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Work Plan for the Feasibility Study for Remedial Action at J-Field, Aberdeen Proving Ground, Maryland

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FOREWORD

This document presents the Work Plan for the Feasibility Study for Remedial Action to be conducted as part of a remedial investigation/feasibility study (RI/FS) to be carried out at J-Field, Aberdeen Proving Ground, Maryland, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. The RI/FS is to be conducted for the U.S. Army under the direction of the Directorate of Safety, Health, and Environment, Aberdeen Proving Ground. This report is one in a series of documents being prepared to define the plans for RI/FS activities at J-Field. Other documents in this series include a Remedial Investigation Work Plan (Benioff et al. 1995a); a Field Sampling Plan (Benioff et al. 1995b); a Quality Assurance Project Plan (Prasad et al. 1995); a Work Plan for the Focused Feasibility Study of the Toxic Burning Pits Area (Biang et al. 1995); and a Work Plan for Conducting an Ecological Risk Assessment (Hlohowskyj et al. 1995).

NOTATION

The following is a list of abbreviations and acronyms, chemicals, and units of measure used in this document. Some acronyms used only in tables are defined in those tables.

ABBREVIATIONS AND ACRONYMS

AEC	U.S. Army Environmental Center
ANL	Argonne National Laboratory
AOC	area of concern
APG	Aberdeen Proving Ground
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (as amended)
CFR	<i>Code of Federal Regulations</i>
COE	U.S. Army Corps of Engineers
COMAR	<i>Code of Maryland Regulations</i>
CWA	chemical warfare agent
DQO	data quality objective
EMD	Environmental Management Division (Aberdeen Proving Ground)
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERT	emergency response team
FFS	focused feasibility study
FR	<i>Federal Register</i>
FS	feasibility study
FSP	Field Sampling Plan
FWQC	federal water quality criterion
HE	high explosives
IRDMS	Installation Restoration Data Management System
LDR	land disposal restriction
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
MSL	mean sea level
NCP	National Contingency Plan
ND	not detected
NPL	National Priorities List

OB	open burning
OD	open detonation
OSHA	Occupational Safety and Health Administration
PAOC	potential area of concern
PB	Prototype Building
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control
RCP	Riot Control Burning Pit
RCRA	Resource Conservation and Recovery Act (as amended)
RFA	RCRA Facility Assessment
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RPDG	Robins Point Demolition Ground
RPTS	Robins Point Tower Site
SAP	Sampling and Analysis Plan
SBDG	South Beach Demolition Ground
SBT	South Beach Trench
SWMU	solid waste management unit
SWQS	state water quality standard
TAL	Target Analyte List
TBC	to be considered
TBP	Toxic Burning Pits
TCL	Target Compound List
TDS	total dissolved solids
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USGS	U.S. Geological Survey
UXO	unexploded ordnance
WPP	White Phosphorus Burning Pits

CHEMICAL SYMBOLS AND ABBREVIATIONS

BNA	base neutral and acid extractable organic compounds
C ₂ H ₃ Cl	vinyl chloride
C ₆ H ₆	benzene
CHCl ₃	chloroform
CK	cyanogen chloride

CN	chloroacetophenone
CS	<i>o</i> -chlorobenzylidene malononitrile
DANC	decontaminating agent, noncorrosive
DCE	dichloroethylene
11DCE	1,1-dichloroethylene
12DCE	1,2-dichloroethylene
trans-12DCE	<i>trans</i> -1,2-dichloroethylene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DM	adamsite
DNT	dinitrotoluene
FM	titanium tetrachloride
FS	sulfur trioxide/chlorosulfonic acid
GA	<i>o</i> -ethyl- <i>N</i> , <i>N</i> -dimethylphosphoramidacyanidate (tabun), a nerve agent
GB	isopropyl methylphosphonofluoridate (sarin), a nerve agent
GD	pinacolyl methylphosphonofluoridate (soman), a nerve agent
GF	cyclohexylmethylphosphonofluoridate, a nerve agent
HMX	cyclotetramethylenetetranitramine
MIBK	methyl isobutyl ketone
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PETN	penta-erythritol tetranitrate
PWP	plasticized white phosphorus
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
TCE	trichloroethane
111TCE	1,1,1-trichloroethane
112TCE	1,1,2-trichloroethane
TCLEA	1,1,2,2-tetrachloroethane
TCLEE	tetrachloroethylene
TKN	total Kjeldahl nitrogen
TNT	trinitrotoluene
TOC	total organic carbon
TOX	total organic halogen
TRCLE	trichloroethylene
VOC	volatile organic compound
VX	methylphosphonothioic acid = <i>o</i> -ethyl <i>S</i> -(2-diisopropylaminoethyl methylphosphonothioate), a nerve agent
WP	white phosphorus

UNITS OF MEASURE

°C	degree(s) Celsius
Ci	curie(s)
pCi	picocurie(s)
d	day(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft ²	square foot (feet)
g	gram(s)
kg	kilogram(s)
µg	microgram(s)
mg	milligram(s)
h	hour(s)
in.	inch(es)
L	liter(s)
lb	pound(s)
m	meter(s)
mi	mile(s)
ppb	part(s) per billion
ppm	part(s) per million

1 INTRODUCTION

1.1 BACKGROUND

The Environmental Management Division (EMD) of Aberdeen Proving Ground (APG), Maryland, is conducting a remedial investigation and feasibility study (RI/FS) of the J-Field area at APG pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. J-Field is within the Edgewood Area of APG in Harford County, Maryland (Figure 1.1). Since World War II, activities in the Edgewood Area have included the development, manufacture, testing, and destruction of chemical agents and munitions. These materials were destroyed at J-Field by open burning¹ and open detonation (OB/OD).

Considerable archival information about J-Field exists as a result of efforts by APG staff to characterize the hazards associated with the site. Contamination of J-Field was first detected during an environmental survey of the Edgewood Area conducted in 1977 and 1978 by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) (predecessor to the U.S. Army Environmental Center [AEC]). As part of a subsequent USATHAMA environmental survey, 11 wells were installed and sampled at J-Field. Contamination at J-Field was also detected during a munitions disposal survey conducted by Princeton Aqua Science in 1983. The Princeton Aqua Science investigation involved the installation and sampling of nine wells and the collection and analysis of surficial and deep composite soil samples. In 1986, a Resource Conservation and Recovery Act (RCRA) permit (MD3-21-002-1355) requiring a basewide RCRA Facility Assessment (RFA) and a hydrogeologic assessment of J-Field was issued by the U.S. Environmental Protection Agency (EPA). In 1987, the U.S. Geological Survey (USGS) began a two-phased hydrogeologic assessment in which data were collected to model groundwater flow at J-Field. Soil-gas investigations were conducted, several well clusters were installed, a groundwater flow model was developed, and groundwater and surface water monitoring programs were established that continue today.

While APG was pursuing the investigation of J-Field under RCRA corrective action, the Edgewood Area was added to the National Priorities List (NPL) on February 21, 1990. Because of that listing, an RI/FS is required for the entire Edgewood Area pursuant to Modification 2 of the RCRA Permit and a March 1990 Federal Facility Agreement between EPA Region III and the Department of the Army. The corrective action requirements of RCRA have been preempted, and J-Field is being evaluated under CERCLA.

¹ Pursuant to Title 40, Code of Federal Regulations (40 CFR), Part 260.10, "open burning" means the combustion of any material without the following characteristics:

- (1) Control of combustion air to maintain adequate temperature for efficient combustion,
- (2) Containment of the combustion-reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion, and
- (3) Control of emission of the gaseous combustion products.

FIGURE 1.1 Location of J-Field in the Edgewood Area at APG
(Source: Adapted from Hughes 1993)

Site characterization activities are currently under way at J-Field. Data gathered from these activities will be used to assess the extent of the contamination problems at various areas of concern (AOCs) within J-Field and the associated risks to human health and the environment. In addition, a focused feasibility study (FFS) is being conducted at the J-Field Toxic Burning Pits (TBP) AOC to develop and evaluate remedial action alternatives to mitigate exposure of human and environmental receptors to contamination source areas within the TBP AOC. The main objective of the FFS is to implement some early remedial action at the TBP AOC.

J-Field is almost flat and is covered by open fields, woods, and nontidal marshes. It encompasses about 460 acres at the southern end of the Gunpowder Neck Peninsula (Figure 1.2). The peninsula is surrounded by tidal estuaries on three sides — Gunpowder River to the west, Chesapeake Bay to the south, and Bush River to the east. For the purposes of the RI/FS, J-Field has been divided into eight geographic areas or features that are designated in this report as AOCs: the Toxic Burning Pits (TBP), the White Phosphorus Burning Pits (WPP), the Riot Control Burning Pit (RCP), the Robins Point Demolition Ground (RPDG), the Robins Point Tower Site (RPTS), the South Beach Demolition Ground (SBDG), the South Beach Trench (SBT), and the Prototype Building (PB) (Figure 1.3). These AOCs correspond to the eight solid waste management units (SWMUs) identified in *RCRA Facility Assessment, Edgewood Area, Aberdeen Proving Ground, MD* (Nemeth 1989). Several subareas within these AOCs could represent discrete sources of contamination. The AOCs and their associated subareas are as follows:

- Toxic Burning Pits (TBP) AOC
 - Main Burning Pits (consisting of a northern burning pit and a southern burning pit)
 - Methylphosphonothioic Acid (VX) Burning Pit
 - Mustard Burning Pit
 - Pushout Area
 - Liquid Smoke Disposal Pit
 - Demolition Area
 - Storage/Unloading Area
 - Square Pit
- White Phosphorus Burning Pits (WPP) AOC
 - Principal Burning Pits (consisting of a northern burning pit, a southern burning pit, and an associated bermed depression that received runoff from the northern burning pit)
 - Pushout Area
 - Mounded Areas
 - Historic White Phosphorus Disposal Area (located south to southeast of the existing principal burning pits)

FIGURE 1.2 Location of J-Field and Major Associated Features on the Gunpowder Neck Peninsula (Source: Adapted from Hughes 1993)

FIGURE 1.3 Locations of Areas of Concern and Principal Site Features at J-Field (Source: Adapted from Hughes 1993)

- Riot Control Burning Pit (RCP) AOC
 - Burning Pit
 - Pushout Area
- Robins Point Demolition Ground (RPDG) AOC
 - Active Area
 - Inactive Area
- Robins Point Tower Site (RPTS) AOC
- South Beach Trench (SBT) AOC
- South Beach Demolition Ground (SBDG) AOC
- Prototype Building (PB) AOC

Although most of the AOCs are no longer used for OB/OD, a portion of the RPDG is currently active and is operating with interim status under RCRA. A RCRA Part B permit application was submitted in November 1988. An amended permit application is being prepared to update the November 1988 submittal. An open burning pan located 50 m west of the PB and an open detonation area at the WPP AOC are also being used for emergency disposal operations.

1.2 SITE HISTORY

The extent of activities at J-Field before World War II is unknown; however, a terrain map from the 1920s-1930s era indicates that some areas of J-Field were cleared at that time. These cleared areas may have been used for test activities (Nemeth 1989; U.S. Army Corps of Engineers [COE] 1923). During World War II, J-Field was used to test high explosives (HE) and chemical munitions. In addition, chemical agents, chemical wastes, and HE were burned or detonated in open pits or buried under several feet of soil. The depths of the pits were maintained by pushing burned soil and ash out toward the nearby marshes. In the case of the TBP AOC, this procedure moved the edge of the adjacent marsh eastward more than 100 ft (Sonntag 1991). Also during World War II, steel-reinforced structures (such as bunkers, buildings, and slab walls) were built at J-Field to use as targets for conventional munitions.

Available information indicates that chemicals disposed of at J-Field have included nerve agents (such as VX), blister agents, riot control agents, white phosphorus, chlorinated solvents, and drummed chemical wastes generated by research laboratories, process laboratories, pilot plants, and machine and maintenance shops. Between 1946 and 1971, limited testing of lethal chemical agents continued at J-Field (Nemeth 1989). Open-air testing of lethal chemical agents stopped in 1969 (Nemeth 1989). Disposal activities at various J-Field locations are summarized in Table 1.1.

TABLE 1.1 Summary of Disposal Activities at J-Field

Site Name	Period of Use	Activity
Toxic Burning Pits (originally 5 separate pits; only 2 remain)	1940-1980	OB/OD of HE in southeastern portion. Disposal of HE-filled munitions, nerve agents, mustard, liquid smoke, chlorinated solvents, and radioactive chemicals.
White Phosphorus Burning Pits	Late 1940s-1980; occasional emergency disposal of white phosphorus	OB/OD of white phosphorus, plasticized white phosphorus, other chemicals. Potential for disposal of CN ^a and trichloroethylene.
Riot Control Burning Pit Area	Late 1940s to early 1970s; riot control agent disposal, 1960s to early 1970s	OB of chemicals, chemical-filled munitions, riot control agents (CS, ^b CN).
Robins Point Demolition Ground	Late 1970s-present	OD of explosive materials, sensitive and unstable chemicals.
South Beach Demolition Ground	Late 1950s-1970s	OD of HE.
Prototype Building Area	During World War II	Stored wastes and HE munitions. Possible storage of solid wastes in building or nearby. Building used to test bombing effects. Periodically used for storage since World War II.
Robins Point Tower Site	Late 1950s-1960s	Potential test burn of radioactively contaminated wood.
South Beach Trench	Late 1950s	Unknown.

^a Chloroacetophenone.

^b o-Chlorobenzylidene malononitrile.

Sources: Adapted from Nemeth (1989); EPA and U.S. Department of the Army (1990).

Procedures for open burning in J-Field pits involved placing 3-4 ft of wood dunnage in a pit, placing the materials to be burned on top of the dunnage, adding fuel oil, and igniting it. Scrap metal items were removed and reburned in the same manner in a reburn pit. Large metal items were recovered and disposed of as scrap.

Decontamination procedures included the use of a chlorinating agent known as "decontaminating agent, noncorrosive" (DANC). DANC is an organic N-chloroamide compound in solution with 1,1,2,2-tetrachloroethane (TCLEA) that was used to decontaminate mustard, Lewisite, and VX. It typically contained 90-95% (by weight) TCLEA. If recovered scrap materials were decontaminated with DANC in the pit before being removed, the oxidizing agent would degrade. The most significant impact from this procedure would have been the introduction of TCLEA into the environment. Available information indicates that the use of DANC at J-Field was widespread and common (Nemeth 1989).

Disposal of radioactive waste is known to have occurred at J-Field. The TBP area was used for disposal of small amounts of radioactively labeled chemicals. In addition, test burns of contaminated wood wastes, including wood contaminated with radium and strontium-90, may have been conducted at the RPTS (Nemeth 1989).

J-Field has had only limited use since 1980. However, the RPDG and the WPP AOCs are still occasionally used for the destruction of explosives-related materials (Nemeth 1989).

1.3 OVERVIEW OF THE RI/FS PROCESS UNDER CERCLA

The EPA has developed procedural and documentation requirements for cleanup of hazardous waste sites under CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA). The general approach that incorporates these requirements is termed the remedial investigation/feasibility study (RI/FS) process (Figure 1.4). The RI/FS process consists of three primary components:

- The *remedial investigation*, which presents information on the environmental setting at a site and the nature and extent of contamination;
- The *baseline risk assessment*, which addresses the environmental fate and transport of contaminants and assesses potential impacts to human health and the environment associated with exposures under current and possible future conditions; and
- The *feasibility study*, which develops, screens, and evaluates technologies and alternatives for site remediation and identifies potential cleanup criteria.

FIGURE 1.4 The Phased RI/FS Process (EPA 1988)

Table 1.2 lists the key J-Field RI/FS documents that have been prepared to date. All documents have been prepared in accordance with the requirements of both CERCLA and the codified National Contingency Plan (NCP) (EPA 1990). The guidance established by EPA for conducting an RI/FS at Superfund sites has also been followed (EPA 1988, 1989a,b).

1.4 PURPOSE OF THE FEASIBILITY STUDY WORK PLAN

The purpose of the FS is to gather sufficient information to develop and evaluate alternative remedial actions to address contamination at J-Field in compliance with the NCP, CERCLA, and SARA. This FS Work Plan summarizes existing environmental data for each AOC and outlines the tasks to be performed to evaluate and select remedial technologies. The tasks to be performed will include (1) developing remedial action objectives and identifying response actions to meet these objectives; (2) identifying and screening remedial action technologies on the basis of effectiveness, implementability, and cost; (3) assembling technologies into comprehensive alternatives for J-Field; (4) evaluating, in detail, each alternative against the nine EPA evaluation criteria and comparing the alternatives to identify their respective strengths and weaknesses; and (5) selecting the preferred alternative for each operable unit.

1.5 REPORT ORGANIZATION

Section 1 of this FS work plan presents background information and summarizes the purpose and scope of the FS within the context of the RI/FS process. Section 2 summarizes the site background, environmental setting, and previous and ongoing investigations conducted at J-Field. Also included is an overview of available information about the nature and extent of contamination at each AOC, the types of waste present, and the potential pathways of contaminant migration. The environmental setting includes site topography, soils and geology, surface water, groundwater, climate, ecology, and land use/demography. Other site aspects discussed in Section 2 include applicable or relevant and appropriate requirements (ARARs) and other measures to be considered (called "to be considereds," or TBCs), environmental media of concern, contaminants of potential concern, the conceptual site model, preliminary remediation goals, and preliminary identification of operable units.

Section 3 describes the activities for each of the eight main FS tasks. A draft outline of the FS report is presented in Section 4, along with a summary of the contents of each report section. All references cited in this report are listed in Section 5. Section 6 presents a list of preparers of this document. Appendix A provides tables summarizing preliminary identification of ARARs and TBCs for J-Field. Appendix B discusses potential areas of concern (PAOCs) at J-Field.

TABLE 1.2 Key J-Field RI/FS Project Documents

Document	Author	Date
Feasibility Study Work Plan for Remedial Action at J-Field, Aberdeen Proving Ground, Maryland (this document)	Argonne National Laboratory	May 1995
Draft Focused Feasibility Study Report for the TBP Area at J-Field, Aberdeen Proving Ground, Maryland	Argonne National Laboratory	September 1994
Remedial Investigation Work Plan for J-Field, Aberdeen Proving Ground, Maryland	Argonne National Laboratory	March 1995
Remedial Investigation Sampling and Analysis Plan for J-Field, Aberdeen Proving Ground, Maryland, Volume 1: Field Sampling Plan	Argonne National Laboratory	March 1995
Remedial Investigation Sampling and Analysis Plan for J-Field, Aberdeen Proving Ground, Maryland, Volume 2: Quality Assurance Project Plan	Argonne National Laboratory	March 1995
Work Plan for Focused Feasibility Study of the Toxic Burning Pits Area at J-Field, Aberdeen Proving Ground, Maryland	Argonne National Laboratory	March 1995
Risk and Biological Impact Assessment at U.S. Army Aberdeen Proving Ground, Maryland, Volume 1: Technical Plan (Final)	ICF-Kaiser Engineers	March 1993
Work Plan for Conducting an Ecological Risk Assessment at J-Field, Aberdeen Proving Ground, Maryland	Argonne National Laboratory	March 1995
Baseline Risk Assessment for Eight Selected Study Areas at Aberdeen Proving Ground, Maryland (Draft)	ICF-Kaiser Engineers	January 1991

2 SITE BACKGROUND

2.1 ENVIRONMENTAL SETTING

2.1.1 Surface Features

J-Field is nearly flat, with a maximum relief of about 10 ft. The ground surface slopes gently toward marshy areas or toward Chesapeake Bay and on-site surface water. In some places, wave erosion has formed short, steep cliffs (2-10 ft high) along the shore (Hughes 1993).

Surface water occurs in demolition craters, in marsh areas, and in a few open ponds within the marshes. Between December and May water collects in wooded areas where drainage is poor because the low-permeability soils slow the rate of infiltration. Figure 2.1 shows the overall topography of the site.

2.1.2 Climate

The climate in the area of APG is temperate and moderately humid and is moderated by the presence of Chesapeake Bay. The average annual precipitation of 45 in. is distributed relatively uniformly during the year. The average annual temperature is about 54°F (Nemeth 1989; Hughes 1993).

2.1.3 Geology and Soils

The stratigraphy of J-Field consists of Quaternary (Talbot) sediments underlain by Cretaceous (Potomac Group) sediments. The Quaternary sediments constitute a fluvial, estuarine, and marginal marine unit of sand, gravel, and silty clay. The Cretaceous sediments are a sand and clay unit of fluvial origin.

The Quaternary sediments can be divided into three units. The surface unit consists of interbedded sand and clay about 30-40 ft thick; the middle unit is silty, sandy clay and organic matter about 36-107 ft thick; and the base unit is gravelly sand and clay about 13-50 ft thick. The Cretaceous sediments consist of interbedded layers of fine-grained sand and massive clay. The top of this layer is at a depth of 110-160 ft. Metamorphic bedrock underlies the sediments at depths ranging from 200 to 900 ft.

2.1.4 Surface Water

The southern and eastern shores of J-Field are covered by an extensive marsh system (Figure 2.2). The marshes may be flooded during storms and very high tides but are

FIGURE 2.1 Topography of the J-Field Area (Source: Adapted from Hughes 1993)

FIGURE 2.2 Locations of Woods, Marshes, Ponds, Open Fields, and Streams at J-Field (Source: Adapted from Hughes 1993)

not affected by normal tides of 1-2 ft. The water level in the marshes is generally about 2 ft above high tide in Chesapeake Bay. The disposal pits at J-Field originally drained into these marshes or into the Gunpowder and Bush rivers. During the 1970s, drainage from the disposal pits was blocked. Currently, surface water can be 1-2 ft deep in the TBP and the WPP during the wet season, generally March to June (Hughes 1993). Several ponds and streams are located within the marshy areas of J-Field (Figure 2.2). The largest pond, which is about 5 ft deep, is southeast of the TBP. Two streams on the eastern side of J-Field are the only on-site streams and do not carry much runoff except during storms.

2.1.5 Groundwater

Four major hydrologic units have been identified beneath J-Field — the surficial aquifer (in the overlying Talbot layer), the leaky confining unit (in the middle layer), the confined aquifer (in the bottom Talbot unit), and the Potomac Group aquifer. Groundwater flow in these units is described below on the basis of current knowledge of the aquifers. Groundwater is currently being modeled in these units. The model results are not yet available, but will be presented in the RI report with other results of the RI field investigation.

2.1.5.1 Surficial Aquifer

The surficial aquifer consists of interbedded sand and clay and corresponds to the surface unit of the Quaternary (Talbot) sediment; it ranges from 25 to 40 ft thick, with elevations following the surface topography. The steepest hydraulic gradients were found near the TBP and WPP. Because the closest pumping of this aquifer is about 4 mi to the west, the major influences on the flow system are recharge, evapotranspiration, and tidal fluctuations. Recharge is mainly through rainfall, and the system discharges into the marshes and Chesapeake Bay. Some recharge from Chesapeake Bay may occur during droughts (Hughes 1993). Figure 2.3 shows the direction of groundwater flow in the surficial aquifer.

A general downward gradient that occurs between the water table and the leaky confining layer indicates that the leaky confining unit is recharged primarily by the surficial aquifer. During the summer, the direction of vertical flow is reversed at some locations. Groundwater under the marsh and the rivers, which are discharge areas, probably leaks upward from the leaky confining aquifer into the surficial aquifer.

2.1.5.2 Leaky Confining Unit

The leaky confining unit consists of silty, sandy clay and organic matter and corresponds to the middle unit of the Quaternary (Talbot) sediments. Vertical leakage from

FIGURE 2.3 Groundwater Flow in the Surficial Aquifer, November 1989
 (Source: Adapted from Hughes 1993)

the leaky confining unit to the underlying confined aquifer occurs at all sites beneath J-Field but is probably quite limited offshore. The direction of vertical flow may be reversed in some offshore areas (Hughes 1993).

