RECORD OF DECISION
for
OPERABLE UNIT C
FORT RICHARDSON
ANCHORAGE, ALASKA

September 1998

Contract No. DAC85-95-D-0015
Delivery Order 0012

Department of the Army
U.S. Army Engineer District, Alaska

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September 1998

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DECLARATION STATEMENT
for
RECORD OF DECISION
FORT RICHARDSON
ANCHORAGE, ALASKA
OPERABLE UNIT C
___________ 1998

SOURCE AREA NAME AND LOCATION

Operable Unit C
Fort Richardson
Anchorage, Alaska

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedial actions for Operable Unit C (OU-C). OU-C consists of two source areas: the Eagle River Flats (ERF) and the former Open Burning / Open Detonation (OB / OD) Pad. This ROD was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986; 42 *United States Code* 9601 *et seq.*, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 *Code of Federal Regulations* 300 *et seq*. This decision is based on the Administrative Record for OU-C.

The United States Army (Army), the United States Environmental Protection Agency (EPA), and the State of Alaska, through the Alaska Department of Environmental Conservation (ADEC), have agreed to the selected remedies.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances resulting from white phosphorus contamination of the ERF source area of OU-C, if not addressed by implementing the response actions selected in this ROD, may present an imminent or substantial threat to public health, public welfare, or the environment. ERF is contaminated with white phosphorus particles.

DESCRIPTION OF THE SELECTED REMEDY

OU-C is the third OU to reach the final-action ROD at the Fort Richardson National Priorities List site. This ROD addresses sediment contamination at the ERF source area of OU-C.

No further action is selected for the former OB / OD Pad for hazardous chemicals. Because of concerns about potential human exposure to unexploded ordnance, the Army has institutional controls that provide monitoring and control of access to the site. These controls are required to remain in place. No analysis of remedial alternatives was conducted for the OB / OD Pad source area. A discussion of the OB / OD Pad is provided in Section 9 of this ROD.

The remedial action objectives (RAOs) for the ERF are designed to accomplish the following:

- Within 5 years of the ROD being signed, reduce the dabbling duck mortality rate attributable to white phosphorus to 50 percent of the 1996 mortality rate attributable to white phosphorus. Radio tracking and aerial surveys suggest that about 1,000 birds died from white phosphorus at ERF in 1996. Therefore, the allowable number of duck deaths from white phosphorus would be approximately 500.
- Within 20 years of the ROD being signed, reduce the mortality attributable to white phosphorus to no more than 1 percent of the total annual fall population of dabbling ERF ducks. Currently, that population is about 5,000. Therefore, the allowable number of duck deaths from white phosphorus would be approximately 50. This long-term goal could be adjusted based on future population studies conducted during the monitoring program.

These objectives will be achieved by reducing the area of white phosphorus-contaminated media and reducing the exposure to white phosphorus. Reducing the exposure will reduce the availability of white phosphorus to ducks, which in turn will reduce duck deaths.

Monitoring at ERF will be conducted to verify that RAOs are achieved. The following are goals of monitoring:

- To verify that an exposure pathway does not exist between waterfowl and white phosphorus-contaminated sediment
- To determine the number of waterfowl using ERF
- To determine the number of waterfowl dying as a result of feeding in white phosphorus-contaminated sediment
- To determine whether remedial action is effective or needs modification

The major components of the preferred remedy for OU-C are listed below. It is assumed that implementation of the remedy will begin in 1999 and end in 2018 (duration of 20 years). Treatment will occur between 1999 and 2003, and will be followed by long-term monitoring from 2004 to 2018. The sequence and schedule of operation and maintenance activities are presented in Tables 1 and 2, respectively.

- Treat white phosphorus-contaminated sediment by draining ponds with pumps for five summers beginning in 1999. Pumping would allow the sediments to dry and the white phosphorus to sublimate and oxidize. The treatment season would begin in May and end in September. A pond elevation survey would be conducted to determine the optimal pump placement. To enhance drainage, explosives may be used to make small sumps for the pumps and shallow drainage channels. These shallow drainage channels would enhance hydraulic connectivity between ponds to encourage drainage.
- Implement the following protective procedures to minimize disturbances to wetlands habitat:
  - Restriction of activities that disturb wildlife in Area B and Area D, which are prime waterfowl habitat areas

– Selection of the narrowest and shortest walking corridors to minimize disturbances to vegetation and habitat

– Proper maintenance of equipment and structures

– Minimization of the use of equipment and of staging-area footprints

– Minimal localized use of explosives

– Preparation of work plans and solicitation of agency reviews

– Monitoring for impacts to wetlands habitat

– Monitoring for waterfowl use of ERF

TABLE 1
Sequence of Activities for the Selected Alternative

Activity	Time Frame
Monitoring Activities	
Waterfowl telemetry and mortality study	Every year for first 8 years, Year 10, Year 15, and Year 20 (11 events)
Aerial waterfowl surveys	Every year for first 8 years, Year 10, Year 15, and Year 20 (11 events)
White phosphorus monitoring of treated ponds	Every year for first 5 years (5 events)
White phosphorus composite sampling in untreated areas	Every year for first 5 years (5 events)
GIS database management	Every year for first 8 years, Year 10, Year 15, and Year 20 (11 events)
Pond survey, ground truthing, limited aerial survey	Year 1 and every year from Year 9 to Year 20 (13 events)
Aerial photography and interpretation	Every other year for 10 years (5 events)
Mapping of physical habitat changes and vegetation rebound	Once every 4 years for 20 years (6 events)
Treatment Activities	
Pond pumping treatment	Every year for first 5 years (5 events)
Cap and fill application	Year 5 (1 event)
Cap and fill integrity inspection	Every year for 4 years after material is placed (Year 5, 6, 7, 8), Year 10, Year 15, and Year 20 (7 events)
Hazing (contingency)	Every year for first 5 years (5 events, if needed)

Table 2

- Sample pond bottoms for white phosphorus at the beginning of the treatment season to confirm or determine that the pond or area requires remediation. The sampling also would establish a white phosphorus baseline and determine additional areas that may require remediation. The baseline sampling would be performed at the beginning of each field pumping season (every year for the first 5 years, starting in 1999).

- Sample pond bottoms for white phosphorus after treatment to determine effectiveness of the treatment system. This verification sampling would be performed at the end of each field pumping season (every year for the first 5 years, starting in 1999).

- Perform telemetry monitoring and aerial surveys every year for the first 5 years concurrently with pumping activities to determine bird populations, usage, and mortality. These activities would begin in 1999. Monitoring would be continued for 3 additional years to verify that short-term goals are maintained. Monitoring also would be conducted at Year 10, Year 15, and Year 20 to ensure that remedial action objectives continue to be maintained.

- Perform limited aerial surveys and ground truthing during Year 9 to Year 20 to evaluate waterfowl mortality, physical habitat changes, and vegetation rebound.

- Perform aerial photography every other year for 10 years (beginning in 1999) to monitor habitat changes resulting from remedial actions. Changes in drainage, topography, and vegetation would be evaluated.

- Perform habitat mapping once every 4 years for 20 years to evaluate impacts to habitat as a result of remedial actions, as well as to observe physical habitat changes and vegetation rebound after pumping is discontinued.

- Perform limited hazing (only as a contingency) during first 5 years starting in 1999 if incidental hazing from pumping operations and other fieldwork activities does not deter bird usage.

- After remedial action objectives are achieved and pumping is discontinued, apply cap-and-fill material in ponded areas that did not drain and dry sufficiently to enable the white phosphorus to sublimate and oxidize. Cap-and-fill material placement is expected to occur in Year 5 (2003).

- Monitor cap and fill material integrity every year for 4 years after the material is placed, and also at Year 10, Year 15, and Year 20.

- Incorporate white phosphorus sampling, telemetry, aerial survey, habitat, and physical landform data into a geographical information system (GIS) database. Perform GIS management every year for the first 8 years, starting in 1999, and then during Year 10, Year 15, and Year 20.

- Maintain institutional controls, including the restrictions governing site access, construction, and road maintenance and the required training for personnel who work at OU-C source areas, as long as hazardous substances, and unexploded ordnance hazards, exist at OU-C.

STATUTORY DETERMINATION

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. The remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because the remedy will result in hazardous substances that present a substantial ecological risk remaining on site, a review will be conducted within 5 years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. Review will continue for 5-year increments until the RAOs are complete.

SIGNATURE

Signature sheet for the foregoing Operable Unit C, Fort Richardson, Record of Decision between the United States Army and the United States Environmental Protection Agency, Region X, with concurrence by the Alaska Department of Environmental Conservation.

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William M. Steele
Lieutenant General, USA
Commanding General
U.S. Army Pacific

SIGNATURE

Signature sheet for the foregoing Operable Unit C, Fort Richardson, Record of Decision between the United States Army and the United States Environmental Protection Agency, Region X, with concurrence by the Alaska Department of Environmental Conservation.

____

Chuck Clarke, Regional Administrator, Region X
United States Environmental Protection Agency

SIGNATURE

Signature sheet for the foregoing Operable Unit C, Fort Richardson, Record of Decision between the United States Army and the United States Environmental Protection Agency, Region X, with concurrence by the Alaska Department of Environmental Conservation.

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Kurt Fredriksson, Director, Spill Prevention and Response
Alaska Department of Environmental Conservation

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Abbreviations

AAC	*Alaska Administrative Code*
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
AOPEC	area of potential ecological concern
AR	Army Regulation
ARAR	applicable or relevant and appropriate requirement
Army	U.S. Army
bw	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
CFR	*Code of Federal Regulations*
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
CSM	conceptual site model
CTV	critical toxicity value
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
ERF	Eagle River Flats
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FS	feasibility study
GIS	geographical information system
HE	high explosive
IRIS	Integrated Risk Information System
LD_{50}	lethal dose for 50 percent of a sample population
LOEL	lowest observed effect level
µg/g	micrograms per gram

µg/kg	micrograms per kilogram
mg	milligram
mg/kg	milligrams per kilogram
msl	mean sea level
NCP	National Contingency Plan
NOEL	no observed effect level
NPL	National Priorities List
OB/OD	Open Burning/Open Detonation
OU	operable unit
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act of 1976
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SOP	Standard Operating Procedure
TBC	to be considered
UCI	Upper Cook Inlet
USAEHA	U.S. Army Environmental Hygiene Agency
USFWS	U.S. Fish and Wildlife Service
UXO	unexploded ordnance

DECISION SUMMARY

RECORD OF DECISION

for

OPERABLE UNIT C
FORT RICHARDSON
ANCHORAGE, ALASKA
SEPTEMBER 1998

This Decision Summary provides an overview of the problems posed by the contamination at Fort Richardson Operable Unit C (OU-C) source area. This summary describes the physical features of the site, the contaminants present, and the associated risks to human health and the environment. The summary also describes the remedial alternatives considered at OU-C; provides the rationale for the remedial actions selected; and states how the remedial actions satisfy the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 statutory requirements.

The United States Army (Army) completed a Remedial Investigation (RI) at OU-C to provide information regarding the nature and extent of contamination in the soils and groundwater. A baseline Human Health Risk Assessment and Ecological Risk Assessment were developed and used in conjunction with the RI to determine the need for remedial action and to aid in the selection of remedies. A Feasibility Study was completed to evaluate remedial options.

SECTION 1

Site Description

Fort Richardson is an active U.S. Army (Army) installation near Anchorage, Alaska. Fort Richardson was established in 1940 as a military staging and supply center during World War II and originally occupied 162,000 acres north of Anchorage. In 1950, the Fort was divided between the Army and Elmendorf Air Force Base. Fort Richardson now occupies approximately 56,000 acres and includes a central cantonment area surrounded by ranges and by impact and maneuver areas to the north, east, and south. The Fort is bounded to the west by Elmendorf Air Force Base, to the east by Chugach State Park, to the north by Knik Arm, and to the south by the Municipality of Anchorage. The population of the Municipality of Anchorage, which includes Elmendorf Airforce Base and Fort Richardson, is approximately 255,000.

Fort Richardson's land use supports its current mission to provide the services, facilities, and infrastructure necessary to support the rapid deployment of Army forces from Alaska to the Pacific Theater. The area managed by Elmendorf Air Force Base adjacent to Fort Richardson is dedicated to military uses; recreational uses are permitted where consistent with the military mission.

Fort Richardson contains features that include flat to rolling wooded terrain. The upland areas near the adjacent Chugach Mountain Range rise to approximately 5,000 feet above mean sea level (msl). The post is located in a climatic transition zone between the maritime climate of the coast and the continental interior climate of Alaska.

The predominant vegetation type at Fort Richardson comprises varying-aged stands of mixed coniferous and deciduous forest. The diverse plant communities provide habitats for a diverse wildlife population including moose, bear, Dall sheep, swans, and waterfowl. There are no known threatened or endangered species residing on the post.

Fort Richardson straddles both the alluvial fan gravels of the Anchorage plain and the moraine and glacial alluvium complex near the shore of Knik Arm. The gravel alluvium of the Anchorage plain underlies the main cantonment. The confined gravel aquifer is from 197 to 394 feet below the surface in this area of the installation. Groundwater flow in this confined aquifer is in a generally western to northwestern direction.

Just north of the main cantonment is the southern edge of the Elmendorf Moraine, a hummocky, long series of ridges running east-west across Fort Richardson and Elmendorf Air Force Base, roughly parallel to Knik Arm. The moraine is chiefly till, including poorly sorted gravel.

Fort Richardson has generated and disposed of various hazardous substances since it began operations. The Fort was added to the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) in June 1994. The listing designated the post as a federal site subject to the remedial response requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.

On December 5, 1994, the Army, Alaska Department of Environmental Conservation (ADEC), and EPA signed a Federal Facility Agreement (FFA) that outlines the procedures and schedules required for a thorough investigation of suspected historical hazardous substance sources at Fort Richardson. Under the FFA, all remedial response activities will be conducted to protect public health and welfare and the environment, in accordance with CERCLA, the National Contingency Plan (NCP), the Resource Conservation and Recovery Act (RCRA), and applicable state laws.

The FFA divided Fort Richardson into four operable units (OUs): OU-A, OU-B, OU-C, and OU-D. The potential source areas at Fort Richardson were grouped into OUs based on the amount of existing information and the similarity of potential hazardous substance contamination. Only OU-C is addressed in this Record of Decision (ROD). OU-A and OU-B were addressed in a ROD signed in September 1997. OU-D will be addressed in a future ROD.

Figure 1-1 shows the location of Fort Richardson and OU-C.

1.1 Operable Unit C Site Locations and Descriptions

OU-C comprises two source areas: the Eagle River Flats (ERF), an ordnance impact area, and the former Open Burning/Open Detonation (OB/OD) Pad. The majority of this ROD addresses ERF. Section 9 provides detail on the site history, results of the remedial investigation (RI), and future activity at OB/OD Pad.

1.1.1 Eagle River Flats

ERF is a 2,160-acre, cornucopia-shaped, estuarine salt marsh at the mouth of the Eagle River. It is surrounded by forested uplands on the west, south, and east sides, and bounded by the Knik Arm on the north. The Eagle River flows through ERF from southeast to northwest, ultimately discharging into Knik Arm. Two creeks, Clunie and Otter, also drain into ERF (Figure 1-2).

ERF is the only impact area for heavy artillery and mortars on Fort Richardson. Approximately 25 derelict cars and trucks have been placed individually or in groups as targets around ERF. Army personnel practice firing at the targets from more than 25 points, at distances of up to 6 miles. The ERF has been used for military training since 1949, creating thousands of craters in the wetlands and associated mud flats and leaving an estimated 10,000 unexploded mortar and artillery shells buried in the shallow subsurface. Four types of munitions have been fired into ERF: high explosives (HEs), white phosphorus smokes, illumination flares, and hexachloroethane-zinc mixture.

Although ERF is an active impact area, it remains a productive wetland, serving as an important staging ground for migrating waterfowl during the spring and fall migrations. ERF also supports local populations of fish, birds, mammals, and macroinvertebrates. A series of ponds distributed throughout ERF provides excellent habitat for dabbling ducks and other waterfowl.

Figure 1-1 (8-1/2x11)

Figure 1-2 (8-1/2x11)

1.1.2 OB/OD Pad

The former OB/OD Pad, also referred to as Demolition Area One or Demo 1, is an 8.5 acre clearing with a 4-acre gravel pad constructed along the east side of ERF. Open burning and open detonation of explosives on Fort Richardson historically have been performed on this pad since at least 1956, according to aerial photography. No OB/OD activities have been performed on OB/OD Pad since November 1988. The pad contains the remains of destroyed surplus and outdated munitions, along with assorted objects such as junked vehicles and rocket motor casings.

OB/OD Pad, which was designated a RCRA regulated unit, was scheduled for closure under 40 *Code of Federal Regulations* (CFR) 265, Subparts G and P. This area was included in OU-C under the FFA. The process for closing the OB/OD Pad in accordance with RCRA regulations is detailed in Sections 9.4 and 9.4.1 of this ROD.

An RI at OB/OD Pad in 1996 that included sampling and analysis of soil and groundwater indicated that concentrations of detected chemicals were considerably below regulatory levels specified in the *Operable Unit C RI/FS Management Plan, Fort Richardson, Alaska,* prepared in 1996. In addition, the ecological and human health risk assessments completed during the RI indicate that the risks are very low.

In addition, OB/OD Pad has restricted public access. Entry onto the pad is by road with a locked gate. Access is controlled and monitored by the Range Control at Fort Richardson. These restrictions are not expected to change. Because of the potential unexploded ordnance (UXO) hazard in the area, OB/OD Pad is not available for future development.

1.2 Land Use

OU-C is situated on land that is withdrawn from the public domain for military purposes by Executive Order. The U.S. Army Alaska holds no deed documents to the land. Current land use is military training. In 1990, the Army banned the firing of smokes containing white phosphorus into the ERF. Several additional restrictions currently apply to training activities at ERF as follows:

- A minimum of 6 inches of ice must cover the ERF before it can be used for firing.
- Firing is allowed only between November 1 and March 31.
- Only point-contact detonators may be used.

Although there are no immediate plans to resume warm-weather firing onto the ERF, future changes to the mission of Fort Richardson could necessitate the use of the training area during the summer months.

SECTION 2

Site History and Enforcement Activities

2.1 ERF Site History

Biological, chemical, and physical investigations have been ongoing at ERF since the early 1980s. The focus of the investigations varied, depending on current site knowledge, and questions that needed to be addressed.

A time-line presentation and a chronological listing of investigations and treatability studies completed through 1996 are presented in Figure 2-1 and Table 2-1, respectively.

In 1980, Army biologists noticed an unusually high number of waterfowl carcasses, including several dead swans, in the ERF marshes. Subsequent, random searches by the Army, U.S. Fish and Wildlife Service (USFWS), and Alaska Department of Fish and Game (ADFG) discovered abnormally high numbers of dead waterfowl, indicating a serious problem. Ground searches conducted in September 1983 found 368 waterfowl carcasses, including about 35 fresh carcasses. In August and September 1984, about 175 carcasses were discovered. At that time, the Army estimated the number of waterfowl deaths to be between 1,500 and 2,000 per year. In a later study, a series of aerial and ground surveys in 1988 documented more than 900 waterfowl carcasses and feather piles in one area of ERF.

