Alice Creek, which drains the Cannikin site, showed residual effects from past releases of drilling muds.

Dolly Varden Trout were found to be abundant in the potentially impacted streams. Chemical analysis of the tissue of fish collected in affected streams showed little evidence of elevated COC concentrations, with the exception at several locations where PCB Arochlor 1260 was above risk-based benchmarks.

Reed Pond shows no visible evidence of mud releases and only slight chemical impacts. There were minor residual affects from mud releases shown in the sampling results of the lake at Drill Site E and Heart Lake. Drilling mud was encountered in a small portion of Cannikin Lake.

A report recently released by the USACE and USFWS (Crayton, 2000) provides further evidence that COCs remaining in streams and ponds associated with DOE drill sites are having no significant impact on Amchitka's biota. This study examined tissue burdens of numerous organic and inorganic COCs, including PCBs, PAHs, and chromium, in nine species of vertebrates representing three trophic levels. PCBs and DDE were judged to be the most significant COCs in Amchitka Island fauna, but the concentrations found were generally well below those known to be associated with adverse effects at the individual or population level. In addition, the highest concentrations of PCBs were found in marine birds, indicating that marine sources of contamination are potentially more significant than upland sources such as the Drill Sites. Following remediation of the drilling mud pits, natural attenuation and covering of contaminated sediments by clean material will continuously reduce and will eventually eliminate contaminant exposure in areas that may be approved for no further action.

The following alternatives have been considered for the remediation of this site:

- No further action
- Clean closure by consolidation

No further action was considered as a viable alternative for the affected streams and lakes due to the small quantity of drilling mud encountered, low level of contamination, observed recovery of affected streams, and removal/interception of the source of contamination.

Clean closure by consolidation with other nearby drilling mud pits was also considered. This alternative was rejected due to the ecological damage that would be caused by the remediation and the potential to accelerate the migration of contamination during the excavation process.

Table 4-8 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 1 - No Further Action is the proposed approach for the streams and lakes. By removing the drilling mud or capping the drilling mud pits, the source of contamination will be removed or isolated, thereby preventing future contamination of the streams and lakes. Chemical analyses have demonstrated that significant recovery has already occurred in these surface waters and biodegradation is expected to continue. Residual contamination is not expected to pose any significant risk to human health or the environment. To verify this, DOE is planning to complete a regional risk assessment on the surface waters that were impacted by historical drilling mud species.

4.2.8 Hot Mix Plant

The hot mix plant consists of two underground rail tank cars containing liquid asphalt. The buried asphalt presents a chemical hazard if the tanks are leaking. It also presents a physical hazard in that the tank could collapse under the weight of a person or vehicle traveling over the rail tank car.

The following alternatives have been considered for the remediation of this site:

- No further action
- Institutional controls
- Clean closure with off-island disposal
- Close in place

No further action was considered, but was determined unacceptable because of the potential groundwater contamination if the tanks are leading or for personal injury or entrapment of wildlife in the event of a collapse of the tank.

Institutional controls in the form of fencing was considered, but was rejected because of the potential for groundwater contamination.

Clean closure with off-island disposal was considered as an alternative for remedial action at this site. This would involve removal of the liquid and placing it in drums for transport to a disposal facility on the mainland.

Closure in place was considered for a viable option to remediate the site. After the liquid is pumped from the tanks. the tank will be filled with native soils to prevent the collapse of the tank by surface traffic (either pedestrian or vehicle) and possible engulfment of personnel.

Table 4-9 provides an assessment of the above remedial action alternatives based on the NCP criteria.

Alternative 7 - Removal of Tank Contents and Closure in Place is the proposed approach. This method will remove the contaminant source and stabilize the tank against potential collapse.

4.3 Cost Comparison

DOE has developed three alternatives and cost estimates to close the mud pits at the six DOE drill sites on Amchitka Island. For comparison purposes, each alternative is listed below along with the components that make up the cost estimate. The three alternatives are soil cover, geosynthetic cap, and clean closure with off-island disposal. The estimates do not include any construction oversight or quality control testing that may be required.

4.3.1 Soil Cover

The cost estimate to close the mud pits using the soil cover alternative has the following assumptions:

- Barge support from Anchorage
- Base camp support for 50 personnel
- On island duration of 120 days
- Davis Bacon wages for operators and laborers
- Sixteen pieces of heavy equipment
- Five articulated dump trucks
- One soil processing plant
- All soils to be used for covers are available on the island
- Cost includes a 25% contingency

The estimated cost to construct a soil cover on all mud pits is approximately $6,916,000.