Lateral flow in the leaky confining unit is generally the same as that of the surficial aquifer. In the western part of the site, the unit is 40 ft thick, with a surface elevation 25 ft below mean sea level (MSL). In the eastern portion of the site, the unit is 107 ft thick and has a surface elevation of 35 ft below MSL. Hydraulic conductivities range from less than 0.01 to 0.20 ft/d, with a median value of 0.05 ft/d (Hughes 1993).

2.1.5.3 Confined Aquifer

The confined aquifer consists of gravelly sand and clay and corresponds to the base unit of the Quaternary (Talbot) sediments. In the western part of J-Field, the top of the confined aquifer is 60 ft below MSL, and the unit is 50 ft thick. In the southeast, this aquifer dips to a surface elevation of 142 ft below MSL and thins to 15 ft thick. Lateral flow directions are similar to those in the water table; however, the hydraulic head and lateral gradients are very small. Groundwater flows away from the TBP toward the marshes and Chesapeake Bay, and wells show evidence of a tidal influence. Seasonal variations in the flow direction of the confined aquifer occur for short periods during the summer (Hughes 1993).

2.1.5.4 Potomac Group Aquifer

The Potomac Group aquifer consists of interbedded, fine-grained sand and massive clay. This aquifer corresponds to the Cretaceous (Potomac Group) sediments of fluvial origin. Surface elevations of the Potomac Group aquifer range from 105 ft below MSL in the eastern part of J-Field to 157 ft below MSL in the western part. The thickness of the aquifer is, in general, uncertain but may be up to 800 ft. The sediments are underlain by metamorphic bedrock. Insufficient data are available to determine lateral or vertical flow directions or the effects of the seasons and tides on the Potomac Group aquifer (Hughes 1993).

2.1.6 Ecology

Gunpowder Neck Peninsula consists primarily of open fields (mowed and unmowed grass), bare ground, and second-growth woods (dominated by maple, oaks, and sweetgum). J-Field supports extensive areas of these second-growth woods and freshwater wetlands (dominated by common reed). A large wetland at the southern end of J-Field (Figure 2.2) supports extensive areas of reed and includes a large area of open water. All wetlands at J-Field are separated from the Chesapeake Bay by beach ridges and thus are not directly influenced by tidal fluctuations except through changes in groundwater levels. A few areas of bare ground are located on the western and eastern sides of J-Field, particularly in the vicinity of disposal pits. Additional freshwater tidal and nontidal wetlands occur along the

periphery of the Gunpowder Neck Peninsula, outside of J-Field. The peninsula is surrounded by freshwater tidal estuaries — Chesapeake Bay to the south, Gunpowder River to the west, and Bush River to the east.

Both the TBP and the WPP AOCs are in open areas cleared of natural vegetation. The area immediately around each pit consists of mowed grass with weeds typical of disturbed habitats and old fields. The TBP are west of a large wetland at the southern end of J-Field. Some of the burned material from these pits has, over time, been pushed into the wetland. The WPP are very close to the Gunpowder River. In 1986, a berm was constructed to prevent waste material from these pits from entering the river. Such material is now diverted into a wetland approximately 100 m north of the pits. The RCP has not been used since the early 1970s; therefore, it is presently overgrown with shrubs and reeds. It is likely that runoff from the pit enters an adjacent wetland and the Gunpowder River.

The biota at J-Field have not been surveyed in detail; however, common species are likely to include those typical of other areas of the APG. Mammals likely to be common at J-Field include the muskrat, raccoon, white-tailed deer, short-tailed shrew, and white-footed mouse. Common birds could include great blue heron and spotted sandpiper. Because of its status as a federal endangered species, the bald eagle (known to occur at J-Field) is of ecological and regulatory interest. Composition of the fish communities in the J-Field wetlands has not been determined. Common species in the surrounding estuary include alewife, American shad, Atlantic menhaden, channel catfish, and white perch.

2.2 BACKGROUND OF J-FIELD AREAS OF CONCERN

The following sections summarize the past disposal operations conducted at each AOC at J-Field. General descriptions of the hydrology and soils in the vicinity of J-Field are also included. PAOCs are addressed in Appendix B.

2.2.1 Toxic Burning Pits AOC

The TBP AOC is located on about 9 acres in the southern portion of J-Field (Figure 1.3). Disposal operations at the TBP area began in the 1940s and have continued until the present. The pits were used most extensively between the late 1940s and the 1960s. Items disposed of included chemical agents, bulk chemical wastes, drummed chemical wastes, HE (by OB/OD), nerve agents, incapacitating agents (also known as riot control agents), chlorinated solvents, and blister agents (Nemeth 1989).

Information from interviews, sampling, and magnetic surveys indicates that five disposal pits were used at the TBP area. The two existing (or main) burning pits (each covering about 4,500 ft²) were the pits most actively used for the disposal of various chemical agents and explosives. Three other burning pits, now covered, were used to dispose of VX, dichlorodiethyl sulfide (mustard), and the primary components of liquid smoke — titanium tetrachloride (FM) and sulfur trioxide/chlorosulfonic acid (FS).

The VX pit and mustard pit are about 100 and 150 ft long, respectively. The liquid smoke disposal pit is fairly small, covering an area of about 24 ft². Liquid smoke was probably disposed of by placing it on the ground and allowing it to vaporize into the atmosphere. HE munitions were also disposed of by detonation in an area along the southeastern edge of the TBP area (Nemeth 1989).

Storage and handling areas have been identified (in aerial photographs) at the upper end of both the VX burning pit and the mustard burning pit. In addition, a square pit approximately 4 ft by 4 ft and 3 ft deep has been identified at the current tree line south of the main burning pits. These storage and handling areas and the pit could be additional sources of contamination in the TBP AOC.

The TBP area is bounded to the northeast by marsh and to the south and southeast by woods and marsh (Nemeth 1989). Because the elevation of the ground surface is highest in the northwestern portion of the TBP area, surface water probably drains toward the south-southeast into the marsh area. The direction of groundwater flow in the surficial aquifer is probably also toward the marsh. Soils are brownish-yellow silty fine sand at the surface, grading to bluish-gray silty fine sand below a depth of 14 ft (Princeton Aqua Science 1984).

2.2.2 White Phosphorus Burning Pits AOC

The WPP AOC is located near the Gunpowder River in the western portion of J-Field (Figure 1.3). The area contains two pits that were used for disposal (by detonation and burning) of white phosphorus (WP), plasticized white phosphorus (PWP), munitions filled with WP, and materials contaminated with WP. After materials were burned and reburned in the pits, debris and soil were pushed out. Some of the materials disposed of at this site probably contained other types of waste in addition to WP. The types and quantities of these other wastes are unknown, although personal interviews indicate that riot control agents may have been disposed of here (Nemeth 1989).

The WPP area has been used as a disposal site since the late 1940s or early 1950s. Aerial photographs show that in 1951, disposal operations were conducted in the southeastern portion of what is currently the open disposal area. The two existing pits were constructed sometime between 1951 and 1957 (Nemeth 1989).

During the late 1950s, the pits were extended to the Gunpowder River. Pushout from the pits was pushed into the river. In 1986, a ditch was excavated to drain water from the pits. The ditch from the northern pit extends north toward a bermed depression that was constructed to hold the water. The ditch associated with the southern pit ends at what is assumed to be a pushout area. During wet weather, water collects in the pits and the bermed depression, even though surface runoff does not enter the pits (Nemeth 1989; Sonntag 1991). As previously noted, the WPP is considered an active emergency disposal facility. As a result, the existing pits and areas potentially affected by emergency disposal operations have been excluded from the RI/FS and are deferred pending the relocation of emergency disposal operations. However, aerial photograph interpretation indicates that two

suspect burning areas may have existed northwest and southwest of the WPP and that a storage area may have existed southeast of the WPP. These areas could represent sources of contamination and are not likely affected by current operations. As a result, these areas will be addressed in this FS.

Surface water drainage from the WPP area flowed west into Gunpowder River. The direction of groundwater flow in the surficial aquifer is also probably toward Gunpowder River to the west (Nemeth 1989). Soils are brownish-yellow silty fine sand at the surface, grading to bluish-grey silty fine sand below a depth of 14 ft (Princeton Aqua Science 1984).

2.2.3 Riot Control Burning Pit AOC

The RCP AOC is located in a heavily wooded area in the southwestern portion of J-Field (Figure 1.3). Except for a small area in the northeastern part of the site, the area is overgrown with vegetation. About 30 ft of an access road has been eroded, and the presence of several fallen trees about 10 ft offshore indicates that this area is rapidly being eroded by wave action.

Disposal operations in the pit began in the late 1940s and continued until operations at the site ceased in the early 1970s. The area immediately east of the access road to the South Beach was probably part of the site and may have been used for burning operations during the 1950s. A trench was excavated in the area sometime between 1957 and 1960 and was later extended southwest to the Gunpowder River to provide drainage from the pit. Between 1960 and the early 1970s, the trench was used for burning riot control agents, munitions filled with riot control agents, and material contaminated with these agents (Nemeth 1989). The main agent disposed of was the tear agent o-chlorobenzylidene malononitrile (CS); some chloroacetophenone (CN) was also disposed of there (Sonntag 1991).

Surface water drainage from the RCP area flows toward the southwest into a small marsh area and the Gunpowder River. The direction of groundwater flow in the surficial aquifer is probably toward the marsh and Gunpowder River to the west-southwest. Shallow soils are predominantly clayey sandy silt (Nemeth 1989).

2.2.4 Prototype Building AOC

The PB AOC is located in the southwestern portion of J-Field, northwest of the TBP area and north of the RCP area (Figure 1.3). The building, constructed during World War II, is an open-sided, three-level reinforced concrete structure. It was originally used for testing the effectiveness of bombs. Since World War II, the PB and the areas to the west and north have been intermittently used for temporary storage of solid waste (Nemeth 1989). Two suspect burning areas have also been identified — one northeast and one west of the PB — on the basis of a review of archival information.

The area around the PB is fairly flat; surface water drains primarily west toward a marsh area (Nemeth 1989) but may also flow north-northwest toward the Gunpowder River. The direction of groundwater flow in the surficial aquifer is probably toward Chesapeake Bay. The shallow soils are predominantly silty, clayey sand with greater amounts of clay and silt near the surface (Nemeth 1989).

2.2.5 South Beach Demolition Ground AOC

The SBDG AOC was located along the southern beach of J-Field (Figure 1.3). The area was used as a demolition site for HE munitions during the 1960s and 1970s, and possibly during the 1950s (Nemeth 1989). Munitions were detonated either on the surface or under several feet of soil. It is reported that remnants of munitions detonated in this area are currently visible about 100 ft offshore during low tide. At high tide, most of the demolition ground area is 1-2 ft below water. A few demolition craters, which are assumedly remnants of the SBDG operations, are visible just inland from the shoreline and east of the end of Rickett's Point Road.

Surface water from the remnants of the SBDG most likely drains south toward Chesapeake Bay. The direction of groundwater flow in the surficial aquifer is probably toward the bay as well. The nature of the shallow soils in the SBDG is undocumented; however, they are most likely composed of clayey sandy silt, similar to the SBT area.

2.2.6 South Beach Trench AOC

The SBT AOC is located near the southern beach of J-Field, southeast of the RCP area (Figure 1.3). The trench, about 75 ft long and 12 ft wide, was excavated between 1957 and 1960. It may have been a borrow pit for nearby demolition activities. Aerial photographs from the 1960s reveal a road leading into and out of the SBT. No information has been found regarding past chemical or hazardous material disposal in this area; however, chemical analyses of soil samples collected from the trench during the RFA showed low levels of chlordane and naphthalene (Nemeth 1989).

Surface water drainage from the SBT is primarily west toward a marsh area (Nemeth 1989), but surface water may also flow south toward Chesapeake Bay. Groundwater in the surficial aquifer probably flows toward Chesapeake Bay. Shallow soils are predominantly clayey sandy silt (Nemeth 1989).

2.2.7 Robins Point Demolition Ground AOC

The RPDG AOC is in the eastern portion of J-Field close to the Bush River (Figure 1.3). The site was first used during the late 1970s for the destruction of HE and HE-filled munitions. The site was also reportedly used during the 1980s for destruction of small amounts of sensitive and unstable chemicals by detonation with explosives (Nemeth 1989).

The original site, now inactive and considered an AOC for the purposes of the RI/FS activities, was a small clearing near the edge of the adjacent marsh. In 1985, the clearing was enlarged, and a berm was built on the western edge of the clearing. Later demolition activities occurred in an area west of the berm; the berm prevented surface runoff from entering the marsh (Nemeth 1989). The area west of the berm has remained active and continues to be used for disposal operations.

Before 1985, surface water drainage from the RPDG flowed directly into the adjacent marsh to the east. The berm constructed in 1985 now prevents runoff from directly entering the marsh. However, water that ponds west of the berm seeps through the berm to the inactive portion of the RPDG. Groundwater in the surficial aquifer probably flows to the east toward the marsh. Shallow soils in the RPDG consist predominantly of clayey silt (Nemeth 1989).

2.2.8 Robins Point Tower Site AOC

The RPTS AOC is located near Robins Point at the southeastern tip of the Gunpowder Peninsula (Figure 1.3). The wooden observation tower was built between 1957 and 1960. The road connecting Robins Point with Rickett's Point Road has existed since about 1917, when APG became an army installation. However, aerial photographs suggest that the area was not used until the 1950s. The Robins Point area was used for launching and observing rockets (Nemeth 1989).

Around 1959, the Robins Point area may have been used for at least one test burn of wood contaminated with radioactive material (including radium and strontium). According to Nemeth (1989), the test burn was to be conducted in a trench (20 ft long, 5 ft wide, and 5 ft deep), with not more than 500 lb of material to be burned in small increments. A 1959 U.S. Army Environmental Hygiene Agency (USAEHA) report recommended that the routine burning of radioactively contaminated materials be conducted in a closed incinerator; correspondence in the USAEHA project file indicates that this recommendation was accepted (Nemeth 1989). The possibility remains, however, that a test burn of radioactively contaminated wood did occur at either the RPDG or the RPTS. Records do not indicate which site was used. However, it is likely that the RPTS was used because the site of the demolition ground was wooded and not yet in use in 1959. In addition, aerial photographs from the 1960s show no roads or open areas at the site of the RPDG.

Surface water from the RPTS probably flows east toward Bush River and south toward the adjacent marsh. Groundwater in the surficial aquifer probably also flows toward Bush River and the marsh. The shallow soils are predominantly sand, with sandy clayey silt near the surface (Nemeth 1989).

2.2.9 Other J-Field Sites

Pursuant to the requests of the Maryland Department of the Environment (MDE), investigative activities have been expanded beyond the eight specified AOCs to include all of J-Field. As a result, a protocol was developed to identify other suspect areas, referred to as PAOCs, on the basis of a review of archival information and walkover surveys. The process used to identify the PAOCs and the sampling activities proposed for the PAOCs are described in Appendix B.

2.3 PRELIMINARY EVALUATION OF J-FIELD AREAS OF CONCERN

Several investigations have been conducted at J-Field to characterize contamination from past operations, install monitoring wells, and characterize the estuarine sediments around the peninsula. Table 2.1 provides a chronological summary of these studies. An overview of the results of these studies is presented in the following sections. These sections present data for J-Field that were collected through January 1993. All data corrected during the RI will be presented in technical updates and the RI report.

2.3.1 Toxic Burning Pits

2.3.1.1 Types of Waste Present

The TBP were used to dispose of HE-filled munitions, nerve agents, mustard agents, chemical warfare agents (CWAs), decontaminating agents, liquid smoke, chlorinated solvents, and radioactive chemicals. In addition, fuel was used to ignite materials placed in the pits.

2.3.1.2 Types of Contaminants Present

A hydrological assessment of J-Field was carried out in two phases by the USGS. Phase I was conducted from 1987 to 1992 to select locations for establishing monitoring wells at the TBP and WPP areas. It was assumed that the pits and the open burning grounds around them were the primary sources of contamination in the area. The goal of Phase II, conducted in 1992, was to determine the extent of contamination in the area of the TBP, sample the RCP area, and determine if contaminated groundwater was moving into Chesapeake Bay (Hughes 1993). The following subsections discuss the findings relative to the nature and extent of contamination in the TBP area.

Soil Gas

During Phase I of the hydrological assessment, the USGS sampled 37 locations around the TBP for soil-gas concentrations of trichloroethylene (TRCLE), tetrachloroethylene

TABLE 2.1 Summary of Previous Investigations at J-Field

Field Investigation	Investigator	Date	Objective/Activity
Environmental Contamination Survey	USATHAMA	1977-1978	Conducted to determine if contamination from past operations was migrating off-post. Eleven monitoring wells (TH1-11) were installed in the surficial aquifer — 10 near the TBP and WPP and 1 near the Robins Point Tower. Ground-water samples were collected and analyzed.
Munitions Disposal Study	Princeton Aqua Science	1983	Installed nine monitoring wells (P1-9) in the surficial aquifer — five near the TBP and four near the WPP. Composite soil samples were collected during drilling of wells. Soil samples were also collected from the pits in the TBP and WPP areas.
RCRA Facility Investigation	USAEHA	1986	Sampled groundwater from TH and P series wells. Soil samples also collected in and around the pits in the TBP, WPP, and RCP areas and near the Prototype Building. A field radiation survey was also performed.
Hydrological Assessment, Phase I	USGS	1987-1992	Drilled exploratory boreholes, collected soil samples, and ran geophysical logs. Installed 12 well clusters (JF1-12), each consisting of 3 wells screened in the upper portions of the confined aquifer, the confining unit, and surficial aquifer. Wells were sampled on a monthly (1987) and quarterly basis (1989-1992); water-level measurements also taken. Conducted slug tests. Currently using MODFLOW model to simulate contaminant pathways in groundwater. A total of 21 surface samples also collected from Gunpowder River and Chesapeake Bay. Soil and soil-gas samples collected in TBP and WPP areas.

TABLE 2.1 (Cont.)

Field Investigation	Investigator	Date	Objective/Activity
Characterization and Interim Remediation	Roy F. Weston, Inc.	1992	Activities included topographic survey of J-Field area; survey of UXO ^a in each burning pit and along shoreline of WPP and RCP; construction of access roads; placement of riprap and gabion structures along WPP and RCP shoreline; removal and staging of surface material and debris from burning pit areas; sampling and staging drums from the Prototype Building; sampling and analysis of soil from the pits and pushout areas; installation of flood control berms in the pit areas, where needed; and collection of surface and subsurface soil samples.
Hydrological Assessment-Phase II	USGS	1992	Continued sampling of groundwater, measuring water levels in all monitoring wells, and slug testing. Four new wells installed. Collected surface water samples from marsh areas and estuaries surrounding J-Field, based on thermal imagery studies conducted by the USGS.
Sediment Sampling Study	EPA	1992	Conducted a study to characterize the estuarine sediments around the Gunpowder Neck Peninsula.

^a UXO = unexploded ordnance.

(TCLEE), alkanes, combined hydrocarbons, and simple aromatics. The relative contours for all contaminants except the alkanes show a broad band of contamination that extends across the eastern end of the pits from the marsh on the north to the marsh on the south (Figure 2.4). The alkanes appear to be limited to the area south of the TBP, and the data suggest a plume of contamination moving into the marsh at the southern edge (Figure 2.5) (Hughes 1993).

Additional soil-gas samples were collected during Phase II from wooded and marshy areas north and south of the TBP and from 15 locations along Chesapeake Bay. Samples were analyzed for combined dichloroethylenes (DCEs) and trichloroethanes (TCEs), combined TRCLEs and TCLEEs, phthalates, and heavy aromatic hydrocarbons (Hughes 1993).

Relative values and contours for concentrations of combined DCE and TCE and of combined TRCLE and TCLEE show a similar distribution, with elevated contamination to the southeast of the TBP. Figure 2.6 shows contours for combined TRCLE and TCLEE. The DCE plus TCE contamination south of the pits is somewhat more extensive, with elevated values extending to the shore of Chesapeake Bay. The concentration contours, when combined with contours from Phase I analyses, suggest that plumes of contaminated groundwater are moving downgradient under the marshes both on the northern and southern sides of the TBP. This hypothesis is supported by the relative contours for heavy aromatics (Figure 2.7), which show locations with more extensive contamination, including along the shore. The data also suggest that contaminated groundwater may be moving beneath, and possibly discharging into, the bay, or that contaminated surface water from the marshes may be moving into shore sediments (Hughes 1993).

Soil

In 1983, soil samples were collected during the installation of monitoring wells at the TBP. Four composite samples were collected at depth intervals of 5 ft. The samples were analyzed for metals, cyanide, phenols, total phosphorus, volatile organic compounds (VOCs), pesticides, polychlorinated biphenyls (PCBs), and herbicides. Some of the results are listed in Table 2.2. The data showed elevated concentrations of lead, zinc, nitrate, and petroleum hydrocarbons in each of the samples. It should be noted that the background samples also contained somewhat elevated concentrations of petroleum hydrocarbons.

During the 1986 RFA (Nemeth 1989), surface soil samples were collected from 20 locations in the TBP and the debris pushout area (Figure 2.8). All of the samples were analyzed for metals, extractable metals, and explosives-related compounds. The results, as summarized in Table 2.3, show that the surface soil in and around the TBP contain elevated levels of metals, especially lead (up to 2.6% in the pushout area [location 12]); mercury (up to 10.8 mg/kg in one of the pits [location 8]); and cadmium (16.6 mg/kg at location 20). Samples from locations 7 and 12 exceeded the RCRA extraction procedure (EP) limit of 5.0 mg/L for lead (40 CFR 261).

FIGURE 2.4 Relative Contours for All Soil-Gas Parameters (except alkanes) at the Toxic Burning Pits Area (Source: Adapted from Hughes 1993)

FIGURE 2.5 Relative Contours for Alkanes in Soil Gas from the Toxic Burning Pits Area
(Source: Adapted from Hughes 1993)

FIGURE 2.6 Relative Contours for Combined TRCLE and TCLEE at the Toxic Burning Pits Area (Source: Adapted from Hughes 1993)

FIGURE 2.7 Relative Contours for Heavy Aromatics in Soil Gas from the Toxic Burning Pits Area (Source: Adapted from Hughes 1993)

TABLE 2.2 Analytical Results for Analysis of Soil Samples from the Toxic Burning Pits AOC Main Burning Pits, January 1983

Parameter ^a	Parameter Concentrations (mg/kg except as noted)		
	Back-ground ^b	Pit 1 ^c	Pit 2 ^c
Arsenic	<0.481	3.56	<0.53
Barium	110	247	257
Cadmium	0.84	4.46	2.19
Chromium	74.70	413	192
Iron	6,000	18,900	17,000
Lead	76.90	717	281
Manganese	153	169	206
Mercury	0.034	0.080	0.008
Potassium	857	1,450	1,650
Zinc	250	1,510	810
pH (standard units)	6.30	8.50	8.80
Nitrate	295	316	249
Total phosphorus	9.00	<0.50	<0.25
Cyanide	<0.50	<0.50	<0.50
Petroleum hydrocarbons	113	800	850
Phenols	0.37	<0.13	0.31
Toluene (µg/kg)	<20.00	32.00	28.00
Ethylbenzene (µg/kg)	20.00	<20.00	<20.00

^a Table lists all parameters detected at least once.

^b Locations of background samples not given.

^c Based on available information, it is inferred that Pit 1 is the northern main burning pit and Pit 2 is the southern main burning pit.

Source: Adapted from Princeton Aqua Science (1984).