Several preliminary studies that focused on finding the cause of the mortality were conducted between 1982 and 1987. Although the results of these studies eliminated a number of possible causes from consideration, the actual cause of the mortality was not identified. In late 1987, an interagency task force was formed to identify the cause of waterfowl deaths. The ERF Task Force consisted of representatives from the U.S. Army Alaska, EPA, USFWS, ADFG, and ADEC. The primary objective of the ERF Task Force was to identify the cause of the waterfowl deaths and recommend remedial alternatives.

In addition to the ERF Task Force member agencies, other agencies that have been involved in the investigations in ERF include the following:

- U.S. Army Corps of Engineers (COE), Alaska District
- U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)
- Army Center for Health Promotion and Preventive Medicine (formerly U.S. Army Environmental Hygiene Agency [USAEHA])
- Army Environmental Center (formerly U.S. Army Toxic and Hazardous Materials Agency)
- U.S. Department of Agriculture

After the formation of the ERF Task Force, several studies and investigations were conducted to identify contaminants of concern, characterize the nature and extent of contamination, and evaluate potential remedial alternatives. The approach to determining the cause of waterfowl mortality included a review of physical and chemical data and an evaluation of waterfowl behavior based on biological data. The studies initiated to assess waterfowl behavior included bird utilization of habitat and bird mortality studies.

On the basis of results of the initial bird utilization and mortality studies, ERF was initially divided into four Areas: A, B, C, and D. Over time, four other areas of potential concern were identified: Area C/D (between Areas C and D), Bread Truck Pond, Pond Beyond, and the mud flats. Additional research throughout ERF eventually led to the following designated areas, which were the focus for RI and feasibility study (FS) activities: A, B, C, C/D, D, Coastal East, Coastal West, Bread Truck, and Racine Island. Figure 1-2 shows the locations and approximate boundaries for the ERF areas.

The results of a 1989 investigation indicated that chemicals from explosive ordnance were the probable cause for the waterfowl mortality in ERF. In February 1990, on the basis of conclusions reached in the 1989 study, the Army temporarily suspended the use of ERF for live firing until the causative agent of waterfowl mortality was identified. Despite the closure, large numbers of waterfowl continued to die at ERF during the spring and fall migrations.

Census data for 1988 and 1989 indicated that dabbling ducks comprised the majority of the affected waterfowl and the ducks were continuing to die. The focus of the following 1990 field season was to find the cause of mortality based on the assumptions that the contaminant(s) resided in sediment, were distributed heterogeneously at ERF, and were slow to degrade.

Field and laboratory studies conducted in 1990 provided evidence that white phosphorus was the likely cause of the mortality. In addition, because white phosphorus persists (does not sublimate and oxidize) when wet or submerged, the water and sediment conditions at ERF are conducive to the long-term retention of white phosphorus in the sediments. ERF investigations performed in the following 3 years focused on defining the extent of the white phosphorus contamination, determining site conditions and other factors that affect the likelihood of exposure to white phosphorus, and understanding the physical dynamics of ERF. In March 1991, the Army initiated a public review process that evaluated alternatives for the resumption of live firing. ERF was reopened for training uses in January 1992, following a series of test firings. Several restrictions were established, including elimination of firing during the summer months and permanent elimination of the use of white phosphorus. The Army also banned the use of white phosphorus in wetland impact areas nationwide on the basis of discoveries in ERF.

The results of the 1992 and 1993 ERF sampling program for pond sediments and waterfowl carcasses generally confirmed that the highest concentrations of white phosphorus were near Area C and Bread Truck Pond, in a densely cratered area east of Eagle River. The existence of craters was considered to be another indicator of the extent of white phosphorus.

During 1994 and 1995, several field investigations of the physical system of ERF and laboratory studies of the potential of white phosphorus to bioaccumulate were completed.

Figure 2-1 (11x17) front

Figure 2-1 (11x17) back

TABLE 2-1
Summary of Previous Investigations at Eagle River Flats

Investigation/Report	Investigators	Field Date(s)
Waterbird Utilization of Eagle River Flats and Upper Cook Inlet: April-October 1996	USFWS	1996
Waterfowl Mortality on Eagle River Flats	DWRC	1996
Movement, Distribution, and Relative Risk of Mallards and Bald Eagles Using Eagle River Flats: 1996	DWRC	1996
Report of USDA–APHIS–Animal Damage Control for the U.S. Army at Eagle River Flats, April-October 1996	USDA	1996
Demonstration of Sample Compositing Methods To Detect White Phosphorus Particles	CRREL	1996
Pond Draining Treatability Study: 1996 Studies–The Draining of Bread Truck Pond	CRREL	1996
Monitoring of Contract Dredge Operations at Eagle River Flats, Alaska	CRREL	1996
Draft Physical System Analyses of Natural Attenuation and Intrinsic Remediation of White Phosphorus Contamination, ERF, Fort Richardson, Alaska	CRREL	1995
Waterbird Utilization of ERF and Upper Cook Inlet: April - October 1995	USFWS	1995
Movement, Distribution and Relative Risk of Waterfowl and Bald Eagles Using ERF	DWRC	1995
Evaluation of AquaBlok™ on Contaminated Sediment to Reduce Mortality of Foraging Waterfowl	DWRC	1995
Waterfowl Use and Mortality at ERF	NEILE	1995
Site Conditions, Ecological Inventory	CRREL	1994
Physical System Dynamics, White Phosphorus Fate and Transport, Remediation and Restoration, Eagle River Flats, Fort Richardson, Alaska	CRREL	1994
Climate and Tides	CRREL	1994
White Phosphorus Evaluation and Characterization, White Phosphorus Toxicity and Bioindicators of Exposure in Waterfowl and Raptors.	PWRC	1994
Toxicological Properties of White Phosphorus: Comparison of Particle Sizes on Acute Toxicity and the Biotransfer of White Phosphorus from Hen to Eggs	Dartmouth	1994
Analysis of the Eagle River Flats White Phosphorus Concentration Database	CRREL	1994
Waterbird Utilization of Eagle River Flats: April-October 1994	USFWS	1994
Waterfowl Use and Mortality at Eagle River Flats	NEILE	1994
Movement, Distribution and Relative Risk of Waterfowl, Bald Eagles and Dowitchers Using Eagle River Flats	DWRC	1994
Evaluation of White Phosphorus Effects on the Aquatic Ecosystem, Eagle River Flats, Fort Richardson, Alaska	USAEHA	1994
Integrated Risk Assessment Model (IRAM) for Determining White Phosphorus Encounter Rate by Waterfowl	DWRC/ CRREL/ NEILE	1994

TABLE 2-1
Summary of Previous Investigations at Eagle River Flats

Investigation/Report	Investigators	Field Date(s)
Treatability Studies; Chemical Hazing of Free-Ranging Ducks in Eagle River Flats: Field Evaluation of ReJex-iT™ WL-05	DWRC	1994
Hazing at Eagle River Flats	ADC	1994
Evaluation of AquaBlok™ on Contaminated Sediments to Reduce Mortality of Foraging Waterfowl	DWRC	1994
Screening Study of Barriers to Prevent Poisoning of Waterfowl in Eagle River Flats, Alaska	CRREL	1994
Investigation of Natural Size Reduction of White Phosphorus Particles in Eagle River Flats Sediments	CRREL	1994
Pond Draining Treatability Study	CRREL	1994
Dredging as a Remediation Strategy for White Phosphorus-Contaminated Sediments at Eagle River Flats, Alaska	CRREL	1994
Appendix A. Eagle River Flats Map Atlas	CRREL	1994
Mapped Craters	CRREL	1993
Contaminant Inventory	USAEHA	12-23 Jul 1993
Treatability Study–Hazing Waterfowl in ERF	ADC	May, Sep-Oct 1993
Treatability Study–Laboratory Evaluation of a Methyl Anthranilate Bead Formulation	DWRC	1993
Treatability Study–Field Behavioral Response and Bead Formulations for Methyl Anthranilate	DWRC	Jun, Aug 1993
Treatability Study–Field Evaluation: Mortality of Mallards Feeding in Areas Treated with Methyl Anthranilate	DWRC	Jun 1993
Waterfowl Mortality at ERF	NEILE	Apr-May, Aug-Oct 1993
Distribution and Concentrations of White Phosphorus in ERF	CRREL	1991–1993
Waterfowl Distribution and Movements in ERF	DWRC	Apr-Jun, Aug-Oct 1993
White Phosphorus Poisoning of Water birds in ERF	PWRC	May-Sep 1993
Toxicological Studies of White Phosphorus in Waterfowl	PWRC	1993
Physical System Dynamics (Sedimentation and Erosion at ERF)	CRREL	May 1992-Sep 1993
Food Chain Invertebrates and Fish: Sediment Bioassay	USAEHA	July 12-23 1993
White Phosphorus in Invertebrates and Fish	PWRC	Jun 1993
Habitat and Vegetation in ERF	CRREL	1993
White Phosphorus in Plants at ERF	CRREL	Jun 1993
Water bird Utilization of ERF	USFWS	Apr-Oct 1993
Treatability Study–Pond Draining	CRREL	Jun-Aug 1993
Treatability Study–Air Drying Contaminated Sediments	CRREL	Jun-Aug 1993

TABLE 2-1
Summary of Previous Investigations at Eagle River Flats

Investigation/Report	Investigators	Field Date(s)
Treatability Study–Geosynthetic Covering of Contaminated Sediment	CRREL	Jul 1993
Treatability Study–Evaluation of Concover and BentoBalls on Contaminated Sediments to Reduce Mortality of Foraging Waterfowl	DWRC	Jun 1993
U.S. Army Eagle River Flats: Protecting Waterfowl from Ingesting White Phosphorus	DWRC	1992
Rapid Uptake and Disappearance of White Phosphorus in American Kestrels	CRREL and Dartmouth Medical School	1992
Draft Report–Preliminary Assessment of Sedimentation and Erosion in the Eagle River Tidal Flats, Fort Richardson, Alaska	CRREL	May-Sep 1992
Hazardous Waste Consultation No. 37-66-JR11-92, Soil Sampling Results, Fort Richardson, Alaska, July 6-7, 1992	USAEHA	July 6-7 1992
Draft Report–Water bird Utilization of Eagle River Flats, April - October 1992	USFWS	Apr-Oct 1992
Draft Report–White Phosphorus Contamination of Salt Marsh Sediments at Eagle River Flats, Alaska, February 1993	CRREL	1991-1992
Waterbird Utilization of Eagle River Flats, April–October 1991. December 1991	USFWS	Apr-Oct 1991
Waterfowl Mortality in Eagle River Flats, Alaska, The Role of Munitions Residues. May 1992	CRREL	1990
Waterbird Utilization of Eagle River Flats, April - October 1990. December 1990.	USFWS	Apr-Oct 1990
Eagle River Flats Expanded Site Investigation, Fort Richardson, Alaska. Final Technical Report, June 1990	ESE	Jul-Oct 1989
Eagle River Flats Waterfowl Mortality Progress Report, August 1989	As noted below	
Laboratory Investigations	ADEC	Sep 15, 1988
Laboratory Investigations	EPA	Jul 11, 1988
Laboratory Investigations	EPA	Jul 22, 1988
Bird Utilization of ERF During Spring, Summer, and Fall, and Associated Mortality	USFWS	Apr-Oct, 1988
Investigations of Waterfowl Mortality, ERF	USFWS	1983-88
Laboratory Investigations	USAEHA	1985
Field Investigations	USFWS	1982-85

Notes:
ADC = Animal Damage Control
CRREL = U.S. Army Cold Regions Research and Engineering Laboratory
DWRC = Denver Wildlife Research Center
ER = Eagle River
ESE = Environmental Science and Engineering, Inc.
NEILE = New England Institute of Landscape Ecology
USAEHA = U.S. Army Environmental Hygiene Agency
USDA = U.S. Department of Agriculture

The bioaccumulation studies were performed to assess the impacts of white phosphorus on wildlife at ERF. Additional studies were conducted on waterfowl utilization of ERF, waterfowl mortality, waterfowl distribution and movements in ERF, and toxicological studies of white phosphorus in waterfowl to determine acute lethal doses for ducks (mallards).

From 1994 through 1997, the ERF investigations focused on finding a feasible remedy for white phosphorus contamination in sediments. Areas of priority for cleanup were evaluated by using white phosphorus sampling, waterfowl telemetry, carcass transects, physical system dynamics, and mapping of landcovers (combinations of topographical features such as ponds and vegetation). A comprehensive geographical information system (GIS) database, established in 1994 and continuously updated, contains results of all ERF data. This information has been used to determine the nature and extent of white phosphorus at ERF and plan feasibility studies for possible remedial actions.

Results of a 1994 CRREL study showed that white phosphorus particles remained intact and relatively unaffected in water-saturated sediments, but began to immediately degrade and disappear when the sediments became unsaturated, especially at warmer temperatures. Therefore, sublimation/oxidation was determined to be a viable remedial option for mud flats and intermittent ponds that have the potential to drain and dry. This conclusion led to additional feasibility studies in 1995, 1996, and 1997 to determine potential technologies that could be used in ERF to result in pond draining and drying of sediments so that degradation would occur.

Results of historical investigations and the RI at OU-C are included in the *Operable Unit C Remedial Investigation Report* and the *Operable Unit C Feasibility Study Report,* which were prepared in 1997.

2.2 Enforcement Activities

Fort Richardson was placed on the CERCLA NPL in June 1994. Consequently, an FFA was signed in December 1994 by EPA, ADEC, and the Army. The FFA details the responsibilities and authority associated with each party pursuant to the CERCLA process and the environmental investigation and remediation requirements associated with Fort Richardson. The FFA divided Fort Richardson into four OUs, one of which is OU-C, and outlines the general requirements for investigation and/or remediation of suspected historical hazardous waste source areas associated with Fort Richardson.

An additional goal of the FFA was to integrate the CERCLA response obligations and RCRA corrective action obligations of the Army. Remedial actions implemented will be protective of human health and the environment. Consequently, the remediation of releases will obviate the need for further corrective actions under RCRA (no further corrective action will be required for source areas).

2.3 Agency Cooperation

The ERF investigation and cleanup activities have represented a unique cooperative effort among the Army, EPA, and ADEC. These activities began before the listing of Fort Richardson on the NPL and have focused on the observed waterfowl mortality. The agencies understand that the historical and anticipated future use of ERF is firing heavy artillery and mortars. Although the inclusion of an active impact area within an OU is unusual, the decision to do so was made to address the waterfowl concerns without adversely affecting the military use of ERF now or in the future.

2.4 Highlights of Community Participation

The public was encouraged to participate in the selection of the remedy for OU-C during a public comment period from February 5 to March 6, 1998. The *Fort Richardson Proposed Plan for Remedial Action, Operable Unit C* presents combinations of options considered by the Army, EPA, and ADEC to address contamination in soil and groundwater. The Proposed Plan was released to the public on February 4, 1998, and was sent to 180 known interested parties, including elected officials and concerned citizens.

The Proposed Plan summarizes available information about OU-C. Additional materials were placed in information repositories established at the Alaska Resources Library, Fort Richardson Post Library, and the University of Alaska Anchorage Consortium Library. The Administrative Record, including other documents used in the selection of the remedial actions, was established in the Public Works Environmental Resource Office on Fort Richardson. The public is welcome to inspect materials available in the Administrative Record and the information repositories during business hours. The Administrative Record Index is provided in Appendix A. The selected remedy presented in Section 7 is based on the Administrative Record.

Interested citizens were invited to comment on the Proposed Plan and the remedy selection process by mailing comments to the Fort Richardson project manager, by calling a toll-free telephone number to record a comment, or by attending and commenting at a public meeting on February 12, 1998, at the Russian Jack Springs Chalet in Anchorage. Twenty-five people attended the public meeting. Five sets of comments were received from the public during the comment period.

The Responsiveness Summary in Appendix B provides more details about community relations activities. It also summarizes and addresses public comments on the Proposed Plan and the remedy selection process.

2.5 Scope and Role of Operable Unit

Four operable units (A, B, C, and D) have been identified at Fort Richardson. Three of these OUs are driven primarily by human health risks. OU-C is the only site at Fort Richardson with white phosphorus contamination and the only site at Fort Richardson driven by ecological risk. OU-C is also unique in that it is still an active impact range. This ROD is the second signed for Fort Richardson. A single ROD for OUs A and B was signed in 1997.

The OU-C RI/FS was performed in accordance with the *Operable Unit C RI/FS Management Plan* (1996). The RI fieldwork at OU-C was conducted during 1996.

The principal threat at the ERF source area within OU-C is particulate white phosphorus in sediment. According to results of the RI, potential risks to the environment are posed by onsite contamination. Accordingly, the agencies have elected to pursue remedial action under CERCLA to address these potential risks.

The RI at the OB/OD Pad source area within OU-C concluded that the contaminants found do not pose a risk to human health and the environment and do not require cleanup action. Therefore, except for continuing controls that are in place to control access and requiring safety training for personnel who must work at the site, no cleanup action will be conducted for OB/OD Pad.

SECTION 3

Summary of Site Characteristics

3.1 Eagle River Flats

3.1.1 Physical Features, Hydrogeologic Conditions, and Transport Pathways

ERF is characterized as a roughly triangular estuarine salt marsh surrounded by forested uplands and the Knik Arm portion of Cook Inlet. It was formed as the Eagle River eroded through the glacial and alluvial deposits of the Anchorage lowland to create a deep valley that subsequently filled with sediment. The topography of ERF is relatively flat, with landform and vegetation changes, and expected tidal flooding frequencies, occurring with subtle changes in elevation. Measured elevations in ERF range from 3 feet above msl at the river bottom of the Eagle River to 18 feet above msl on top of the highest levees along the river.

The discharge from Eagle River bisects ERF. It can vary substantially from the impacts of spring meltwater and rainstorms. With an average flow rate of 530 cubic feet per second, Eagle River drains approximately 1,300 square miles of mountains and lowlands. Sediment concentration of Eagle River does not depend on the discharge rate of the river, and results of studies of ERF physical dynamics suggest that the tides have a greater suspended sediment concentration than the river.

Distributary channels (or gullies) cut deeply through the mud flats and connect ponds with Eagle River. Subtle changes in elevation of the channel floors dictate whether tidal flooding occurs daily, occasionally, or rarely. Where elevations are 7 feet to 12 feet above msl, as in the bottoms of gullies, flooding occurs daily during high tides. At between 12 and 14 feet above msl, such as the heads of gullies and some mud flats, flooding occurs only with the highest tide of each month. Only extreme high tides, in combination with high river-discharge levels, flood areas between 14 and 15 feet above msl, such as the major pond basins, higher mud flats, and some levees.

In summer, there may be long periods between flooding tides, and parts of ERF can become relatively dry. During winter, Eagle River continues to flow, but ice thickens over ERF with succeeding flood events during cold temperatures. Ice breakup typically occurs in April or early May. It appears that the hydrology and sedimentology of the upper third of ERF is dominated by the river, with the remainder dominated by the tides.