4.3.2 Geosynthetic Cap

The cost estimate to close the mud pits with a geosynthetic cap has the following assumptions:

- Barge support from Anchorage

- Base camp support for 50 personnel
- On-island duration of 120 days
- Davis Bacon wages for operators and laborers
- Sixteen pieces of heavy equipment
- Five articulated dump trucks
- One soil processing plant
- Installed price of liner is approximately $1.00/square foot (vendor quote)
- Quantity of liner is approximately 475,000 square feet
- Cost of the soil saved by capping with geosynthetics is negligible
- Cost includes a 25% contingency

The estimated cost to construct a geosynthetic cap on all mud pits is approximately $7,510,000.

4.3.3 Clean Closure with Off-Island Disposal

The cost estimate to close the mud pits by removing the drilling muds from the island and transporting the muds for disposal at a permitted commercial facility in the lower 48 has the following assumptions:

- Barge support from Anchorage for equipment and personnel
- Base camp support for 80 personnel
- On-island duration of 140 days
- Davis Bacon wages for operators and laborers
- Eighteen pieces of heavy equipment
- Five articulated dump trucks
- Ten truck chassis to transport roll-off containers on the island
- One soil processing plant
- Barge support from Seattle for roll-off containers and Portland Cement
- A 10 percent mixture of Portland Cement is necessary to bind free liquids
- Total yardage of drilling mud is approximately 27,000 yd^3
- Unit weight of drilling mud/cement mixture is 1.8 $tons/yd^3$
- Final waste disposal is within 100 miles of the Port of Seattle
- Cost includes a 25% contingency

The estimated cost of clean closure and off-island disposal is approximately $24,055,000.

Table 4-1
Summary of Alternatives

Site Description	Alternative 1 No Further Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure (Off-Island Disposal)	Alternative 7 Close in Place
Milrow (Rifle Range Road)	O	O	O	X	O	O	
Long Shot - West Mud Pit	O	O	O	X			
Long Shot - East Mud Pit	O	O	O	X			
Cannikin - Northwest Mud Pit	O		O	X			
Cannikin - South Mud Pit	O				X	O	
Cannikin - North Mud Pit	O			X	O		
Drill Site D - Northwest Mud Pit	O		O	X			
Drill Site D - Northeast Mud Pit	O		O	X			
Drill Site D - South Mud Pit	O		O	X			
Drill Site E - North Mud Pit	X			O	O		
Drill Site E - South Mud Pit	O		O	X			
Drill Site F Mud Pit	O		O	X	O		
Streams and Lakes	X				O		
Hot Mix Plant[1]	O	O				X	X

O = Alternative considered
X = Proposed Alternative

[1]A combination of Alternatives 6 and 7 are proposed for the Hot Mix Plant.

Table 4-2
Assessment of Remedial Action Alternatives for Rifle Range Road Mud Pit (Milrow Site)
(Page 1 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Limit access by installation of a physical barrier around the site. • Contaminant reduction through natural attenuation. • Long-term monitoring.	• Isolates the contaminants from the environment by placing a soil layer over the drilling mud pits. • Reduces future migration by diverting surface water from the drilling mud pit. • Contaminant reduction through natural attenuation. • Periodic inspection and maintenance.	• Isolates the contaminants from the environment by installation of a geosynthetic barrier. • Cap includes a flexible membrane liner to prevent surface water infiltration into the contaminated drilling mud. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Excavation of the contaminated material • Transportation of excavated material to another site for incorporation into a geosynthetic cap or soil cover • Backfilling site with native soils.	• Excavation of the contaminated material • Mix contaminated material with on-site soil or imported reagent to eliminate free liquids. • Transport material to Anchorage or Seattle via chartered barge. • Transport material to a permitted disposal facility via a commercial transporter.
Overall Protection of Human Health and the Environment	• Does not provide adequate protection because of the significant volume of drilling mud. • Close proximity of drilling mud pit to Rifle Range Road allows easy access by personnel.	• Does not provide adequate protection because of the significant volume of drilling mud. • Controls in the form of fencing would not prevent access by birds and water fowl.	• Minimal risk because the soil cover isolates contaminants from the environment. • Provides protection to potential receptors until contaminants naturally attenuate.	• Minimal risk because the geosynthetic cap provides a highly impermeable barrier between the contaminants and the environment.	• Removing the contaminated material removes the risk to human health and the environment. • Moderate risk to the remediation workers during the transportation of contaminated material.	• Removing the contaminated material removes the risk to human health and the environment. • High risk to the public and environment during the transportation of contaminated material.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Minimal remediation worker exposure during installation of physical barriers.	• Moderate remediation worker occupational risk during excavation, transportation, and placement of soil cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during construction of geosynthetic cap. • Moderate remediation worker chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during excavation, transportation, and consolidation of contaminated materials. • Moderate remediation workers chemical risk from exposure to site contaminants.	• High remediation worker occupational risk during excavation, transportation, and disposal of contaminated materials. • High remediation workers chemical risk from exposure to site contaminants.