FIGURE 2.8 Locations in the Toxic Burning Pits Area where Surface Soil and Surface Water Samples Were Collected during the 1986 RCRA Facility Assessment (Source: Adapted from Nemeth 1989)

TABLE 2.3 Analytical Results for Analysis of Soil Samples J1-J20 from the Toxic Burning Pits, 1986

Parameter ^a	J1	J2 ^b	J3	J4	J5	J6	J7	J8	J9
Total Metals (mg/kg)									
Arsenic	54.8	25.2	21.5	40.5	18.5	9.7	47.3	25.7	43.9
Barium	592	277	313	90.5	134	<60	488	172	296
Cadmium	8.13	4.57	2.52	4.88	1.58	2.20	17.3	8.64	6.10
Chromium	75.5	54.4	45.9	95.9	70.8	10.7	73.3	76.0	53.3
Lead	472	548	378	85.3	60.3	38.5	2,998	720	1,369
Mercury	0.78	0.87	0.46	0.15	0.22	0.17	2.16	10.8	7.29
Silver	14.0	<5.0	<5.0	12.1	<5.0	<5.00	15.2	7.01	<5.0
Extractable Metals (mg/L)									
Cadmium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.228	<0.10	<0.10
Lead	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5.23	<0.50	<0.50
Silver	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	J10	J11	J12	J13	J14	J17	J18	J19	J20
Total Metals (mg/kg)									
Arsenic	32.2	12.6	24.1	8.26	28.7	15.9	6.5	9.74	12.3
Barium	208	101	855	107	256	<60	81.4	<60	<60
Cadmium	4.75	0.27	3.57	1.01	1.47	5.02	<0.20	5.38	16.6
Chromium	58.0	12.1	80.1	19.2	30.4	63.9	6.65	15.4	13.5
Lead	4,101	15.8	26,040	41.8	1,522	203	12.1	140	1,622
Mercury	6.10	0.11	0.77	0.11	0.59	0.20	<0.10	0.28	3.40
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	8.64	<5.0	<5.0	<5.0
Extractable Metals (mg/L)									
Cadmium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.112
Lead	<0.50	<0.50	31.2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver	<0.50	<0.50	<0.50	<0.50	0.154	<0.50	<0.50	<0.50	<0.50

^a Includes parameters that were detected in at least one soil sample.

^b VOCs were measured in sample J2 only; 1,000 µg/kg TRCLE and traces of other VOCs were found.

Source: Nemeth (1989).

Composite samples from locations 1 and 2 contained 13,000 µg/kg heptachlor epoxide and lower concentrations of other pesticides. Aroclor 1248 (a PCB) was detected at a concentration of 230,000 µg/kg. Composites from locations 3 through 5, 7 through 10, 19, and 20 (near the PB) also contained pesticides — 1,000 µg/kg each dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyltrichloroethane (DDT) (in locations 19 and 20 only); and 3,700 µg/kg PCBs (locations 3 through 5 only). Hughes (1993) states that detection of pesticides in samples containing PCBs may represent false positives. PCBs reportedly were used as heat-transfer fluids at the Edgewood Area and disposed of at J-Field (Nemeth 1989). Trace concentrations of organic compounds were also detected in samples: TRCLE (at 1,000 µg/kg) and traces of other VOCs in the sample from location 2, the only sample analyzed for VOCs.

Soil samples were collected by the USGS from depths of approximately 1 ft below land surface at 36 sites in J-Field, including the TBP area (Figure 2.9). The samples were analyzed for indicator parameters, metals, VOCs, semivolatile compounds, and explosives (Hughes 1992). The results of these analyses, except for explosives, are presented in Table 2.4. Soil samples showed some metals contamination, especially at locations 39 and 30, north of the Mustard Pit. Traces of organic compounds were also detected in some samples.

Soil samples were also collected in the TBP area by Weston in October 1992 (Figure 2.10). The samples were collected at depths of 2, 4, and 6 ft in the pits; and at depths of 3 in. and 1 ft in the marshes and pushout areas. Tables 2.5 and 2.6 summarize the analytic results for parameters detected in some of these samples.

The highest concentrations of organic compounds were found in the area of the Mustard Pit: TCLEA, up to 3,270,000 µg/kg at 6 ft; 1,1,2-trichloroethane (112TCE), up to 8,500 µg/kg at 6 ft; TCLEE, up to 25,700 µg/kg at 6 ft; and TRCLE, up to 263,000 µg/kg at 6 ft. Organic compounds, including TCLEA, 112TCE, acetone, methylene chloride, and TRCLE, were detected in the main burning pits (see Table 2.6). High levels of PCBs were detected in the southern main pit (up to 143,000 µg/kg at 2 ft), the mustard pit (up to 178 µg/kg at 6 ft), the southern marsh (up to 3,200 µg/kg at 1 ft), and the pushout area northwest of the main pits (up to 3,800 µg/kg at 1 ft). The highest concentrations of lead were found in the southern main pit (340 mg/kg at 2 ft), the mustard pit (121 mg/kg at 6 ft), the southern marsh — (542 mg/kg at 1 ft), the marsh east of the main pits (79,800 mg/kg at 3 in.), and the pushout area northwest of the main pits (1,180 mg/kg at 3 in.).

Surface Water

Surface water samples (J15 and J16) were collected from the TBP area as part of the 1986 RFA (Nemeth 1989). Sampling locations are shown in Figure 2.8. Samples were analyzed for metals, explosives-related compounds, inorganic compounds, gross alpha, gross beta, radium-226, radium-228, VOCs, semivolatile compounds, and PCBs. The results are summarized in Table 2.7 for locations J15 and J16.

FIGURE 2.9 Locations where Soil Samples Were Collected by the USGS in 1991
(Source: Adapted from Hughes 1992)

TABLE 2.4 Analytical Results for Analysis of Soil Samples from the Toxic Burning Pits Area, April 1991^a

Parameter	Concentration by Soil Sample Location ^b												
	23	24	25	26	27	28	29	30	31	32	33	34	36
Metals (mg/kg)													
Arsenic	3.7	3.2	ND	4.5	4.2	7.8	49	21	2.6	3.3	3.5	6.6	3.2
Cadmium	ND	ND	ND	ND	ND	2.4	16	ND	ND	ND	ND	ND	ND
Chromium	14	11	6.6	16	15	37	121	46	12	13	13	17	17
Copper	21	50	10	22	19	233	786	48	4.2	11	15	40	17
Lead	17	40	14	41	38	662	87,100	952	15	17	29	42	19
Antimony	ND	ND	ND	ND	ND	ND	1,120	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	20	96	157	ND	7,960	ND	25	ND	ND	ND	ND
Volatile Organic Compounds (µg/kg)													
Acetone	5.89	13.9	6.73	15.8	6.75	9.80	15.7	4.88	2.24	ND	21.0	ND	ND
cis-1,2-Dichloroethylene	NA	NA	NA	NA	NA	2.4	NA	2.40	NA	NA	NA	NA	NA
Trichloroethylene	ND	ND	ND	ND	ND	1.12	ND	ND	ND	ND	ND	ND	ND
Semivolatile Organic Compounds (µg/kg)													
Butylbenzyl phthalate	ND	598	ND	ND	720	ND	580	ND	ND	ND	ND	ND	ND
Benzoic acid	353	7,000	1,500	ND	ND	ND	420	420	ND	ND	2,100	ND	ND
Other (mg/kg)													
Total Kjeldahl nitrogen	1,040	2,340	695	249	247	637	605	488	627	1,030	1,730	639	552
Total organic carbon	958	2,590	1,630	1,190	1,720	1,590	1,630	1,190	1,390	871	1,810	752	1,010
Total organic halogen	ND	ND	157	20	48	37	34	ND	ND	ND	ND	ND	ND

^a ND = not detected; NA = not analyzed.

^b Locations are shown in Figure 2.9.

Source: Hughes (1992).

TABLE 2.5 Analytical Results for Target Compound List Analytes in Selected Soil Samples from the Toxic Burning Pits, 1992^a

TCL ^b Analyte	Concentrations (µg/kg) by Soil Sample Location							
	JBP1-E(2') ^c	JBP1-E(4')	JBP2-E(2')	JBP2-E(4')	JVXP(4')	JVXP(6')	JSDP(4')	JSDP(6')
<i>Volatile Organic Compounds</i>								
1,1,2,2-Tetrachloroethane	6.74	ND ^d	ND	ND	167	39	15,200	25.6
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	80.5	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	16.4	33	44.7	116	ND	ND	344	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	6.23	ND	6.30	7.03	8.25	44.0	12.4
Tetrachloroethylene	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND
<i>trans</i> -1,2-Dichloroethylene	ND	ND	ND	ND	ND	ND	78.0	ND
Trichloroethylene	28.1	ND	ND	ND	ND	15.8	345	ND
Vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND
Xylenes	12.4	ND	ND	ND	ND	ND	ND	ND
<i>Semivolatile Organic Compounds</i>								
2-Methylnaphthalene	471	ND	ND	ND	ND	ND	ND	ND
Hexachloroethane	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	580	ND	ND	ND	ND	ND	ND	ND
<i>PCBs</i>								
Aroclor 1248	143,000	1,180	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	224	ND	ND	ND	ND	ND

TABLE 2.5 (Cont.)

TCL Analyte	Concentration (µg/kg) by Soil Sample Location					
	JHDP(4')	JHDP(6')	JBPM-A(3")	JBPM-A(1')	JBPM-B(3")	JBPM-B(1')
<i>Volatile Organic Compounds</i>						
1,1,2,2-Tetrachloroethane	289,000	3,270,000	123	1,460	13,200	15,200
1,1,2-Trichloroethane	2,100	8,540	61.0	ND	80.2	ND
1,1-Dichloroethane	ND	8.99	ND	ND	ND	ND
1,1-Dichloroethylene	31.3	77.6	ND	ND	ND	ND
1,2-Dichloroethane	40.1	62.4	ND	ND	ND	ND
Acetone	177	113	275	ND	324	ND
Benzene	19.1	83.1	ND	ND	ND	ND
Carbon tetrachloride	17.1	172	ND	ND	ND	ND
Chloroform	142	445	ND	ND	ND	ND
Methylene chloride	44.9	41.2	36.1	ND	36.2	ND
Tetrachloroethylene	ND	25,700	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND
<i>trans</i> -1,2-Dichloroethylene	3,860	3,220	ND	ND	50.4	ND
Trichloroethylene	6,780	263,000	843	26,000	517	ND
Vinyl chloride	315	302	ND	ND	ND	ND
Xylenes	ND	ND	ND	ND	ND	ND
<i>Semivolatile Organic Compounds</i>						
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND
Hexachloroethane	ND	628	ND	498	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND
<i>PCBs</i>						
Aroclor 1248	ND	178	ND	ND	ND	ND
Aroclor 1254	ND	ND	1,700	3,160	ND	ND

^a Only detected analytes are reported; for samples with duplicate analyses, the higher value is reported.

^b TCL = Target Compound List.

^c Sample depth shown in parentheses.

^d ND = not detected.

TABLE 2.6 Analytical Results for Target Analyte List Analytes in Selected Soil Samples from the Toxic Burning Pits, 1992^a

TAL ^b Analyte	Concentration (mg/kg) by Soil Sample Location						
	JBP1-E(2') ^c	JBP1-E(4')	JBP2-E(2')	JBP2-E(4')	JVXP(4')	JVXP(6')	JSDP(4')
Antimony	5.08	ND ^d	ND	ND	ND	ND	ND
Arsenic	5.02	4.18	3.50	2.33	1.19	ND	1.38
Beryllium	0.309	0.453	0.228	0.380	ND	ND	ND
Cadmium	3.21	ND	ND	ND	ND	ND	ND
Chromium	36.6	18.2	14.2	12.7	5.33	3.15	4.09
Cobalt	5.64	ND	ND	ND	ND	ND	ND
Copper	248	10.1	6.85	10.1	ND	ND	ND
Lead	340	10.5	15.9	96.3	10.5	2.6	3.37
Zinc	1,220	123	94.4	76.5	33.8	13.1	13.5

TAL Analyte	Concentration (mg/kg) by Soil Sample Location						
	JSDP(6')	JHDP(4')	JHDP(6')	JBPM-A(3")	JBPM-A(1')	JBPM-B(3")	JBPM-B(1')
Antimony	ND	ND	ND	ND	ND	13.7	ND
Arsenic	ND	3.94	6.29	4.80	22.5	7.49	3.58
Beryllium	ND	0.457	0.408	0.434	0.263	0.339	0.398
Cadmium	ND	ND	7.23	2.95	6.05	5.94	ND
Chromium	5.54	11.9	44.1	37.8	67.9	53.4	15.6
Cobalt	ND	ND	ND	ND	ND	6.41	ND
Copper	ND	ND	123	305	392	521	4.77
Lead	8.22	10.5	121	145	542	79,800	11.2
Zinc	12.8	25.1	296	690	678	1,000	46.9

^a Only detected analytes are reported; for samples with duplicate analyses, the higher value is reported.

^b TAL = Target Analyte List.

^c Sample depth shown in parentheses.

^d ND = not detected.

Source: Mazelon (1993).

TABLE 2.7 Analytical Results for Surface Water Samples from the Toxic Burning Pits Area, 1986

Parameter ^a	Location	
	J15	J16
<i>Dissolved Metals (µg/L)</i>		
Cadmium	<1.0	2.0
Lead	40	104
Mercury	0.60	<0.20
<i>Inorganic Compounds (µg/L)</i>		
Nitrate and nitrite as N	<30	60
Sulfate	12,000	16,000
Chloride	3,000	4,000
Total dissolved solids	NA ^b	34,000
<i>Radioactivity (pCi/L)</i>		
Gross alpha	<0.8	7.0
Gross beta	5.7	15
Radium-226	NA	0.50
Radium-228	NA	1.4

^a Includes parameters that were detected in one or more samples. No detection limits given for VOCs, semivolatile compounds, and PCBs.

^b NA = Not analyzed.

Source: Nemeth (1989).

The surface water contained some lead contamination. The lead concentration at location 16 was above the primary drinking water standard (50 µg/L). The gross alpha radionuclide was also slightly elevated at location 16. The radioactivity measurements were consistent with results from a field radiation survey of the TBP for materials emitting beta and gamma radioactivity. No radiation above background levels was detected (Nemeth 1989).

The USGS collected nearshore surface water samples from the Gunpowder River (9 locations) and the Chesapeake Bay (11 locations) at low tide. One sample was collected onshore in a drainage ditch. Sampling locations are shown in Figure 2.11. Filtered and unfiltered samples were analyzed for water quality parameters, metals, and a few organic compounds. Nitrate concentrations in samples from locations 3, 7, and 13 ranged from 280 to 400 µg/L. The metals data showed the presence of lead (from not detected [ND]¹ to

¹ The detection limits for analyses were not reported.

FIGURE 2.11 Locations of Surface Water Samples Collected at J-Field in 1988
(Source: Adapted from USGS 1991)

28 µg/L) and zinc (50-133 µg/L) at locations 1 through 4. Lead and zinc concentrations at the other locations ranged from ND to 2.68 and 48 µg/L, respectively. Mercury and nickel concentrations were slightly elevated at location 1 (0.54 and 33.7 µg/L, respectively). No evidence was found of elevated concentrations of arsenic, barium, or chromium. Comparison of results from filtered and unfiltered samples showed that the elevated metals concentrations may be associated with the suspended solids in the samples (Hughes 1993).

Acetone, toluene, phenol, total organic carbon (TOC), and total organic halogen (TOX) were analyzed in the filtered and unfiltered samples from nine locations. Phenol (ND to 51.9 µg/L), TOC (4,000-7,000 µg/L), and TOX (21.6-30.4 µg/L) were detected in the unfiltered samples only. The presence of acetone in some of the samples may represent laboratory contamination. Toluene (3.05 µg/L) was found at location 1 (Hughes 1993).

The data for the nearshore surface water have shown essentially no contamination. Contaminants appear to be associated with the suspended solids, suggesting that the nearshore sediments may be contaminated.

In August 1992, the EPA emergency response team (ERT) collected nearshore surface water and sediment samples at 17 locations around the peninsula — in the Gunpowder and Bush rivers and in Chesapeake Bay (Figure 2.12). Filtered surface water samples were analyzed for VOCs, base neutral and acid extractable organic compounds (BNA), Target Analyte List (TAL) metals, pesticides, PCBs, and inorganic parameters (sulfate, total Kjeldahl nitrogen [TKN], total phosphorus, and cyanide). The data showed that beryllium, lead, and mercury were below their respective detection limits of 6,000, 6,000, and 200 µg/L. Zinc concentrations ranged from 11,000 µg/L at locations 3, 4, and 16 to 96,000 µg/L at location 6. Nickel concentrations ranged from 28,000 µg/L at most locations to 38,000 µg/L at location 9. No cyanide, VOCs, pesticides, or PCBs were detected.

Sediment samples, collected at the same locations as the surface water, were analyzed for CWAs and CWA degradation products, explosives, VOCs, BNA, TAL metals, pesticides, PCBs, and other parameters (TOC, sulfate, total phosphorus, TKN, and percent solids). The results indicate that there is essentially no contamination in sediments at these locations, although lead was detected at concentrations ranging from 2 mg/L at location 11 to 22 mg/L at location 17. Arsenic and cadmium were also detected: arsenic at concentrations ranging from 1 to 6 mg/L (at location 6) and cadmium at concentrations ranging from <0.5 to 3 mg/L (at location 8). The detection limit for beryllium was fairly high, ranging from 0.5 to 2.6 mg/L. The only VOC detected was acetone, up to 101 µg/kg at location 7.

Groundwater

Eleven groundwater monitoring wells (TH series) were installed in J-Field during the 1977 environmental survey. Locations of these wells are shown in Figure 2.13. Only one well (TH4) was installed in the area of the TBP. Well depths ranged from 20 to 25 ft. The

FIGURE 2.12 Locations of Surface Water and Sediment Samples Collected at J-Field in 1992 (Source: EPA 1992a)

FIGURE 2.13 Locations of All Wells Installed at J-Field (Source: Adapted from Hughes 1993)

wells were screened in the surficial aquifer with 25-ft-long screens (Sonntag 1991). Samples collected from the wells in 1977 were analyzed for metals, inorganic chemicals, white phosphorus, mustard degradation products, cholinesterase inhibitors, semivolatile compounds, and VOCs. Organic contaminants (up to 200,000 $\mu\text{g/L}$) were found in all of the wells (no data were given for TH7).

Five additional wells were installed around the TBP as part of a munitions disposal study (Figure 2.13, P series) (Princeton Aqua Science 1984). The wells were screened in the surficial aquifer from depths of 17-20 ft with 15-ft-long screens (Sonntag 1991). Water samples collected from the wells in 1983 were analyzed for metals, nitrate, TOX, TOC, radioactivity, pesticides, herbicides, and secondary drinking water parameters. Two of the five wells (P4 and P5) contained elevated concentrations of the gross beta radionuclide (140 and 12 pCi/L, respectively). Two wells (P3 and P4) contained TOX (6.6 and 7.1 mg/L,

respectively). Two wells (P2 and P5) contained elevated concentrations of nitrates (12 and 10 mg/L, respectively).

The P-series wells were sampled again in 1986 as part of the Edgewood Area RFA (Nemeth 1989). The samples were analyzed for metals, explosives-related compounds, inorganic compounds, radioactivity, thiodiglycol, VOCs, semivolatile compounds, and PCBs. The results are summarized in Table 2.8. Elevated concentrations of VOCs were found in only two wells (P3 and P4), near the area exhibiting soil-gas contamination. The compounds found include *trans*-1,2-dichloroethylene (*trans*-12DCE), up to 8,500 µ/L in well P4; TRCLE, up to 6,700 µg/L in well P4; vinyl chloride, up to 550 µg/L in well P3; and TCLEE, up to 420 µg/L in well P3. The data also indicate that the elevated gross beta activity detected in well P3 was due to naturally occurring potassium-40; however, it is not clear why potassium concentrations were so much higher in this well than in the others.

Thirty-eight additional monitoring wells were installed by the USGS in 1988 and 1989 (Sonntag 1991; Hughes 1993). Two of these wells, JF1 and JF2, were installed and screened in the Potomac Group. The 36 other wells were placed in nests of 3 at 12 different locations (Figure 2.13). Well nests JF3-JF8 were placed in the TBP area. The nested wells were screened in the confined aquifer, the leaky confining unit, and the surficial aquifer. The naming convention for the well nests involves a combination of letters and numbers. The letters with numbers (i.e., JF1-JF12) indicate the location. This location indicator code is then coupled with the numbers 1, 2, or 3 to indicate the strata being monitored. The confined aquifer is designated by the number 1, the leaky confining unit by the number 2, and the surficial aquifer by the number 3.

During 1990, samples from 55 of the 58 existing wells at J-Field were analyzed for metals, inorganic compounds, VOCs, and semivolatile organic compounds. Several of the wells were also analyzed for organosulfur, explosives, and radioactive contaminants. Wells were selected for specific contaminant analyses on the basis of the nature of disposal activities that had occurred nearby (USGS 1991).

Table 2.9 summarizes the analytical results indicating the presence of metals and other inorganic compounds. Concentrations of lead (124 µg/L) in well P9 and arsenic (60 µg/L) in well JF83 exceed maximum contaminant levels (MCLs). Both of these wells are downgradient from the TBP. Potassium concentrations ranged from not detected to 140 µg/L. Except for one measurement at well P3, the elevated concentrations of potassium (above 50 µg/L) occurred in the leaky confining unit or the confined aquifer. Movement of sea water into the groundwater may not be a source of potassium because wells with elevated potassium do not have elevated chloride concentrations.

The analytical results (summarized in Table 2.10) show that the TBP are contaminated with VOCs, and a contaminant plume in the groundwater extends downgradient to the southeast. This condition is reflected in the elevated concentrations of 112TCE, 1,2-dichloroethylene (12DCE), TCLEA, TCLEE, and TRCLE in well nests JF5, JF7, and JF8. The concentrations are highest in the surficial aquifer — up to 7,150 µg/L 12DCE in wells

TABLE 2.8 Analytical Results for Groundwater from the P-Series Monitoring Wells, 1986

Parameter ^a	Concentration by Well				
	P1	P2	P3	P4	P9
<i>Dissolved Metals (µg/L)</i>					
Arsenic	<10	<10	24	<10	<10
Cadmium	<1	<1	<1	3	<1
Lead	<5	<5	<5	90	<5
Selenium	<5	9	54	26	<5
Potassium	1,040	733	113,000	1,380	782
<i>Inorganic Compounds (µg/L)</i>					
Nitrate/nitrite as N	490	12,000	<50	<50	8,000
Sulfate	54,000	105,000	362,000	93,000	94,000
Chloride	4,800	23,000	304,000	866,000	24,000
Total phosphate as P	NA ^b	NA	NA	NA	NA
Total dissolved solids	125,000	328,000	1,403,000	1,087,000	262,000
<i>Radioactivity (pCi/L)</i>					
Gross beta	1.3	2.5	100	<4.8	1.4
Potassium-40	NA	NA	120	NA	NA
Radium-226	NA	NA	0.43	NA	NA
<i>Volatile Organic Compounds (µg/L)</i>					
Benzene	ND ^c	ND	6.0	ND	ND
Chlorobenzene	ND	ND	980	ND	ND
Ethyl benzene	ND	ND	3.0	ND	ND
Toluene	ND	ND	5.0	ND	ND
Chloroform	ND	ND	7.0	3.0	ND
Carbon tetrachloride	ND	5.0	ND	ND	ND
112TCE	ND	ND	7.0	130	ND
TCLEA	ND	ND	ND	200	5.0
Vinyl chloride	ND	ND	550	48	ND
trans-12DCE	ND	ND	2,220	8,500	ND
TRCLE	ND	ND	980	6,700	5.0
TCLEE	ND	ND	420	ND	ND

^a Includes all parameters that were detected at least once. Metals analyzed but not detected: barium (<300 µg/L), chromium (<10 µg/L), mercury (<0.2 µg/L), and silver (<25 µg/L).