In addition to Eagle River, several small tributary streams enter ERF. Otter Creek, a small perennial stream, drains Otter Lake and enters ERF near its southern end. Clunie Creek, believed to be a groundwater channel depression, drains several small lakes east and northeast of ERF and enters ERF just north of OB/OD Pad.

3.1.2 Nature and Extent of Contamination

As discussed in Section 2, since the initial reports of elevated waterfowl mortality in the early 1980s, a multidisciplinary investigation has been conducted to identify the cause of the mortality (shown in 1990 to be white phosphorus), the extent of the white phosphorus contamination, and the potential effects of white phosphorus and other munitions on the biota in ERF. White phosphorus was released into ERF by ordnance used to create smoke for marking targets. White phosphorus that did not fully oxidize could remain as particles in the sediment. Ingestion of white phosphorus particles by feeding waterfowl has created high levels of mortality. Birds have been observed to die within hours of ingesting white phosphorus in a number of ponds in ERF.

Sampling results have focused primarily on a relatively small number of areas in ERF where the greatest levels of mortality were observed. The results of this sampling have demonstrated that elevated levels of white phosphorus exist in most ponds where the highest mortality levels occur; however, sampling efforts in several ponds where high mortality has been observed have not demonstrated that white phosphorus exists extensively in the sediment. This finding suggests that some birds may fly away from the point of exposure before succumbing. The potential for birds to move following exposure, coupled with limitations on sampling efforts because of the hazard posed to site workers by UXO, has complicated identification of the horizontal and vertical extent of white phosphorus contamination.

Previous sampling results and detailed observations of wildlife populations within ERF have identified swans and dabbling ducks as the primary receptors of white phosphorus contamination. Although low levels of white phosphorus have been found in plants, macroinvertebrates, and fish, existing data do not show that these populations have been significantly affected by the presence of white phosphorus in ERF. Only a small percentage of plants, macroinvertebrates, and fish contained detectable levels of white phosphorus.

There is some evidence indicating that scavengers that feed on waterfowl carcasses in ERF have been exposed to white phosphorus. It is believed, however, that reducing the mortality effect in dabbling waterfowl to acceptable levels also will reduce effects in the predators and scavengers that have been identified as secondary receptors (that is, those that eat the dabbling ducks) because of the reduction in their exposure concentrations.

Researchers used observations of carcass locations and crater densities in areas used by waterfowl to identify areas most likely to contain white phosphorus. The sediments in these areas were extensively sampled for white phosphorus with the use of radial transects and close sampling in open ponds. The distribution of ponds and analytical results of white phosphorus in sediment were compiled and used in conjunction with landcovers and bird usage data to identify hot ponds that are the areas likely presenting the highest risk. The UXO hazard in ERF makes extensive future sampling efforts infeasible.

The findings documented in the RI report are based primarily on data collected before implementing the CERCLA process at OU-C. Compilation and review of all the data have led to the following conclusions:

1. **White phosphorus is the primary cause of waterfowl mortality.** Symptoms exhibited by ducks exposed to white phosphorus in ERF are similar to those observed in ducks dosed with white phosphorus in the laboratory. White phosphorus also was detected in tissue samples collected from duck carcasses found in ERF.

2. **White phosphorus was deposited in the sediment primarily during range firing activities.** White phosphorus marking rounds were used during training activities in ERF for several decades. Rounds were fired into ERF and detonated, dispersing white phosphorus particles over large areas. Further distribution of the particles likely occurred when HE rounds exploded in white phosphorus-contaminated soil and sediment.

3. **Craters in ERF potentially indicate the level of range firing activity.** Detonation of HE generally creates a crater at the point of impact. Although white phosphorus munitions do not form craters upon detonation, they typically have been used in conjunction with HE training activities. Therefore, it can be deduced that the more craters in an area, the more munitions have likely been fired there, resulting in higher probability of white phosphorus contamination.

4. **The distribution of white phosphorus particles throughout ERF sediments is not uniform.** The dispersion of the white phosphorus particles was affected by the nature of detonations in an area and whether munitions were detonated on land or over water. Some areas were used more frequently as targets and, therefore, received higher amounts of white phosphorus. In addition to differences in the distribution of white phosphorus, particle sizes vary greatly, ranging from 0.01 inch to 0.113 inch. Particle densities vary substantially even within small areas. The impacts of white phosphorus shells typically resulted in “hot spots” of 3 to 6 feet in diameter. These hot spots contain large numbers of white phosphorus particles and are generally surrounded by a 3-foot ring containing fewer particles.

5. **The detection frequencies and concentrations for white phosphorus in sediment are highest in Area C, Bread Truck, and Racine Island.** Sixty-three percent of the overall ERF sampling locations had nondetectable concentrations, but at least 45 percent of the locations in each of these three areas had detectable concentrations. The highest concentration, 3,071 micrograms per gram (µg/g), was found on Racine Island.

6. **White phosphorus particles can break down (sublimate and oxidize) when exposed to air and warm temperatures, but are long lasting in water-saturated sediment.** White phosphorus particles that land on soil or dry sediment are readily oxidized and burn under ambient air conditions. Because they are not water soluble, however, white phosphorus particles have an indefinite life when submerged in the water and allowed to settle into pond or marsh bottom sediments. White phosphorus monitoring has shown that particulate white phosphorus persists in permanently flooded ponds, but naturally sublimates and oxidizes in ponds that only flood intermittently. Therefore, intermittently flooded ponds were eliminated from further remediation.

7. **Waterfowl are exposed to white phosphorus from the sediment of ponds and sedge marshes while they are feeding.** Some white phosphorus particles may resemble seeds and macroinvertebrates that dabbling ducks and swans feed on. As the waterfowl forage for food in pond and marsh bottom sediments, they may intentionally or inadvertently pick up the white phosphorus particles.

8. **Dabbling ducks and swans are the primary receptors of white phosphorus.** Dabbling ducks and swans forage for food in pond and marsh bottom sediments. In addition, mortality rates of dabbling ducks have been observed to be significantly higher than

mortality rates of other waterfowl in ERF as well as in other Upper Cook Inlet (UCI) marshes. Telemetry data in 1996 suggest that the mortality rate among radio-tagged mallards was about 35 percent. Mallards were selected as the indicator species because they are the most frequently observed species of dabbling waterfowl at ERF.

9. **Predation and human exposure to white phosphorus by consumption are not high-level concerns at present.** There has been no verified mortality resulting from predators feeding on white phosphorus-contaminated waterfowl carcasses. Although a dead eagle was found with white phosphorus contamination, current predator mortality appears low. In addition, the results of analyses of tissue collected from dabbling ducks taken by hunters near ERF do not indicate a threat to humans ingesting the meat.

10. **Permanent ponds, with associated sedge marsh, having confirmed presence of white phosphorus and/or moderate-to-high crater density and observed moderate-to-high dabbling duck and/or swan use are the most significant exposure areas.** According to the conceptual site model (CSM), areas of greatest concern are where there is a source (white phosphorus-contaminated sediment), a receptor (dabbling duck or swan), and a potential for exposure (foraging for food).

11. **The movement of white phosphorus through Eagle River to Knik Arm appears to be minimal.** Low-level amounts of white phosphorus have been detected in the sediments traveling through the gullies, but no sediment and water samples from the river had any detectable white phosphorus. No sampling has been performed in the Knik Arm at the mouth of the Eagle River.

During the initial phases of the white phosphorus sampling in ponds, crater density in mud flats adjacent to ponds and mortality observations were the main criteria used in selecting ponds to be sampled. Sampling priority was placed on ponds and adjacent mud flat areas that had high density of crater coverage and high numbers of observations of water bird mortality.

The most significant areas of concern for exposure to white phosphorus are the sediments of ponds and some marshes, for which all of the following conditions apply:

1. White phosphorus presence has been confirmed and / or the number of craters (density) is moderate to high.

2. Moderate to high use by ducks and / or swans has been observed.

3. High numbers of waterfowl deaths have been observed.

The ponds where these conditions exist (hot ponds) are the areas believed to present the highest risk of white phosphorus exposure to waterfowl. Twenty-two hot ponds were identified, covering 57 acres in Areas A, C, C / D, Racine Island and Bread Truck. To aid in the evaluation of alternatives for the FS, the hot ponds identified in the RI were divided into six pond groups based on physical site characteristics: (1) Northern A (7 ponds); (2) Pond 290 (1 pond); (3) Ponds 183 and 146 (2 ponds); (4) Northern C and C / D ponds (8 ponds); (5) Racine Island (3 ponds); and (6) Bread Truck (1 pond). The characteristics of these pond groups are discussed below. Figure 3-1 provides an illustration of the pond group locations.

- **Northern A Pond Group**. Seven ponds in Area A comprise this group. The 14.3-acre area has uneven topography and a medium to high number of craters. The ponds are believed to be interconnected by a small to medium-sized area of surrounding marsh. Thirteen percent of samples collected in Area A contained white phosphorus at detectable concentrations. In 1996 birds being tracked spent more than 60 percent of their time in Area A. In addition, 23 percent of the dead ducks found at ERF in 1996 were found in Area A.

- **Pond 290.** Pond 290 is in Area A and is 2.2 acres in size. This pond does not appear to be connected to other ponds in the area and, therefore, is addressed separately. Low levels of white phosphorus contamination have been detected in the north end of this pond. In 1997 numerous dead ducks were found in Pond 290.

- **Ponds 183 and 146.** Ponds 183 and 146 are in Area C. Pond 183 is 7.2 acres in size, and Pond 146 is 13.6 acres in size. These ponds have a high number of craters. Pond 183 is connected to Pond 146. In 1996, birds that were tracked by radio spent 10 percent of their time in Area C. Thirty-five percent of the dead ducks found at ERF in 1996 were found in Area C. More than 50 percent of the samples collected in Area C contained white phosphorus.

- **Northern C and C/D Ponds.** Eight ponds totaling 8.9 acres comprise the Northern C and C/D pond group. This pond group has a medium to high number of craters. The ponds are believed to be interconnected to a large area of permanent ponds and marsh, which provide constant sources of water flow or recharge. Ten percent of the samples collected in Area C/D had detectable concentrations of white phosphorus. In 1996, birds being tracked spent 8 percent of their time in Area C/D, and 16 percent of the dead ducks among those being tracked were found in Area C/D.

Table 3-1 identifies the 18 ponds described above and provides information on duck use and deaths in these areas.

TABLE 3-1
Identification of ERF Areas, Pond Groups, and Ponds Requiring Cleanup

Hot Pond Group	Size (acres)	ERF Area	1996 Duck Use (%)	1996 Duck Death (%)	Number of Craters
Northern A: Pond Numbers 138, 208, 226, 228, 246, 256, 258	14.3	A	62	23	medium to high
Pond 290	2.2				
Ponds 183 and 146	20.8	C	10	35	high
Northern C and C/D: Pond Numbers 129, 145, 155, 40, 49, 85, 93, 112	8.9	C/D	8	16	medium to high

Note: 1996 duck use and death percentages are based on birds that were radio collared in 1996. Percentages do not add up to 100 percent because areas with low percentages of deaths were not selected for cleanup.

Figure 3-1

The remainder of the 22 hot ponds have undergone some treatment during the investigation and treatability study phase at ERF:

- **Racine Island Ponds.** The Racine Island ponds include Ponds 285, 293, and 297, which together total about 2.5 acres in size. Pond 285 is 1 acre, and Ponds 293 and 297 together are 1.5 acres. These ponds contain high numbers of craters. Elevated white phosphorus concentrations, including some of the highest concentrations of all samples collected at ERF, were detected in 73 percent of samples collected in these ponds. In 1996, 16 percent of the dead ducks found in ERF were found in the Racine Island ponds. Capping and filling technology was tested at Pond 285 in 1995. This pond was filled with a gravel-clay mixture that prevented ducks from feeding in the contaminated sediment. The mixture also supported the growth of vegetation. Ponds 293 and 297 in the Racine Island Area were drained by breaching in 1997. (Draining of Pond 297 will continue in 1998 until completed.) Draining by breaching has discouraged waterfowl use. The treatability study was conducted as a time-critical removal action because the breaching needed to be completed before the ground melted in spring to protect the people performing the work from explosive hazards.

- **Bread Truck Pond.** Pond 109 is about 8.2 acres in size and contains a high number of craters. White phosphorus contamination was detected in 45 percent of samples collected in this pond. In 1996, 5 percent of the dead ducks found at ERF were at this pond. Pond draining by breaching was tested at Pond 109 in 1996. The draining technology removed the duck feeding habitat at Pond 109, which resulted in less duck use.

3.2 Treatability Studies

Because of the heterogeneity of white phosphorus distribution, the UXO safety hazards, and the physical setting, several treatability studies were performed to identify alternatives that were not only effective in reducing exposure to white phosphorus contamination, but also implementable and cost-effective. The technologies listed below were tested at ERF. The first three were considered to be not implementable, not effective, or too expensive. The remaining four technologies were considered feasible, and were incorporated into the alternatives presented in Section 5 of this ROD.

Unfeasible Methods

- Dredging–removal and drying of sediments that contain white phosphorus from permanently flooded areas. This technology was not retained because it was only moderately effective, altered duck habitat, and cost as much as 10 times more than other technologies.

- Geosynthetics–use of textile material as liners for the bottoms of ponds. The material acts as a physical barrier. This technology was not retained because a large-scale implementation method has not been developed. In addition, the use of geosynthetics altered duck habitat and installation of the material presented high risks to human safety.

- Methyl anthranilate–application of this bird repellent. Methyl anthranilate settles to the bottom of ponds and deters waterfowl from feeding. This technology was not retained because its long-term effectiveness was marginal and it was very costly.

Feasible Methods

- Capping and filling–application of a material to act as a physical barrier to the white phosphorus in the sediments of pond bottoms. The material used was called AquaBlok™, a composite mixture of gravel and bentonite that expands in water to form an impenetrable blanket over contaminated sediment. This technology was tested at

Pond 285 at the Racine Island Area in 1995. The gravel-bentonite mixture filled the pond and prevented ducks from feeding in the contaminated sediment. The material also supported the growth of vegetation.

- Hazing–use of visible objects and sounds to deter waterfowl from use of an area, thereby preventing exposure to white phosphorus. Hazing was conducted throughout ERF with propane exploders, pyrotechnics, scarecrows, hovercrafts, flagging, balloons, and other visual, acoustic, and behavioral devices designed to frighten birds. This technology was retained as a contingency response action, in the event birds are not deterred by the incidental hazing associated with remedy implementation. The hazing contingency has been incorporated into Alternatives 2, 3, 4, and 5, which are discussed in Section 5. (Hazing also occurs unintentionally when human activity and equipment operations deter birds.)
- Pond draining by breaching–use of explosives to create a channel from a pond containing white phosphorus, which allows the water to drain into a gully or Eagle River. The draining activity permits the sediments of pond bottoms to dry and reduces the feeding habitat of dabbling ducks in breached ponds. Draining by breaching was retained and incorporated into Alternative 4. Pond draining by breaching was tested at Pond 109 in the Bread Truck Area in 1996 and at Ponds 293 and 297 in the Racine Island Area. Both areas were heavily contaminated with white phosphorus. The draining technology removed or discouraged the duck feeding habitat at Pond 109, which resulted in less duck use.
- Pond draining by pumping–use of pumping systems to draw water from ponds containing white phosphorus. The pumped water is discharged to gullies along the Eagle River. The draining activity permits the sediments of pond bottoms to dry and, therefore, allows white phosphorus to sublimate and oxidize. This technology was tested at Pond 183 in Area C in 1997 and was found to be successful in removing white phosphorus. Draining by pumping was retained and incorporated into Alternatives 3 and 4.

SECTION 4

Summary of ERF Site Risks

Baseline risk assessments were conducted to determine the need for and extent of remediation to be protective of human health and ecological values at ERF. These evaluations are discussed in detail in Appendices A and B of the *Final Operable Unit C, Remedial Investigation Report, Fort Richardson, Alaska* (1997), which is available at the information repositories. The baseline risk assessments for OU-C include the ERF artillery impact range and OB/OD Pad. The baseline risk assessments determined potential risks in the absence of remedial action.

The risk assessments were based on studies that identified the chemicals present and focused on the chemicals of potential concern (COPCs). Results determined that risks within ERF were limited to white phosphorus particles in sediment. The studies documented the history of white phosphorus and ordnance use; the distribution, fate, and transport of white phosphorus particles; and the toxicological effects of white phosphorus contamination within OU-C.

White phosphorus is acutely toxic in minute quantities to humans and wildlife. In humans, toxic effects of white phosphorus exposure include death at low doses, nausea, vomiting, garlic-like odor on breath and in excrement, lethargy, convulsions, coma, fatty infiltration of liver and other organs, enlargement of the liver with jaundice, kidney failure, and electrocardiographic changes suggestive of an acute heart attack.

Eye exposure to white phosphorus fumes causes conjunctivitis, photophobia, and lacrimation. Inhalation causes shortness of breath and hoarseness, but no permanent tissue damage. Chronic occupational exposure causes phossy jaw (a disease of the jawbone leading to tissue destruction and infection).

The most significant white phosphorus impacts at ERF are occurring to bird populations. Dabbling ducks, such as northern pintails, mallards, and green-winged teal, and swans (trumpeter and tundra) are the most affected species, as indicated by their high mortality. Lethal oral doses for waterfowl have been established in toxicity studies. Sublethal effects include reduced reproductive output in hens and teratogenic deformities in embryos, including scoliosis, lordosis, submandibular edema, micropthalmia, and spina bifida.

Sublethal doses caused histopathological changes in the liver, spleen, heart, and duodenum. Changes in blood chemistry (blood urea nitrogen, potassium, lactate dehydrogenase, glucose, hematocrit, and hemoglobin) also were observed. Repeated subchronic exposures resulted in mortality and histopathologic effects (liver and kidney damage) that were consistent with acute exposures from single doses at similar concentrations.

4.1 Human Health Risk Assessment

The human health risk assessment determined that the limited human exposure at ERF reduces potential risks and that risks of potential exposure to white phosphorus were very low. The risk assessment also noted the existence of potential onsite risk to humans from UXO. ERF is currently an active firing range and UXO risks are inherent. Any change in the status of the range (if it became inactive) would be addressed under the Munitions Rule.

This subsection describes the background, approach, and conclusions of the human health risk assessment.

A previous human health risk evaluation of hunters who may eat white phosphorus-contaminated ducks from ERF, prepared in 1991 by the Army and the Alaska State Epidemiologist, concluded that there is a very low human health risk. A baseline human health risk assessment was designed and completed during the RI to determine the current and potential human health risks based on the most up-to-date information available for ERF. The baseline assessment assumed that no remedial action will be performed and included more exposure scenarios than were reviewed in the 1991 risk evaluation.

Initially, several different current and potential exposure scenarios were considered, including onsite and offsite activities. Although hunting in ERF is banned, the offsite hunter scenario was addressed quantitatively because of the current level of hunting in nearby areas and the potential for contaminated ducks to fly to those areas. In addition, because no physical barriers prevent access to ERF from Knik Arm or Eagle River, an onsite recreation scenario was considered.