Table 4-2
Assessment of Remedial Action Alternatives for Rifle Range Road Mud Pit (Milrow Site)
(Page 2 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Immediately complies with ARARs by removing the contaminated material from the site.	• Immediately complies with ARARs by removing the contaminated material from the site.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent only after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented. • Available cover soils are highly permeable, some surface water intrusion to contaminants expected.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after implemented.	• Alternative effective and permanent after implemented.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Reduces contaminant mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented. • Available cover soils are highly permeable, some surface water intrusion to contaminants expected.	• Contaminant migration is essentially eliminated. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminants are removed from the site	• Contaminants are removed from the site
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective because contaminants are removed from the site.	• Alternative effective because contaminants are removed from the site.

Table 4-2
Assessment of Remedial Action Alternatives for Rifle Range Road Mud Pit (Milrow Site)
(Page 3 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Periodic monitoring and maintenance required.	• Alternative easy to implement other than logistical challenges • Implementation requires mobilization of extensive equipment. • Periodic inspection and maintenance required.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment and materials. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative difficult to implement due to logistical challenges and distance to nearest drilling mud pit (over 3 miles). • Implementation requires mobilization of extensive equipment • Periodic monitoring and maintenance will not be required.	• Alternative difficult to implement due to large quantity of material to process and transport. • Logistical challenges due to remote location • On-Island transportation distances up to 20 miles on poorly maintained roads. • Requires barging large quantities of contaminated material.
Cost	• No cost associated with this alternative	• Cost will be minimal to implement. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Cost to implement is approximately $6,916,000[1] • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Moderate cost to implement ($7,510,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Would give slight cost savings over Alternative 4. • Periodic monitoring and maintenance costs will not be required.	• Extensive costs to implement ($24,055,000)[1] due to the large volume of material requiring transport via chartered barge service followed by commercial transport and disposal at a permitted disposal facility.
Stakeholder Acceptance	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance likely because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance unlikely because of high implementation cost and environmental risk during the transportation of contaminated material	• Stakeholder acceptance is unlikely because of high implementation cost and public risk during transportation of contaminated material, with minimal benefits.
Community Acceptance	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance is likely because of the moderate implementation cost, with significant benefit.	• Community acceptance is likely because of the moderate implementation cost, with significant benefit	• Community acceptance is likely because the material is removed from the site.	• Community acceptance is unlikely because of high implementation cost and public risk during the transportation of contaminated material.

Table 4-2
Assessment of Remedial Action Alternatives for Rifle Range Road Mud Pit (Milrow Site)
(Page 4 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Control of the Source Release	• Does not control the source of contamination	• Does not control the source of contamination.	• Controls the source of contamination.	• Containment through stabilization will essentially eliminate migration of contaminants from the source.	• The source of contamination is removed.	• The source of contamination is removed.

[1]Costs shown represent total cost if all mud pits are closed by this method.

Table 4-3
Assessment of Remedial Action Alternatives for Long Shot Mud Pits
(Page 1 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Limit access by installation of a physical barrier around the site. • Contaminant reduction through natural attenuation. • Long-term monitoring.	• Isolates the contaminants from the environment by placing a soil layer over the drilling mud pits. • Reduces future migration by diverting surface water from the drilling mud pit. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Isolates the contaminants from the environment by installation of a geosynthetic barrier. • Cap includes a flexible membrane liner to prevent surface water infiltration into the contaminated drilling mud. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.
Overall Protection of Human Health and the Environment	• Does not provide adequate protection because of the significant volume of drilling mud. • Close proximity of drilling mud pits to Infantry Road allows easy access by personnel.	• Does not provide adequate protection because of the significant volume of drilling mud. • Controls in the form of fencing would not prevent access by birds.	• Moderate risk because, although the soil cover isolates contaminants from the environment, the close proximity of Rainbow Creek necessitates a more impermeable cover. • On-site soils may not be suitable to prevent infiltration of surface waters.	• Minimal risk because the geosynthetic cap provides a highly impermeable barrier between the contaminants and the environment.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Minimal remediation worker exposure during installation of physical barriers.	• Moderate remediation worker occupational risk during excavation, transportation, and placement of soil cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during construction of geosynthetic cap. • Moderate remediation worker chemical risk from exposure to site contaminants.
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is reduced. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.