^b NA = not analyzed.

^c ND = not detected.

Source: Nemeth (1989).

TABLE 2.9 Analytical Results for Selected Inorganic Compounds, TOC, and Metals in Groundwater from the Toxic Burning Pits, 1990

Well	Chloride (mg/L)	Potassium (mg/L)	TOC (mg/L)	Arsenic (µg/L)	Cyanide (µg/L)	Lead (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Zinc (µg/L)
P2	<100	<50	<10	ND ^a	ND	ND	ND	3.8	ND
P3	<100	61.8	25	30.2	ND	ND	61.9	ND	ND
P4	390	<50	<10	ND	ND	ND	ND	ND	292
P9	<100	<50	<10	ND	ND	124	ND	ND	ND
TH4	<100	<50	<10	ND	ND	ND	ND	2.35	ND
JF51	<100	140	<10	ND	13.9	ND	ND	ND	ND
JF52	<100	<50	<10	ND	ND	ND	ND	ND	ND
JF53	<100	<50	<10	ND	ND	ND	440	ND	ND
JF61	<100	98	160	8.03	ND	ND	ND	ND	ND
JF62	<100	<50	10	ND	ND	ND	ND	ND	ND
JF63	180	<50	50	4.11	ND	ND	ND	ND	ND
JF71	<100	79	<10	3.32	ND	ND	ND	ND	ND
JF72	<100	<50	180	ND	ND	ND	ND	3.21	ND
JF73	<100	<50	<10	5.52	ND	ND	ND	ND	ND
JF81	130	<50	<10	ND	ND	ND	ND	ND	ND
JF82	<100	74.7	100	20.4	88	ND	ND	ND	ND
JF83	120	<50	<10	60	ND	ND	ND	6.18	ND

^a ND = not detected.

Source: USGS (1991).

TABLE 2.10 Analytical Results for Selected VOCs in Groundwater from the Toxic Burning Pits Area, 1990

Well ^a	VOC ^b Concentrations (µg/L)								
	112TCE	11DCE	12DCE	C2H3CL	C6H6	CHCL3	TCLEA	TCLEE	TRCLE
P2	4.02	ND ^c	10.2	ND	ND	ND	101	ND	440
TH4	ND	ND	ND	ND	ND	ND	3.73	ND	ND
JF53	110	8.04	850	132	ND	ND	3,500	ND	820
JF52	10	ND	420	ND	ND	2.2	34.3	ND	52
JF51	ND	3.79	430	ND	ND	ND	ND	ND	520
JF63	ND	ND	7.33	ND	ND	7.6	ND	17.6	600
JF62	ND	ND	ND	ND	ND	ND	ND	ND	2.7
JF61	ND	ND	ND	ND	ND	ND	ND	ND	1.8
JF73	67.3	6.81	7,150	ND	ND	2.9	340	ND	1,800
JF72	ND	ND	32.6	ND	ND	1.9	ND	ND	4.5
JF71	ND	ND	ND	ND	ND	24	ND	ND	7.3
JF83	7,100	19	7,150	56.3	4.88	50	250	1,000	4,900
JF82	ND	30.1	210	ND	ND	5.6	ND	47.2	1,400
JF81	7,100	ND	34.6	ND	ND	ND	290	ND	230

^a TBP wells not listed contained no VOCs, or traces of 111TCE, C2H5CL, CCL4, CH3CL, and C6H5CL. No data for wells P1, P3, P4, JF43, JF41.

^b Installation Restoration Data Management System (IRDMS) acronyms are used for VOCs: 112TCE = 1,1,2-trichloroethane; 11DCE = 1,1-dichloroethylene; 12DCE = 1,2-dichloroethylene; C2H3CL = vinyl chloride; C6H6 = benzene; CHCL3 = chloroform; TCLEA = 1,1,2,2-tetrachloroethane; TCLEE = tetrachloroethylene; and TRCLE = trichloroethylene.

^c ND = not detected.

Source: USGS (1991).

JF73 and JF83. The data also show that some contamination extends down into the leaky confining unit and the confined aquifer (1,400 $\mu\text{g/L}$ TRCLE in the leaky confining unit [JF82] and 7,100 $\mu\text{g/L}$ 112TCE in the confined aquifer [JF81]). Because the well screens monitoring the confined aquifer are at depths of 70 ft or more (well JF81 is screened at a depth of 120-123 ft), VOC contamination extends more than 100 ft deep.

Because TRCLE was detected most often, the TRCLE data were used to create a contour map of contamination in the surficial aquifer (Figure 2.14). Those contours show that a plume of contaminated groundwater extends south of the TBP area to the shore and, possibly, into the bay. Additional data on VOC concentrations in the groundwater at locations farther south and closer to the shore are needed to determine if the plume in the surficial aquifer extends into the bay.

FIGURE 2.14 Contours of TRCLE Concentrations ($\mu\text{g/L}$) in the Surficial Aquifer (contour interval = 200 $\mu\text{g/L}$) (Source: Adapted from Hughes 1993)

Data for the single wells screened in the Potomac Group sediments (JF1 and JF2) indicate low concentrations of VOC contamination in the deeper strata. Well JF1 contained 2.25 µg/L 1,1,1-trichloroethane (111TCE) at a depth of 185-190 ft; well JF2 contained 6.7 µg/L TRCLE at 208-213 ft. These values are questionable because one of the two blanks associated with the sampling event contained detectable concentrations of TCLEA, TCLEE, and TRCLE.

Groundwater samples from a few wells were analyzed for explosives and organosulfur compounds. Results are summarized in Table 2.11. The data indicate some contamination with organosulfur compounds (including degradation products of mustard) in the surficial aquifer downgradient from the TBP. The maximum concentration was 140 µg/L 1,4-dithiane in well P3 just north of the western end of the TBP. No organosulfur

TABLE 2.11 Analytical Results for Organosulfur and Explosives-Related Compounds in Groundwater from the Toxic Burning Pits Area, 1990

Concentrations of Organosulfur Compounds (µg/L)					
Well	4-Chlorophenyl-methylsulfoxide	4-Chlorophenyl-sulfone	1,4-Dithiane	1,4-Oxithiane	Thiodiglycol
P3	ND ^a	ND	140	ND	NA ^b
P4	ND	ND	8.28	ND	NA
JF53	ND	ND	2.11	ND	ND
JF63	ND	ND	8.21	8.24	21
JF83	ND	20.5	ND	ND	NA
Concentrations of Explosives-Related Compounds (µg/L)					
	DNT ^c	Nitro-benzene	Nitro-cellulose	PETN ^d	RDX ^e
P9	ND	ND	226	ND	0.496
JF43	ND	ND	21.3	ND	ND
JF51	ND	0.0889	ND	ND	ND
JF63	ND	ND	ND	15.9	ND
JF73	ND	ND	ND	ND	1.18

^a ND = not detected.

^b NA = no data available.

^c DNT = dinitrotoluene.

^d PETN = penta-erythritol tetranitrate.

^e RDX = hexahydro-1,3,5-trinitro-1,3,4-triazine.

Source: USGS (1991).

contamination was found in the middle or lower aquifers. Explosives-related compounds were also found in low concentrations (up to 226 µg/L nitrocellulose) in the water table and the lower aquifer. Because nitrocellulose is not soluble in water, this value is either lab error or due to suspended solids in the groundwater sample.

Concentrations of the radioactive species uranium, thorium-230, cesium-137, and strontium-90 were measured in monitoring wells P1, P3, P4, JF53, JF52, JF51, JF63, and JF73. Elevated concentrations of cesium-137 (up to 172 pCi/L) and strontium-90 (up to 128 pCi/L), measured as beta radiation, were found in wells P3, JF51, and JF73 (USGS 1991). If these values are confirmed by additional measurements, they would indicate the presence of radioactive contaminants.

In 1992, the USGS analyzed groundwater collected from wells in the TBP area (Figure 2.13) for VOCs (Table 2.12). The data indicate that VOCs are present in the three aquifers underlying J-Field (surficial unit, confining unit, and confined unit); that concentrations of TRCLE, TCLEE, TCLEA, chloroform (CHCL3), 12DCE, and 112TCE have increased significantly since 1990 (see also Table 2.10); and that concentrations of 1,1-dichloroethylene (11DCE) have not been detected.

TABLE 2.12 Analytical Results for Selected VOCs in Groundwater Samples from the Toxic Burning Pits Area, 1992

Well ^a	VOC Concentrations (µg/L)					
	112TCE	12DCE	C2H3CL ^b	TCLEA	TCLEE	TRCLE
P3	ND ^c	980	600	ND	3,400	570
P4	65	3,300	ND	ND	ND	3,600
P9	ND	ND	10	ND	ND	ND
JF53	290	10,000	95	4,900	ND	4,200
JF52	1	140	ND	1	ND	3
JF51	ND	210	ND	ND	ND	97
JF63	ND	120	ND	75	130	4,400
JF62	ND	4	ND	ND	ND	13
JF61	ND	2	ND	ND	2	10
JF73	90	920	ND	9,000	280	5,100
JF71	ND	ND	ND	2	ND	3
JF83	2,000	12,000	ND	260,000	3,600	41,000
JF82	ND	190	ND	ND	ND	1,800
JF81	ND	22	ND	5	3	220

^a TBP wells not listed contained no VOCs. No data were obtained for wells P1, P2, JF43, 42, 41, and JF72.

^b C2H3CL = vinyl chloride.

^c ND = not detected.

Source: USGS (1992).

The highest VOC concentrations were found in well clusters JF5, 6, 7, and 8 in all three aquifers. The greatest increases in concentrations were found in JF83, which monitors the surficial aquifer south of the main burning pits — TRCLE increased from 4,900 µg/L in 1990 to 41,000 µg/L in 1992, TCLEE increased from 1,000 µg/L to 3,600 µg/L, TCLEA increased from 250 µg/L to 260,000 µg/L, and 12DCE increased from 7,150 µg/L to 12,000 µg/L. Concentrations of 112TCE decreased from 7,100 µg/L in 1990 to 2,000 µg/L in 1992 (USGS 1992).

2.3.1.3 Potential Pathways of Contaminant Migration

Existing data indicate that the main pathway of contaminant migration at the TBP AOC is movement through the vadose zone down into the groundwater and then transport by groundwater.

Contaminants are apparently moving from their source, down into the groundwater, and then downgradient into the marshes by surficial aquifer discharge or into the estuaries by groundwater upwelling, or to locations even farther downgradient.

The direction of groundwater movement in the Talbot aquifers appears to be away from the TBP AOC toward the low-lying marshes and under the Gunpowder and Bush rivers. However, the lateral gradients in the lower aquifers are quite small (USGS 1991). The vertical movement of groundwater appears to be down through the aquifers; however, offshore there may be upward flow from each of the three Talbot aquifers into the Gunpowder and Bush rivers. Movement in the surficial and confined aquifers is affected by the tides (USGS 1991).

Surface water and associated sediment transport may play some role in contaminant migration in that surface runoff, particularly after intense storms, may carry dissolved and suspended contaminants from the contaminated areas into the marshes and estuaries. Surface water percolating through and leaching contaminated soils may be a major pathway by which contaminants, especially metals and VOCs, move down into the groundwater. Any contaminants that may have been present in the past in sufficient quantities to exist as free liquid in the soil would be expected to migrate down, independent of the presence of water.

Because of the generally humid conditions in the J-Field study area, wind transport of contaminated soil in areas with a good vegetative cover is expected to be minor. Diffusion of contaminated soil gas into the atmosphere and direct volatilization of contaminants from the soil are also expected to be minor release mechanisms. However, because portions of the TBP AOC are unvegetated or are sparsely covered with stressed vegetation, the air pathway may be significant and will be investigated.

2.3.2 White Phosphorus Burning Pits

2.3.2.1 Types of Waste Present

The WPP area was used for the disposal of WP, PWP, and other related chemicals. It is also possible that riot control agents such as CN and TRCLE were disposed of in the WPP (Nemeth 1989).

2.3.2.2 Types of Contaminants Present

The first phase of the USGS hydrological assessment was conducted to select locations for monitoring wells at the TBP and WPP. It was assumed that the pits and the open burning grounds around them are the primary sources of contamination. The following subsections discuss the findings relative to the nature and extent of contamination in the WPP area.

Soil Gas

During Phase I of the hydrological assessment, the USGS sampled 35 locations around the WPP for soil-gas concentrations of TRCLE, TCLEE, combined hydrocarbons, and simple aromatics. The highest relative flux values of contamination were found north of the pits and to the west along the shore of Gunpowder River. Isolated areas of contamination were found to the south. The relative flux contours for TCLEE, shown in Figure 2.15, are similar to those for the other measured contaminants. However, the simple aromatics contamination north of the pits is more extensive than is shown in Figure 2.15 (Hughes 1993).

Soil

In 1983, soil samples were collected from each of the four monitor well boreholes at the WPP (Figure 2.16). For each borehole, one sample was obtained as a composite of samples collected over 5-ft intervals. The samples were analyzed for metals, cyanide, phenols, total phosphorus, VOCs, pesticides, PCBs, and herbicides.

The only significant contamination found was lead, at 1,360 mg/kg in the sample from borehole JBP-4. Arsenic (10 mg/kg), barium (208 mg/kg), and possibly cadmium (1.33 mg/kg) were found in the same sample. No VOCs were found in any of the samples at a detection limit of 5 µg/kg. Cyanide was not found at a detection limit of 20 µg/kg. Samples from the other boreholes showed essentially no contamination (Princeton Aqua Science 1984). One composite sample was collected from each of the two main pits in the WPP AOC. The samples from the pits, along with background samples, were analyzed for several chemical parameters (Table 2.13). The results show significant levels of lead (up to 2,960 mg/kg) and

FIGURE 2.15 Relative Flux Contours for TCLEE at the White Phosphorus Pits
(Source: Adapted from Hughes 1993)

zinc (up to 2,720 mg/kg) in each sample. High concentrations of petroleum hydrocarbons (up to 5,800 mg/kg) were also detected. The elevated levels of petroleum hydrocarbons in the background samples (62 mg/kg) indicate that these samples were collected at contaminated locations. Elevated levels of phosphorus (up to 1,573 mg/kg) were also detected in the WPP samples.

As part of the 1986 RFA (Nemeth 1989), surface soil samples were collected at two locations (31 and 32) in and around the WPP. Figure 2.17 shows the sampling locations. The samples were analyzed for metals, extractable metals, and explosives-related compounds. The results, as summarized in Table 2.14, show that the surface soil in and around the WPP contained elevated levels of metals, especially lead (up to 255 mg/kg), chromium (up to 28.9 mg/kg), cadmium (up to 2.40 mg/kg), and barium (up to 149 mg/kg). Neither of the two samples exceeded the RCRA EP limits for metals.

FIGURE 2.16 Locations of Soil Borings at the White Phosphorus Pits (Source: Adapted from Princeton Aqua Science 1984)

TABLE 2.13 Concentrations of Chemical Parameters in Soil from the White Phosphorus Pits at J-Field

Parameter ^a	Concentration ^b (mg/kg, unless noted)		
	Background ^c	Pit 1 ^d	Pit 2 ^d
Arsenic	1.46	2.93	0.915
Barium	247	939	525
Cadmium	0.519	6.70	2.74
Chromium	34.3	203	183
Iron	14,800	18,100	17,900
Lead	889	2,960	1,310
Manganese	267	260	197
Mercury	0.042	0.037	0.065
Potassium	2,420	2,260	2,520
Zinc	45.4	2,530	2,720
pH (standard units)	6.9	7.7	6.8
Nitrate	202	498	136
Total phosphorus	26	220	1,573
Cyanide	<0.5	<0.5	0.77
Petroleum hydrocarbons	62	2,260	5,800
Phenols	<0.130	<0.134	0.636
Aromatics			
Toluene (µg/kg)	45.8	75.6	27.4
Ethylbenzene (µg/kg)	<20	<20	51.6

^a Table lists parameters detected in at least one sample.

Parameters measured but not detected are other aromatics (<20 µg/kg), VOCs (<10 µg/kg), herbicides (<10 µg/kg), pesticides (<20 µg/kg), and PCBs (<10,000 µg/kg).

^b Results are based on composite soil samples taken in January 1983.

^c Locations of background samples not given.

^d Based on available information, it is inferred that Pit 1 is the northern pit and Pit 2 is the southern pit.

Source: Adapted from Princeton Aqua Science (1984).

FIGURE 2.17 Locations of Surface Soil (J31 and J32) and Surface Water Samples (J37 and J38) in the White Phosphorus Pits Area (Source: Adapted from Hughes 1993)

The USGS collected soil samples (at approximately 1-ft depths) from 36 sites in J-Field, including the WPP area (Figure 2.15). The samples were analyzed for indicator parameters, metals, VOCs, semivolatile compounds, and explosives (Hughes 1992). The results are presented in Table 2.15. Levels of metals were fairly low, except that at location 1 (just east of the pits), the concentration of zinc was 942 mg/kg. No VOCs were detected.

Soil samples were also collected in the WPP area by Weston in October 1992. Samples were collected at depths of 2 and 4 ft in the pits and at depths of 3 in. and 1 ft in the marshes and pushout areas. Table 2.16 summarizes the analytic results for parameters detected in some of these samples.

Surface Water

Surface water samples (J37 and J38) were collected from the WPP area as part of the 1986 RFA (Nemeth 1989). Sampling locations are shown in Figure 2.17. Samples were analyzed for metals, explosives-related compounds, inorganic compounds, gross alpha and beta, VOCs, BNAs, pesticides, and PCBs. The results are summarized in Table 2.17 for locations J37 and J38.

The surface water contained some lead contamination. Sulfate and total dissolved solids (TDS) were slightly elevated in the WPP surface water, and gross alpha was also slightly elevated. None of the values for the other radioactive parameters was indicative of contamination.

Surface water samples were collected by the USGS at low tide close to the J-Field shore in the Gunpowder River (four locations near the WPP). One sample was collected onshore in a drainage ditch. Locations are shown in Figure 2.11. Both filtered and unfiltered samples were analyzed for water quality parameters, metals, and a few organic compounds. A sample taken at location 3 had nitrate concentrations of 380 µg/L. The metals data showed low concentrations of lead (ND to 28 µg/L) and zinc (50 to 133 µg/L) at locations 1 to 4. Mercury and nickel concentrations were slightly elevated at location 1 (0.54 and 33.7 µg/L, respectively). No evidence was found of arsenic, barium, or chromium contamination. Comparison of data for filtered and unfiltered samples indicates that the slightly elevated metals concentrations may be associated with the suspended solids in the samples. This conclusion is based on the lower concentrations of metals in filtered samples for the few locations where both filtered and unfiltered data were obtained (Hughes 1993).

TABLE 2.14 Analytical Results for Soil Samples J31 and J32 from the White Phosphorus Pits, 1986

Parameter ^a	J31	J32
Total Metals (mg/kg)		
Arsenic	14.1	12.3
Barium	141	149
Cadmium	2.46	2.40
Chromium	28.9	18.1
Lead	255	184
Mercury	<0.10	0.14
Silver	<1.00	<5.00
Extractable Metals (mg/L)		
Barium	<10.0	<10.0
Cadmium	<0.10	<0.10
Chromium	<0.50	<0.50
Lead	<0.50	<0.50

Source: Nemeth (1989)

**TABLE 2.15 Analytical Results for Soil Samples from the White Phosphorus Pits Area,
April 1991**

Parameter	Concentrations by Soil Sample Location									
	1	2	3	4	5	6	7	8	9	10
<i>Metals (mg/kg)</i>										
Arsenic	4.2	2.7	2.8	2.3	ND ^a	ND	ND	ND	2.9	2.9
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	16	12	12	8.9	9.6	8.8	11	9.7	13	11
Copper	42	3.8	20	3.6	5.0	4.7	11	6.1	6.3	9.9
Lead	ND	25	41	5.3	19	18	15	18	15	17
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	942	ND	ND	18	ND	ND	ND	ND	ND	26
<i>Volatile Organic Compounds (µg/kg)</i>										
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
<i>Semivolatile Organic Compounds (µg/kg)</i>										
Butylbenzyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic acid	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	4,830	ND	ND	ND	ND	ND	ND	ND	ND	ND

^a ND = not detected.

Source: Hughes (1992).

TABLE 2.16 Analytical Results for TCL and TAL Analytes in Selected Soil Samples from the White Phosphorus Pits, 1992^a

Parameter	Concentrations by Soil Sample Location					
	JWP1-E(2') ^b	JWP1-E(4')	JWP2-E(2')	JWP2-E(4')	JWPM-A(3")	JWPM-A(1')
<i>Volatile Organic Compounds (µg/kg)</i>						
Methylene chloride	ND ^c	ND	9.53	15.2	13.4	ND
Acetone	494	156	165	38.9	185	21.5
Toluene	ND	ND	ND	ND	ND	ND
Xylenes	ND	16.6	ND	ND	11.2	9.17
<i>PCBs (µg/kg)</i>						
Aroclor 1254	ND	ND	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND	ND	ND
<i>TAL Analytes (mg/kg)</i>						
Antimony	ND	ND	ND	ND	5.92	ND
Arsenic	3.22	2.24	2.82	ND	4.20	2.46
Beryllium	0.279	0.796	0.520	ND	0.318	0.335
Cadmium	ND	0.626	ND	ND	2.02	ND
Chromium	11.6	12.8	16.7	4.93	15.8	7.53
Cobalt	ND	ND	ND	ND	ND	ND
Copper	10.5	8.63	8.40	ND	59.4	11.0
Lead	8.37	8.87	6.46	4.89	209	44.3
Zinc	24.0	62.5	13.0	19.7	284	37.9
Nickel	ND	13.7	ND	6.18	ND	ND

TABLE 2.16 (Cont.)

Parameter	Concentrations by Soil Sample Location					
	JWPM-C(3")	JWPM-C(1')	JWPP-A(3")	JWPP-A(1')	JWPP-C(3")	JWPP-C(1')
Volatile Organic Compounds ($\mu\text{g/kg}$)						
Methylene chloride	10.8	5.83	17.0	7.51	9.29	8.35
Acetone	16.1	45.0	ND	252	ND	178
Toluene	7.42	ND	ND	ND	ND	6.54
Xylenes	18.4	ND	ND	ND	ND	11.8
PCBs ($\mu\text{g/kg}$)						
Aroclor 1254	ND	ND	ND	ND	323	ND
Aroclor 1260	215	ND	ND	ND	ND	ND
TAL Analytes (mg/kg)						
Antimony	ND	ND	ND	ND	10.2	ND
Arsenic	4.00	1.96	4.48	2.60	3.29	3.55
Beryllium	0.239	0.182	0.254	0.218	0.267	0.308
Cadmium	2.11	ND	ND	ND	1.62	0.576
Chromium	20.8	8.37	12.4	10.6	21.9	9.83
Cobalt	ND	ND	ND	ND	ND	ND
Copper	111	ND	10.4	ND	109	19.8
Lead	556	7.29	23.2	25.0	235	156
Zinc	15.2	7.57	109	34.9	651	257
Nickel	1,080	24.6	8.27	8.18	9.65	9.47

^a Only detected analytes are reported; for samples with duplicate analyses, the higher value is reported.

^b Sample depth shown in parentheses.

^c ND = not detected.

Source: Mazelon (1993).

TABLE 2.17 Analytical Results for Surface Water Samples from the White Phosphorus Pits Area, 1986

Parameter	Location	
	J37	J38
<i>Dissolved Metals ($\mu\text{g/L}$)</i>		
Cadmium	<1.0	3.0
Lead	6.0	44
Mercury	<0.20	<0.20
<i>Inorganic Compounds ($\mu\text{g/L}$)</i>		
Nitrate and nitrite as N	<30	200
Sulfate	160,000	15,000
Chloride	5,000	3,000
Total dissolved solids	388,000	114,000
<i>Radioactivity (pCi/L)</i>		
Gross alpha	2.8	4.2
Gross beta	8.0	8.7

Source: Nemeth (1989).