Other human health risk scenarios were eliminated from consideration because of the low potential for exposure or because exposure was mitigated by other site conditions.

4.1.1 Offsite Hunter Exposure Scenario

The exposure assessment for this scenario was based on an evaluation of the exposure pathway and the estimated reasonable maximum exposure (RME). The RME is defined in EPA guidance as “the highest exposure that is reasonably expected to occur at a site” and represents a conservative exposure case that is still within the range of possibilities.

This offsite hunter scenario was developed from ADFG information to estimate that a very active hunter might consume 23 ducks during a year. This estimate was adjusted, considering the probability that a harvested duck would be contaminated with white phosphorus from ERF. This probability was estimated as 0.005 based on (1) the proportion of ducks in ERF compared to other areas of Cook Inlet and (2) data on the mortality rate from white phosphorus exposure and the proportion of time ducks from ERF spend off site.

The portion sizes of duck meals (112 and 90 grams for an adult and child, respectively) were estimated by using guidance from the EPA. An average concentration of 0.12 µg/g of white phosphorus for the duck portion was estimated by using field and laboratory studies. The chronic oral reference dose developed by EPA (2×10^{-5} milligrams per kilogram [mg/kg] of body weight [bw] per day) and standard risk assessment equations also were used. The calculated hazard quotients, which are estimates of the risk associated with a specified exposure to a noncarcinongenic contaminant, were 0.005 and 0.003, respectively, for the child and adult consumers in the scenario (Table 4-1). These quotients are considerably below the reference value of one, indicating that the likelihood for significant chronic effects from the consumption of contaminated ducks in the offsite hunter scenario is very low.

TABLE 4-1
Noncancer Risks in Offsite Duck Hunter Scenario

	White Phosphorus Concentration (µg/g)	Meat Portion (g/meal)	Meals per year	Exposure (mg/kg/day)	Hazard Quotient
Child	0.12	90	23	7.5×10^{-8}	0.005
Adult	0.12	112	23	6.0×10^{-8}	0.003

Oral reference dose is 2×10^{-5} mg/kg-bw/day (from EPA's Integrated Risk Information System, 1996).
Additional assumptions:
Body weight: 36 kg for child and 70 kg for adult (from EPA *Risk Assessment Guidance for Superfund*, Vols. I and II, 1989).
0.5 percent of consumed ducks were those contaminated by white phosphorus at ERF.

On the basis of assumptions of the scenario, an adult would have to consume between 20 and 39 contaminated ducks each year, depending on the portion size consumed at each meal, before the EPA oral reference dose for white phosphorus would be exceeded. Because the ducks at the ERF represent a small fraction of the total ducks in Cook Inlet, this event appears to have very low likelihood.

EPA has classified white phosphorus as a D carcinogen, meaning that it is not classified for human carcinogenicity, on the basis of no available data for humans or animals. No cancer slope factor is available, and no cancer risk was calculated.

4.1.2 Onsite Recreation Scenario at ERF

Although prohibited, access to ERF is not prevented by physical barriers. Means of access to ERF are from Knik Arm or from upstream on the Eagle River. In addition, people on rafts or other boats on the river can enter ERF by going past the Route Bravo Bridge beyond the boat takeout, which is approximately 500 yards upstream from the bridge. Figure 4-1 shows the locations of Route Bravo Bridge and the ERF vicinity. Few trespassers have been observed in ERF in recent times.

For an upper-bound risk assessment for exposure to white phosphorus, it was assumed that intruders, a child and an adult, enter ERF for a few hours on each of 10 days in the summer, are exposed to an average white phosphorus concentration of 10 µg/g (which exceeds the mean values for all areas except Racine Island), and ingests 200 and 100 milligrams (mg) of sediment, respectively, at each visit. With these conservative assumptions, the calculated hazard quotients are 0.08 and 0.02, respectively, which are much less than 1, the value of concern. No cancer risk was calculated, as discussed in Section 4.1.1.

4.1.3 Uncertainties

The level of uncertainty in the risk results is a function of both site-specific characteristics and the risk assessment process in general. Site-specific contributions include the following:

- White phosphorus concentrations in tissue were available from a variety of sampling events over a period of several years, and little data were available for muscle, which would be the major tissue expected to be ingested by humans.

Figure 4-1 (8-1/2x11)

- Measured concentrations were assumed to be representative of the future, which likely overestimates the risk, given the likelihood of white phosphorus losses over time in areas of ERF that occasionally become dry.
- Several judgments, which were designed to be conservative and therefore will lead to an overestimate of the risk, had to be made for the exposure scenarios. Examples of these judgments are the number of potentially contaminated ducks that a hunter would consume and the time of exposure to white phosphorus at ERF in a year.
- The location and explosive potential of onsite UXO are not known.
- The parameter values may not accurately represent current or future conditions that may lead to an over- or underestimate of the risk. In particular, this scenario has not considered hunters who may subsist on duck during the hunting season. Their consumption rate may be up to 10 times greater than that assumed in the offsite hunter scenario. It should be noted, however, that the calculated hazard quotient was 0.001 for the adult consumer in the offsite hunter scenario, and an additional exposure factor of 10 times would still result in a hazard quotient substantially below one.

4.2 Ecological Risk Assessment

An ecological risk assessment was prepared to address the current and future potential impacts posed by white phosphorus contamination to the plants and animals of ERF in the absence of cleanup action. The effects of white phosphorus exposure to ducks and swans have been shown to be lethal. No other direct effects to wildlife or plants were identified. This subsection describes the background, approach, and conclusions of the ecological risk assessment.

The ecological risk assessment was conducted in three steps–problem formulation, analysis, and risk characterization–to determine whether white phosphorus particles in surface water and sediments at ERF may adversely affect local populations of ecological receptors. The assessment was consistent with the EPA framework document for ecological risk assessment and used previous reports and chemical data compiled during RI activities.

4.2.1 Ecological Problem Formulation

Studies at ERF conducted over several years provided detailed habitat surveys and information on relevant receptors (mainly ducks and swans). The previous studies had already established that particulate white phosphorus was the sole chemical of potential ecological concern (COPEC) within ERF.

A CSM was developed for ERF based on information provided in previous reports. A CSM provides a written or pictorial representation of an environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources through environmental media to receptors within the system. The CSM for exposure routes and pathways for sediment at ERF is shown in Figure 4-2.

Measurement and assessment endpoints were selected based on characteristics of the COPECs, sensitive receptors or indicator species, and the expected or observed ecological effects caused by the stressors. These biological and physical endpoints can be used to

Figure 4-2 (8-1/2x11)

evaluate remedial success and to guide remedial decisionmaking to protect animals, plants, and their habitat in ERF and nearby Knik Arm.

Areas of potential ecological concern (AOPECs) were chosen based on physical characteristics that corresponded with maximum exposure of waterfowl to white phosphorus or because of their proximity to areas that were known to be contaminated and that waterfowl preferred for feeding habitat. Ponded areas were determined to be AOPECs because they are preferred feeding habitat for dabbling waterfowl. On the basis of earlier studies, these areas include sedge marsh, permanent ponds, and intermittent ponds. The geographical areas of highest potential ecological concern are Areas A , C, and C/D; Bread Truck; and Racine Island, as well as nearby sedge marshes.

The CSM for ERF showed that the primary exposure pathway is by incidental ingestion of white phosphorus particles contained within shallow pond sediments by dabbling ducks when they feed. In deeper ponds, swans are exposed to white phosphorus in a similar manner. Direct ingestion of the white phosphorus particles occurs because birds regularly feed in habitats where white phosphorus is found. These birds either confuse the white phosphorus particles with their natural food items (such as invertebrate larvae or plant seeds) or accidentally ingest the particles along with pond sediments.

Of all bird species observed at ERF, three species of dabbling ducks (mallard, northern pintail, and green-winged teal) have accounted for nearly 97 percent of all bird mortality. These three duck species are considered to be primary ecological receptors that feed mainly in shallow ponds. Swans feed in deeper water habitats than those used by the dabbling ducks and also are considered to be primary ecological receptors. Because minimal shorebird deaths have been discovered during the years of mortality studies in ERF, these receptors have been ranked as having a moderate hazard probability. Shorebirds have less exposure to white phosphorus because they feed in areas that periodically dry (which allows the white phosphorus to sublimate) and they select organisms from the sediment rather than sifting though the sediment or uprooting vegetation like dabbling ducks (and therefore are less likely to ingest nonfood particles).

4.2.2 Ecological Risk Analysis

The analysis phase consists of two main components: (1) characterization of exposure and (2) characterization of ecological effects. Conservative assumptions were used in estimating potential exposure and effects to the selected indicator species.

Exposure Assessment.

Information used to evaluate potential ecological exposures at ERF includes characterization of the ecosystem, evaluation of tissue concentrations of white phosphorus in biota collected at ERF, and in situ and laboratory analysis of potential exposure to white phosphorus in environmental media from the different areas at ERF. The potential receptors that were considered for ERF included aquatic vegetation, aquatic invertebrates, fish, and birds, as well as their consumers.

Investigations at ERF determined that aquatic plants growing within contaminated sediments contained low levels of white phosphorus in plant roots, but no white phosphorus in plant tissue. Therefore, the risks to grazing animals from plant consumption are very low when compared to incidental ingestion of the sediment containing white phosphorus particles. No observed mortality of geese and wigeons, waterfowl that feed mainly on vegetation, supports this conclusion.

White phosphorus impacts to aquatic invertebrates and fish were investigated in separate studies. In general, the population diversity of benthic macroinvertebrates was not affected by white phosphorus contamination under field conditions, even though representative aquatic species were shown to be sensitive to white phosphorus in laboratory tests. Sampling and analysis of ERF macroinvertebrates and fish did not reveal significant accumulations of white phosphorus that would constitute a significant risk for birds or mammals who eat them.

Secondary receptors include predators and scavengers such as the bald eagle, herring gull, raven, wolf, coyote, and fox. Studies of activities and potential risk related to scavengers and predators indicated a potential for indirect impacts from white phosphorus exposure through consumption of dead and moribund white phosphorus-contaminated waterfowl. Evidence of direct impacts on scavengers and predators (through direct ingestion of white phosphorus-contaminated sediments) was not confirmed by field studies.

Although the uptake of white phosphorus by predators is rapid, the potential for bioaccumulation in the food chain may be limited because of rapid loss of white phosphorus upon reduction of dose, as seen in laboratory tests. No white phosphorus was detected in the leg muscle of a coyote collected from behind the Canoe point tower in the woods closer to ERF. White phosphorus was detected in one dead eagle collected in ERF; however, the cause of death could not be determined.

The above studies of various ERF biological components have shown that the most significant white phosphorus impacts are occurring to bird populations. Dabbling ducks, such as northern pintails, mallards, and green-winged teal, and swans (trumpeter and tundra) are the most affected species, as indicated by their high mortality at ERF. Mortality of dabbling ducks has been concentrated in areas of ERF where suitable pond habitat is located. White phosphorus measured in tissue samples from field-collected ducks (such as mallards, pintails, and teal) and swans that had been exposed to in situ white phosphorus showed similar or higher white phosphorus concentrations than corresponding tissues of mallards in toxicological feeding studies.

Effects Assessment.
The ecological effects assessment evaluated the cause-and-effect relationships between white phosphorus and waterfowl through an evaluation of field studies and laboratory toxicity studies as well as literature on the ecological effects of white phosphorus.

Waterfowl mortality studies were completed by counting duck carcasses along permanent transects in ERF and in the surrounding woods. The studies found that eagle predation and scavenging of white phosphorus-affected ducks and carcasses are much more prevalent in spring than in fall. Some ducks are consumed where they are captured, and some are carried to other locations. The spring duck mortality rate dropped from 1992 to 1995. The declining mortality rates in fall were attributed to the implementation of hazing (use of visible objects and mechanized sounds to intentionally deter waterfowl from entering an area) in the most contaminated areas, lack of suitable foraging habitat, and reduction of available white phosphorus. Because mortality transects were not evaluated during the 1996 field season, the effect of the lack of hazing on duck mortality was not evaluated by using transects. Although field studies did not establish a reliable estimate of bird mortality in the reference areas of UCI, the mortality rate in ERF is likely much higher than the background mortality rate in reference areas.

Daily movements, habitat preference, turnover rates, site-specific exposure, and mortality of birds in ERF were studied with radio telemetry studies conducted from 1993 to 1996. Radio-transmitted ducks and eagles were used in the telemetry studies. ERF duck habitat preference during nonhazing periods indicated that the two most commonly used habitats were sedge marshes and the permanent ponds (at 28.7 and 11.4 percent, respectively). Other habitat types such as Ramenski's sedge, halophytic herb, interior sedge, and intermittent ponds had progressively lower duck use percentages. Turnover rate among the ERF ducks was high; the average length of stay was 12.5 days. Mortality of radio-equipped ducks on ERF was 35 percent in 1996. Mallard mortality exceeded proportional area use in ERF Areas C and C/D, Racine Island, and Bread Truck Pond. Duck deaths were recorded for each year. None of the 31 radio-equipped bald eagles died from white phosphorus exposure.

The USFWS conducted aerial bird population surveys of ERF during spring, summer, and fall (April through October) from 1989 through 1997 as part of ongoing water bird studies. The objective of these surveys was to monitor bird abundance and distribution in ERF during spring, summer, and fall. Waterfowl were counted or estimated and recorded by species or species group.

Laboratory and field toxicity tests of birds (primarily mallards) and aquatic macroinvertebrates were conducted to determine acute and chronic toxicity as well as potential effects to secondary receptors. A target white phosphorus concentration in sediment at ERF was not established for the following reasons. Because white phosphorus occurs in particulate form in ERF, its uneven distribution, caused by deposition by munition rounds, creates considerable uncertainty for sampling and quantification. Actual dosage to waterfowl from sediment is affected by the suitability of the feeding habitat (such as water depth) and the relative efficiency of each species in locating and ingesting white phosphorus particles of different sizes during feeding.

Birds.

Various types of toxicity tests were conducted to determine the lowest dose of white phosphorus resulting in mortality (5.2 mg/kg bw) and the lethal dose for 50 percent of a sample population (LD_{50}) (4.05 to 6.4 mg/kg bw) for mallards. A lowest observed effect level (LOEL) based on mortality was estimated for particles of white phosphorus to be between 3 and 4 mg/kg-bw/day, and a LOEL based on sublethal effects (liver, kidney, and heart tissue damage) would be less than 2 mg/kg-bw/day. Preliminary reproductive studies indicated that hens exposed to sublethal levels of white phosphorus have reduced reproductive output and embryos with teratogenic deformities, including scoliosis, lordosis, submandibular edema, microphthalmia, and spina bifida. Toxicological effects in birds tested under laboratory conditions were similar to those observed in field toxicity tests.

Histopathological changes were observed in the liver, spleen, heart, and duodenum (small intestine) in some birds treated with white phosphorus. The combination of changes in some blood chemistry indicators (such as blood urea nitrogen, potassium, lactate dehydrogenase, glucose, hematocrit, and hemoglobin) could be used as an indicator of possible white phosphorus exposure. Test results for repeated subchronic exposures indicated that mortality and histopathologic effects (liver and kidney damage) were consistent with acute exposures from single doses at similar concentrations.

The results of studies of white phosphorus toxicity for secondary receptors indicated that the greatest risk was through ingestion of portions of the digestive tract that contained pelletized white phosphorus. For example, a duck gizzard could have more than 100 times the white phosphorus dose compared to other tissues. Although the uptake of white phosphorus by predators is rapid, the potential for bioaccumulation in the food chain may be limited because of the rapid elimination of white phosphorus seen upon reduction of dose in laboratory tests. Bioaccumulation and toxicity could be significant if the ingested dosage exceeds the degradation rate of the receptor. These studies indicate that predators could be exposed to harmful doses of white phosphorus, which could result in sublethal effects such as decreased reproductivity or survival. However, the absorption, distribution, and metabolism of white phosphorus within an individual species results in a low likelihood that white phosphorus is being transferred within the food web.

Macroinvertebrates.
Laboratory toxicity tests and field studies of aquatic biota were conducted to determine acute toxicity (lethal concentration for 50 percent of sample population) and chronic toxicity (no observed effect level [NOEL]) of white phosphorus in sediment, as well as impacts on the community structure of benthic macroinvertebrates. Toxicity tests indicated that sediments from Racine Island were not toxic to organisms living in them in the field, but were toxic to laboratory organisms at diluted concentrations. *Chironomus riparius* was more sensitive to white phosphorus than *Hyallela azteca*, and the lowest NOELs were 26 micrograms per kilogram (µg/kg) and 1,500 µg/kg, respectively. The community structure of benthic macroinvertebrates within ERF did not appear to be affected by white phosphorus concentrations in sediment or surface water.

4.2.3 Ecological Risk Characterization

In this part of the risk assessment, the likelihood of adverse ecological effects occurring as a result of exposure to white phosphorus in ERF is evaluated. Risk characterization consists of two steps: (1) risk estimation and (2) risk description. For the ecological risk assessment, waterfowl mortality was considered to be the only significant effect of white phosphorus on ecological resources at ERF.

Area characteristics such as habitat (vegetation, landform, pond), white phosphorus concentrations, and duck use were combined in the GIS database to identify areas where all these factors exist together (overlap) that could be considered as a hot area. Other areas were included because of their proximity to known white phosphorus-contaminated area and because they contain preferred feeding habitat for dabbling waterfowl. The geographical areas of highest potential ecological concern are Areas A , C, and C/D; Bread Truck; and Racine Island, as well as nearby sedge marshes. Dying waterfowl or carcasses have been collected from all these areas. Comparison of white phosphorus levels in various tissues of these ducks showed higher than the corresponding maximum tissue concentrations for mallard white phosphorus toxicity studies, indicating that the ducks ingested enough white phosphorus in ERF to result in mortality.

Duck mortality studies show that the largest proportions of dead or dying ducks in ERF were observed in Area C (37 percent), Racine Island (22 percent), Area A (22 percent), Bread

Truck (12 percent), and Area C/D (6 percent). Of these areas, only Area A did not contain confirmed or identified hot areas for white phosphorus exposure. Dead swans also were observed in Area C (44 percent), Areas A and D (25 percent), and Area C/D (6 percent). No observations of dead or dying birds in the coastal areas (east or west) were recorded in the GIS database. Plant, fish, and invertebrate sampling and white phosphorus analysis from these hot areas did not show significant uptake of white phosphorus.

Duck use of the various areas used in the telemetry studies was estimated by using the telemetry observations during periods when hazing was not occurring. The results indicated relative use by ducks as follows: Area C, 22 percent; Coastal East, 16 percent; Area C/D, 14 percent; Area B, 10 percent; Bread Truck, 7 percent; Area A, 7 percent; Coastal West, 5 percent; Area D, 4 percent; and Racine Island, 3 percent. Comparison of duck mortality to duck use indicates that highest mortality occurs in Area C, Bread Truck, and Racine Island.

Of the three habitat types considered to be preferred by ERF waterfowl, the following percentages of total habitat areas were found in the white phosphorus-contaminated ERF areas (C and C/D, Bread Truck, and Racine Island): permanent ponds, 29 percent; intermittent ponds, 19 percent; and sedge marsh, 51 percent.