Table 4-3
Assessment of Remedial Action Alternatives for Long Shot Mud Pits
(Page 2 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Reduces contaminant mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant migration is essentially eliminated. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative somewhat effective by reducing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Periodic monitoring and maintenance required.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment and materials. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.
Cost	• No cost associated with this alternative.	• Cost will be minimal to implement. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Moderate cost to implement ($6,916,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs	• Moderate cost to implement ($7,510,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.

Table 4-3
Assessment of Remedial Action Alternatives for Long Shot Mud Pits
(Page 3 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap
Stakeholder Acceptance	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance unlikely because of the close proximity of Rainbow Creek.	• Stakeholder acceptance likely because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.
Community Acceptance	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance unlikely because of the close proximity of Rainbow Creek.	• Community acceptance is likely because of moderate implementation cost, with significant benefit.
Control of the Source Release	• Does not control the source of contamination.	• Does not control the source of contamination.	• Partially controls the source of contamination.	• Containment through stabilization will essentially eliminate migration of contaminants from the source.

[1]Costs shown represent total cost if all mud pits are closed by this method.

Table 4-4
Assessment of Remedial Action Alternatives for Cannikin Mud Pits
(Page 1 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Isolates the contaminants from the environment by placing a soil layer over the drilling mud pits. • Reduces future migration by diverting surface water from the drilling mud pit. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Isolates the contaminants from the environment by installation of a geosynthetic barrier. • Cap includes a flexible membrane liner to prevent surface water infiltration into the contaminated drilling mud. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Excavation of the contaminated material. • Transportation of excavated material to another site for incorporation into a geosynthetic cap or soil cover. • Backfilling site with native soils.	• Excavation of the contaminated material. • Mix contaminated material with on-site soil or imported reagent to eliminate free liquids. • Transport material to Anchorage or Seattle via chartered barge. • Transport material to a permitted disposal facility via a commercial transporter.
Overall Protection of Human Health and the Environment	• Does not provide adequate protection because of the significant *volume of drilling mud.* • Close proximity of drilling mud pit to Infantry Road allows easy access by personnel.	• Minimal risk because the soil cover isolates contaminants from the *environment.* • Soil cover is sloped to minimize surface water infiltration into contaminated media.	• Minimal risk because the geosynthetic cap provides a highly impermeable *barrier between the* contaminants and the environment.	• Removing the contaminated material removes the risk to *human health and the* environment. • Moderate risk to the remediation workers during the transportation of contaminated material.	• Removing the contaminated material removes the risk to human health and the environment. • High risk to the public and environment during the transportation of contaminated material.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Moderate remediation worker occupational risk during excavation, transportation, and placement of soil cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during construction of geosynthetic cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during excavation, transportation, and consolidation of contaminated materials. • Moderate remediation workers chemical risk from exposure to site contaminants.	• High remediation worker occupational risk during excavation, transportation, and disposal of contaminated materials. • High remediation workers chemical risk from exposure to site contaminants.

Table 4-4
Assessment of Remedial Action Alternatives for Cannikin Mud Pits
(Page 2 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Immediately complies with ARARs by removing the contaminated material from the site	• Immediately complies with ARARs by removing the contaminated material from the site.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after implemented.	• Alternative effective and permanent after implemented.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Greatly reduces contaminant mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant migration is essentially eliminated. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminants are removed from the site.	• Contaminants are removed from the site.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective because contaminants are removed from the site.	• Alternative effective because contaminants are removed from the site.

Table 4-4
Assessment of Remedial Action Alternatives for Cannikin Mud Pits
(Page 3 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment and materials. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative somewhat easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance will not be required.	• Alternative difficult to implement due to large quantity of material to process and transport. • Logistical challenges due to remote location. • On-island transportation distances up to 20 miles on poorly maintained roads. • Requires barging large quantities of contaminated material.
Cost	• No cost associated with this alternative.	• Moderate cost to implement ($6,300,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Moderate cost to implement ($7,510,000)[1]. • Periodic inspection and maintenance will be required.	• A small (<1%) cost savings can be realized by consolidating the South Exploratory Mud Pit into the North Exploratory Mud Pit because of the close proximity to each other. • Periodic inspection and maintenance costs will not be required.	• Extensive costs to implement ($24,055,000) due to the large volume of material requiring transport via chartered barge service followed by commercial transport and disposal at a permitted disposal facility.
Stakeholder Acceptance	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance likely for the larger NW drilling mud pit because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely for the larger Northwest drilling mud pit because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely for the two smaller drilling mud pits because they can be cost effectively combined with the Northwest drilling mud pit with minimal impact to ecologically sensitive areas	• Stakeholder acceptance is unlikely because of high implementation cost and public risk during transportation of contaminated material, with minimal benefits.