A few organic constituents (acetone, toluene, phenol, TOC, and TOX) were measured in samples from two locations. TOC and TOX were detected in the unfiltered samples only (4,000 and 21.6 $\mu\text{g/L}$, respectively). Toluene was found only at location 1 (3.05 $\mu\text{g/L}$) (Hughes 1993).

In general, the nearshore surface water samples collected to date show little contamination. What contamination there is appears to be associated with the suspended solids. This suggests that the nearshore sediments may be contaminated. Additional data are needed to evaluate this situation. No data are available on concentrations of pollutants in surface water or sediments in the marshes on J-Field.

Groundwater

Three monitoring wells (designated TH) were installed at the WPP in 1977 (Figure 2.13) as part of an environmental contamination survey conducted by USATHAMA (Nemeth 1989). The depth of the wells ranged from 20 to 25 ft. The wells were screened in the surficial aquifer (Sonntag 1991). Water samples collected from the wells in 1977 were analyzed for metals, indicator chemicals, WP, mustard degradation products, cholinesterase inhibitors, BNAs, and VOCs.

Low levels of organic contamination were found in all wells. A mustard degradation product, 1,3-dithiane, was found at a concentration of 6 $\mu\text{g/L}$ in well TH1 near the WPP.

Aliphatic and aromatic organic compounds were found at levels up to 200 µg/L in most well samples. Organic compounds introduced by the well construction procedure or possible sample contamination were found at higher concentrations (e.g., tetrahydrofuran up to 8,000 µg/L).

Four additional wells were installed around the WPP (wells P5-P8 in Figure 2.13) as part of a munitions disposal study (Princeton Aqua Science 1984). The wells were 17-20 ft deep and were screened with 15-ft-long screens in the surficial aquifer (Sonntag 1991). Samples collected from the wells in 1983 were analyzed for metals, nitrate, TOX, TOC, radioactivity, some pesticides and herbicides, and secondary drinking water contaminants. Analyses indicated no major concentrations of metals, pesticides, or herbicides.

Samples collected from these four wells in 1986 as part of an RFA (Nemeth 1989) were analyzed for metals, explosives-related compounds, indicator parameters, radioactivity, thiodiglycol, VOCs, BNAs, pesticides, and PCBs. Sulfate, TDS, and TRCLE were the only parameters that showed any elevated concentrations.

Twelve additional monitoring wells were installed at the WPP in late 1988 and 1989 by the USGS (Sonntag 1991; Hughes 1993). The wells were installed as three-well nests at four different locations (Figure 2.13). At each site, the three wells were screened in the confined aquifer, the leaky confined unit, and the surficial aquifer of the Talbot Formation. The groundwater samples collected from the nested wells were analyzed for metals, other inorganic parameters, VOCs, and semivolatile organic compounds. Some analyses were performed for organosulfur, explosives-related, and radioactive compounds. Wells were selected for these analyses on the basis of their proximity to potential disposal areas for these materials (USGS 1991).

Potassium concentrations detected in the samples varied considerably, with most ranging from ND to 10 µg/L. All of the elevated values (above 50 µg/L) occurred in the leaky confined unit or the confined aquifer. Movement of sea water into the groundwater does not appear to be the source of the potassium, because wells with elevated potassium concentrations did not have elevated chloride concentrations.

Low levels of VOC contamination were detected in the WPP. Only one well, P8, showed contamination by TRCLE (40 µg/L). Some contamination by other VOCs was detected in wells P7 and JF10-2. (Acetone is excluded because of the possibility that its presence is a result of laboratory quality control [QC] procedures.)

2.3.2.3 Potential Pathways of Contaminant Migration

Existing data indicate that the main pathway of contaminant migration at the WPP AOC is movement through the vadose zone down into the groundwater and then transport by the groundwater.

The direction of groundwater movement in the Talbot aquifers appears to be away from the WPP AOC toward the Gunpowder River. However, the lateral gradients in the lower aquifers are quite small (USGS 1991). The vertical movement of groundwater appears to be down through the aquifers; however, offshore there may be upward flow from each of the three Talbot aquifers into the Gunpowder and Bush rivers. Movement in the surficial and confined aquifers is affected by the tides (USGS 1991).

Surface water and associated sediment transport may play some role in contaminant migration in that surface runoff, particularly after intense storms, may carry dissolved and suspended contaminants from the contaminated areas into the marshes and estuaries. Lateral contaminant migration by surface water is expected to be minor (Sonntag 1991). However, in the past, the surface water pathway may have been more significant because the pits were operated to allow drainage to flow to the Gunpowder River (Weston 1992). Surface water percolating through and leaching contaminated soils may be a major pathway by which contaminants, especially metals and VOCs, move down into the groundwater. Any contaminants that may have been present in the past in sufficient amounts to exist as free liquid in the soil would be expected to migrate downward, independent of the presence of water.

Because of the generally humid conditions in the J-Field study area, wind transport of contaminated soil in areas with a good vegetative cover is expected to be minor. Diffusion of contaminated soil gas into the atmosphere and direct volatilization of contaminants from the soil are also expected to be minor release mechanisms. However, because portions of the WPP AOC are unvegetated or are sparsely covered with stressed vegetation, and because at least part of the WPP AOC is expected to be used for OB/OD, the air pathway may be significant and will be investigated.

2.3.3 Riot Control Burning Pit

2.3.3.1 Types of Waste Present

The RCP area was used for burning of riot control agents and disposing of munitions filled with riot control agents and of materials contaminated with these chemicals. The primary riot control chemicals disposed of in the burning pit were tear agents (CS and possibly CN) and items contaminated with those agents.

2.3.3.2 Types of Contaminants Present

Soil Gas

Soil-gas sampling and analysis were conducted during Phase I of the USGS hydrological assessment. Soil-gas samples collected from 12 locations on a 100-ft grid around the RCP were analyzed for TRCLE, TCLEE, alkanes, combined hydrocarbons, and simple

aromatics. Relative flux values indicated contamination by chlorinated solvents at areas north and south of the pits. Contamination by phthalates and heavy aromatic compounds appeared to be more extensive, with phthalates showing elevated contamination along Rickett's Point Road and at one location south of the pit. The highest measured flux value for aromatic compounds was at a location south of the pit. Figure 2.18 shows the relative flux contours for heavy aromatics at the pit.

Soil

A soil sample was collected immediately northeast of the disposal trench during the 1986 RFA (Nemeth 1989). That sample contained a significant amount of ash and other residue from burning operations; analysis showed slightly elevated levels of total cadmium, chromium, lead, and silver, and very low levels of polyaromatic hydrocarbons (PAHs).

Soil samples were collected by the USGS at 36 sites at J-Field, including the RCP area (locations 16 through 20 in Figure 2.9). The samples were collected at 1-ft depths and were analyzed for indicator parameters, metals, VOCs, semivolatile compounds, and explosives-related compounds (Hughes 1992). The results of the analyses are presented in Table 2.18. Soil samples showed some metals contamination, especially at locations 16, 17, and 18 north of the pit, where lead concentrations ranged from 34 to 68 mg/kg. Zinc was found at 158 mg/kg at location 16. Organic compounds (acetone, butylbenzyl phthalate, and benzoic acid) were also detected in some samples.

Soil samples were also collected in the RCP area by Weston in October 1992 (Figure 2.19). The samples were collected at 3-in., 2-ft, and 4-ft depths in the pit and at 3-in. and 1-ft depths in the marshes and pushout areas. Tables 2.19 and 2.20 summarize the analytic results for parameters detected in some of these samples. The data indicate that several areas are contaminated with metals, mainly at the surface (within 3 in. to 2 ft). The highest concentrations of lead were found in the center of the RCP (up to 339 mg/kg at 3 in.). Lead concentrations ranged from 31 to 90 mg/kg at the ends of the pit, in the marshes, and in the pushout areas. Other metals detected include beryllium, up to 0.451 mg/kg in the marsh east of the RCP; chromium, up to 106 mg/kg at the eastern end of the RCP; copper, up to 742 mg/kg at the eastern end of the RCP; and zinc, up to 742 mg/kg in the center of the RCP. Organic compounds were also detected, including benzoic acid, chlorobenzene, di-n-butyl phthalate, acetone, methylene chloride, styrene, toluene, xylene, and pesticides. PCBs were not detected.

Surface Water

Surface water samples were collected by the USGS at low tide close to the shore near the RCP area (locations 7-12 in Figure 2.11). Both filtered and unfiltered samples were analyzed for major water quality parameters, metals, and a few organic compounds. Nitrate concentrations from location 7 ranged from 200 to 400 µg/L. Phenol, TOC, and TOX were

FIGURE 2.18 Relative Flux Contours of Heavy Aromatics at the Riot Control Burning Pit (Source: Adapted from Hughes 1993)

TABLE 2.18 Analytical Results for Soil Samples from the Riot Control Burning Pit Area, April 1991

Parameter	Concentration by Soil Sample Location						
	16	17	18	19	20	21	22
Metals (mg/kg)							
Arsenic	4.4	3.8	3.4	2.9	3.7	3.3	ND ^a
Cadmium	ND	ND	ND	ND	ND	ND	ND
Chromium	11	8.6	8.7	7.5	11	8.8	7.4
Copper	9.5	10	9.5	5.4	7.0	7.2	15
Lead	68	41	34	2.1	41	1.7	22
Antimony	ND	ND	ND	ND	ND	ND	ND
Zinc	158	ND	ND	ND	ND	ND	ND
Volatile Organic Compounds (µg/kg)							
Acetone	7.27	29.6	9.01	6.47	10.2	9.51	2.45
Trichloroethylene	ND	ND	ND	ND	ND	ND	ND
Semivolatile Organic Compounds (µg/kg)							
Butylbenzyl phthalate	ND	ND	528	ND	ND	ND	3,700
Benzoic acid	3,400	12,000	ND	1,800	949	654	3,700

^a ND = not detected.

Source: Hughes (1992).

also detected in the unfiltered sample from location 7 (51.9, 7,000, and 20 µg/L, respectively). As described in Section 2.3.1.2, the USGS and the EPA ERT sampled surface water and sediment from areas offshore of the RCP.

In general, the nearshore surface water quality data from the samples collected to date show essentially no contamination. What contamination there is appears to be associated with the suspended solids. This finding suggests that the nearshore sediments may be contaminated.

Groundwater

Two monitoring wells (TH9 and TH10 in Figure 2.13) were installed near the RCP area as part of the 1977 environmental contamination survey (Nemeth 1989). The depth of the wells ranged from 20 to 25 ft. The wells were screened in the surficial aquifer (Sonntag 1991). Water samples collected from the wells in 1977 were analyzed for metals, indicator chemicals, WP, mustard degradation products, cholinesterase inhibitors, BNAs, and VOCs. Only very low levels of organic contamination were detected. Because of the erosion of the shoreline west of the RCP, well TH9 was abandoned, and the shoreline was stabilized with gabion baskets and riprap.

FIGURE 2.19 Locations of Soil Samples Collected by Weston in 1992 from the Riot Control Burning Pit (Source: Adapted from Mazelon 1993)

Two monitoring well nests (JF1 and JF2 in Figure 2.13) were installed near the RCP in late 1988 and 1989 by the USGS (Sonntag 1991; Hughes 1993). At each site, the wells were screened in the confined aquifer, the leaky confined unit, and the surficial aquifer of the Talbot Formation. One monitoring well (well 143) was installed south of the RCP AOC in 1992.

Groundwater samples were analyzed for metals, VOCs, and semivolatile organic compounds during a 1990 sampling episode. Samples from wells JF22 and JF23 were analyzed for organosulfur and explosives-related compounds. None of these compounds was detected, but the results showed some contamination by fluoride in both wells. Cyanide was

TABLE 2.19 Analytical Results for TCL Analytes in Selected Soil Samples from the Riot Control Burning Pit Area, 1992^a

TCL Analyte	Concentrations (µg/kg) by Soil Sample Location					
	JBT1-E(3") ^b	JBT1-E(2')	JBT1-E(4')	JBP1-W(3")	JBT1-W(2')	JBT1-W(4')
<i>Volatile Organic Compounds</i>						
Acetone	61.8	46.2	191	236	82.2	18.5
Benzene	ND ^c	ND	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND
Chloromethane	10.3	7.7	5.22	13.2	17.6	6.75
Styrene	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND
Xylenes	ND	ND	ND	ND	ND	ND
<i>Semivolatile Organic Compounds</i>						
2-Methylnaphthalene	52	ND	ND	ND	ND	ND
Benzoic acid	ND	ND	ND	183	79.2	47.8
bis-(2-Chloromethyl) ether	ND	ND	ND	ND	ND	ND
bis-(2-Ethylhexyl) phthalate	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	ND	ND	ND	217	111	54.1
Fluoranthene	ND	ND	ND	ND	ND	ND
Hexachlobenzene	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND
<i>Pesticides</i>						
4,4' DDD	ND	ND	ND	ND	ND	ND
4,4' DDE	2.22	ND	ND	10.6	ND	ND
4,4' DDT	ND	ND	ND	ND	ND	ND
<i>PCBs</i>						
Aroclor 1248	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND	ND

TABLE 2.19 (Cont.)

TCL Analyte	Concentrations (µg/kg) by Soil Sample Location							
	JBTM-A(3")	JBTM-A(1')	JBTM-C(3")	JBTM-C(1')	JBTP-A(3")	JBTP-A(1')	JBTP-C(3")	JBTP-C(1')
Volatile Organic Compounds								
Acetone	171	55.4	169	91	70.4	74.3	ND	ND
Benzene	ND	ND	ND	2.46	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	4.89	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	20.3	ND
Chloroethane	12.2	2.72	ND	ND	ND	ND	ND	ND
Chloromethane	10.2	5.75	5.87	9.75	12.2	5.69	5.69	3.26
Styrene	8.57	ND	ND	ND	ND	18	ND	ND
Toluene	42.3	16.2	7.9	1.77	ND	1.44	ND	ND
Xylenes	159	77.2	ND	ND	ND	ND	ND	ND
Semivolatile Organic Compounds								
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic acid	4,380	100	ND	63.6	840	336	ND	106
bis-(2-Chloromethyl) ether	438	ND	ND	ND	64.5	ND	54	ND
bis-(2-Ethylhexyl) phthalate	ND	ND	ND	ND	ND	41.5	ND	ND
Di-n-butyl phthalate	126	53.5	ND	ND	ND	ND	ND	188
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlobenzene	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides								
4,4' DDD	ND	ND	ND	ND	ND	ND	ND	ND
4,4' DDE	32.9	ND	ND	1.79	10.1	ND	4.69	ND
4,4' DDT	8.28	ND	ND	ND	ND	ND	ND	ND
PCBs								
Aroclor 1248	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND	ND	ND	ND	ND

^a Only detected analytes are reported; for samples with duplicate analyses, the higher value is reported.

^b Sample depth shown in parentheses.

^c ND = not detected.

TABLE 2.20 Analytical Results for TAL Analytes in Selected Soil Samples from the Riot Control Burning Pit Area, 1992^a

TAL Analyte	Concentration (mg/kg) by Soil Sample Location						
	JBT1-E(3") ^b	JBT1-E(2')	JBT1-E(4')	JBT1-W(3")	JBT1-W(2')	JBT1-W(4')	JBTM-A(3")
Antimony	ND ^c	5.31	ND	ND	ND	ND	ND
Arsenic	4.96	4.27	ND	ND	2.94	1.84	2.77
Beryllium	0.374	0.343	ND	0.355	0.362	0.278	0.555
Cadmium	5.24	2.73	ND	0.907	0.690	ND	0.994
Chromium	106	40	11.9	11.3	17.3	16.6	14.2
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	742	262	116	23.2	ND	9.79	12.3
Lead	1.14	49.2	10.9	60.5	8.98	8.92	57.1
Zinc	281	139	45.6	119	17.2	14.6	46.6
Nickel	40.2	23.2	9.89	ND	9.08	8.01	12.6

TAL Analyte	Concentration (mg/kg) by Soil Sample Location						
	JBTM-A(1')	JBTM-C(3")	JBTM-C(1')	JBTP-A(3")	JBTP-A(1')	JBTP-C(3")	JBTP-C(1')
Antimony	ND ^c	ND	ND	ND	ND	ND	ND
Arsenic	ND	1.87	1.72	ND	2.18	2.28	1.81
Beryllium	0.337	0.451	0.279	0.418	0.328	ND	0.745
Cadmium	0.586	0.898	0.696	1.7	0.601	ND	ND
Chromium	8.06	12.1	11.1	12.6	14.2	14.1	24.3
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	ND	9.01	ND	8.98	ND	11.3	9.41
Lead	5.97	52.2	7.61	33.2	7.23	41.8	9.13
Zinc	5.02	58.9	6.77	22.2	11.3	39.4	36.3
Nickel	ND	8.27	7.16	17.5	ND	ND	11.2

^a Only detected analytes are reported; for samples with duplicate analyses, the higher value is reported.

^b Sample depth shown in parentheses.

^c ND = not detected.

found in well JF22 at a concentration of 65.6 µg/L. The VOC measurements for well JF13 showed the presence of benzene (1,500 µg/L) and methylisobutylketone (640 µg/L). Benzene was also detected at 800 µg/L in well JF13 during a 1992 sampling episode. No volatile organic compounds were detected in the newly installed well (143) (USGS 1992).

2.3.3.3 Potential Pathways of Contaminant Migration

Existing data indicate that the main pathway of contaminant migration at the RCP AOC is movement through the vadose zone down into the groundwater and then transport by groundwater.

The direction of groundwater movement in the Talbot aquifers appears to be away from the RCP AOC toward the Gunpowder River and Chesapeake Bay. However, the lateral gradients in the lower aquifers are quite small (USGS 1991). Vertical movement of groundwater appears to be down through the aquifers. Offshore, there may be upward flow from each of the three Talbot aquifers into the Gunpowder and Bush rivers. Movement in the surface and confined aquifers is affected by the tides (USGS 1991).

Surface water and associated sediment transport may play some role in contaminant migration in that surface runoff, particularly after intense storms, may carry dissolved and suspended contaminants from the contaminated areas into the river and bay. Lateral contaminant migration by surface water is expected to be minor (Sonntag 1991). However, surface water percolating through and leaching contaminated soils may be a major pathway by which contaminants, especially metals and VOCs, move down into the groundwater. Any contaminants that may have been present in the past in sufficient amounts to exist as free liquid in the soil would be expected to migrate down, independent of the presence of water.

Because of the generally humid conditions in the J-Field study area, wind transport of contaminated soil in areas with a good vegetative cover is expected to be minor. Diffusion of contaminated soil gas into the atmosphere and direct volatilization of contaminants from the soil are also expected to be release mechanisms.

2.3.4 South Beach Trench

2.3.4.1 Types of Waste Present

No information is available concerning chemical or hazardous material disposal in the SBT. It is possible that the trench was originally used as a borrow pit to obtain soil for the demolition work on the South Beach of J-Field (Nemeth 1989). A review of aerial photographs reveals the presence of an additional trench, which is now filled in but visible, about 40 ft west of current SBT. In the photographs, the western trench is oriented east-west and is about 300 ft in length. Small drums are scattered in the woods near the western trench (U.S. Army 1965).

2.3.4.2 Types of Contaminants Present

Soil Gas

Soil-gas samples have not been collected from this area.

Soil

Analysis of a single soil sample collected in the SBT area as part of an environmental survey in 1983 (Nemeth 1989) showed a low level of chlordane (53 µg/kg) and tentatively identified several other organic compounds. Two soil samples were collected by the USGS in the SBT area (locations 21 and 22 in Figure 2.9). The samples were collected at 1-ft depths and analyzed for indicator parameters, metals, VOCs, semivolatile compounds, and explosives-related compounds (Hughes 1992). The results indicate that metals are present in low concentrations: lead, ranging from 2 to 22 mg/kg; copper, from 7 to 15 mg/kg; and chromium, from 7 to 9 mg/kg. Acetone was the only organic compound detected (ranging from 10 to 25 mg/kg).

Surface Water

Surface water samples have not been collected at the SBT.

Groundwater

A monitoring well (TH10 in Figure 2.13) was installed south of the trench during the 1977 environmental survey (Nemeth 1989). Water collected from this well was analyzed for extractable organic compounds; analyses showed the presence of hydrocarbons, dimethylnaphthalene, and N,N-dimethylformamide. This well was also sampled as part of the RFA, with analysis for VOCs, BNAs, pesticides, and PCBs. No contaminants were detected in the water at that time (Nemeth 1989).

The USGS sampled well TH10 in 1991 as part of the hydrological assessment, Phase I. The water was analyzed for metals, water quality parameters, major ions, VOCs, and explosives-related compounds. No contamination was detected. Samples collected in 1992 from wells JF1 and JF2 were analyzed for VOCs. Benzene concentrations ranged from 110 to 800 µg/L in the surficial aquifer. Low levels of acetone were also detected.

2.3.4.3 Potential Pathways of Contaminant Migration

The main pathway of contaminant migration at the South Beach Trench is believed to be movement through the vadose zone into the groundwater and then transport by the groundwater.

The direction of groundwater movement in the Talbot aquifers appears to be away from the trench area toward the bay. However, the lateral gradients in the lower aquifers are quite small (USGS 1991). The vertical movement of groundwater appears to be down through the aquifers; however, offshore there may be upward flow from each of the three Talbot aquifers into the Gunpowder and Bush rivers. Movement in the surficial and confined aquifers is affected by the tides (USGS 1991).

Surface water and associated sediment transport may play some role in contaminant migration in that surface runoff, particularly after intense storms, may carry dissolved and suspended contaminants from contaminated soil down into the bay. Lateral contaminant migration by surface water is expected to be minor (Sonntag 1991). However, surface water percolating through and leaching contaminated soils may be a major pathway by which contaminants, especially metals and VOCs, move down into the groundwater. Any contaminants that may have been present in the past in sufficient amounts to exist as free liquid in the soil would be expected to migrate down independent of the presence of water.

Because of the generally humid conditions and the presence of a vegetative cover over the South Beach Trench, wind transport of contaminated soil is expected to be minor. Diffusion of contaminated soil gas into the atmosphere and direct volatilization of contaminants from the soil are also expected to be minor.

2.3.5 South Beach Demolition Ground

2.3.5.1 Types of Waste Present

The SBDG was used as a demolition site for HE during the 1960s and 1970s. Items were detonated either at the ground surface or buried several feet deep. Because of the high rates of erosion at J-Field, the SBDG is now offshore in the Chesapeake Bay (Hughes 1993). Its presence is marked only by the abundant fragments of munitions and pieces of metal that can be observed at low tide.

2.3.5.2 Types of Contaminants Present

Soil Gas and Soil

Soil-gas and soil sampling and analysis were not conducted because the area is now offshore.

Surface Water

Surface water samples were collected by the USGS in 1991 at low tide close to the SBDG shore (locations 12 and 13 in Figure 2.11). Both filtered and unfiltered samples were

analyzed for major water quality parameters, metals, and a few organic compounds. Phenol, TOC, and TOX were detected in the unfiltered sample from location 13 (9.6, 4,000, and 30.4 µg/L, respectively).

As described in Section 2.3.1.2, the USGS and EPA ERT sampled surface water and sediment from the location of the SBDG. In general, the nearshore surface water data from the samples collected to date show essentially no contamination. What contamination that does exist appears to be associated with the suspended solids. This suggests that the nearshore sediments may be contaminated. Additional data are needed to evaluate the nearshore sediments.

Groundwater

Groundwater sampling and analysis were not performed because the area is now offshore and no wells are present in the immediate area.