The actual percentage of utilization by waterfowl in these white phosphorus-contaminated ERF areas (as indicated by telemetry observations during non-hazing periods) was higher than would be indicated by the relative proportion of those habitats based on area: permanent ponds, 47 percent; intermittent ponds, 31 percent; and sedge marsh, 54 percent. (These percentages are calculated independently by area; they are not expected to add up to 100 percent.)

When the waterfowl utilization of the hot spots was compared to waterfowl utilization for all of ERF (rather than limiting the comparison to the three preferred habitat types only), the percentage of waterfowl utilization was much lower: permanent ponds, 5.4 percent; intermittent ponds, 2.3 percent; and sedge marsh, 16 percent.

Comparison of bird use of ERF with overall bird use in UCI marshes was based on aerial surveys conducted during the 1995 field season. In general, about 3 to 5 percent of waterfowl (swans, geese, ducks) in UCI were found in ERF wetlands. Between 9 and 52 percent of UCI eagles were found to use ERF. The relative proportion of birds would be expected to vary from year to year.

Studies of duck mortality between 1993 and 1995 with telemetry indicated an average annual mortality rate of about 16 percent for ducks in ERF. However, mortality results from the 1996 study based on a larger sample of birds and without hazing indicated a mortality rate of 35 percent, a value that is probably more indicative of current risk at ERF without remediation.

Ecological Risk Summary.

The weight of evidence indicates that ingestion of white phosphorus particles by ducks and swans is the cause of most of the elevated waterfowl mortality in ERF. White phosphorus has been identified at elevated levels in the sediment of three areas of ERF: Area C, Bread Truck, and Racine Island. Area C/D is adjacent to these areas and also could have high levels of white phosphorus that were not detected because of the limited sediment sampling. Area A also may be of ecological concern because of its heavy use by waterfowl and documented duck mortality.

The significance of waterfowl mortality at ERF is given perspective by providing an estimate of the proportion of UCI waterfowl that are using ERF. Only a small percentage of UCI waterfowl (3 to 5 percent) may be using ERF (based on 1 year of surveys). If the estimated 35 percent in-ERF mortality rate from telemetry studies is accepted as indicative of current risk at ERF and it is assumed that approximately 5 percent of UCI waterfowl use ERF, the estimated percentage of UCI waterfowl affected by white phosphorus in ERF would be about 2 percent. Field studies have not established a reliable estimate of bird mortality in reference UCI marshes; however, mortality in ERF is much higher than background mortality in the reference areas.

Uncertainties associated with this assessment stem from the nature of the studies used to (1) characterize the ecosystem, (2) estimate white phosphorus concentrations in ERF biota tissues, and (3) characterize exposure of ERF biota to white phosphorus contamination. Limitations of aerial and ground bird census methods contribute to the uncertainty associated with the ecosystem characterization. The actual cause of telemetry bird death was not always determined. Uncertainty in studies to estimate white phosphorus tissue concentrations was affected by live-versus-dead bird samples, uneven distribution of sample locations, lack of predator tissue samples, lack of tissue sample information, and variations in the tissues analyzed and the white phosphorus detection limits and analytical instrumentation. Uncertainty in the exposure analysis resulted from difficulties in sampling and quantification of white phosphorus because of a lack of sampling for white phosphorus in some areas and the irregular distribution of white phosphorus at ERF.

Estimates of uncertainty (or confidence intervals) were not provided in most previous studies. Uncertainties associated with the laboratory tests include intra- and inter-study variations, limitations of study design, and the ability to match laboratory conditions to those observed in the field. Additional uncertainties include the limitations of the bird mortality studies, such as the assumption that birds do not travel a significant distance after exposure before dying, the uneven distribution of mortality transects, and the accuracy of the ground survey counts used in calculating the mortality ratio. In addition, levels of white phosphorus in fish and invertebrates may have been below detection limits. The single largest source of error associated with comparison of ERF bird use to that of the UCI marshes was that the comparison was based on a single field season. Considerable variation from year to year already has been demonstrated in the ERF population studies.

SECTION 5

Description of Alternatives

5.1 Need for Remedial Action

If not addressed by implementing the response action selected in this ROD, the actual or threatened releases of hazardous substances resulting from white phosphorus contamination of the ERF source area of OU-C from exploded ordnances may present an imminent and substantial threat to public health, public welfare, or the environment.

The specific reasons for conducting remedial actions at OU-C are as follows:

- White phosphorus in the shallow ponded sediment of ERF has contributed to elevated waterfowl mortality.
- ERF is an important staging ground for migrating waterfowl during spring and fall migration.

5.2 Remedial Action Objectives

As part of the RI/FS process, remedial action objectives (RAOs) were developed in accordance with the NCP and EPA guidance for conducting RI/FS investigations. The primary objective of the remedial action is to reduce the number of waterfowl deaths attributable to white phosphorus.

Short and long-term RAOs for the remedial action at OU-C are as follows:

- Within 5 years of the ROD being signed, reduce the dabbling duck mortality rate attributable to white phosphorus to 50 percent of the 1996 mortality rate attributable to white phosphorus. Radio tracking and aerial surveys suggest that about 1,000 birds died from white phosphorus at ERF in 1996. Therefore, the allowable number of duck deaths from white phosphorus would be approximately 500.
- Within 20 years of the ROD being signed, reduce the mortality attributable to white phosphorus to no more than 1 percent of the total annual fall population of dabbling ERF ducks. Currently, that population is about 5,000. Therefore, the allowable number of duck deaths from white phosphorus would be approximately 50. This long-term goal could be adjusted based on future population studies conducted during the monitoring program.

These objectives will be achieved by reducing the area of white phosphorus-contaminated media and reducing the exposure to white phosphorus. Reducing the exposure to white phosphorus will reduce the availability of white phosphorus to ducks, which in turn will reduce duck deaths.

Monitoring through aerial surveys and radio telemetry at ERF will be conducted to ensure that RAOs are achieved. The goals of monitoring will be as follows:

- To ensure that an exposure pathway does not exist between white phosphorus-contaminated sediment and waterfowl
- To determine the number of waterfowl using ERF
- To determine the number of waterfowl dying as a result of feeding on white phosphorus-contaminated sediment
- To determine whether remedial action is effective or needs modification

5.3 Significant Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria

A full list of applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria is provided in Section 8. The following ARAR and TBC criterion, respectively, are the most significant regulations that applied to the remedy selections for ERF:

- Section 404 of the Clean Water Act (CWA), which coincides with Alaska water quality standards, for protection of wetlands
- Provisions in the Migratory Bird Treaty Act of 1918 that prohibit unregulated “taking” of birds, including poisoning at waste sites

5.4 Description of Alternatives

Many technologies were considered to clean up the white phosphorus-contaminated sediment at OU-C. Appropriate technologies were identified and screened for applicability to site conditions. The potential technologies were then assembled into alternatives. Potential remedial alternatives for OU-C were identified, screened, and evaluated in the FS.

With the exception of Alternative 1, the following ERF-wide monitoring activities would be conducted throughout all of ERF: a telemetry study of mallard movement and mortality, aerial bird population surveys, and aerial photography of physical changes in habitat. The changes in physical characteristics that are of interest include drainage, topography, and vegetation. Some vegetation differences can be detected with the use of photography that uses varying wavelengths, but some ground truthing and revisiting of study plots also would be required.

In addition to the monitoring activities, hazing would be used as necessary in ERF to deter waterfowl during critical migration periods. Hazing involves the use of visible objects and sounds to deter waterfowl from using an area, thereby preventing exposure to white phosphorus. Visual, acoustic, and behavioral devices have been used throughout ERF to deter birds from contaminated areas.

The activities described above are referred to as ERF-wide activities.

The alternatives evaluated in the FS and the Proposed Plan are described in the following paragraphs. All alternatives include the use of institutional controls to control access. The Army restricts entry by maintaining a locked gate at the entrance to OU-C, posting signs next to Eagle River for boaters, and regulating admission to OU-C through the Range Control.

Alternative 1: No Action

CERCLA requires evaluation of a no-action alternative as a baseline reflecting current conditions without any cleanup effort. This alternative is used for comparison to each of the other alternatives and does not include monitoring.

Published studies suggest that several natural processes occurring at ERF may lead to some natural restoration over time. These processes include white phosphorus sublimation and oxidation, gully advancement that leads to natural pond draining and the sublimation and oxidation of white phosphorus, and the covering of white phosphorus with sediment (called sedimentation). Because no monitoring would occur under Alternative 1, the effects of the natural processes on the white phosphorus in pond sediments and its toxic effects on waterfowl that use ERF would not be known. No costs would be associated with this alternative.

Alternative 2: Detailed Monitoring

No treatment technologies would be implemented in Alternative 2. Only natural processes such as gully recession, sedimentation, and white phosphorus sublimation and oxidation would continue at ERF. However, under this alternative extensive, active monitoring for these natural processes would be performed to understand whether natural processes are occurring and to determine the level of protection for the environment that is achieved.

Alternative 2 expands on the ERF-wide activities currently planned for the entire ERF. It adds the activity of monitoring ERF to determine whether natural restoration is occurring and at what rate. Monitoring would include additional aerial photography, measurement of net sedimentation, and an elevation survey. Aerial photography would measure pond changes and gully recession. Net sedimentation measurements would determine whether exposure pathways between contaminated sediment and waterfowl are being broken. The elevation survey of ground surface and pond bottoms would determine pond interconnectiveness and flooding potential.

In addition, baseline monitoring of white phosphorus in sediment would be performed by using a composite sampling method to determine current white phosphorus levels. This monitoring would help identify areas with white phosphorus contamination and provide baseline information. Limited monitoring of sublimation and oxidation conditions would be performed to detect whether conditions have been suitable for white phosphorus sublimation and oxidation. Verification sampling of white phosphorus also would be performed to confirm the success of this alternative if the pond conditions have been sufficient to expect substantial white phosphorus sublimation / oxidation and loss.

The estimated time frame for cleanup goals to be achieved is between 10 years and more than 50 years, depending on the portion of ERF.

Detailed monitoring would be conducted for 20 years or until it is consistently demonstrated that remedial goals are achieved. The estimated 20-year present-worth cost of this alternative is $5,850,000, which includes $150,000 for capital costs and $286,000 per year for annual monitoring.

Alternative 3: Pumping with Capping and Filling

The objective of this alternative is to temporarily drain ponds to allow the pond sediments to dry and allow white phosphorus to sublimate and oxidize. This alternative consists of draining ponds by pumping after flooding cycles and/or rain. After several drying periods and verification sampling (approximately 5 years), capping and filling would be performed in areas where white phosphorus remains.

This pumping technology was tested during the summer 1997 pond pumping treatability study. Baseline and verification sampling was performed before and after pumping. During the summer of 1997, baseline and verification samplings showed an 80 percent decline in white phosphorus concentrations in the top 3.5 inches of sediments.

In each pond system, a dedicated pump system would be installed annually after spring breakup and would be removed before the winter freeze. The typical useful drying season is mid-May to mid-September. Pumped water would be discharged to an adjacent unconnected pond, river, gully, or open area. Mounted on floats, each pump system would be completely automated to start and stop at established elevations of pond surface. Scheduled maintenance service and refueling would be required. Figure 5-1 provides an illustration of a floating pump system.

To create holes for placement of the pumps and short ditches for drainage from the pumps, minor use of explosives may be included in this alternative. The affected areas would be very small, and impacts would be minimal and temporary.

The pump systems are expected to operate for 5 consecutive years, based largely on tide predictions. Tidal fluctuations affect the ability of the ponds to dry. This alternative includes baseline (before the pumping season) sampling of white phosphorus to confirm the ponds requiring cleanup and verification (after the pumping season) sampling to confirm that white phosphorus has sublimated and oxidized or to determine areas that require further cleanup.

Although Alternative 3 includes the ERF monitoring and hazing activities, it does not include the extensive natural process monitoring described for Alternative 2. Baseline and verification sampling of white phosphorus is expected to continue annually for 5 years.

After 5 years of pumping and monitoring, those pond systems where white phosphorus exposure remains a concern would be capped and filled. A composite material would be applied to areas of the pond systems that do not dry and still contain white phosphorus. These areas generally will be isolated and will contain deep depressions that are not connected hydraulically to other portions of the pond system being drained. The cap-and-fill material is a manufactured gravel and bentonite mixture called AquaBlok™. This material expands in water, sealing spaces in gravel and creating a barrier to permeability. It will be applied only to small, deep portions of the pond bottoms. Therefore, despite its swelling characteristics, it is not expected to significantly change feeding habitat or overall

Figure 5-1

pond depths. This material also supports vegetation growth. It provides a barrier between the dabbling waterfowl and the sediment contaminated with white phosphorus.

During treatability studies at ERF, the cap-and-fill material was applied from a helicopter. The application was similar to spreading fertilizer. Areas where capping and filling would be performed would be inspected regularly for integrity and thickness. Following application, restoration of the pond systems would occur naturally through precipitation and tidal flooding. Figures 5-2 and 5-3 show helicopter and truck applications of cap-and-fill material.

Temporary pumping is expected to be conducted for 5 years or until it is consistently demonstrated that remedial goals are achieved. Minor capping and filling then would be performed in small unremediated ponded areas, where necessary. ERF-wide activities (monitoring) would be performed for the first 8 years of the remedy and then during Year 10, Year 15, and Year 20 to ensure that remedial goals are consistently maintained. On the basis of these assumptions, the estimated 20-year present-worth cost of this alternative is $5,685,000, which includes $251,000 for capital costs (additional pumps) and $272,000 per year for operation and maintenance, which cover monitoring.

Alternative 4: Breaching and Pumping with Capping and Filling

The objective of this alternative is to breach ponds, allowing water to flow out and the sediments to dry. Breaching would be done by using explosive charges. Breaching results in the permanent removal of duck habitat.

Figure 5-2

Figure 5-3

Alternative 4 includes the use of explosives to create a ditch from a hot pond (or pond system) to Eagle River or a nearby gully or creek that ultimately would permit the water to drain into Cook Inlet. Areas that do not drain through the breached gully then would be drained with the pump system that is described for Alternative 3. For example, the elevations of some pond bottoms may be lower than the breached gully elevation, and a pump would be needed to fully drain water from the ponds and dry the sediments. Finally, areas that do not dry sufficiently would be capped and filled as described above. Although breaching allows large volumes of water to be drained quickly, it also lowers the threshold elevation and allows a breached pond system to be reflooded often with lower tides.

Use of explosives would occur in March, when ERF is frozen and access is easier. It is expected that explosives would be strategically placed to create a 20-foot-wide, 6-foot-deep ditch. Pumping operations would be similar to those for Alternative 3, but would require smaller pumps because most of the water is expected to be drained through the breached gully system. The drying season also would be the same as described under Alternative 3.

Breaching considerations would include preference of gullies that naturally progress toward pond systems, the shortest possible drainage route, and the shallowest possible ditch. These criteria would minimize negative effects on existing habitat.

Pond breaching would be conducted within the first year of the ROD being signed and would be followed by 8 years of pumping ponds that do not drain. Remedial goals are expected to be achieved in a longer time than under Alternative 3 because the lower breached threshold elevations would result in increased tidal flooding sequences. Additional years for pumping would be needed because breached ponds would be flooded more often, resulting in a lower rate of sublimation and oxidation.

Baseline (before pumping season) and verification (after pumping season) sampling will be performed every year for 8 years. Minor capping and filling then would be performed in small unremediated ponded areas, where necessary. Application of the cap-and-fill material would be similar to that for Alternative 3 and would require the same follow-up inspection. ERF-wide activities (monitoring) would continue to be performed after pumping is complete for the duration of the remedy to ensure that remedial goals are consistently maintained. Alternative 4 does not include the extensive natural process monitoring performed under Alternative 2. On the basis of these assumptions, the estimated 20-year present worth costs of this alternative is $9,132,000, which includes $2,064,000 for capital cost (mostly explosives and additional pumps) and $353,000 per year for operation and maintenance, which cover monitoring.

Alternative 5: Capping and Filling

The objective of this alternative is to cap and fill portions of hot ponds where the presence of white phosphorus has been identified. As mentioned under the discussion of Alternative 3, capping and filling prevents white phosphorus ingestion by ducks. Alternative 5 is particularly well suited for areas that cannot be drained or dried. Unlike the limited applications proposed under Alternatives 3 and 4, capping and filling under Alternative 5 would cover the entire pond systems. Because of the swelling characteristics of the cap-and-fill material, pond bottom elevations likely would be raised, and in some cases, shallow ponds would be filled.

Implementation is expected to take 1 year. The cost of applying cap-and-fill material by helicopter is high. Truck application is about twice as fast as application by helicopter, and the equipment cost for trucks would be as much as one-tenth the cost for helicopter application. Therefore, where capping and filling is required over larger areas, the applications likely would be by vehicles on wheels or tracks during winter. The use of vehicles would require driving heavy equipment on the frozen ground to transport the material. Transport to and spreading at the ponds would be done when ice thickness is sufficient to support the weight without damage to the ground surface. At some ponds, the cap-and-fill material could be spread in a slurry in the spring.

Cap and fill material would be placed within the first 3 years after the ROD being signed, followed by up to 20 years of monitoring to demonstrate that remedial goals are achieved. Alternative 5 includes the ERF-wide activities, as well as baseline sampling for white phosphorus and inspection of the integrity of areas where capping and filling is performed. However, Alternative 5 does not include the extensive natural process monitoring under Alternative 2. The estimated 20-year present worth cost of this alternative is $6,165,000, which includes $2,694,000 for capital costs (cap-and-fill material and application) and $174,000 per year for operation and maintenance, which cover monitoring.

SECTION 6

Summary of Comparative Analysis of Alternatives

The selection of alternatives was based on an evaluation using the nine CERCLA criteria specified in Table 6-1. The first two criteria are known as threshold criteria that must be met by all selected remedial actions. The following five criteria are known as balancing criteria, and the final two criteria are referred to as modifying criteria.

TABLE 6-1
Criteria for Evaluation of Alternatives

THRESHOLD CRITERIA: Must be met by all alternatives.

1. **Overall protection of human health and the environment.** How well does the alternative protect human health and the environment, both during and after construction?
2. **Compliance with requirements.** Does the alternative meet all applicable or relevant and appropriate state and federal laws?

BALANCING CRITERIA: Used to compare alternatives.

3. **Long-term effectiveness and permanence.** How well does the alternative protect human health and the environment after completion of cleanup? What, if any, risks will remain at the site?
4. **Reduction of toxicity, mobility, and volume through treatment.** Does the alternative effectively treat the contamination to significantly reduce the toxicity, mobility, and volume of the hazardous substances?
5. **Short-term effectiveness.** Are there potential adverse effects to either human health or the environment during construction or implementation of the alternative?
6. **Implementability.** Is the alternative both technically and administratively feasible? Has the technology been used successfully at similar areas?
7. **Cost.** What are the relative costs of the alternative?

MODIFYING CRITERIA: Evaluated as a result of public comments.