Table 4-4
Assessment of Remedial Action Alternatives for Cannikin Mud Pits
(Page 4 of 4)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation	Alternative 6 Clean Closure with Off-Island Disposal
Community Acceptance	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance is likely because of moderate implementation cost, with significant benefit.	• Community acceptance is likely because receptor pathways have been eliminated.	• Community acceptance likely for the two smaller drilling mud pits because they can be cost effectively combined with with minimal impact to ecologically sensitive areas.	• Community acceptance is unlikely because of high implementation cost and public risk during the transportation of contaminated material, with minimal benefits.
Control of the Source Release	• Does not control the source of contamination.	• Controls the source of contamination.	• Controls the source of contamination.	• The source of contamination is removed.	• The source of contamination is removed.

[1]Costs shown represent total cost if all mud pits are closed by this method.

Table 4-5
Assessment of Remedial Action Alternatives for Drill Site D Mud Pits
(Page 1 of 2)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Isolates the contaminants from the environment by placing a soil layer over the drilling mud pits. • Reduces future migration by diverting surface water from the drilling mud pit. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Isolates the contaminants from the environment by installation of a geosynthetic barrier. • Cap includes a flexible membrane liner to prevent surface water infiltration into the contaminated drilling mud. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.
Overall Protection of Human Health and the Environment	• Does not provide adequate protection because of the significant volume of drilling mud. • Close proximity of drilling mud pit to Infantry Road allows easy access by personnel.	• Minimal risk because the soil cover isolates contaminants from the environment. • Provides adequate protection to potential receptors until contaminants naturally attenuate.	• Minimal risk because the geosynthetic cap provides a highly impermeable barrier between the contaminants and the environment.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Moderate remediation worker occupational risk during excavation, transportation, and placement of soil cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during construction of geosynthetic cap. • Moderate remediation workers chemical risk from exposure to site contaminants.
Compliance with Applicable, Relevant and/or Appropriate Requirements	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Greatly reduces contaminant mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant migration is essentially eliminated. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.

Table 4-5
Assessment of Remedial Action Alternatives for Drill Site D Mud Pits
(Page 2 of 2)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment and materials. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.
Cost	• No cost associated with this alternative.	• Moderate cost to implement ($6,916,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Moderate cost to implement ($7,510,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.
Stakeholder Acceptance	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance likely because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.
Community Acceptance	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance is likely because of moderate implementation cost, with significant benefit.	• Community acceptance is unlikely because added cost for geosynthetic layer does not provide significant benefit above soil cap alone.
Control of the Source Release	• Does not control the source of contamination.	• Controls the source of contamination.	• Controls the source of contamination.

[1]Costs shown represent total cost if all mud pits are closed by this method.

Table 4-6
Assessment of Remedial Action Alternatives for Drill Site E Mud Pits
(Page 1 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Isolates the contaminants from the environment by placing a soil layer over the drilling mud pits. • Reduces future migration by diverting surface water from the drilling mud pit. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Isolates the contaminants from the environment by installation of a geosynthetic barrier. • Cap includes a flexible membrane liner to prevent surface water infiltration into the contaminated drilling mud. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Excavation of the contaminated material. • Transportation of excavated material to another site for incorporation into a geosynthetic cap or soil cover. • Backfilling site with native soils.
Overall Protection of Human Health and the Environment	• Minimal risk at the North drilling mud pit because contamination is confined to a small area. • Does not provide adequate protection at the South drilling mud pit because of the significant volume of contamination.	• Minimal risk because the soil cover isolates contaminants from the environment. • Soil cover is sloped to minimize surface water infiltration into contaminated media.	• Minimal risk because the geosynthetic cap provides a highly impermeable barrier between the contaminants and the environment	• Removing the contaminated material removes the risk to human health and the environment. • Moderate risk to the remediation workers during the transportation of contaminated material.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Moderate remediation worker occupational risk during excavation, transportation, and placement of soil cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during construction of geosynthetic cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during excavation, transportation, and consolidation of contaminated materials. • Moderate remediation workers chemical risk from exposure to site contaminants.
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Immediately complies with ARARs by removing the contaminated material from the site.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after implemented.