2.3.5.3 Potential Pathways of Contaminant Migration

The main pathway of contaminant migration at the SBDG is expected to be by surface water, including wave action and tidal action. This conclusion is valid only for metals, because organic compounds most likely would have degraded in the bay. Because this area is currently under water, wind transport of contaminants is expected to be an insignificant migration pathway.

2.3.6 Prototype Building

2.3.6.1 Types of Waste Present

The PB area was believed to be used primarily for the storage of solid waste when disposal operations were active at J-Field. In addition, a review of aerial photographs suggests that there was a burning area about 200 ft west of the PB and near the edge of the existing tree line. The southern boundary of the area is marked by piles of soil, while its northern edge is marked by tall reeds and shallow ponded water. A rusted drum and scrap metal have been found on the ground surface (U.S. Army 1965). Another suspect burning area is located northeast of the PB. No records were kept of the types or quantities of material stored or potentially burned at the PB.

2.3.6.2 Types of Contaminants Present

Soil Gas

Soil-gas sampling and analysis were not performed in this area.

Soil

As part of the 1986 RFA (Nemeth 1989), surface soil samples collected at several locations near the PB (Figure 2.8) were analyzed for metals, extractable metals, and explosives-related compounds. Composites of samples from different locations were analyzed for BNAs, pesticides, and PCBs.

Cadmium and lead were detected at concentrations of 16.6 and 1,622 mg/kg (respectively) near the southern side of the PB. Organic compounds were also present in the soil samples, but below measurable levels. A composite sample taken near the PB contained low concentrations of pesticides, including 1.0 mg/kg each of DDD, DDE, and DDT.

Soil samples were collected by the USGS in 1991 at 36 sites in J-Field, including the PB (locations 11 through 15 in Figure 2.9). The samples were collected at 1-ft depths and analyzed for indicator parameters, metals, VOCs, semivolatile compounds, and explosives-related compounds (Hughes 1992). The analyses showed that metals contamination is present at the site, especially at location 15, where lead was detected at 93.3 mg/kg, chromium at 18.8 mg/kg, copper at 47.5 mg/kg, and zinc at 158 mg/kg. Limited analyses for organic compounds were also conducted; no significant contamination was found.

Surface Water

As noted in Section 2.3.1.2, the USGS and EPA ERT sampled surface water and sediment offshore from the PB.

Groundwater

Three monitoring wells were installed in the area of the PB (wells TH5, TH6, and TH8 in Figure 2.13). Analysis of a water sample collected from TH5 during an environmental survey (Nemeth 1989) showed only compounds related to well construction. Minor amounts of hydrocarbons were detected in groundwater from TH8. The compounds 1,1,1-TCE and dimethyl disulfide were detected in well TH6 (on the southern side of the PB).

An additional monitoring well nest, JF3, was installed near the PB by the USGS (Sonntag 1991; Hughes 1993). The well nest consists of three wells, screened in the confined aquifer, the leaky confined unit, and the surficial aquifer of the Talbot Formation (Figure 2.13). Groundwater samples were analyzed for metals, water quality parameters,

VOCs, and semivolatile organic compounds. The results of VOC measurements on samples from well TH8 showed that benzene (6.43 µg/L) and methylisobutylketone (120 µg/L) contamination is present. However, no VOCs were detected in well TH8 or in wells JF3-1, JF3-2, and JF3-3 during a 1992 sampling episode (USGS 1992).

2.3.6.3 Potential Pathways of Contaminant Migration

The main pathway of contaminant migration at the PB is believed to be movement through the vadose zone into the groundwater and then transport by the groundwater.

The direction of groundwater movement in the Talbot aquifers appears to be away from the PB toward the Gunpowder River. However, the lateral gradients in the lower aquifers are quite small (USGS 1991). The vertical movement of groundwater appears to be down through the aquifers; however, offshore there may be upward flow from each of the three Talbot aquifers and into the Gunpowder and Bush rivers. Movement in the surface and confined aquifers is affected by the tides (USGS 1991).

Surface water and associated sediment transport may play some role in contaminant migration in that surface runoff, particularly after intense storms, may also carry dissolved and suspended contaminants from the soil toward the river. Lateral contaminant migration by surface water is expected to be minor (Sonntag 1991). However, surface water percolating through and leaching contaminated soils may be a major pathway by which contaminants, especially metals and VOCs, move down into the groundwater. Any contaminants that may have been present in the past in sufficient amounts to exist as free liquid in the soil would be expected to migrate down, independent of the presence of water.

Because of the generally humid conditions in the J-Field study area, wind transport of contaminated soil in areas with a good vegetative cover is expected to be a minor migration pathway. Diffusion of contaminated soil gas into the atmosphere and direct volatilization of contaminants from the soil are also expected to be minor. However, because portions of the PB area are unvegetated or are sparsely covered with stressed vegetation, and because at least part of the area is expected to be used for open burning, the air pathway may be significant.

2.3.7 Robins Point Tower Site

2.3.7.1 Types of Waste Present

Robins Point was a launch and observation site for rocket testing programs conducted in the J-Field area. No information has been uncovered to indicate that solid or hazardous waste was generated or handled at this site. However, Nemeth (1989) found records indicating that radioactive contaminated wood may have been burned at this site.

2.3.7.2 Types of Contaminants Present

Soil Gas

Soil-gas sampling and analysis were not conducted in this area.

Soil

Field inspection of this site found no visual evidence of soil contamination. Because no information exists that waste was ever handled in this area, soil sampling and analysis were not conducted. No radiation above normal background levels was detected in a field radiation survey conducted during February 1988 (Nemeth 1989).

Surface Water

As noted in Section 2.3.1.2, the USGS and the EPA ERT sampled surface water and sediment offshore from the RPTS.

Groundwater

Groundwater samples from monitoring well TH11 (Figure 2.13) were analyzed for extractable organic compounds. Results indicated very low levels of triethylchlorobenzene and TCLEE. As part of the 1986 RFA, the well was resampled for VOCs, BNAs, pesticides, and PCBs. No contaminants were detected.

An additional monitoring well (JF1) was installed near the tower by the USGS as part of their hydrological assessment (Sonntag 1991; Hughes 1993). The well is screened in the Potomac Group (Figure 2.13). Groundwater samples were analyzed for metals, water quality parameters, VOCs, and semivolatile organic compounds. Data for well JF1 showed low levels of VOC contamination (2.25 µg/L 111TCE at a depth of 185-190 ft). However, this finding must be taken as provisional, because one of the two quality control water blanks also showed contamination with TCLEA, TCLEE, and TRCLE (USGS 1992). For the sake of comparison, an upgradient well (JF2) of similar depth, located at the J-Field gate entrance also had detectable concentrations of TRCLE during the same sampling episode. Acetone and 1,1-dichloroethane were detected at concentration of 4 and 1 µg/L, respectively in a 1992 sampling event (USGS 1992).

2.3.7.3 Potential Pathways of Contaminant Migration

No information is available to verify that solid or hazardous waste was generated or handled at this site. A test burn of radioactive contaminated wood may have occurred at the

site; however, the limited sampling conducted to date indicates that this area is not a source of contamination. Thus there are no potential pathways for contaminant migration.

2.3.8 Robins Point Demolition Ground

2.3.8.1 Types of Waste Present

The inactive portion of the RPDG was used primarily for demolition of explosive materials. Small amounts of sensitive and unstable chemicals were occasionally destroyed at the area. A portion of the RPDG is still used for emergency disposal operations.

2.3.8.2 Types of Contaminants Present

Soil Gas

Soil-gas sampling and analysis were not conducted in this area.

Soil

Surface soil collected during the 1986 RFA was analyzed for metals, explosives-related compounds, and organic compounds. The analyses did not detect any contamination in the RPDG (Nemeth 1989).

Soil samples were collected by the USGS at 36 sites at J-Field, including the RPDG (locations 37 through 41 in Figure 2.9). The samples, collected at 1-ft depths, were analyzed for indicator parameters, metals, VOCs, semivolatile organic compounds, and explosives (Hughes 1992). The results indicated the presence of metals in low concentrations, including lead, up to 20.3 mg/kg at location 38; chromium, up to 16.3 mg/kg at location 37; copper, up to 75.5 mg/kg at location 37; and zinc, up to 22.8 mg/kg at location 39. Limited analyses for organic compounds were also conducted; no significant contamination was found.

Surface Water

Laboratory analyses of standing water conducted during the 1986 RFA did not detect any contamination by metals, explosives, or organic compounds (Nemeth 1989).

Groundwater

Two monitoring wells were installed in the active portion of the RPDG in 1992 and will be sampled as a part of the RI. However, groundwater contamination is not expected

given the short period of time the site was used, the nature of the operations, and the absence of soil and surface water contamination.

2.3.8.3 Potential Pathways of Contaminant Migration

Given the nature of the operations at the site and the absence of soil and surface water contamination, it is doubtful that any contamination still exists at this site. However, surface water that ponds west of a berm separating the active from the inactive portion of the RPDG seeps through the berm and discharges into the inactive portion of the site. As a result, surface water may play some role in contaminant migration in that surface runoff may carry dissolved and suspended contaminants from the active portion of the site into the inactive portion.

2.4 OTHER RELEVANT SITE ASPECTS

2.4.1 Preliminary Identification of ARARs and TBC Information

Section 121 of CERCLA requires that remediation actions must attain standards, requirements criteria, or limitations that are "legally applicable or relevant and appropriate" requirements (ARARs) under the site-specific scenario for any hazardous substance that will remain on-site after remediation. Section 121 of CERCLA further specifies that state standards can be considered as potential ARARs when they are promulgated standards that are more stringent than federal standards, providing the state standards have been identified by the state in a timely matter during the RI/FS process.

The distinction between "applicable" and "relevant and appropriate" requirements is made clear in the revised National Contingency Plan (NCP) contained in 40 CFR Part 300. In general, the term "applicable requirements" pertains to substantive requirements that relate specifically to a hazardous substance, remedial action, location, or other "circumstance" found at a CERCLA site. Such substantive requirements could include cleanup standards, criteria, or limits promulgated under state or federal statutes. "Relevant and appropriate requirements" are substantive requirements that may not be directly applicable to a specific CERCLA site scenario but are deemed to address problems or situations sufficiently similar to such a scenario encountered at the CERCLA site that their use is well suited to the particular site.

Potential requirements for a proposed CERCLA remedial action can also be referred to as "to be considered" (TBCs). The TBC category consists of standards or guidelines that have been published but not promulgated and that may have significance for all or part of the action. Potential TBC requirements are typically considered only if no promulgated requirements exist that are either applicable or relevant and appropriate.

Although it may be premature to establish specific ARARs and TBCs for J-Field because additional information must be gathered about the site, the early identification of

ARARs and TBCs can aid the planning process by allowing investigators to make decisions regarding which remedial alternatives will likely be sufficiently protective and cost effective. The lists of preliminary and potential ARARs presented in Tables A.1 through A.4 constitute sets of requirements that can be expanded, reduced, and/or refined as additional information is gathered about the site. The ARARs presented in these tables have been separated into (1) Maryland state regulations and TBCs and (2) federal regulations and TBCs for J-Field. The federal ARARs have been further subdivided into contaminant-specific, location-specific, and action-specific ARARs.

2.4.1.1 Contaminant-Specific ARARs

Contaminant-specific ARARS are methodologies, or health- or risk-based numerical thresholds, that can be applied to site-specific conditions at a CERCLA site to establish standards. Contaminant-specific ARARs establish the allowable amount or concentration of a hazardous substance that may exist or be released to the ambient environment. The list of chemical constituents included in the tables in Appendix A is somewhat speculative because the investigative effort may not have identified all constituents present at the site.

Chemical warfare agents and the residue from their treatment are considered acute-listed hazardous wastes under Maryland hazardous waste management regulations and are listed as Class I Toxic Air Pollutants under Maryland regulations. As such, these regulations are included in Appendix A as potential ARARs. However, there are no CWA treatment standards for land disposal or specific numerical limits on CWA in media.

Because whatever standards or criteria the U.S. Army may have developed to regulate OB/OD activities have not been promulgated, such standards or criteria have not been included in Appendix A. However, ANL will rely on CWA-related standards or criteria developed by the U.S. Army, the host installation, and associated tenant activities throughout the investigation and remediation of the site. Such CWA-related standards or criteria will be evaluated for inclusion as TBC information.

2.4.1.2 Location-Specific ARARs

Location-specific ARARs relate to limitations placed on the concentrations of hazardous substance or performance standards established for particular locations. Relevant locations could include threatened or endangered species habitats or other sensitive ecosystems or habitats, wetlands, floodplains, or historic or archaeological sites.

2.4.1.3 Action-Specific ARARs

Action-specific ARARs are technology- or performance-based standards that relate to actions associated with remediation of the site.

2.4.2 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) can be developed for the operable units at J-Field on the basis of the existing information. These goals, which are in essence preliminary cleanup levels, require information on the environmental media of concern, the chemicals of concern, and the probable land use for each operable unit at J-Field (EPA 1991a).

2.4.2.1 Environmental Media of Concern and Potential Concern

It is useful to distinguish environmental media that are of concern and of potential concern. A medium is of concern if existing analytical data are sufficient to show that the medium is contaminated. A medium is of potential concern if the existing sampling data for the medium are insufficient to show contamination, but sampling data for other media or the site history indicate a potential for contamination. The status of the environmental media for the eight J-Field sites is summarized in Table 2.21. Details are provided in the following subsections.

Toxic Burning Pits

Existing analytical data indicate that soil and groundwater are environmental media of concern at the TBP AOC. Surface water and sediments in the adjacent marshes are media of potential concern. No existing analytical data show that these media are contaminated, but the possibility of surface runoff into the marshes to the east and south, pushout of burned soil and debris into the marshes, and general J-Field history indicate a potential for concern. The elevated soil-gas contamination in the area and the possible existence of contaminated fugitive dust indicate that the atmosphere may also be a medium of potential concern (ANL 1993, 1994).

White Phosphorus Burning Pits

Soil and groundwater are also media of concern at the WPP AOC. In addition, offshore sediments are of potential concern. This conclusion is based on the shore erosion occurring in the area (Weston 1992) and the observed elevated concentrations of metals and TOX in unfiltered water samples only (USGS 1991). Any surface water in the area is also a medium of potential concern. However, there are no marshes nearby, so marsh sediments and water are not media of potential concern. The atmosphere is a medium of potential concern because of the possibility of contaminated windborne fugitive dust originating at the site, elevated soil-gas contamination, and the reported odor of the chemical agent CN in the area (Nemeth 1989; Weston 1992).

TABLE 2.21 Environmental Media of Concern or Potential Concern at the J-Field Sites

Site	Concern (Y) or Potential Concern (P) ^a					
	Soil	Marsh Sediment	Offshore Sediment	Surface Water	Ground-water	Atmosphere
Toxic Burning Pits (TBP)	Y	P	-	P	Y	P
White Phosphorus Burning Pits (WPP)	Y	-	P	P	Y	P
Riot Control Burning Pit (RCP)	P	P	P	P	Y	P
Prototype Building (PB)	Y	-	-	P	P	P
South Beach Trench (SBT)	P	-	-	-	-	-
South Beach Demolition Ground (SBDG)	-	-	P	P	P	-
Robins Point Demolition Ground (RPDG)	P	P	-	P	P	P
Robins Point Tower Site (RPTS)	P	-	-	-	P	-

^a A hyphen indicates that the medium is not of concern/potential concern.

Riot Control Burning Pit

Existing data indicate that groundwater is the only medium of concern at the RCP AOC. Soils, surface water, and sediments, both in the nearby marsh and offshore, are media of potential concern, as is the atmosphere. The potential concern for soils and the atmosphere stems from the elevated soil-gas contamination, possible contaminated fugitive dust, and site history (ANL 1994). The potential concern for sediments is based on the shore erosion in the area (Weston 1992), the potential for surface runoff, and the site history.

Prototype Building

Soil is the only medium of concern at the PB AOC. Groundwater and any surface water at the site are media of potential concern. The potential concern for groundwater is based on possible leaching of soils at the site and the proximity of the site to areas with contaminated groundwater. The potential concern for the atmosphere is based on the possibility of windborne contaminated dust leaving the PB site.

South Beach Trench

No media of concern have been identified at the SBT AOC. The presence of a few munitions fragments in the trench, the lack of any disposal history, and the low level of chlordane (0.053 ppm) in a soil sample taken at the site (Nemeth 1989; Sonntag 1991) indicate that soil is the only medium of potential concern.

South Beach Demolition Ground

No media of concern have been identified at the SBDG AOC. Groundwater, offshore sediments, and water are media of potential concern. This potential concern is based on the past use of the site for HE munitions disposal in holes and the extensive erosion that has placed the site offshore in Chesapeake Bay covered with sand (Nemeth 1989; Sonntag 1991).

Robins Point Demolition Ground

No media of concern have been identified at the RPDG AOC. The site history indicates that soils and possibly surface water, sediments, and groundwater in and under the nearby marsh are media of potential concern. (The absence of explosives or metals in the few soil samples collected from the site [Nemeth 1989] is believed to be an insufficient reason to exclude soils and other media as of potential concern.) The atmosphere is also a medium of potential concern because of the possible occurrence of windborne contaminated fugitive dust.

Robins Point Tower Site

No media of concern have been identified at the RPTS AOC. Soil and groundwater are the only media of potential concern. This categorization is based on the lack of information regarding the use of the site for material disposal. The site was used as an observation and launch site for rocket testing. A test burn of material, mainly wood contaminated with radioactivity, was planned for the site in 1959 but may not have occurred (Nemeth 1989).

2.4.2.2 Contaminants of Potential Concern

At each J-Field site, contaminants of potential concern are those that have been detected in samples at concentrations significantly above background, or that could reasonably be expected (on the basis of site history or use) to be present in significant quantities. Tables 2.22 and 2.23 summarize the contaminants of potential concern identified for the J-Field sites. Each table is divided into two sections. The first section lists contaminants of potential concern based on sampling data for each environmental medium; the second section gives contaminants of potential concern based on site history and use. Entries in the second section are not associated with specific environmental media because

TABLE 2.22 Preliminary Identification of Contaminants of Potential Concern for the Toxic Burning Pits at J-Field

Based on Analytical Data ^a			
<i>Soil Gas</i>	<i>Soil</i>	<i>Groundwater</i>	
Trichloroethylene	Arsenic	Arsenic	Ethyl benzene
Tetrachloroethylene	Cadmium	Nickel (?)	Toluene
Dichloroethylene	Chromium (?)	Lead	Chloroform
Trichloroethanes	Lead	Selenium	Carbon tetrachloride
Alkanes	Mercury	Zinc	1,1,2-Trichloroethane
Phthalates	Zinc	Nitrate	1,1,2,2-Tetrachloroethane
Heavy aromatics	Trichloroethylene	Cyanide	Vinyl chloride
	Petroleum hydrocarbons	Sulfate	1,1-Dichloroethylene
	PCBs	PETN	<i>trans</i> -1,2-Dichloroethylene
	Heptachlor epoxide	Nitrocellulose	Trichloroethylene
	Other VOCs	RDX	Tetrachloroethylene
	Other pesticides	Nitrobenzene	Sulfone
		Cesium-137	1,4-Dithiane
		Strontium-90	1,4-Oxithiane
		Benzene	Thiodiglycol
		Chlorobenzene	
Based on Site History			
CWAs		Degradation products of CWAs	
VX		HE munitions	
Mustard		Explosives-related compounds	
G-agents ^b		Chlorinated solvents	
Incapacitating agents (CS, CN)		Smoke munitions (FS, FM)	

^a A question mark indicates status uncertain.

^b G-agents are the nerve agents GA (*o*-ethyl-*N,N*-dimethylphosphoramidacyanidate [tabun]), GB (isopropyl methylphosphonofluoridate [sarin], GD (pinacolyl methylphosphonofluoridate [soman]), and GF (cyclohexylmethylphosphonofluoridate).

TABLE 2.23 Preliminary Identification of Contaminants of Potential Concern at the White Phosphorus Burning Pits and Other J-Field Sites^a

Part I: White Phosphorus Burning Pits

Based on Analytical Data		
<i>Soil Gas</i>	<i>Soil</i>	<i>Groundwater</i>
Trichloroethylene	Barium	Nitrate
Tetrachloroethylene	Chromium	Cyanide
Simple aromatics	Lead	Dinitrotoluene
Other hydrocarbons	Zinc	Nitrocellulose
	Nitrate	RDX
	Petroleum hydrocarbons	1,3-Dithiane
	Aromatics (?)	Thiodiglycol
	Cyanide	4-Chlorophenyl methylsulfoxide
		Trichloroethylene
Based on Site History		
White phosphorus	Other chemicals (small amounts)	
White phosphorus munitions		

Part II: Other Sites^b

Based on Analytical Data		
<i>Soil Gas</i>	<i>Soil</i>	<i>Groundwater</i>
Heavy aromatics (RCP)	Lead (RCP, PB)	Zinc ? (SBT, RPTS)
Phthalates (RCP)	Cadmium (PB)	Cyanide (RCP, RPDG)
DCE or TCE and TRCLE or TCLEE (RCP)	Chromium ? (RCP)	Benzene (RCP, PB)
	DDD, DDE, DDT (PB)	Methyl isobutyl ketone (RCP, PB)
	Chlordane (SBT)	Trichloroethane (RPTS)
Based on Site History		
CS, CN, DM, riot control agents (RCP)	HE, sensitive chemicals, CK ?, radium and strontium-90 ? (RPDG, RPTS)	
HE munitions (PB, SBDG)		

^a A question mark indicates status uncertain.

^b Codes in parentheses indicate sites involved: RCP = Riot Control Burning Pit, PB = Prototype Building, SBT = South Beach Trench, RPTS = Robins Point Tower Site, RPDG = Robins Point Demolition Ground, SBDG = South Beach Demolition Ground.

they are not based on sampling data. Surface water data are not included in the tables because relatively few contaminants were found. Where contaminants have been found in surface water, the contaminants of potential concern are the subset of volatile organics listed under the "groundwater" heading in Tables 2.22 and 2.23.

The information in the tables can be combined with a conceptual model for each site to determine the potential contaminants of concern for each environmental medium. For example, each contaminant listed in the soil-gas column would be expected, on the basis of site geohydrology, to be a contaminant of potential concern both for soil and groundwater. The table entries are discussed by site in the following sections.

Toxic Burning Pits

Analytical data show the presence of many contaminants of potential concern in the TBP AOC. Extensive plumes of soil gas contaminated with chlorinated solvents, aromatics, alkanes, and other organic materials that apparently originated from one or more of the various pits at the TBP have been detected. Soil samples show high concentrations (up to 2.6%) of lead and lower concentrations of other metals. Low concentrations of VOCs (including TRCLE) were found, as were PCBs and some pesticides. However, it is reported that the pesticide measurements may represent "false positives" (Nemeth 1989). The trace amounts of BNAs detected in the soil do not justify listing them as contaminants of potential concern.

Analyses of standing water samples from the TBP AOC show lead and possibly mercury as contaminants of potential concern. Groundwater data show that many VOCs are present at sufficiently high concentrations to be contaminants of potential concern. Several of them, such as 12DCE, TRCLÉ, and vinyl chloride, are present at concentrations well above the federal MCL values. Metals, such as lead and arsenic, and nitrate are also present at concentrations above federal MCLs. Cyanide is also present. Mustard degradation products (up to 21 µg/L thiodiglycol) and explosives (up to 213 µg/L nitrocellulose) have been found in some of the wells near the pits. The radioactive species cesium-137 and strontium-90 are listed as contaminants of potential concern because elevated concentrations (up to 172 pCi/L) were found in three wells (P3, JF51, and JF73) (USGS 1991).