8. **State acceptance.** What are the state's comments or concerns about the alternatives considered and about the preferred alternative? Does the state support or oppose the preferred alternative?
9. **Community acceptance.** What are the community's comments or concerns about the alternatives considered and the preferred alternative? Does the community generally support or oppose the preferred alternative?

6.1 Threshold Criteria

6.1.1 Overall Protection of Human Health and the Environment

Alternatives 1 and 2 are not protective of the environment and, therefore, will not be further evaluated in this ROD. Risk reduction by natural processes may take from 10 to more than 20 years.

The levels of protection to the environment provided by Alternatives 3 and 4 would be significantly higher. White phosphorus-contaminated sediment would be actively treated through draining, and the exposure pathway between untreated sediment and waterfowl would be blocked with cap-and-fill material. Cap-and-fill material would be applied only to small depressions. Therefore, despite the swelling potential of the material, overall pond bottom depths and feeding habitat are not expected to change significantly from impacts of the cap-and-fill material under Alternatives 3 and 4. No adverse impacts from the cap-and-fill material were observed during previous treatability studies. In addition, the limited application of this material under Alternatives 3 and 4 is expected to preclude significant habitat changes.

Although Alternative 4 would treat and remove white phosphorus, it also would cause permanent large-scale changes to pond habitats. Ponds that were originally waterfowl feeding habitats would be permanently removed. In addition, after long periods of drying, vegetation would die and rebound would be unlikely.

Alternative 5 would provide protection by blocking the exposure pathway with a barrier material; however, it does not treat or remove the white phosphorus. Alternative 5 also would result in changes to habitat because the cap-and-fill material would cover the entire pond system and the elevations of pond bottoms would be raised. In some cases, shallow ponds would be filled entirely.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

A significant ARAR that applies to the OU-C site is Section 404 of the CWA, for protection of wetlands. The Migratory Bird Treaty Act of 1918 is a TBC that prohibits unregulated “taking” of birds.

All state ARARs would be met by Alternatives 3, 4, and 5. These alternatives include active treatment and/or covering of white phosphorus-contaminated sediment to prevent waterfowl exposure.

All federal ARARs would be met by Alternatives 3 and 5. However, Alternative 4 would not meet Section 404 of the CWA, in that this alternative would permanently destroy wetland habitat.

6.2 Balancing Criteria

6.2.1 Long-term Effectiveness and Permanence

Alternatives 3 and 4 would involve treatment and removal of the white phosphorus contamination through sublimation and oxidation and, therefore, would provide long-term effectiveness and permanence. Residual risk of future exposure to white phosphorus would remain in some small areas because capping and filling would not treat and remove white phosphorus. Under Alternatives 3 and 4, cap-and-fill material would be applied to areas of pond bottoms that do not dry.

It is expected that draining ponds by pumping and breaching (Alternatives 3 and 4) would alter, and in some cases temporarily or permanently destroy, some wetlands at ERF. Alternative 4 would have the most destructive impact on wetlands, because it would permanently eliminate habitat. Under Alternative 3, impacts to the ERF wetlands habitat would be temporary. Under both Alternatives 3 and 4, the protective procedures for conducting activities that may disturb wetlands would be established and followed during the cleanup to minimize impacts. These protective procedures include: (1) pumping restrictions in Area B and Area D, which are prime waterfowl habitat; (2) selection of the narrowest and shortest walking corridors to minimize disturbances to vegetation and habitat; (3) proper maintenance of equipment and structures; (4) minimization of equipment and staging area footprints; (5) minimal localized use of explosives; (6) preparation of work plans and solicitation of agency review; (7) monitoring for impacts to wetlands habitat; and (8) monitoring for waterfowl use of ERF.

Alternative 5 would not provide permanent removal of the white phosphorus, but it would block the exposure pathway. Residual risk, which is risk resulting from contaminants that remain after treatment is complete, would remain in the entire area of the pond that is covered under Alternative 5. Residual risk remains because capping and filling does not actively treat and remove the white phosphorus in sediments; instead, capping and filling only prevents exposure of ducks to white phosphorus-contaminated sediment. The white phosphorus would remain below the cap-and-fill material. The remaining residual white phosphorus would still be present, just not accessible.

6.2.2 Reduction of Toxicity, Mobility, and Volume Through Treatment

Alternatives 3 and 4 would treat the largest area of white phosphorus-contaminated sediment by reducing water level, drying pond sediment, and causing white phosphorus removal by sublimation and oxidation. Residual risk is expected to be low under Alternatives 3 and 4, as demonstrated in treatability studies. Alternative 5 does not involve treatment to reduce toxicity and volume of white phosphorus-contaminated sediment, although it would prevent exposure by reducing the mobility of white phosphorus. Residual risk would be highest under Alternative 5, because contaminated sediment would be only covered and not treated.

6.2.3 Short-term Effectiveness

It is estimated that the cleanup objective of reducing duck deaths by 50 percent in 5 years would be met by Alternatives 3 and 4. RAOs would be achieved faster under Alternative 3, but exposure would be reduced more slowly. The slower removal of exposure would occur under Alternative 3 because bird habitat would still be available until all pond water is removed by pumps. Once the water is removed (1 week), the pond would remain dry and would only become wet again during heavy rains or high tides. Although the threshold elevation of breached ponds would be lowered under Alternative 4 to allow a large volume of water to initially drain to Eagle River, the ponds then would flood more frequently during lower tides. The frequent refilling of the pond system under Alternative 4 would not allow pond sediment to dry quickly. Therefore, 5 years of pumping would be needed for cleanup under Alternative 3, as opposed to 8 years of pumping under Alternative 4.

The criterion of short-term effectiveness also would be met under Alternative 5, when capping and filling were completed. Application of cap-and-fill material throughout ERF is estimated to take a total of 2 to 3 weeks and would occur within the first 3 years of remedy implementation.

Alternatives 4 and 5 may result in permanent changes, and Alternative 3 would result in temporary changes to pond bottoms, habitat, and bird use. The limited application of cap-and-fill material in Alternative 3 is not expected to result in large-scale permanent habitat changes. Short distances of vegetation or uneven topography may restrict water movement within and between ponds. To enhance draining of the ponds, Alternative 3 also may include limited use of explosives to clear small drainage channels that radiate from the pump location. The effects from use of explosives to create the small drainage channels is expected to be very short term.

All alternatives would pose some short-term potential risk to onsite workers during monitoring activities and during setup, operation and maintenance, and removal of monitoring and cleanup equipment. These potential risks could be minimized by engineering and institutional controls. The most significant risk to workers is from the existence of UXO at ERF. To reduce this risk, all areas where workers would be exposed would be cleared of unexploded ordnance either visually or electronically.

The community would not experience any significant effects from the alternatives. The explosions produced for pond breaching in Alternative 4 may affect the community through impacts such as noise and vibration. Use of explosives on clear weather days would reduce these impacts (cloud cover reflects and emphasizes sounds from explosions), and a community relations program would be used to alert the public in advance of these activities.

6.2.4 Implementability

Alternatives 3 and 4 would use readily available technologies and would be feasible to construct and operate. Treatability studies of pond breaching and pond pumping were successfully conducted in the summers of 1996 and 1997. Alternative 5, which includes a containment technology only, also would use readily available materials. Minor technical difficulties are anticipated during application of cap-and-fill material because of the presence of craters throughout ERF. Visual inspections of caps to assess their integrity would be performed under Alternatives 3 through 5.

Alternatives 3 through 5 involve UXO ordnance hazards to onsite field personnel. Steps previously described, including having work areas and pathways cleared by unexploded ordnance specialists, would be taken to minimize risk.

6.2.5 Costs

The estimated costs for each alternative evaluated are provided in Table 6-2. The estimates are based on the information available at the time the alternatives were developed. The costs projected over 20 years are estimated for purposes of comparison and are considered to be accurate to within -30 percent to +50 percent. Costs are described by using the present-worth methodology with a discount rate equal to 5 percent. Capital cost includes the purchase price of the pumps, monitoring equipment, cap-and-fill material, and explosives. It also covers the labor and transportation associated with initial setup of equipment.

Annual operation and maintenance cost includes startup and dismantling activities, routine maintenance, refueling, pump system setup and removal, and annual monitoring. Also included are the activities conducted in the entire ERF and sampling of sediments for white phosphorus. In addition, annual operation and maintenance cost covers labor,

TABLE 6-2
Cost Estimate for Cleanup Action Alternatives

Location	Capital Cost ($000)	Average Annual O&M Present Worth ($000)	20 Year O&M Present Worth ($000)	Total Cost–20 Year O&M ($000)
Alternative 1–No Action	0	0	0	0
Alternative 2–Detailed Monitoring	150	286	5,700	5,850
Alternative 3–Pumping with Capping and Filling	251	272	5,434	5,685
Alternative 4–Breaching and Pumping with Capping and Filling	2,064	353	7,068	9,132
Alternative 5–Capping and Filling	2,694	174	3,471	6,165

Notes:
O&M = Operation and maintenance
Average = The 20-year present-worth O&M cost divided by 20.

Present worth means costs are expressed as U.S. dollars in 1998. The amount indicates moneys needed in 1998 dollars to complete the project over 20 years. The majority of these costs will be used to achieve the 5-year cleanup goal. A discount rate of 5 percent is used.

Costs include ERF-wide long-term monitoring and contingency hazing.

transportation, and clearance of work areas by UXO specialists associated with these activities.

Under Alternative 4, costs do not include restoring breached ponds to reestablish habitat.

6.3 Modifying Criteria

6.3.1 State Acceptance

The State of Alaska has been involved with the development of remedial alternatives for OU-C and concurs with the Army and EPA in the selection of Alternative 3.

6.3.2 Community Acceptance

Community response to the preferred alternative was generally positive. Community response to the remedial alternatives is presented in the Responsiveness Summary in Appendix B, which addresses comments received during the public comment period.

SECTION 7

Selected Remedy

Alternative 3 is the selected alternative for treating white phosphorus-contaminated sediment at OU-C. It is the least expensive of the treatment-oriented alternatives. A thorough assessment of alternatives considered current risks, residual risks, impacts to habitat, and costs. Alternatives 1 and 2 were eliminated because they did not satisfy threshold criteria. Although Alternative 4 would actively treat a large portion of the ERF, it does not meet overall protection of the environment or ARARs because it permanently removes wetlands. Alternative 5, capping and filling does not provide reduction in contamination through treatment, and would leave a large amount of residual risk.

Protection of human health and the environment and compliance with ARARs will best be attained through pond draining with pumping, ERF-wide monitoring activities, and institutional controls.

7.1 Major Components of the Selected Remedy

The major components of the preferred remedy for OU-C are listed below. It is assumed that implementation of the remedy will begin in 1999 and end in 2018 (duration of 20 years). The sequence and schedule of operation and maintenance activities are presented in Tables 7-1 and 7-2, respectively.

- Treat white phosphorus-contaminated sediment by draining ponds with pumps for five summers beginning in 1999. Pumping would allow the sediments to dry and the white phosphorus to sublimate and oxidize. The treatment season would begin in May and end in September. A pond elevation survey would be conducted to determine the optimal pump placement. To enhance drainage, explosives may be used to make small sumps for the pumps and shallow drainage channels. These shallow drainage channels would enhance hydraulic connectivity between ponds to encourage drainage.
- Implement the following protective procedures to minimize disturbances to wetlands habitat:
  - Restriction of activities that disturb wildlife in Area B and Area D, which are prime waterfowl habitat areas
  - Selection of the narrowest and shortest walking corridors to minimize disturbances to vegetation and habitat
  - Proper maintenance of equipment and structures
  - Minimization of the use of equipment and of staging-area footprints
  - Minimal localized use of explosives
  - Preparation of work plans and solicitation of agency reviews

TABLE 7-1
Sequence of Activities for the Selected Alternative

Activity	Time Frame
Monitoring Activities	
Waterfowl telemetry and mortality study	Every year for first 8 years, Year 10, Year 15, and Year 20 (11 events)
Aerial waterfowl surveys	Every year for first 8 years, Year 10, Year 15, and Year 20 (11 events)
White phosphorus monitoring of treated ponds	Every year for first 5 years (5 events)
White phosphorus composite sampling in untreated areas	Every year for first 5 years (5 events)
GIS database management	Every year for first 8 years, Year 10, Year 15, and Year 20 (11 events)
Pond survey, ground truthing, limited aerial survey	Year 1 and every year from Year 9 to Year 20 (13 events)
Aerial photography and interpretation	Every other year for 10 years (5 events)
Mapping of physical habitat changes and vegetation rebound	Once every 4 years for 20 years (6 events)
Treatment Activities	
Pond pumping treatment	Every year for first 5 years (5 events)
Cap and fill application	Year 5 (1 event)
Cap and fill integrity inspection	Every year for 4 years after material is placed (Year 5, 6, 7, 8), Year 10, Year 15, and Year 20 (7 events)
Hazing (contingency)	Every year for first 5 years (5 events, if needed)

  - Monitoring for impacts to wetlands habitat
  - Monitoring for waterfowl use of ERF

- Sample pond bottoms for white phosphorus at the beginning of the treatment season to confirm or determine that the pond or area requires remediation. The sampling also would establish a white phosphorus baseline and determine additional areas that may require remediation. The baseline sampling would be performed at the beginning of each field pumping season (every year for the first 5 years, starting in 1999).
- Sample pond bottoms for white phosphorus after treatment to determine effectiveness of the treatment system. This verification sampling would be performed at the end of each field pumping season (every year for the first 5 years, starting in 1999).
- Perform telemetry monitoring and aerial surveys every year for the first 5 years concurrently with pumping activities to determine bird populations, usage, and mortality. These activities would begin in 1999. Monitoring would be continued for 3 additional years to verify that short-term goals are maintained. Monitoring also would

Table 7-2

be conducted at Year 10, Year 15, and Year 20 to ensure that remedial action objectives continue to be maintained.

- Perform limited aerial surveys and ground truthing during Year 9 to Year 20 to evaluate waterfowl mortality, physical habitat changes, and vegetation rebound.
- Perform aerial photography every other year for 10 years (beginning in 1999) to monitor habitat changes resulting from remedial actions. Changes in drainage, topography, and vegetation would be evaluated.
- Perform habitat mapping once every 4 years for 20 years to evaluate impacts to habitat as a result of remedial actions, as well as to observe habitat rebound after pumping is discontinued.
- Perform limited hazing (only as a contingency) during first 5 years starting in 1999 if incidental hazing from pumping operations and other fieldwork activities does not deter bird usage.
- After remedial action objectives are achieved and pumping is discontinued, apply cap-and-fill material in ponded areas that did not drain and dry sufficiently to enable the white phosphorus to sublimate and oxidize. Cap-and-fill material placement is expected to occur in Year 5 (2003).
- Monitor cap and fill material integrity every year for 4 years after the material is placed, and also at Year 10, Year 15, and Year 20.
- Incorporate white phosphorus sampling, telemetry, aerial survey, habitat, and physical landform data into a GIS database. Perform GIS management every year for the first 8 years, starting in 1999, and then during Year 10, Year 15, and Year 20.
- Maintain institutional controls, including the restrictions governing site access, construction, and road maintenance and the required training for personnel who work at OU-C source areas.

The concept of appropriate institutional controls and expectations about their use, as specified in the NCP at 40 CFR 300.430(a)(1)(iii)(D), is incorporated by reference into this ROD.

Institutional control SOPs applicable to selected remedies at CERCLA OUs on Fort Richardson are currently being developed by the Army in close consultation with the EPA and ADEC. They will be completed and incorporated into the final OU-D ROD for Fort Richardson. These institutional control SOPs will be implemented sitewide for all of Fort Richardson when the OU-D ROD is signed. The SOPs will include institutional controls that specify particular restrictions, controls, and mechanisms that will be used to protect public health, safety, and the environment. The objective of these institutional controls is protection of human health, safety, and the environment by limiting or preventing access to contaminated areas or otherwise denying exposure pathways.

7.2 Agency Review of the Selected Remedy

The goal of this remedial action is to reduce waterfowl deaths attributed to white phosphorus. Section 5 outlines the RAOs for OU-C. On the basis of information obtained during the RI and careful analysis of all remedial alternatives, the Army, EPA, and ADEC believe that the selected remedy will achieve this goal. Monitoring data will be reviewed by the EPA, ADEC, and the Army every year pumping occurs to determine whether the selected remedy is meeting or will meet the short-term and long-term RAOs. This telemetry monitoring will continue until short-term RAOs are met. It will continue for 3 years after achieving the short-term RAO to ensure that the short-term RAO is consistently maintained. After that time, monitoring will be conducted at Year 10, Year 15, and Year 20 to determine whether the long-term RAOs are being met by the selected remedy.

If at any time, monitoring data reveal that either the short-term or long-term RAOs (or both) are not being met, then the EPA, ADEC, and Army will meet within 3 months of the discovery of these failures of the selected remedy in order to determine what, if any, changes are needed to the selected remedy in order to provide adequate protection of human health and the environment.

Because the remedy will result in hazardous substances remaining on site above levels specified in the long-term RAOs, a review will be conducted within 5 years after commencement of the selected remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. This 5-year review process will continue on 5-year increments until the selected remedy has been certified by the EPA, ADEC, and Army to be complete. After the first 5 years of implementation, if the monitoring and performance data indicate that the selected remedy and any enhancements to the selected remedy are not protective of human health and the environment, the selected remedy will be reevaluated by the EPA, ADEC, and Army to determine what, if any, changes or additional remedial actions are necessary to protect human health and the environment. At this time, the telemetry results, interpretation methods, and remedial action objectives will also be reevaluated.

SECTION 8

Statutory Determinations

The main responsibility of the Army, EPA, and ADEC under their legal CERCLA authority is to select remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA, as amended by SARA, provides several statutory requirements and preferences. The selected remedy must be cost-effective and use permanent treatment technologies or resource recovery technologies to the extent practicable. The statute also contains a preference for remedies that permanently or significantly reduce the volume, toxicity, or mobility of hazardous substances through treatment. Finally, CERCLA requires that the selected remedial action must comply with ARARs established under federal and state environmental laws, unless a waiver is granted.

8.1 Protection of Human Health and the Environment

The selected remedy for OU-C will provide long-term protection of human health and the environment and satisfy the requirements of Section 121 of CERCLA.

The selected remedy will provide long-term protection of human health and the environment by draining ponds and removing the white phosphorus contamination from sediments through drying of the sediments and subsequent sublimation and oxidation of the white phosphorus particles. The small, deep, isolated areas of pond bottoms that do not dry sufficiently will be covered with a cap-and-fill technology. Draining ponds and drying sediments to allow the white phosphorus to sublimate will eliminate the potential exposure route for waterfowl. Monitoring will be completed to ensure the effectiveness of the remedy.

Hazing will be conducted at ERF as a contingency measure during critical migration periods to reduce the threat of exposure to contaminated sediments until remediation goals are met.

Institutional controls will be in place to limit access to OU-C and minimize the threat of exposure to Army training activities and onsite UXO.

No unacceptable short-term risks will be caused by implementation of the remedy.

8.2 Compliance With Applicable or Relevant and Appropriate Requirements and To-Be-Considered Guidance

The selected remedy for OU-C will comply with all ARARs of federal and state environmental and public health laws. These requirements include compliance with all the location-, chemical-, and action-specific ARARs listed below. No waiver of any ARAR is being sought or invoked for any component of the selected remedy.