Table 4-6
Assessment of Remedial Action Alternatives for Drill Site E Mud Pits
(Page 2 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Greatly reduces contaminant mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant migration is essentially eliminated. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminants are removed from the site.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective because contaminants are removed from the site.
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment and materials. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative somewhat easy to implement other than logistical challenges. • May be difficult to locate small mud quantity.
Cost	• No cost associated with this alternative.	• Moderate cost to implement ($6,916,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Moderate cost to implement ($7,510,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Minimal cost • Manual excavation • Transport in front-end loader
Stakeholder Acceptance	• Stakeholder acceptance likely for the North drilling mud pit where contaminated material is less than 4 cubic yards. • Stakeholder acceptance unlikely for South drilling mud pit where significant contamination is present.	• Stakeholder acceptance likely for the larger South drilling mud pit because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely for the larger South drilling mud pit because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance unlikely for the North drilling mud pit because the material cannot be moved with minimal risk to ecologically sensitive areas.

Table 4-6
Assessment of Remedial Action Alternatives for Drill Site E Mud Pits
(Page 3 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation
Community Acceptance	• Community acceptance likely for the North drilling mud pit where contaminated material is less than 4 cubic yards. • Community acceptance unlikely for South drilling mud pit where significant contamination is present.	• Community acceptance is likely because of moderate implementation cost, with significant benefit.	• Community acceptance is likely because the geosynthetic layer isolates the contaminants from receptors.	• Community acceptance is unlikely because minimal benefits associated with removal of the small quantity of material from the North drilling mud pit do not warrant the implementation cost and risk during the transportation of the contaminated material.
Control of the Source Release	• Does not control the source of contamination.	• Controls the source of contamination.	• Controls the source of contamination.	• The source of contamination is removed.

[1]Costs shown represent total cost if all mud pits are closed by this method.

Table 4-7
Assessment of Remedial Action Alternatives for Drill Site F Mud Pit
(Page 1 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Isolates the contaminants from the environment by placing a soil layer over the drilling mud pits. • Reduces future migration by diverting surface water from the drilling mud pit. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Isolates the contaminants from the environment by installation of a geosynthetic barrier. • Cap includes a flexible membrane liner to prevent surface water infiltration into the contaminated drilling mud. • Contaminant reduction through natural attenuation. • Periodic monitoring and maintenance.	• Excavation of the contaminated material. • Transportation of excavated material to another site for incorporation into a geosynthetic cap or soil cover. • Backfilling site with native soils.
Overall Protection of Human Health and the Environment	• Does not provide adequate protection because of the significant volume of drilling mud. • Close proximity of drilling mud pit to Infantry Road allows easy access by personnel.	• Minimal risk because the soil cover isolates contaminants from the environment. • Soil cover is sloped to minimize surface water infiltration into contaminated media.	• Minimal risk because the geosynthetic cap provides a highly impermeable barrier between the contaminants and the environment.	• Removing the contaminated material removes the risk to human health and the environment. • Moderate risk to the remediation workers during the transportation of contaminated material.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Moderate remediation worker occupational risk during excavation, transportation, and placement of soil cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during construction of geosynthetic cap. • Moderate remediation workers chemical risk from exposure to site contaminants.	• Moderate remediation worker occupational risk during excavation, transportation, and consolidation of contaminated materials. • Moderate remediation workers chemical risk from exposure to site contaminants.
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant exposure and migration is essentially eliminated. • Contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Immediately complies with ARARs by removing the contaminated material from the site.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after implemented

Table 4-7
Assessment of Remedial Action Alternatives for Drill Site F Mud Pit
(Page 2 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Greatly reduces contaminant mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminant migration is essentially eliminated. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminants are removed from the site.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective by preventing contaminant migration until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective because contaminants are removed from the site.
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment and materials. • Periodic monitoring and maintenance required. • Difficult to maintain due to the isolated location.	• Alternative somewhat easy to implement other than logistical challenges. • Implementation requires mobilization of extensive equipment. • Periodic monitoring and maintenance will not be required.
Cost	• No cost associated with this alternative.	• Moderate cost to implement ($6,916,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Moderate cost to implement ($7,510,000)[1]. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• No cost savings vs. Alternative 3 or 4
Stakeholder Acceptance	• Stakeholder acceptance unlikely due to significant volume of drilling mud.	• Stakeholder acceptance likely for the larger western portion of the drilling mud pit because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely for the larger western portion of the drilling mud pit because significant volume of mud is contained. • Site can be remediated with minimal impact to ecologically sensitive areas.	• Stakeholder acceptance likely for the smaller eastern end of the drilling mud pit because it can be cost effectively combined with the western end of the drilling mud pit with minimal impact to ecologically sensitive areas.