The site history indicates the potential presence of additional contaminants for which sufficient analytical data are not available. These contaminants include CWAs, such as VX, G-agents, mustard, and incapacitating and smoke agents, as well as CWA degradation products (Tables 2.22 and 2.23). Although most of the CWAs at J-Field are expected to be degraded by now, they are included as contaminants of potential concern because of their extreme toxicity and their possible presence in UXO.

White Phosphorus Burning Pits

Soil-gas data for the WPP AOC show the presence of some VOCs (such as TRCLE and TCLEE) and some aromatics. Soil data show the presence of metals, with lead concentrations up to 2,960 ppm. Other contaminants of potential concern found at the WPP include petroleum hydrocarbons, nitrate, cyanide, and possibly aromatic hydrocarbons. Total phosphorus was found to be elevated, and because the analytical data do not include the form of the measured phosphorus, the possibility that an appreciable fraction is present as WP must be considered. Lead and possibly sulfate are considered surface water contaminants of potential concern on the basis of analytical data for samples of standing water collected from the pits.

Groundwater data show that nitrate, cyanide, some explosives-related compounds, some mustard degradation products, and TRCLE are contaminants of potential concern. Existing data do not indicate the presence of PCBs or pesticides in the groundwater.

The site history indicates that WP munitions and other forms of WP may have been disposed of at the WPP AOC; therefore, WP is a contaminant of potential concern. WP may be present either in pure form or as PWP.

Riot Control Burning Pit

Because of soil-gas analysis results, heavy aromatics, phthalates, and some chlorinated solvents (DCE or TCE and TRCLE or TCLEE) are considered contaminants of concern at the RCP. Soil data show that lead and possibly chromium are contaminants of potential concern. Insufficient data exist regarding organic materials as contaminants of potential concern in soil at the site.

Groundwater data indicate that cyanide, benzene, and methyl isobutyl ketone (MIBK) are contaminants of potential concern. Insufficient data exist to determine if volatile compounds and other organic compounds, including CWAs and CWA degradation products, are contaminants of potential concern.

The site history indicates that riot control agents such as adamsite (DM), chloroacetophenone (CN), and especially o-chlorobenzylidene malononitrile (CS) are contaminants of potential concern.

Prototype Building

Passive soil-gas studies indicate minor organic contamination in discrete areas east of the PB AOC. Soil data indicate that lead, cadmium, and pesticides (and their breakdown products, such as DDD, DDE, and DDT) are also contaminants of potential concern. Benzene and MIBK are contaminants of potential concern in groundwater. The site history suggests that explosives and contaminants in unspecified wastes, including the contents of the four drums presently on the site (Weston 1992), may be contaminants of potential concern.

South Beach Trench

No data exist on soil-gas contamination at the SBT AOC. On the basis of one surface soil sample, chlordane is a contaminant of potential concern. Sampling data from one monitoring well (TH10) indicate that zinc may be a contaminant of potential concern in the groundwater. Insufficient data are available to determine if other organic compounds or metals are contaminants of potential concern in either the soil or groundwater at the site.

Information on the site history and use is lacking. The presence of a few munitions fragments on the site (Nemeth 1989) is insufficient to suggest contaminants of potential concern.

South Beach Demolition Ground

Existing environmental data are insufficient to indicate the presence of any contaminants of potential concern at the SBDG AOC. In any case, most of the site is currently offshore and covered with sand. The site history of HE munitions demolition indicates that metals and explosives may be contaminants of potential concern.

Robins Point Demolition Ground

Existing environmental media (surface soil and surface water) sampling data do not support the listing of any contaminants of potential concern for the RPDG AOC; however, the site history indicates that explosives and possibly cyanide may be contaminants of potential concern. An item filled with cyanogen chloride (CK) was reportedly destroyed at the site, and cyanide is a degradation product of CK.

Robins Point Tower Site

No sampling data exist on which to base the listing of contaminants of potential concern for soil gas or soil for the RPTS AOC. Groundwater data from two wells (TH11 and JF1) indicate that zinc and 111TCE may be contaminants of potential concern. Site history and use indicate it is possible that rocket fuel components and the radioactive species radium and strontium-90 may be contaminants of potential concern. The radioactive species could be present if the once-planned test burn of radioactively contaminated wood was actually conducted at the site.

Other J-Field Sites

Currently there are no chemical data to identify contaminants of potential concern at the PAOCs.

2.4.2.3 Present and Probable Future Land Use

Current use of J-Field is limited to one OB area and two OD areas. These areas are operating under RCRA interim status. One area, a pan located about 50 m west of the PB is planned to be used to burn small amounts of propellants or explosives. One OD area is the RPDG, used to detonate munitions. The other area, near the WPP, is used for emergency detonation of items containing white phosphorus (WP).

It is currently anticipated that OB/OD activities will continue at the three areas now in use. The levels of activities were reported in January 1991 to be one or two emergency disposal operations per year at the WPP AOC and about 100 days of operations per year at the RPDG AOC (ICF-Kaiser Engineers 1991). In addition, it is possible that non-RCRA-permitted flashing of small quantities of explosives will be conducted at J-Field. These activities may include flashing of small amounts of explosives left in opened and cleaned shell casings. These actions are needed to certify that the casings are "5X" clean. No CWAs will be disposed of at J-Field (Benioff 1992).

Hunting and trapping are not allowed at J-Field. Seasonal hunting of migratory birds is permitted along the entire shore of J-Field (Wrobel 1994). Areas of the Gunpowder River and Chesapeake Bay near J-Field are used for fishing from boats (ICF-Kaiser Engineers 1991). Access to the shore is prohibited.

The FS will evaluate the final remedial alternative selection for both restricted and unrestricted land use scenarios.

2.4.2.4 Conceptual Site Model

A conceptual site model that links sources and release mechanisms to receptors through various pathways and exposure routes for J-Field is presented in Figure 2.20. The model has been prepared on the basis of our current understanding of the contamination scenario at J-Field. It is based on the risk and biological impact assessment technical plan prepared by ICF-Kaiser Engineers (1993) and on existing data.

At this early stage of investigation, the proposed model shown in Figure 2.20 is applicable to each of the AOCs at J-Field. As additional data are gathered, it may be necessary to modify the model.

In the conceptual site model, the main sources of contamination are considered to be the eight AOCs. The primary release mechanisms associated with these AOCs are considered to be related to the primary waste-handling activities conducted at J-Field (i.e., OB/OD). Precipitation falling on the OB/OD areas and other contaminated areas would cause the infiltration/percolation of contaminants. In addition, because operating procedures could have involved the addition of assorted fuels to facilitate OB, infiltration and percolation of these fuels are also considered primary release mechanisms.

* NAPLs = Non-aqueous-phase liquids

FIGURE 2.20 Conceptual Site Model for J-Field

Because of the potential for soils at each AOC to have become contaminated through the primary release mechanisms, soil is considered one of the more significant secondary sources of contamination. Groundwater is also considered a significant secondary source of contamination because of the potential for contamination from infiltration and percolation. In addition, because of the nature of OB/OD activities, significant amounts of debris (such as exploded or unexploded ordnance) could exist within each AOC. Such debris could also represent a significant secondary source of contamination for the secondary release mechanisms.

Several processes have been identified as secondary release mechanisms in the exposure mode. Because of the potential existence of areas of contaminated soil and debris, an associated potential exists for the release of contaminants as dust and as volatilization products of contaminants into the air pathway from debris, soil, and/or groundwater. The discharge of groundwater into surface water bodies such as marshes and streams and into Chesapeake Bay, as suggested by thermal imagery studies, is a potentially significant release mechanism for groundwater into media with exposure routes to receptors.

Because of the possible existence of UXO, some potential exists for contaminants to be released to the soil or air pathways as a result of "secondary" detonations. Infiltration and percolation are also considered significant secondary release mechanisms because they can cause contaminants in soil and debris to migrate to groundwater or to surface water and sediments. Surface runoff can also be a significant mechanism for the release of contaminants to surface water, sediments, and to areas of previously uncontaminated soil.

Analysis of potential impacts to human receptors at J-Field is based on the current limited human activity. Robins Point is currently the main active site for demolition of munitions. Fishing and crabbing from boats occur just offshore, even though they are not permitted along the J-Field shoreline. Trapping and hunting occur at nearby I-Field, and hunting of migratory birds is approved for the area along the J-Field shoreline.

The conceptual site model (Figure 2.20) accounts for these activities by separating the human receptors into on-site (workers and trespassers) and off-site (hunters and fishermen) categories. Potential exposures of these receptors and of terrestrial and aquatic biota through different pathways and exposure routes are indicated in the figure by solid black dots.

No potential exposures are indicated for groundwater because no direct routes are likely. Groundwater is not used downgradient of J-Field; the nearest pumping well is about 4 mi distant across the Gunpowder River (Hughes 1993). The potential is minimal for dermal exposure of workers to groundwater while withdrawing samples from monitoring wells. Indirect exposure routes for groundwater by upwelling into Chesapeake Bay or discharge to marshes and streams are indicated in Figure 2.20 by a pathway arrow from groundwater to surface water and sediments.

2.4.2.5 Preliminary Remediation Goals

PRGs for each environmental medium of concern and each site at J-Field are, in essence, preliminary estimates of cleanup levels that should be attained by conducting remedial actions. For surface water and groundwater, PRGs can be chosen to be based on ARARs. Commonly used ARARs consist of federal MCLs, nonzero maximum contaminant level goals (MCLGs), state water quality standards (SWQSs), and federal water quality criteria (FWQC). The choice among these values depends on the ultimate receptor, the availability of the chosen ARAR for the contaminant of concern, and similar factors. For example, for water that is a current or potential source of drinking water, FWQC may have to be used for those parameters for which no MCL, nonzero MCLG, or SWQS are available (EPA 1991b). For pathways for which aquatic life in the marshes or estuaries is the ultimate receptor, freshwater or marine criteria can be used as cleanup levels.

Surface water and groundwater ARARs applicable to the J-Field contaminants of potential concern, except CWA and CWA degradation products, are summarized in Table 2.24. Some available data for CWA and CWA degradation products are provided in Table 2.25. As the tables show, very few water pathways criteria are available for many explosives-related compounds, CWA, and CWA degradation products. Atmospheric criteria for CWA, given in Table 2.25, can be used for atmospheric pathways for workers, which were selected for baseline risk assessment by ICF-Kaiser Engineers (1991).

Chemical-specific ARARs for soils, which are needed to establish cleanup levels, are generally not available (EPA 1991b). The water quality criteria and other standards can be used to develop soil cleanup levels. However, this procedure requires model calculations for each exposure pathway considered. For groundwater pathways to the marshes or estuaries, the model evaluates the contaminant moving down through the vadose zone, entering and mixing with the groundwater, being transported to the point of discharge, and mixing with marsh or estuary water at the discharge point. For each step, a transfer or dilution factor is determined by the model. Use of these model calculations gives soil cleanup levels as concentrations that will result in water concentrations at or below the selected criteria for the site, exposure pathway, and chemical parameter considered. Similar types of transfer factors or dilutions are needed for the surface water and air pathways.

The information currently available for J-Field is not sufficient to carry out model calculations to estimate soil cleanup levels. In addition, very little information is available on which to base an estimate of the significance of the different exposure pathways. Such is especially the case for CWA, for which very little data are available. Therefore, the use of even very simplified model equations requiring estimates for transfer and dilution factors as inputs would result in such crude estimates as to be potentially misleading and useless. For these reasons, preliminary estimates will not be given here of the soil cleanup levels for contaminants of concern for each of the sites at J-Field. It is expected that the collection of additional data will enable such estimates to be made.

TABLE 2.24 Federal Water Quality Criteria, Standards, and Guidelines for Contaminants of Potential Concern at J-Field^a

Concentrations (µg/L, except as noted)									
Parameter	MCL	Human Health				Aquatic Life			
		Water Ingestion		Fish Ingestion		Freshwater		Marine	
		Threshold Toxicity Protection	10 ⁻⁶ Cancer Risk	Threshold Toxicity Protection	10 ⁻⁶ Cancer Risk	Acute	Chronic	Acute	Chronic
Metals and Inorganic Compounds									
Arsenic	50	– ^b	0.025	–	0.0175	850(V) ^c 360(III)	48(V) ^c 190(III)	2,319(V) ^c 69(III)	13(V) ^c 36(III)
Barium	1,000	–	–	–	–	–	–	–	–
Cadmium	10	10	–	–	–	3.9 ^d	1.1 ^d	43	9.3
Chromium	50	50(VI) 179,000(III)	–	– 3.4 × 10 ⁶ (III)	–	16(VI) 1,700(III) ^d 210(III) ^d	11(VI)	1,100(VI) 10,300(III) ^c	50(VI)
Lead	50	50	–	50	–	82 ^d	3.2 ^d	140	5.6
Mercury	2	10	–	0.146	–	2.4	0.012	2.1	0.025
Nickel	–	15.4	–	100	–	1,800 ^d	96 ^d	140	7.1
Selenium	10	10	–	–	–	260	35	410	54
Zinc	5,000 ^e	5,000	–	–	–	320 ^d	47	170	58
Cyanide	200	200	–	–	–	22	5.2	1	1
Nitrate (as N)	10,000	–	–	–	–	–	–	–	–
Sulfate	250,000 ^e	–	–	–	–	–	–	–	–
Volatile Organic Compounds									
Carbon tetrachloride	5	–	0.42	–	6.94	35,200 ^c	–	50,000 ^c	–
Chloroform	100	–	0.19	–	15.7	28,900 ^c	1,240 ^c	–	–
Ethyl benzene	700	2,400	–	3,280	–	32,000 ^c	–	430 ^c	–
1,1-Dichloroethylene	7	–	0.033	–	1.85	11,600 ^c	–	224,000 ^c	–

TABLE 2.24 (Cont.)

Concentrations (µg/L, except as noted)									
Parameter	MCL	Human Health							
		Water Ingestion				Fish Ingestion			
		Threshold Toxicity Protection	10 ⁻⁶ Cancer Risk	Threshold Toxicity Protection	10 ⁻⁶ Cancer Risk	Aquatic Life			
						Freshwater		Marine	
						Acute	Chronic	Acute	Chronic
Volatile Organic Compounds (Cont.)									
1,1-Dichloroethylene	7	—	0.033	—	1.85	11,600 ^c	—	224,000 ^c	—
Toluene	1,000	15,000	—	424,000	—	17,500 ^c	—	6,300 ^c	5,000 ^c
Methylisobutylketone	—	—	—	—	—	—	—	—	—
112TCE	5	—	0.60	—	41.8	—	9,400 ^c	—	—
12DCE	70(cis) 100(trans)	—	—	—	—	11,600	—	224,000	—
Vinyl chloride	2	—	2	—	525	—	—	—	—
TRCLE	5	—	2.8	—	80.7	45,000 ^c	21,900 ^c	2,000	—
TCLEA	—	—	0.17	—	10.7	—	2,400 ^c	9,020 ^c	—
TCLEE	5	—	0.88	—	8.85	5,280 ^c	840 ^c	10,000 ^c	450 ^c
Benzene	5	—	0.67	—	40	5,300 ^c	—	5,100 ^c	700 ^c
Monochlorobenzene	100	488	—	—	—	250 ^c	50 ^c	160 ^c	129 ^c
Semivolatile Organic Compounds									
PAHs	—	—	0.0031	—	0.031	—	—	300 ^c	—
Phthalates	—	—	—	—	—	940 ^c	3 ^c	2,944	3.4 ^c
Petroleum hydrocarbons	—	—	—	—	—	—	—	—	—
Pesticides, PCBs									
Chlordane	2	—	0.022	—	0.00048	2.4	0.0043	0.09	0.004
Heptachlor	0.4	—	0.011	—	0.00029	0.528	0.003	0.053	0.0036
Heptachlorepoide	0.2	—	—	—	0.00029	—	—	—	—
DDD	—	—	—	—	—	—	—	—	—
DDE	—	—	—	—	—	1,050 ^c	—	14 ^c	—
DDT	—	—	0.0012	—	0.000024	1.1	0.001	0.13	0.001
PCBs	0.5	—	0.013	—	0.000079	2.0	0.014	10	0.03

TABLE 2.24 (Cont.)

Concentrations (µg/L, except as noted)									
Parameter	MCL	Human Health				Aquatic Life			
		Water Ingestion		Fish Ingestion		Freshwater		Marine	
		Threshold Toxicity Protection	10 ⁻⁶ Cancer Risk	Threshold Toxicity Protection	10 ⁻⁶ Cancer Risk	Acute	Chronic	Acute	Chronic
Explosives-Related Compounds									
2,4-Dinitrotoluene	—	—	0.05 ^f	—	9.1	330 ^{c,g}	230 ^{c,g}	590 ^{c,g}	370 ^{c,g}
2,6-Dinitrotoluene	—	—	0.05 ^f	—	—	—	—	—	—
TNT	—	2 ^f	—	—	—	—	—	—	—
HMX	—	400 ^f	—	—	—	—	—	—	—
RDX	—	2 ^f	—	—	—	—	—	—	—
1,3,5-Trinitrobenzene	—	—	—	—	—	—	—	—	—
1,3-Dinitrobenzene	—	1 ^f	—	—	—	—	—	—	—
Nitrobenzene	—	19,800	—	—	—	27,000 ^c	—	6,680 ^c	—
Nitroglycerin	—	5 ^f	—	—	—	—	—	—	—
Nitrocellulose	—	Nontoxic	—	—	—	—	—	—	—
Pentaerythritol-tetranitrate	—	—	—	—	—	—	—	—	—
Tetrazene	—	—	—	—	—	—	—	—	—
2,4,6-Trinitrobenzaldehyde	—	—	—	—	—	—	—	—	—
Tetryl	—	—	—	—	—	—	—	—	—
2,4,6-Trinitrophenylmethylnitramine	—	—	—	—	—	—	—	—	—
Other^h									
Thiodiglycol	—	—	—	—	—	8.2 × 10 ⁷ , i	—	6.8 × 10 ⁵ , i	—
VX	—	—	—	—	—	0.3 ⁱ	—	0.3 ⁱ	—
1,4-Dithiane	—	—	—	—	—	1.2 × 10 ⁵	—	26,500 ⁱ	—
White phosphorus	—	0.1 ^f	—	—	—	—	—	—	—
Diisopropyl methylphosphonate	—	600 ^f	—	—	—	—	—	—	—

See footnotes on next page.

TABLE 2.24 (Cont.)

- ^a In the body of the table, roman numerals in parentheses represent the valence state of the element.
- ^b A "-" = value not available.
- ^c Insufficient data to develop criteria. Value given is lowest observed effect level.
- ^d Hardness-dependent criteria; value is for 100 mg/L.
- ^e Secondary MCL.
- ^f Lifetime health advisory for adults or 10^{-6} cancer risk (EPA 1992c).
- ^g Reported value is for dinitrotoluene, isomer unspecified.
- ^h Only those CWAs and degradation products are listed for which water quality data are available.
- ⁱ 96H-LC₅₀ values — 50% of organisms will die in 96 h (ICF-Kaiser Engineers 1994).

Source: EPA (1986) unless otherwise specified.

TABLE 2.25 Atmospheric Criteria for Chemical Warfare Agents that Are Contaminants of Potential Concern at J-Field

Chemical Warfare Agent	Recommended Exposure Limit ^a (mg/m ³)	
	Time-Weighted Average	Immediately Dangerous to Life and Health
Lethal Chemical Agents		
Tabun (GA)	— ^b	—
Sarin (GB)	0.0001	0.2
Soman (GD)	0.00003	—
VX	0.00001	0.4
Mustard (H, HD, HT)	0.003	0.5
Lewisite (L)	0.0001 ^c	—
Incapacitating Agents		
Adamsite (DM)	—	—
Chloroacetophenone (CN)	—	—
o-Chlorobenzylidene malonitrile (CS)	—	—
3-Quinuclidinyl benzilate (BZ)	0.004	—
Blood Agents		
Cyanogen chloride (CK)	—	—
Smoke/Incendiary Agents		
Titanium tetrachloride (FM)	—	—
Sulfur trioxide-chlorosulfonic acid (FS)	—	—
White phosphorus (WP)	0.1	200

^a As recommended by the Surgeon General for the work place.

^b A "—" = not applicable.

^c Value is a ceiling.

Source: Weston (1992).

2.4.3 Preliminary Identification of Operable Units

Operable units are portions of an overall response action that eliminate or mitigate a release, threat of release, or an exposure pathway. An operable unit may be implemented as a final remediation for a defined portion of a site or as an interim action before the RI/FS is completed, as in the case of the soil and groundwater at the TBP (to be documented in the J-Field Focused Feasibility Study [FFS] Report). Those operable units implemented as interim actions are generally followed by long-term remediation.

Operable units are usually defined on the basis of the locations of "hot spots" (locations of significantly elevated contaminant concentrations), the site geology, the chemical and physical nature of contamination, and the extent and location of threats to human health and the environment. At J-Field, the following preliminary operable units have been identified:

- Implementing Toxic Burning Pits Interim Remedial Action — the FFS for the TBP AOC will address soil contamination in the two main pits and associated pushout area (but will not include the marsh) and groundwater in the surficial aquifer in the general TBP AOC vicinity;
- Remediating soil contamination at all OB/OD pits and pushout areas;
- Remediating soil contamination at the PB;
- Remediating soil contamination at PAOCs;
- Remediating sediment and surface water contamination in the marshes;
- Remediating groundwater contamination in the surficial aquifer; and
- Remediating groundwater contamination in the confined aquifer.

The necessity of remediating the areas mentioned here will be evaluated during the FS once the baseline risk assessment and the RI are complete. The FS will evaluate remediation alternatives to address the contamination at those areas considered to warrant remedial action.

3 FEASIBILITY STUDY TASKS

In general, the FS process can be separated into two phases: (1) development and screening of alternatives; and (2) detailed analysis of alternatives. Alternatives will be developed concurrently with the RI site characterization activities. This process is iterative, with the results of the RI aiding in the development of alternatives and screening of technologies and the range of alternatives guiding subsequent site characterization and treatability studies.

The FS will consist of eight tasks:

- Task 1: Development of Remedial Action Objectives and General Response Actions,
- Task 2: Identification of Remedial Action Technologies and Assembly of Alternatives,
- Task 3: Screening of Remedial Action Alternatives,
- Task 4: Performance of Treatability Studies,
- Task 5: Detailed Analysis of Alternatives,
- Task 6: Cost Analysis,
- Task 7: Selection of Preferred Alternative, and
- Task 8: FS Report Preparation.

Each of these tasks is described in the following sections.

3.1 TASK 1: DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

3.1.1 Development of Remedial Action Objectives

Remedial action objectives to address contaminants of concern, potential exposure pathways, and remediation goals for this FS have been developed for J-Field on the basis of available information. These objectives consist of specific goals for protecting human health and the environment and are as follows:

- To protect human health and the environment by developing response actions that mitigate chemical contamination in various media at J-Field;

- To minimize contaminant migration to off-site areas;
- To institute solutions for contaminated media that permanently or significantly reduce their toxicity, mobility, or volume;
- To implement actions in a manner that ensures compliance with ARARs; and
- To implement actions in a manner that ensures minimum impact to human health and the environment.

3.1.2 Development of General Response Actions

General response actions (e.g., no action, treatment, containment, removal) have been developed to meet the objectives specified in Section 3.1.1. Currently available information indicates that the main source of contamination at J-Field is soil that has been contaminated by disposal activities. Table 3.1 lists response actions and associated remedial technologies and process options to address sources of contamination in soil at J-Field. Because some simultaneous remediation of groundwater and surface water may be required, response action categories and associated technologies for these media have also been identified (Tables 3.2 and 3.3). Remediation of the soil and groundwater will be approached by development of limited remedial alternatives that will allow for quick action on the basis of limited design information, with larger-scale actions to follow.