8.2.1 Applicable or Relevant and Appropriate Requirements

An ARAR may be either applicable or relevant and appropriate. Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. A requirement is applicable if the jurisdictional prerequisites of the environmental standard show a direct correspondence when objectively compared with the conditions at the site. An ARAR is relevant and appropriate if, although it may not meet the definition of "applicable," it is promulgated under federal or state law and still addresses problems or situations sufficiently similar to those encountered at the CERCLA site so that the use of the ARAR is well-suited to the particular area.

Pursuant to EPA guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. This classification was developed to help identify ARARs, some of which do not fall precisely into one group or another. These categories of ARARs are defined below:

- **Chemical-specific ARARs** are usually health- or risk-based numerical values or methodologies that establish an acceptable amount or concentration of a chemical in an ambient environment.
- **Location-specific ARARs** are restrictions placed on the concentration of hazardous substances or the conduct of activity solely because the ARARs occur in special locations.
- **Action-specific ARARs** are usually technology- or activity-based requirements for remedial actions.

TBC requirements are generally nonpromulgated federal or state standards or guidance documents that are to be used on an as-appropriate basis in developing cleanup standards. They usually fall into three categories:

- Health effect information with a high degree of certainty
- Technical information about how to perform or evaluate site investigations or response actions
- State or federal policy documents

8.2.2 Chemical-Specific ARARs

On the basis of available information collected to date about the chemicals of concern associated with past activities at OU-C, white phosphorus at ERF has been identified as the chemical of concern. Currently, there are no promulgated numerical cleanup or discharge limitation values for white phosphorus; therefore, there are no chemical-specific ARARs for potential remedial actions at OU-C.

8.2.3 Location-Specific ARARs

- CWA, Section 404: Section 404 of the CWA, which is implemented by the EPA and the Army through regulations found in 40 CFR 230 and 33 CFR 320 to 330, prohibits the discharge of dredged or fill materials into waters of the United States without a permit.

This statute is applicable to the protection of wetlands at ERF. Section 404 of the CWA authorizes the COE to regulate the discharge of dredged or fill material into all "waters of the United States (including wetlands)." The definition of "discharge of dredged material" was revised by the EPA and COE (*Federal Register*, 58:45008) on August 25, 1993. Under the newly defined "discharge of dredged material," the COE regulates discharges associated with mechanized land clearing, ditching, channelization, and other excavation activities that destroy or degrade wetlands or other waters of the United States under Section 404 of the CWA.

The substantive requirements of the CWA Section 404 (b)(1) guidelines (hereinafter referred to as the Guidelines) are applicable to cleanup activities that involve water discharges from the pumping operations and channel clearing conducted in wetlands at ERF. The Guidelines were promulgated as regulations in 40 CFR 230.10 and include the following:

- 40 CFR 230.10(a) states that no discharge of dredged or fill material will be permitted if a practicable alternative exists to the proposed discharge that would have less impact on the aquatic ecosystem, as long as the alternative does not have other significant adverse environmental consequences.
- 40 CFR 230.10(b) states that no discharge of dredged or fill material will be permitted if it causes or contributes to violations of any applicable state water quality standard or violates any applicable toxic effluent standard or discharge prohibition under CWA Section 307.
- 40 CFR 230.10(c) prohibits discharges (or activities) that will cause or contribute to significant degradation of the waters of the United States.
- 40 CFR 230.10(d) states that when a discharge (or activity) would degrade the waters of the United States, and there are no practicable alternatives to the discharge, compliance with the Guidelines can be achieved generally through the use of appropriate and practicable mitigation measures to minimize or compensate for potential adverse impacts of the discharge (or activity) on the aquatic ecosystem.

8.2.4 Action-Specific Requirements

- Alaska Oil Pollution Regulations (Title 18, *Alaska Administrative Code*, Chapter 75 [18 AAC 75]) set requirements for discharge reporting, cleanup, and disposal of hazardous substances for spills of hazardous substances to Alaska's land or water within specified time frames. The broad ADEC definition of "hazardous substance" includes constituents such as oil and other petroleum products. The selected remedy will involve the use of onsite diesel generators to power the pump systems. These regulations are applicable for the discovery and cleanup of spills of diesel fuel or other hazardous substances at OU-C that are regulated by the State of Alaska.
- Alaska Water Quality Standards (18 AAC 70) in general, apply to groundwater and surface water and establish criteria for protected classes of water use. Where water is used for more than one purpose, the most stringent water-quality criteria ARARs will be used. Eagle River is protected for all water use classes. Specific criteria applicable to Eagle River will depend on the parameter being evaluated and the potential impact or discharge that may occur as a result of implementation of the remedy. The "Criteria for

Growth, Propagation of Fish, Shellfish, other Aquatic Life and Wildlife" are the most stringent and, therefore, applicable to OU-C. Because pumping and installation of cap-and-fill material may affect surface water, these ARARs are applicable.

- Regulations contained in 40 CFR 266, Subpart M, specify when military munitions become solid, and possibly hazardous, wastes and include requirements for storage and transportation of military munitions wastes that are designated as hazardous waste.

8.2.5 To-Be-Considered Criteria or Guidance

- Migratory Bird Treaty Act of 1918 and the treaties cited therein: This statute implements the 1916 Convention between the United States and Great Britain (for Canada) for the protection of migratory birds. It establishes a federal prohibition, to be enforced by the Secretary of the Interior, against the illegal taking of migratory birds. This prohibition applies to birds included in the respective international conventions between the United States and Great Britain, Mexico, Japan, and the Soviet Union. Fort Richardson is implementing remedial action at ERF primarily to protect migratory birds, to satisfy the intent of this treaty.

- Executive Order 11990, Protection of Wetlands: 40 CFR 6, Subpart A sets forth EPA policy for carrying out the provisions of Executive Order 11990, Protection of Wetlands. These regulations are applicable to cleanup and monitoring activities conducted in ERF wetlands. Activities will be conducted during implementation of the selected remedy to minimize adverse impacts to the wetlands.

- ADEC, Draft Water Quality Standards (18 AAC 70) and Draft Revision to Oil and Hazardous Substances Cleanup Standards, May 4, 1998 (18 AAC 75): These proposed regulations include numerical cleanup standards and procedures for developing risk-based cleanup standards for hazardous substance releases to ensure protection of human health and the environment. These draft regulations are TBCs for the cleanup of releases of hazardous substances, such as diesel fuel from pump generators, during remediation.

- Army Regulation (AR) 200-2 (Environmental Quality), Environmental Effects of Army Actions, states Department of Army policy, assigns responsibilities, and establishes procedures for the integration of environmental considerations into Army planning and decisionmaking in accordance with 42 *United States Code* 4321 *et seq., National Environmental Policy Act of 1969*; the Council on Environmental Quality regulations of November 29, 1978; and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions,* January 4, 1979.

- AR 210-20 (Master Planning for Army Installations) explains the concept of comprehensive planning and establishes policies, procedures, and responsibilities for implementing the Army Installation Master Planning Program. It also establishes the requirements and procedures for developing, submitting for approval, updating, and implementing the Installation Master Plan.

- AR 190-13 (Enforcement of Hunting, Trapping and Fishing on Army Lands in Alaska): Appendix B in this Army regulation describes enforcement of hunting, trapping, and fishing laws on Fort Richardson, Alaska. The appendix lists the Eagle River Flats Impact

Area, including a 300-meter buffer zone, as closed to all hunting and fishing; and also specifies that no fishing or watercraft are allowed in the Eagle River Flats Impact Area.

- AR 385-63 (Access Restrictions to Army Impact Areas and Ranges): Range safety, trespassing precautions, and education programs for range impact areas are included in Chapter 2 of this Army regulation. The regulation requires that SOPS be published for the safe operation and use of ranges and that ranges, maneuver areas, and training facilities be maintained and managed. In addition, range boundaries must be surveyed and posted as off-limits to prevent trespass by unauthorized personnel. This regulation also includes precautions that must be taken to prevent all unauthorized persons from entering the surface danger zones of a range before firing, trespassing on target ranges during firing, and entry into an impact area by unauthorized personnel until it has been searched and any duds are destroyed. Access for training maneuvers may be permitted upon completion of a visual surface clearance operation. Education requirements included in the regulation specify that all personnel must be properly cautioned on the dangers of UXO; military family members must be instructed that ranges are off-limits and cautioned about the hazards; and the local news media will be used periodically to warn nearby communities of the hazards in trespassing on range areas and handling UXO.

AR 350-2: Chapter 5 of this AR addresses impact areas, which include a high hazard impact area such as ERF. In the regulation, a high hazard impact area is defined as an impact area that is permanently designated within the training complex and used to contain sensitive HE ammunition and explosives and the resulting fragments, debris, and components. The regulation also requires that all impact areas are marked with warning signs, barriers, and/or guards. Passing any of these hazard warnings without Range Control permission is forbidden. Entry into an impact area must be approved by Range Control. In addition, the regulation requires that anyone observing personnel or vehicles in an impact area inform Range Operations immediately. Range Control will investigate, and request military police assistance, at the site.

8.3 Cost Effectiveness

The combination of remedial actions identified as the selected remedy for OU-C will reduce or eliminate the risks to human health and the environment at an expected cost of $5.7 million. The remedy is cost-effective. It provides an overall protectiveness proportional to its cost.

By tailoring the remedy so that pumping treatment is applied to ponds that are preferred by waterfowl and where white phosphorus has been detected and/or craters observed, the selected remedy cost-effectively provides an appropriate level of protection. Allowing natural processes to recover intermittent ponds avoids costly and unnecessary remedial action.

8.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The Army, State of Alaska, and EPA have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner at OU-C. Of those alternatives that protect human health and the environment and comply with ARARs, the Army, State of Alaska, and EPA have determined that the selected remedy provides the best balance of trade-offs in terms of long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost; and the statutory preference for treatment as a principal element in considering state and community acceptance.

The selected remedy would use readily available technologies and would be feasible to construct. The placement and use of pumping systems and later use of cap-and-fill material would be focused on the areas of highest white phosphorus contamination in ERF sediments. Pumping and potential cap-and-fill technologies provide a permanent solution by eliminating the source of white phosphorus contamination or eliminating the exposure pathway.

8.5 Preference for Treatment as a Main Element

The selected remedy for OU-C satisfies the statutory preference for treatment of sediment by using pond pumping as the main method to permanently reduce the toxicity, mobility, and volume of contaminated sediment. Pond pumping will dry the pond bottoms to encourage sublimation and oxidation of white phosphorus particles from the sediment.

SECTION 9

OB/OD Pad

9.1 Site History

OB/OD Pad was used for open burning and open detonation of explosives on Fort Richardson from at least 1956, according to historical aerial photographs. Records and literature that specifically address OB/OD Pad are limited, especially information about the types and quantities of wastes burned and disposed. Most of the historical records were destroyed; however, some documentation is available for 1983 and 1985. Much of the recorded history of pad operations, acquired from file records and interviews with Explosive Ordnance Disposal personnel, is summarized in the *Operable Unit C RI/FS Management Plan* (1996) and the *Operable Unit C OB/OD Pad Site Investigation Work Plan* (1996).

The quantity of material disposed of at the site since its initial use in the 1950s is not known. From available Fort Richardson file information, the pad was used approximately five times per year during the summer months. Charges were limited to 100 pounds or less, and were frequently set off in sets of three to eight charges. Open detonation activities were typically conducted 1 day per month, from late spring to early fall. OB/OD activities conducted in the 1980s were limited to a 2-acre area in the western portion of the pad. Occasionally, explosive materials from non-military sources were detonated on the pad. Many of the materials destroyed at the pad were originally reactive, ignitable, and toxic. According to Explosive Ordnance Disposal personnel, no liquids, such as paint thinner or antifreeze, were disposed of at OB/OD Pad. Small quantities of diesel fuel, approximately 5 gallons or less, were used to ignite smaller pieces of ordnance in the 1960s. No OB/OD activities have been conducted at the pad since November 1988.

The only sampling program conducted at OB/OD Pad before the 1996 RI was the collection of surface soil samples by USAEHA in 1992. The sampling was intended to screen for potential surface soil contamination from OB/OD operations. Sampling was limited to surface soils primarily because of the danger of encountering UXO in subsurface soils.

9.2 Site Characteristics

9.2.1 Physical Features, Hydrogeologic Conditions, and Transport Pathways

OB/OD Pad was engineered in glacial till composed of sandy gravel and gravelly sand. The pad slopes toward the southwest, from the surrounding upland forest to the edge of ERF. The surface soils consist of poorly sorted sandy gravels, with a mix of pebbles, cobbles, and clayey soils. The gravel pad has been periodically graded in the past by the Army to facilitate use and access. Most of the grading occurred in the southwest corner, where most of the OB/OD activities were conducted in the past. The pad was graded as recently as 1994 during construction of a dredge spoils-retention basin. The pad supports a sparse vegetative cover in the form of woody shrubs, with some grasses and broad-leaved herbaceous plants.

A berm separates the pad from the forest on the northern border. The berm appears to consist of local material bulldozed from the pad surface and is more heavily vegetated than the pad. Beyond the berm lies a mixed forest of white spruce, alder, paper birch, and poplar. A road, controlled by a gate one-quarter mile from the pad, enters at the southeast corner of the pad and provides the primary vehicular access to the site.

On its southern side, OB/OD Pad contacts the wetlands of ERF. The contact appears to consist of surface material pushed from the pad a short distance onto the wetlands. This edge now forms a bluff rising approximately 10 feet from the marsh.

Disposal through burning was performed either on the ground surface or in an excavated pit. Materials that were destroyed during OB/OD activities included fuses, HE projectiles, smoke pots, mortar rounds, star clusters, flares, mines, rocket motors, shape charges, detonation cord, dynamite, and some flammable solids. Existing records indicate that no liquids were disposed of there. During the 1960s, smaller pieces of ordnance were ignited on the ground surface by using diesel fuel. Occasionally pits were excavated and small-arms ammunition was disposed of by covering with other material soaked in a small volume of diesel fuel and igniting. The ordnance disposal by detonation would tend to spread shrapnel and explosives over adjacent areas on the pad surface.

During well drilling for the 1996 RI, a layer of gravel, generally 6 to 13 feet thick, was observed overlying poorly graded sand throughout the depth the wells were drilled. The coarse-grained material suggests that precipitation infiltrates freely through the pad surface to the groundwater table. Groundwater elevations range from 19 to 36 feet below the ground surface. On the basis of groundwater measurements taken during the RI, the water table appears to be generally flat with a slight gradient to the southwest. It is believed that the groundwater movement patterns are strongly influenced by both the tides and Eagle River.

9.2.2 Nature and Extent of Contamination

Surface soil sampling conducted by USAEHA in 1992 for a list of five explosive-related analytes showed that contaminants were spread throughout the pad, with most contamination found at depths less than 18 inches and predominantly on the western half of the pad. An additional study conducted at the ERF in 1991 analyzed 128 sediment samples collected along transects extending from the edge of OB/OD Pad into ERF. Elevated concentrations (greater than 1 part per million) of 2,4-dinitrotoluene (2,4-DNT) were recorded in over half the samples, indicating that some migration of OB/OD Pad contaminants into ERF had occurred in the past. The concentrations of 2,4-DNT were not considered acutely toxic.

The RI of the soil and groundwater at OB/OD Pad was completed in 1996. Nine monitoring wells were installed and developed, and groundwater samples were collected. Surface and subsurface soil and groundwater samples were analyzed for an extensive list of volatile and semivolatile organic chemicals, including those included in the 1992 investigation, and metals. During the 1996 RI, very few chemicals were detected in either the soil or the groundwater All detected chemicals had concentrations considerably below their action levels specified in the *Operable Unit C RI/FS Management Plan* (1996). Figures 9-1 and 9-2 show sampling locations and the metal and organic concentrations detected in soil samples collected during the RI. Table 9-1 summarizes the regulatory levels for soil compared to the

Figure 9-1

Figure 9-2

TABLE 9-1
Regulatory Levels for Detected Chemicals in Soil

Parameter	Action Level[a] (µg/g)	Maximum Concentration in OB/OD Pad Samples (µg/g)	Number of Boreholes with Detected Constituents
2,4,6-TNT	40	0.36	1
2,4-DNT	100	40	2
2,6-DNT	100	1.20	1
2-Amino-4,6-DNT	none	0.47	2
4-Amino-2,6-DNT	none	0.45	2
Arsenic	80	10.2	7
Barium	4,000	127	7
Chromium	400	58.4	7
Lead	1,000	10.8	7
Mercury	20	0.28	2
Zinc	24,000[b]	86.4	7
Di-n-butylphthalate	8,000	14	1
N-nitrosodiphenylamine	100	3.7	1

[a] Source: *Operable Unit C RI/FS Management Plan,* 1996.
[b] For zinc chloride (as total zinc).

maximum concentrations for the detected chemicals in soil. Table 9-2 summarizes maximum metals concentrations from OB/OD Pad soil samples and representative values from reference areas in Alaska. The concentrations at OB/OD Pad are in the range of the reference values.

Figures 9-3 and 9-4, respectively, summarize the detected inorganic and organic concentrations for groundwater samples collected from the monitoring wells at OB/OD Pad. Table 9-3 summarizes the maximum detected organic and inorganic concentrations and compares them with reference values and cleanup action levels in the 1996 Management Plan. All groundwater concentrations were considerably below closure action levels, with the possible exceptions of chromium and zinc, which were determined to be naturally occurring compounds.

No organic compounds were detected in subsurface samples collected during the RI. Surface contamination was very low, indicating contaminants have not sorbed to soil particles. Very limited low-plasticity material was observed in the subsurface. It is likely that the limited presence and low concentrations of contaminants on the surface are the result of regular grading of OB/OD Pad.

Table 9-2

Figure 9-3

Figure 9-4

TABLE 9-3
Detected Chemicals in Groundwater

	Concentration (µg/L)					
Parameter	**Action Level[a]**	**Background[b]**	**Reference Area[c]**	**MCL[d]**	**Maximum in OB/OD Pad Investigation**	**Number of Wells with Detects**
RDX	100	–	none	NA	6.3	4
HMX	2,000	–	none	NA	1.1	1
Arsenic	50	1-9.9	5	50	5.4	3
Barium	2,000	0.50-510	42	2,000	49.5	6
Chromium	100	1-46	5	100	9.2	6
Lead	15	0.23-11,200	1	15[e]	1	1
Mercury	2	0.10-0.64	2	2	0.2	1
Zinc	10,500[f]	1-1,300	6	5,000[g]	16.3	6

NA = Not available

[a]Source: *Operable Unit C RI/FS Management Plan, Fort Richardson, Alaska* 1996*.*

[b]Filtered metals, Fort Richardson background concentrations, *from Background Data Analysis Report, Fort Richardson, Alaska,* 1996.

[c]Eagle River Valley groundwater from *Eagle River Flats Expanded Site Investigation, Fort Richardson, Alaska*, 1990.

[d]MCL = Maximum contaminant level (EPA).