Table 4-7
Assessment of Remedial Action Alternatives for Drill Site F Mud Pit
(Page 3 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 3 Soil Cover	Alternative 4 Geosynthetic Cap	Alternative 5 Clean Closure by Consolidation
Community Acceptance	• Community acceptance unlikely due to significant volume of drilling mud.	• Community acceptance is likely because of moderate implementation cost, with significant benefit.	• Community acceptance is likely because contaminant pathways to receptors have been eliminated.	• Community acceptance likely for the smaller eastern end of the drilling mud pit because it can be cost effectively combined with the western end of the drilling mud pit with minimal impact to ecologically sensitive areas.
Control of the Source Release	• Does not control the source of contamination.	• Controls the source of contamination.	• Controls the source of contamination.	• The source of contamination is removed.

[1]Costs shown represent total costs if all mud pits are closed by this method.

Table 4-8
Assessment of Remedial Action Alternatives for Surface Water (Streams and Lakes)
(Page 1 of 2)

Assessment Factors	Alternative 1 No Action	Alternative 5 Clean Closure by Consolidation
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative. • Contaminant reduction through natural attenuation.	• Excavation of the contaminated material. • Transportation of excavated material to another site for incorporation into a geosynthetic cap or soil cover.
Overall Protection of *Human Health and the* Environment	• Minimal risk because contamination is confined to a few small areas and *level of contamination is low.* • Minimizes risk in areas where remedial action would cause extensive damage to sensitive ecological areas. • Regional risk assessment will be done to verify that there is no unacceptable risk associated with leaving the mud in place.	• Removing the contaminated material removes the risk to human health and the environment. • High risk to the environment during the removal activity. • Moderate risk to remediation workers during the transportation of contaminated material.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Moderate remediation worker occupational risk during excavation, transportation, and consolidation of contaminated materials. • Moderate remediation workers chemical risk from exposure to site contaminants.
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not prevented. • Regional risk assessment will be done to verify that there is no unacceptable risk associated with leaving the mud in place.	• Immediately complies with ARARs by removing the contaminated material from the site.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after implemented.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Residual contamination is not expected to pose any significant risk to *human health or the environment.* • Inadvertent intrusion is not prevented.	• Contaminants are removed from the site.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective because contaminants are removed from the site; however, removal process may accelerate release of contamination resulting in short-term environmental impact.
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative difficult to implement due to logistical challenges and because the material to be removed is below the water surface. • Implementation requires mobilization of extensive equipment.
Cost	• No cost associated with this alternative.	• Cost to implement will be significant due to remote location. • Periodic monitoring and maintenance costs will not be required.

Table 4-8
Assessment of Remedial Action Alternatives for Surface Water (Streams and Lakes)
(Page 2 of 2)

Assessment Factors	Alternative 1 No Action	Alternative 5 Clean Closure by Consolidation
Stakeholder Acceptance	• Stakeholder acceptance is likely because residual contamination is limited to a few small areas at low concentrations. • No significant risk to human health or the environment is anticipated. • Significant recovery has already occurred and biodegradation is expected to continue. • Remedial activity would likely do more ecological damage and would potentially accelerate spread of contamination through disturbance of the streams.	• Stakeholder acceptance unlikely due to the impact to ecologically sensitive areas and the potential for accelerating the spread of contamination.
Community Acceptance	• Community acceptance is likely because residual contamination is limited to a few small areas at low concentrations. • No significant risk to human health or the environment is anticipated. • Significant recovery has already occurred and biodegradation is expected to continue. • Remedial activity would likely do more ecological damage and would potentially accelerate spread of contamination through disturbance of the streams.	• Community acceptance unlikely due to the impact to ecologically sensitive areas and the potential for accelerating the spread of contamination. • Additionally, significant expenditure of funds would result in little or no benefit.
Control of the Source Release	• Primary source of contamination is isolated due to natural sediment deposition over the drilling mud still in the streams.	• The source of contamination is removed.

Table 4-9
Assessment of Remedial Action Alternatives for the Hot Mix Plant
(Page 1 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 6 Clean Closure with Off-Island Disposal	Alternative 7 Close in Place (Hot Mix Plant
Key Components	• Regulatory requirements mandate the evaluation of the no action alternative.	• Limit access to buried rail tank cars by installation of a physical barrier around the site. Long-term monitoring.	• Removal of the asphaltic liquid. • Transport material to Anchorage or Seattle via chartered barge. • Transport material to a permitted disposal facility via a commercial transporter.	• Filling an underground rail tank car with native soils to prevent potential future collapse of the tank.
Overall Protection of Human Health and the Environment	• Does not provide adequate protection to human health because of the potential for *collapse of the buried tank*.	• Does not provide adequate protection to groundwater if the tank is leaking.	• Removing the contaminated material removes the risk to human health and the environment. • High risk to the public and environment during the transportation of contaminated material.	• Filling the rail tank car eliminates the risk of future collapse of the tank.
Remediation Worker Protection	• No worker exposure associated with implementation.	• Minimal remediation worker exposure during installation of physical barriers.	• High remediation worker occupational risk during removal, transportation, and disposal of contaminated materials. • High remediation workers chemical risk from exposure to site contaminants.	• Minimal remediation worker exposure during soil placement.
Compliance with Applicable, Relevant and/or Appropriate Requirements (ARARs)	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is not *prevented*.	• Does not comply because contaminants remain above regulatory limits until they naturally attenuate. • Inadvertent intrusion is prevented.	• Immediately complies with ARARs by removing the contaminated material from the site.	• Collapse of tank (physical hazard) is prevented.
Long-Term Effectiveness and Permanence	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative effective and permanent after contaminants naturally attenuate below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective and permanent after implemented.	• Inadvertent intrusion is prevented.

Table 4-9
Assessment of Remedial Action Alternatives for the Hot Mix Plant
(Page 2 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 6 Clean Closure with Off-Island Disposal	Alternative 7 Close In Place (Hot Mix Plant
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is not prevented.	• Does not reduce contaminant toxicity or mobility. • Contaminants remain toxic until they naturally attenuate. • Inadvertent intrusion is prevented.	• Contaminants are removed from the site.	• Does not reduce contaminant toxicity.
Short-Term Effectiveness	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is not prevented.	• Alternative not effective until contaminants naturally attenuate to below regulatory limit. • Inadvertent intrusion is prevented.	• Alternative effective because contaminants are removed from the site.	• Alternative effective by eliminating physical hazard. • Alternative does not eliminate chemical hazard.
Implementability	• Alternative easy to implement and easy to maintain.	• Alternative easy to implement other than logistical challenges. • Periodic monitoring and maintenance required.	• Alternative difficult to implement due to large quantity of material to process and transport. • Logistical challenges due to remote location. • On-island transportation distances up to 20 miles on poorly maintained roads. • Requires barging large quantities of contaminated material.	• Alternative easy to implement other than logistical challenges.
Cost	• No cost associated with this alternative.	• Cost will be minimal to implement. • Periodic monitoring and maintenance will be performed in conjunction with other on-island activities to minimize costs.	• Costs for transport to the mainland, followed by commercial transport and disposal at a permitted disposal facility ($125,000).	• After liquid is removed, costs are minimal to fill in with native soils.
Stakeholder Acceptance	• Stakeholder acceptance unlikely because of the potential for personal injury.	• Stakeholder acceptance unlikely because of the potential for personal injury.	• Stakeholder acceptance is likely because the contaminated material is removed.	• Stakeholder acceptance likely because the moderate implementation cost provides significant protection.
Community Acceptance	• Community acceptance unlikely because of the potential for personal injury.	• Community acceptance unlikely because of the potential for personal injury.	• Community acceptance likely because the contaminated material is removed.	• Community acceptance likely because the moderate implementation cost provides significant protection.

Table 4-9
Assessment of Remedial Action Alternatives for the Hot Mix Plant
(Page 3 of 3)

Assessment Factors	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 6 Clean Closure with Off-Island Disposal	Alternative 7 Close in Place (Hot Mix Plant
Control of the Source Release	• Does not control the source of contamination.	• Does not control the source of contamination.	• The source of contamination is removed.	• The source of contamination is contained.

5.0 Proposed Remedial Actions

Based on the evaluations performed in this plan, the remedial actions proposed for each site are summarized in Table 5-1.

Table 5-1
Proposed Remedial Actions

Site	Proposed Remedial Action
Long Shot	Geosynthetic Caps
Rifle Range Road (Milrow)	Geosynthetic Cap
Drill Site D	Geosynthetic Caps
Drill Site E Northern Pit Southern Pit	 No Further Action Geosynthetic Cap
Drill Site F	Geosynthetic Cap
Cannikin Northwest Pit (at SGZ) North Postshot Drill Back South Postshot Drill Back	 Geosynthetic Cap Geosynthetic Cap Clean Close - Consolidate into North Postshot Drill Back Pit
Hot Mix Plant	Remove tank contents for offsite disposal, close tank in place
Surface Water Drainages	No Further Action[1]

[1]Pending regional risk assessment results

6.0 References

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