[e]Action level

[f]For zinc chloride (as total zinc).

[g]Secondary MCL.

9.3 Summary of Site Risks

9.3.1 Human Health Risk Assessment

The human health risk assessment for OB/OD Pad used an onsite recreation scenario to evaluate site risk. Although currently prohibited, people on rafts or other boats might gain access to OB/OD Pad by going under the Route Bravo Bridge on Eagle River or coming upstream from Knik Arm and hiking across ERF (Figure 4-1). Pad access is also possible by a road, but there is a locked gate with warning signs. No trespassers have been observed at OB/OD Pad, however.

For the recreational scenario in OB/OD Pad, an upper-bound risk assessment for exposure to the surface soil was performed. As with this scenario at ERF, it was assumed that child and adult intruders are on OB/OD Pad for a few hours on each of 10 days in the summer. A child was assumed to weigh 36 kg, ingest 200 mg of soil per visit, and visit the pad 10 times per year for 10 years. An adult was assumed to weigh 70 kg, ingest 100 mg of soil per visit, and visit the pad 10 times per year for 20 years. These were considered to be conservative values given that no trespassers had been observed at the pad.

Exposure to soil was calculated according to the following equation:

$$E = C*IR*EF*ED / (1,000,000*BW*AT)$$

where:

E	=	exposure (mg / kg-bw / day)
C	=	soil concentration (µg / g)
IR	=	soil ingestion rate (mg / day)
EF	=	exposure frequency (days / year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	days averaging time (365*ED for noncancer effects and 25,550 for cancer effects)

Hazard indexes and cancer risks were calculated for the detected chemicals at each sampling location. The noncancer risks were evaluated as a hazard quotient, which is calculated as follows:

$$HQ = E / RfD$$

where:

HQ	=	hazard quotient
E	=	exposure (mg / kg-bw / day)
RfD	=	reference dose (mg / kg-bw / day)

The cancer risk was calculated from:

$$R = E*SF$$

where:

R	=	cancer risk (excess lifetime cancer risk)
E	=	exposure (mg / kg-bw / day)
SF	=	oral slope factor (kg-day / mg)

By using the recreational scenario assumptions described above, the calculated cancer risks were about 10^{-7} for the child and adult, and the largest calculated hazard indexes were 0.01 and 0.003 for the child and adult, respectively.

The concentrations of arsenic and chromium are similar to those at nearby reference areas. If these chemicals are excluded from the risk calculations, the cancer risks and hazard indexes decrease because these metals are significant contributors. The EPA has used a cancer risk level of 1×10^{-6} and a hazard index of 1 as levels of concern. Calculated risks for the recreational scenario are substantially less than these levels of concern.

Table 9-4 summarizes the toxicological characteristics from the EPA 1996 Integrated Risk Information System (IRIS) database for the detected chemicals. Because IRIS does not have information on two of the detected chemicals, 2-amino-4,6-DNT and 4-amino-2,6-DNT, they are not included in the table.

Excess lifetime cancer risk is the incremental increase in the risk of getting cancer over and above the rate one would have if not exposed to the conditions of the defined recreational

Table 9-4

exposure scenarios. The individual chemical cancer risks were summed across chemicals to estimate the risk associated with a simultaneous exposure to multiple chemicals.

Table 9-5 summarizes the calculated risks. The calculated cancer risks are about 10^{-7} for the child and adult at all sampling locations, with the major contribution from the arsenic concentrations. However, concentrations of arsenic in OB/OD Pad are similar to other surrounding non-contaminated areas. If arsenic is excluded from the cancer risk estimate, the calculated cancer risks decrease by about an order of magnitude.

TABLE 9-5
Summary of Risks in the Onsite Recreational Scenario

	Hazard Index		Cancer Risk	
Location	**Adult**	**Child**	**Adult**	**Child**
MW-1	0.0030	0.001	1×10^{-7}	2×10^{-7}
MW-2	0.0008	0.003	1×10^{-7}	2×10^{-7}
MW-3	0.003	0.01	1×10^{-7}	2×10^{-7}
MW-4	0.0002	0.008	1×10^{-7}	2×10^{-7}
MW-5	0.0003	0.001	8×10^{-8}	2×10^{-7}
MW-6	0.0002	0.0008	9×10^{-8}	2×10^{-7}
MW-7	0.0004	0.001	1×10^{-7}	2×10^{-7}

The onsite recreational scenario is a potential future scenario, because there is no evidence that it is occurring today. It involves assumptions of representative concentrations, soil ingestion rates, and frequency and duration of visits.

The hazard indexes range from 0.0008 to 0.01 for the child and 0.0002 to 0.003 for the adult, with the major contribution from chromium concentrations (with the assumption of chromium VI) at all locations. At Well MW-2, 2,4-DNT is also a significant contributor. At Well MW-3, 2,4,6-TNT is a significant contributor. The chromium concentrations measured at OB/OD Pad are similar to reference values in surrounding non-contaminated areas. If chromium is excluded from the assessment, all hazard indexes decrease by different amounts, depending on the relative contribution of chromium to the hazard index.

In considering the value of the cancer risk, the EPA has used a cancer risk level of 1×10^{-6} or less as acceptable for hazardous waste sites. Under the recreational scenario at all sampling locations, the cancer risks in Table 9-5 are about 10^{-7}, which is less than the cancer risk criterion, and the noncancer hazard indexes also are considerably under their criterion of one.

Uncertainties are present in this assessment, including future human activities in the area, probability and magnitude of UXO detonation, environmental concentrations, appropriate exposure factors for the scenarios, and toxicity factors. Because the calculated hazard quotients are so small, it is unlikely that other reasonable combinations of exposure factors could result in a hazard quotient greater than 1 for the scenarios. It is likely that the greatest risk in the recreational scenarios come from potential explosions from UXO.

9.3.2 Ecological Risk Assessment

A number of inorganic and organic contaminants were detected in surface soils and groundwater at OB/OD Pad during the 1996 RI. The surface soil and groundwater contaminants were observed at relatively low levels in samples collected from the soil borings and installed monitoring wells on OB/OD Pad. All detected inorganic and organic contaminants were considerably below regulatory levels included in the 1996 Management Plan. Groundwater contaminants would be diluted even further as groundwater discharged into and mixed with surface waters of ERF. Therefore, none of the detected contaminants in groundwater was retained as a COPEC for OB/OD Pad.

Inorganic and organic surface soil contaminants were screened to determine whether any of these chemicals should be considered as a COPEC for OB/OD Pad. The maximum detected inorganic concentrations from recent soil samples were similar to or below corresponding background levels. Therefore, none of the inorganic chemicals was retained as a COPEC.

Additional risk to ecological receptors at OB/OD Pad was assessed by comparing maximum concentrations of detected organic chemicals to available data or derived critical toxicity values (CTVs). Organic chemicals were compared to soil CTVs derived for a small mammal, the deer mouse, considered to be representative of small rodents at OB/OD Pad (Table 9-6). None of the organic soil contaminants detected at the pad was retained as a COPEC.

Larger mammals were not expected to derive a significant proportion of their diet on the limited pad area. Risk to plants was estimated, but toxicity to plants and significant uptake and bioaccumulation of the detected explosive residues or semivolatile organic compounds was not expected to occur. Overall use of OB/OD Pad by ducks, as indicated by telemetry and lack of preferred feeding habitat, was very low (about 1 percent of all observations). Therefore, waterfowl were not evaluated as potential ecological receptors. Risk to terrestrial invertebrates was not evaluated because of the lack of applicable CTVs. None of the detected contaminants in the OB/OD Pad surface soil and groundwater samples were retained as a COPEC. Therefore, OB/OD Pad was not considered to be an area of potential ecological concern.

On the basis of results of the 1996 site investigation at OB/OD Pad and an evaluation of data collected during previous studies at this site, no further action is selected for OB/OD Pad for hazardous chemicals. Because of concerns regarding potential human exposure to UXO, existing institutional controls to monitor and control access to OU-C apply to OB/OD Pad.

9.4 OB/OD Pad Closure

This ROD selects the final remedial action for OU-C, as well as the EPA decision under RCRA regarding hazardous waste closure of the OB/OD Pad at this time. (The OB/OD Pad is being treated administratively as part of OU-C as agreed by the EPA, ADEC, and Army in the 1994 FFA.)

The EPA, ADEC, and Army are issuing this ROD as part of their public participation responsibilities under Section 117(a) of CERCLA. The EPA also is issuing this ROD pursuant to public notice and other requirements for closure of the OB/OD Pad, which is a

TABLE 9-6
Critical Toxicity Values for Organic Soil Contamination at OB/OD Pad[a]

Organic	Maximum Reported OB/OD Pad Value (µg/g)	Deer Mouse[b] Soil CTV	COPEC[c]
2,4,6-TNT	0.36	2	No
2,4-DNT	39	10	No[e]
2,6-DNT	3.9U	199	No
2-amino-4,6-DNT	0.47	103	No
4-amino-2,6-DNT	0.45	103	No
Di-n-butylpthalate[d]	14	3,718	No
N-nitrosodiphenylamine	4.2	251	No

Notes:
µg/g = micrograms per gram. This metric unit of measurement is commonly used for soil concentrations. It is equivalent to parts per million.
TNT = Trinitrotoluene
U = Flagged by laboratory as estimated value.
[a] CTV derived as described in Toxicological Benchmarks for Wildlife, Electronic Database VI.5, U.S. Department of Energy, 1996, and *Wildlife Exposure Factors Handbook,* EPA, 1993.
[b] Deer mouse considered to represent small mammal receptors at site.
[c] Chemical of potential ecological concern
[d] *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants* (Suter et al., Oak Ridge National Laboratory, 1993) estimates a no observed effect concentration for plants at 200 µg/g that represents a soil CTV for plants.
[e] CTV is a conservative extrapolation that assumes plant concentration in mouse diet is equal to soil concentration. The deer mouse soil CTV is derived from data from dog toxicity studies that increases uncertainty in the value.

hazardous waste regulated unit under the authority of Sections 3004(a) and 3005(e) of RCRA, as amended, and its implementing regulations codified in 40 CFR 264 and 265.

The EPA, ADEC, and Army recognize the similarities between RCRA corrective action and CERCLA remedial action processes and their common objective of protecting human health and the environment from potential releases of hazardous substances, wastes, or constituents. Actions taken to remediate OU-C will comply with the provisions of both CERCLA and RCRA.

The EPA, ADEC, and Army are electing to combine response actions under RCRA and CERCLA remedial action primarily because the OB/OD Pad is administratively subject to RCRA closure authority; however, the OB/OD Pad also is in the same physical location as the rest of OU-C, which is subject to CERCLA authority. Thus, regardless of regulatory authority, it is only natural that the investigation and, if necessary, any remedial physical response be applied to these adjacent OU-C areas. In addition, there were similar, but not identical, historical actions that took place at the OB/OD Pad (destruction of explosives) in comparison to the rest of OU-C (use as a firing range with residuals of explosives remaining). By applying CERCLA authority concurrently with RCRA closure and corrective action requirements through this integrated plan, the EPA, ADEC, and Army intend to minimize response costs as much as possible while remaining fully protective.

This ROD for OU-C fulfills the RCRA corrective action and the CERCLA remedial action processes for describing and analyzing closure and remedial alternatives. (The 1996 RI was functionally equivalent to a RCRA facility investigation.) To fulfill the requirements for the RCRA closure process, the Army will submit a closure plan in accordance with procedures described in Section 9.4.1

9.4.1 Closure Process

The OB/OD Pad was identified in the 1991 Federal Facility Compliance Agreement (FFCA), signed by the Army and EPA, as a RCRA-regulated, land-based unit. As such, the OB/OD Pad is subject to the interim status standards codified in 40 CFR 265. Under the 1991 FFCA, the Army was required to submit a closure plan for this unit that had to comply with the requirements for closure codified in 40 CFR 265, Subparts G and P. In addition, pursuant to the terms of the 1994 CERCLA FFA, the Army, ADEC, and EPA agreed that where feasible, any RCRA corrective actions required at solid waste management units at Fort Richardson would be integrated with any ongoing CERCLA response actions so that duplication of effort would not occur and the Army could realize cost savings as a result. However, the 1994 FFA also specified that such integration efforts would not obviate the need for the Army to meet its RCRA closure obligations under the 1991 FFCA.

Although the OB/OD Pad is not currently active, EPA believes that it is prudent to allow final RCRA closure of the OB/OD Pad concurrently with final clearance of the operating range. Because the OB/OD Pad is physically part of the operating range, RCRA closure at this time would be technically complex, with little, if any, demonstrable environmental benefit. In addition, as part of the RCRA/CERCLA integration effort under the 1994 FFA, the Army has completed some investigatory work and sampling efforts at and near the OB/OD Pad. The result of these activities indicate levels of organic and metal contaminants below any health-based action levels and RCRA “clean closure” requirements. For these reasons, the EPA is approving a delay of closure of the OB/OD Pad in accordance with 40 CFR 265.113(b)(1)(i). Delay of closure under this provision is subject the requirements of 40 CFR 265.113(b), which states, among other things, that final closure, by necessity, will take longer than 180 days to complete.

Additionally, the facility must take, and continue to take, all steps to prevent threats to human health and the environment from the unclosed, but not operating, hazardous waste management unit or facility, including compliance with applicable interim status requirements, 40 CFR 265.113(b)(2). The Army has indicated, and the EPA agrees through the signing of this ROD, that the OB/OD Pad meets the requirement for extension of time for closure specified in 40 CFR 265.113(b)(1)(i), provided that an interim closure plan acceptable to EPA is completed by the Army as specified below.

According to the requirement specified in the 1991 FFCA and in 40 CFR 265.112(a) for compliance with RCRA interim status standards, the Army will submit, within 150 days from the date the ROD for OU-C becomes final, a draft interim closure plan for the OB/OD Pad that meets the requirements specified in 40 CFR 265, Subparts G and P. The draft interim closure plan will be developed and completed in accordance with the procedures for submittal and review of primary documents specified in Paragraphs 20.12 through 21.13

of the 1994 FFA. Final closure will occur under the authority of the 1991 FFCA, RCRA, and its implementing regulations.

No less often than during the CERCLA 5-year reviews, the Army will evaluate whether acceptable delay of closure by the EPA becomes no longer viable for one of the following reasons:

- The ERF is no longer operating.
- The post is being closed.
- Any other reason.

The findings of this evaluation will be submitted to EPA for review and approval. If either the EPA or the Army believe that delay of closure is no longer viable, the OB/OD Pad will be closed under the substantive and procedural RCRA closure requirements in effect at that time, and at that time, the Army will revise and resubmit the interim closure plan for the OB/OD Pad to the EPA for review and approval. Upon approval of the final closure plan, the Army will close the OB/OD Pad in accordance with the terms and conditions of that final closure plan.

In addition, the Army may elect to close the site under 40 CFR 265, Subparts G and P, at any earlier time. This closure will also require compliance with all substantive and administrative closure requirements, including EPA approval.

SECTION 10

Documentation of Significant Changes

The selected remedy for the ERF portion of OU-C is the same as the preferred alternative described in the Proposed Plan.

In the Proposed Plan, the OB/OD Pad was not identified as a RCRA unit subject to closure. Subsequent review of the Administrative Record indicated that it is necessary to close the OB/OD Pad in accordance with the administrative and substantive requirements in 40 CFR 265, Subparts G and P, and the 1991 FFCA. Section 9.4 of this ROD outlines the procedures that the Army will follow to close the OB/OD Pad.

TABLE 9-2
Sediment/Soil Concentrations from OB/OD Pad and Reference Areas (µg/g)

Chemical	Maximum in OB/OD Investigation	Fort Richardson and Elmendorf Mean Background[a]	Goose Bay Sediments[b]	Alaska Soils and Surficial Materials[c] (geometric mean, arithmetic mean)	Alaska Stream and Lake Sediments[c] (arithmetic mean)	Chugach Mountains[c] (geometric mean)	Average of Alaska Means[c] (geometric mean, arithmetic mean)	Arithmetic Mean of Eagle River Bridge and Cottonwood Slough Sediments[c]
Arsenic	10.2	5.46-7.2	15, 13	6.7, 9.6	17.3	--	6.7, 13	7
Barium	127	52.5-113.8	140, 110	595, 678	811	672	633, 744	190
Chromium	58.4	19.8-32	42, 21	50, 64	115	111	80, 89	56
Lead	10.8	5.3-10	12, 7.9	12, 14	12	25	18, 13	15
Mercury	0.28	--	<0.1, <0.1	--	--	--		0.097
Zinc	86.4	36.7-52.1	100, 86	70, 79	157	--	70, 118	133

[a]From *Background Data Analysis Report, Fort Richardson, Alaska,* Ecology and Environment, Inc., 1996.
[b]From *Interagency Expanded Site Investigation: Evaluation of White Phosphorus Contamination and Potential Treatability at Eagle River Flats, Alaska,* C. Bouwkamp, CRREL, 1994.
[c]From *Eagle River Flats Expanded Site Investigation,* Environmental Science and Engineering, Inc., 1990.

TABLE 9-4
Toxicological Parameters

Chemical	Noncancer Effects						Cancer Effects	
	Oral Reference Dose (mg/kg/day)	Uncertainty Factor	Modifying Factor	Confidence in Study	Confidence in Database	Confidence in Value	Weight of Evidence	Oral Slope Factor (kg-day/mg)
Arsenic	0.0003	3	1	medium	medium	medium	A	1.5
Barium	0.07	3	1	medium	medium	medium		
Chromium III	1	100	10	low	low	low		
Chromium VI	0.005	500	1	low	low	low	A	
Lead							B2	
Mercury							D	
Zinc	0.3	3	1	medium	medium	medium	D	
2,4,6-TNT	0.0005	1,000	1	medium	medium	medium	C	0.03
2,4-DNT	0.002	100	1	high	high	high		
2,6-DNT	0.001	3,000						
Di-n-buytlphthalate	0.1	1,000	1	low	low	low		
N-nitrosodiphenylamine							B2	0.0049

Modifying factor—An uncertainty factor which is greater than zero and less than or equal to 10; the magnitude of the MF depends upon the professional assessment of scientific uncertainties of the study and database not explicitly treated with the standard uncertainty factors (e.g., the completeness of the overall data base and the number of species tested); the default value for the MF is 1.

Uncertainty factor—One of several, generally 10-fold factors, used in operationally deriving the reference dose (RfD) from experimental data. UFs are intended to account for (1) the variation in sensitivity among the members of the human population; (2) the uncertainty in extrapolating animal data to the case of humans; (3) the uncertainty in extrapolating from data obtained in a study that is of less-than-lifetime exposure; and (4) the uncertainty in using lowest-observed adverse effect data rather than no-observed adverse effect data.

Weight-of-evidence for carcinogenicity—The extent to which the available biomedical data support the hypothesis that a substance causes cancer in humans. A: Human carcinogen. B1: Probable human carcinogen, indicating that limited human data are available. B2: Probable human carcinogen, sufficient evidence in animals, and inadequate or no evidence in humans. C: Possible human carcinogen. D: Not classifiable as to human carcinogenicity. E: Evidence of noncarcinogenicity for humans.