Existing data will be used to identify site conditions that may limit or promote the use of certain response actions. Table 3.4 lists site characteristics that will be evaluated during this process. Response actions that are precluded by site characteristics or identified as not applicable on the basis of increased understanding of site conditions will be eliminated from further consideration. This process will include identification of waste characteristics that limit the effectiveness or applicability of certain technologies. Such waste characteristics include the following:

- Contaminant concentration,
- Toxicity of contaminant,
- Radiological characteristics,
- Chemical composition and characteristics,
- Persistence of contaminant,
- Mixture of contaminants, and
- Presence of UXO or CWAs.

TABLE 3.1 General Response Actions and Technology Types for Soil and Sediment

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
No Action		
Not applicable	Not applicable	No-action alternative is included to provide a baseline for comparison with other alternatives.
Institutional Control		
Access restrictions	Fences and guards	Limit potential human exposure to all contaminants.
Use restrictions	Legal titles and deeds	Limit potential human exposure to all contaminants.
Monitoring	Soil samplers, surface water samplers, groundwater wells	Provide data for assessing potential for exposure.
Containment		
Surface controls/diversions	Graded contours, swales, berms, soil stabilization	Limit contaminant migration from contaminated area and minimize potential human and ecological exposure from contaminant migration.
Capping	Clay cap, riprap, asphalt or concrete, synthetic membrane material, or combination	Limit contaminant migration from contaminated area and minimize potential human and ecological exposure from contaminant migration.
Lateral barriers	Slurry wall, grout curtain, sheet piling, cryobarriers	Limit contaminant mobility and mitigate potential exposure from contaminant migration.
Bottom sealing	Grout layer injection, block displacement, cryobarriers	Limit contaminant mobility and mitigate potential exposure from contaminant migration.
Removal		
Excavation	Backhoe, bulldozer, scraper and front end loader, dragline, power shovel, clamshell, rotary drilling, trenching, hand excavation	Eliminate potential exposure by removing contaminated source material from the environment (material must be further managed).
Dredging	Cutting head, clamshell, dragline	Eliminate potential exposure by removing contaminated source material from the environment (material must be further managed).

TABLE 3.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>Removal (Cont.)</i>		
Pumping (wet sediments or slurried soil)	Centrifugal, reciprocating, and positive displacement pumps	Eliminate potential exposures by removing contaminated source material from the environment (material must be further managed).
<i>In Situ Treatment</i>		
Physical/Chemical Dewatering/drying	Solar evaporation, gravity drainage trenches	Limit contaminant mobility, reduce volume of contaminated materials, and transfer contaminants from liquid to solid or gas phase.
Vapor extraction	Soil vapor extraction, air stripping, soil venting, air-sparging, vacuum extraction	Removal of volatile organic contaminants from soil and sediment by transfer of contaminants to gaseous phase.
Liquid extraction	Aqueous soil flushing, surfactant flushing, hydraulic fracturing to enhance fluid and vapor flow in subsurface	Enhance mobility of contaminants in aqueous phase to facilitate contaminant removal.
Chemical transformation	Hydrolysis, oxidation/reduction reactions, neutralization, precipitation, electrokinetics, electrochemical reduction and immobilization, photochemical	Reduce contaminant toxicity and/or mobility by transformation of contaminants to nonmobile or nontoxic forms.
Solidification/Stabilization	Lime-based and Portland cement-based pozzolanic reaction, silicates, sorbents, chemical immobilization	Reduce contaminant mobility by fixation of primarily inorganic contaminants into stable solid matrix (soil or sediment volume typically increases).
Thermal Thermal extraction	Thermally enhanced vapor extraction, steam/hot water injection, steam/hot air extraction, radio frequency heating, electrical resistance heating, soil heating	Removal of volatile and semivolatile organic contaminants by mass transfer to the gaseous medium and reduction in contaminated soil volume.

TABLE 3.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>In Situ Treatment (Cont.)</i>		
Thermal (Cont.)		
Thermal destruction	Vitrification	Reduction of toxicity, mobility, and volume of contaminated soil or sediment; destruction of organic contaminants; and fixation of inorganic contaminants in vitrified soil. Total volume of contaminated material is typically reduced.
Biological		
Passive	Aerobic and anaerobic: surface impoundments such as stabilization pits, lagoons, wetlands, vegetation-enhanced biodegradation, biodegradation cells	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated soil or sediment volume.
Active	Aerobic and anaerobic: injection and extraction well systems with pumping	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated soil or sediment volume.
<i>Ex Situ Treatment</i>		
Physical/Chemical		
Dewatering/drying	Filtration, centrifugation, sedimentation, expression, drying bed, evaporation, electrokinetics	Limit contaminant mobility by removal of liquid phase, reduce volume of contaminated materials, and transfer contaminants from liquid to solid or gas phase.
Particle separation	Screening, classification, gravity concentration and separation, magnetic separation, flotation, electrostatic separation, sediment washing	Reduce volume of contaminated soil or sediment by removal of fraction that contains majority of contamination (used as pretreatment step before application of other treatment technologies).
Volume reduction	Crushers, shredders, pulverizers, tumbling and hammer mills, compaction	Reduce contaminated soil or sediment volume (used as pretreatment step before application of other treatment technologies).
Vapor extraction	Low-temperature fluidized bed, soil venting	Removal of volatile organic contaminants from soil and sediment by transfer of contaminants to gas phase.

TABLE 3.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>Ex Situ Treatment (Cont.)</i>		
Physical/Chemical (Cont.)		
Liquid extraction	Soil washing, solvent extraction, selective extraction, acid leaching, heap leach mining	Enhance mobility of contaminants in aqueous phase to facilitate contaminant removal.
Chemical transformation	Dechlorination, dehalogenation, hydrolysis, oxidation and reduction, neutralization, precipitation, dissolution, electrokinetics, chemical binding, chelation, photochemical	Reduce contaminant toxicity and/or mobility by transformation of contaminants to nonmobile or nontoxic forms.
Stabilization/solidification	Pozzolanic processes, thermoplastic encapsulation, silicate and adsorbent binding, chemical immobilization	Reduce contaminant mobility by fixation of primarily inorganic contaminants into stable solid matrix (soil or sediment volume typically increases).
Thermal		
Thermal extraction	Low- and high-temperature stripping, thermal vacuum desorption, vacuum pyrolysis, anaerobic thermal processor	Removal of volatile and semivolatile organic contaminants by mass transfer to the gaseous medium and reduction in contaminated soil volume.
Thermal destruction	Incineration (slagging, fluidized bed, rotary kiln, infrared, multiple hearth), vitrification, pyrolysis, molten salt oxidation, supercritical water oxidation, cyclone furnace, high-temperature thermal processor, entrained bed gasification, gas phase reduction, plasma torch furnace, circulating bed combustor, flash smelting, catalytic extraction	Reduction of toxicity, mobility, and volume of contaminated soil or sediment; destruction of organic contaminants; and transfer of inorganic contaminants to reduced volume of treatment residual (ash, slag, glass) for further management. Total volume of contaminated material is reduced.
Biological		
Composting	Open and static windrows and reactor vessels	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated soil or sediment volume.
Land application	Land farming	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated soil or sediment volume.

TABLE 3.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>Ex Situ Treatment (Cont.)</i>		
Biological (Cont.)		
Reactor	Aerobic and anaerobic processes	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated soil or sediment volume.
	Suspended growth: continuous and plug flow, activated sludge	
	Attached growth: biological contactor, trickling filter, fixed-film fluidized bed	
<i>Disposal</i>	Engineered disposal facility, vault disposal, landfill using synthetic and earth-based materials	Limit contaminant mobility by containment in permanent disposal cells engineered to minimize contaminant migration and to mitigate potential exposures from contaminant migration or direct contact.

TABLE 3.2 General Response Actions and Technology Types for Groundwater

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
No Action		
Not applicable	Not applicable	No-action alternative is included to provide a baseline for comparison with other alternatives.
Institutional Control		
Access restrictions	Fences and other barriers at wells or groundwater discharge points	Limit potential human exposure to all contaminants.
Use restrictions	Legal titles and deeds, drilling restrictions	Limit potential human exposure to all contaminants.
Monitoring	Groundwater wells, surface water samplers	Provide data for assessing potential for exposure.
Containment		
Lateral barriers	Slurry wall, grout curtain, sheet piling, cryobarriers, deep soil mixing, angled barriers	Limit contaminant mobility and mitigate potential exposure from contaminant migration.
Bottom sealing	Grout layer injection, block displacement, cryobarriers, angled barriers	Limit contaminant mobility and mitigate potential exposure from contaminant migration.
Migration control	Pumping (injection and extraction wells), sorbent barriers, gravel layer drain and vapor vent	Limit migration of contaminated groundwater plume.
Surface controls/diversions	Graded contours, swales, berms, soil stabilization	Limit contaminant migration from contaminated area(s) to groundwater.
Capping	Clay cap, riprap, asphalt or concrete, synthetic membrane material, or combination	Limit contaminant migration from contaminated area(s) to groundwater.
Removal		
Interception	Subsurface drains, interceptor/recovery trenches	Eliminate potential exposures by removing contaminated groundwater from the environment (collected water must be further managed).

TABLE 3.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
Removal (Cont.)		
Well extraction	Recovery wells, wellpoints, suction wells, deep wells	Eliminate potential exposures by removing contaminated groundwater from the environment (collected water must be further managed).
In Situ Treatment		
Physical/Chemical		
Vapor extraction	Air stripping, air sparging, vacuum extraction, in-well aeration, dual phase extraction	Limit contaminant mobility, reduce volume of contaminated groundwater, and transfer volatile organic contaminants from liquid to gas phase.
Liquid extraction	Aqueous flushing, surfactant flushing, hydraulic fracturing to enhance fluid and vapor flow in subsurface, dual-phase extraction, free-product recovery.	Enhance mobility of contaminants in groundwater to facilitate contaminant removal.
Chemical transformation	Chemical injection to promote hydrolysis, oxidation/reduction reactions, neutralization, precipitation, and immobilization; electrokinetics, electrochemical reduction	Reduce contaminant toxicity and/or mobility by transformation of contaminants to nonmobile or nontoxic forms.
Contact reaction system	Trenches with in situ treatment systems, permeable treatment beds, funnel and gate treatment systems (in situ reactor cells — powdered metal, granular activated carbon, resins)	Reduce contaminant toxicity and/or mobility downgradient of groundwater flow by transformation of contaminants to nonmobile or nontoxic forms.
Thermal		
Thermal extraction	Thermally enhanced vapor extraction, steam/hot air extraction, vacuum extraction, electrical resistance heating, dynamic underground stripping	Removal of volatile and semivolatile organic contaminants by mass transfer to the gaseous medium and reduction in contaminated groundwater volume.

TABLE 3.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>In Situ Treatment (Cont.)</i>		
Biological		
Passive	Aerobic and anaerobic: in situ microbial filters, biodegradation cells as part of a contact reaction system, natural attenuation	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated groundwater volume.
Active	Aerobic and anaerobic: nutrient and microbial injection with extraction well systems and pumping	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated groundwater volume.
<i>Ex Situ Treatment</i>		
Physical/Chemical		
Suspended solids removal	Filtration, centrifugation, flocculation, freeze crystallization, sedimentation	Limit contaminant mobility by removal of contaminated solids, reduce volume of contaminated water, and transfer contaminants from liquid to solid phase.
Contaminant extraction	Adsorption, osmosis, reverse osmosis, ultrafiltration, electrolysis, electrodialysis, ion exchange, membrane microfiltration, polymer adsorption	Remove contaminants from water by transfer of contaminants to solid phase.
Vapor extraction	Air stripping, evaporation	Removal of volatile organic contaminants from water by transfer of contaminants to gaseous phase.
Liquid-liquid extraction	Solvent extraction, selective extraction	Enhance mobility of contaminants in water to facilitate contaminant removal.
Chemical transformation	Dechlorination, dehalogenation, hydrolysis, oxidation and reduction, neutralization, precipitation, coprecipitation, dissolution, electrokinetics, chemical binding, chelation, photochemical transformation, X-ray radiation, ultraviolet oxidation	Reduce contaminant toxicity and/or mobility by transformation of contaminants to nonmobile or nontoxic forms.

TABLE 3.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>Ex Situ Treatment (Cont.)</i>		
Thermal		
Thermal extraction	Low- and high-temperature stripping, distillation	Removal of volatile and semivolatile organic contaminants by mass transfer to the gaseous medium and reduction in contaminated water volume.
Thermal destruction	Liquid-injection incineration, molten salt oxidation, supercritical water oxidation, wet air oxidation, photocatalytic oxidation (ultraviolet or natural light), thermal gas phase reduction	Reduction of toxicity, mobility, and volume of contaminated aqueous waste; destruction of organic contaminants; and transfer of inorganic contaminants to reduced volume of treatment residual for further management (total volume of contaminated water is reduced).
Biological Reactor	Aerobic and anaerobic processes	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated water volume.
	Suspended growth: continuous and plug flow, activated sludge, biomass beads	
	Attached growth: biological contactor, trickling filter, fixed-film fluidized bed	
Land application	Land farming, spray irrigation, overland flow, constructed wetlands	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated water volume.
<i>Disposal</i>	Reinjection or discharge to land, surface water, or a water treatment facility	Disposal used in conjunction with treatment, which limits contaminant toxicity, mobility, and volume and mitigates potential exposure and contaminant migration by removal of contaminated groundwater from the environment.

TABLE 3.3 General Response Actions and Technology Types for Surface Water

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
No Action		
Not applicable	Not applicable	No-action alternative is included to provide a baseline for comparison with other alternatives.
Institutional Control		
Access restrictions	Fences and other barriers at surface water bodies or discharge points	Limit potential human exposure to all contaminants.
Use restrictions	Legal titles and deeds	Limit potential human exposure to all contaminants.
Monitoring	Surface water samplers, sediment sampling, groundwater wells	Provide data for assessing potential for exposure.
Containment		
Surface controls/diversions	Dikes, graded contours, swales, berms	Limit contaminant migration from contaminated surface water to soil, groundwater, or other surface water bodies.
Lateral barriers	Slurry wall, grout curtain, sheet piling, cryobarriers, deep soil mixing, angled barriers	Limit contaminant mobility and mitigate potential exposures from contaminant migration.
Bottom sealing	Grout layer injection, block displacement, cryobarriers, angled barriers	Limit contaminant mobility and mitigate potential exposures from contaminant migration.
Removal		
Interception	Drains, interceptor/recovery trenches, skimming and sinker collection	Eliminate potential exposures by removing contaminated surface water from the environment (collected water must be further managed).
Pumping	Centrifugal, reciprocating, and positive displacement pumps	Eliminate potential exposures by removing contaminated surface water from the environment (collected water must be further managed).

TABLE 3.3 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>In Situ Treatment</i>		
Physical/Chemical		
Nonthermal extraction	Photolysis, filtration, clarification, flotation, flocculation, ultraviolet radiation, sedimentation, free-product recovery	Limit contaminant mobility, reduce volume of contaminated surface water, and transfer contaminants from liquid to solid or gas phase.
Chemical transformation	Chemical injection to promote hydrolysis, oxidation/reduction reactions, neutralization, precipitation, chelation, dechlorination, adsorption, and immobilization; electrokinetics, electrochemical reduction	Reduce contaminant toxicity and/or mobility by transformation of contaminants to nonmobile or nontoxic forms.
Thermal		
Thermal extraction	Solar evaporation, enhanced solar evaporation	Removal of volatile and semivolatile organic contaminants by mass transfer to the gaseous medium and reduction in contaminated surface water volume.
Biological		
Passive	Aerobic and anaerobic: wetland systems, natural attenuation	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated surface water volume.
Active	Aerobic and anaerobic: nutrient and microbial injection with mixing systems and pumping	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated surface water volume.
<i>Ex Situ Treatment</i>		
Physical/Chemical		
Suspended solids removal	Filtration, centrifugation, flocculation, freeze crystallization, sedimentation	Limit contaminant mobility by removal of contaminated solids, reduce volume of contaminated water, and transfer contaminants from liquid to solid phase.

TABLE 3.3 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>Ex Situ Treatment (Cont.)</i>		
Physical/Chemical (Cont.) Contaminant extraction	Adsorption, osmosis, reverse osmosis, ultrafiltration, electrolysis, electrodialysis, ion exchange, membrane microfiltration, polymer adsorption	Remove contaminants from water by transfer of contaminants to solid phase.
Vapor extraction	Air stripping, evaporation	Removal of volatile organic contaminants from water by transfer of contaminants to gas phase.
Liquid-liquid extraction	Solvent extraction, selective extraction	Enhance mobility of contaminants in water to facilitate contaminant removal.
Chemical transformation	Dechlorination, dehalogenation, hydrolysis, oxidation and reduction, neutralization, precipitation, coprecipitation, dissolution, electrokinetics, chemical binding, chelation, photochemical transformation, X-ray radiation, ultraviolet oxidation, immobilization	Reduce contaminant toxicity and/or mobility by transformation of contaminants to nonmobile or nontoxic forms.
Thermal Thermal extraction	Low- and high-temperature stripping, distillation	Removal of volatile and semivolatile organic contaminants by mass transfer to the gaseous medium and reduction in contaminated water volume.
Thermal destruction	Liquid-injection incineration, molten salt oxidation, supercritical water oxidation, wet air oxidation, photocatalytic oxidation (ultraviolet or natural light), thermal gas phase reduction	Reduction of toxicity, mobility, and volume of contaminated aqueous waste; destruction of organic contaminants; and transfer of inorganic contaminants to reduced volume of treatment residual for further management (total volume of contaminated water is reduced).

TABLE 3.3 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Remediation Goal
<i>Ex Situ Treatment (Cont.)</i>		
Biological Reactor	Aerobic and anaerobic processes	Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated water volume.
	Suspended growth: continuous and plug flow, activated sludge, biomass beads	
	Attached growth: biological contactor, trickling filter, fixed-film fluidized bed	
	Land farming, spray irrigation, overland flow, constructed wetlands	
Land application		Reduction of contaminant toxicity and mobility through degradation of organic contaminants and reduction in contaminated water volume.
<i>Disposal</i>	Injection to surface water or discharge to land, surface water, or a water treatment facility	Disposal used in conjunction with treatment, which limits contaminant toxicity, mobility, and volume and mitigates potential exposure and contaminant migration by removal of contaminated surface water from the environment.

TABLE 3.4 Site Characteristics That May Affect Response Actions

• Volumes or areas of waste	• Depth to bedrock
• Site configuration	• Depth to confining layers
• Past disposal methods	• Direction and rate of groundwater flow
• Climate	• Depth to groundwater
• Soil type	• Receptors
• Presence of surface water	• Ecological factors
• Existing land uses	

3.2 TASK 2: IDENTIFICATION OF REMEDIAL ACTION TECHNOLOGIES AND ASSEMBLY OF ALTERNATIVES

The CERCLA/SARA program permits remedial actions to be staged through multiple operable units, defined as discreet actions that comprise incremental steps toward the final remedy. The information developed in Task 1 (Section 3.1) will be used to assemble technologies¹ into alternatives to remediate all identified operable units through removal and/or treatment of the sources of contamination.

Operable units include interim actions (e.g., pumping and treating groundwater to retard plume migration) that must be followed by subsequent actions to fully address the scope of the problem (e.g., a final groundwater operable unit that defines the remediation goals and restoration time frame for the site). This approach may be taken because of the need to respond to a pressing problem that will worsen if unaddressed, or because of an opportunity to undertake a limited action that will achieve significant risk reduction quickly. The concept of dividing remedial actions into operable units incorporates consideration of the interrelationship of site problems and recognizes the need or desire to initiate actions quickly when appropriate. Where the problems are reasonably separable, this phased response, implemented through operable units, promotes a more rapid reduction of risk.

As mandated by SARA, three principal categories of alternatives are to be considered: (1) containment with treatment, (2) containment without treatment, and (3) no action. The first category will include alternatives that encompass a range of options in which treatment is used to reduce the toxicity, mobility, or volume of wastes, but that vary in the degree to which long-term management of residuals or untreated waste is required.

¹ For this work plan, the term *treatment technologies* refers to general categories, such as thermal destruction or chemical treatment. The term *process options* refers to specific processes within a technology, for example, the technology of thermal destruction includes incinerators, and process options within this technology deal with specific incinerator types (rotary kiln, fluidized bed, etc.).

The second category will include one or more alternatives that incorporate containment with little or no treatment. The no-action alternative may include some site monitoring, but alternatives incorporating administrative or access controls (e.g., deed restrictions, site fencing) will be presented as *limited action* alternatives.

The universe of potentially applicable technology types and process options will be reduced in an initial screening through evaluation of technical feasibility (also referred to as *implementability*), effectiveness, and relative cost. The criteria for this initial screening will be applied only to technologies and the general response actions they are intended to satisfy, not to the site as a whole. Evaluation of technical feasibility will focus primarily on whether the technologies and process options will meet remedial action objectives.

Cost considerations will be limited to relative capital costs and operating and maintenance (O&M) costs. Costs will be estimated on the basis of engineering judgment, with each option evaluated as high, medium, or low cost relative to other options in the same technology. During this phase, only costs associated with different general technology types will be considered.

Evaluation of technology effectiveness will include comparison of technology types and the potential effectiveness of process options to (1) handle the estimated areas or volumes of waste and meet remediation goals, (2) mitigate potential impacts to human health and the environment during construction and implementation, and (3) perform reliably with respect to the contaminants and conditions at the site. Additional site data may have to be collected for some media to adequately evaluate effectiveness.

3.3 TASK 3: SCREENING OF REMEDIAL ACTION ALTERNATIVES

Information developed in Tasks 1 and 2 will be screened to limit the number of alternatives evaluated during more detailed phases of the FS. This screening process will include refinement of the initial alternatives on the basis of any new information that becomes available, the baseline risk assessment (including the ecological risk assessment), and other site investigations. In this more in-depth phase, each alternative will be evaluated with respect to feasibility, effectiveness, and cost. Alternatives will also be evaluated to ensure that they will protect human health and the environment relative to potential pathways of concern and areas of the site being addressed as separate operable units. If practicable, the range of treatment and containment technologies initially developed will be preserved; however, if alternatives within a portion of this range are not feasible, they will be eliminated.

Evaluation of the feasibility (implementability) of alternatives will consider both technical and administrative feasibility. The evaluation of technical feasibility will address the ability to construct, reliably operate, meet technology-specific regulations, and effectively monitor components into the future. Evaluation of administrative feasibility will consider the ability to comply with the substantive requirements of any permits issued; availability

of treatment, storage, and disposal services; and the requirements for, and availability of, specific equipment and technical specialists.

In terms of effectiveness, each alternative will be evaluated for its ability to (1) protect human health and the environment; (2) reduce toxicity, mobility, or volume (i.e., to effect changes in one or more characteristics of the hazardous substance that, as a result of treatment, decrease the inherent threats or associated risks); and (3) perform reliably with respect to the contaminants and conditions at the site. These elements will be evaluated for the construction and implementation periods (short-term effectiveness) and for the period after the remedial action is complete (long-term effectiveness).

Although cost factors are not as important as other criteria for selection of alternatives under CERCLA, they will be considered whenever the cost of an alternative far exceeds (by at least an order of magnitude) that of other alternatives without a demonstrated and equivalent difference in protectiveness, implementability, and reliability. Cost estimates will be developed for use in screening activities to the extent that comparisons of alternatives are possible. The estimates will be based on standard cost-estimating data, including cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and estimates derived for similar sites (modified for site-specific information).

3.4 TASK 4: PERFORMANCE OF TREATABILITY STUDIES

Treatability studies will be performed, as appropriate, to collect additional data on technologies identified during the alternative development process and to determine the applicability of specific remedial technologies to site conditions and problems. The sufficiency of existing data to evaluate alternatives will be assessed to determine the need for treatability studies. Where possible, additional data needs will be identified through an expanded literature search with the following objectives:

- Determine whether the performances of the technologies under consideration have been sufficiently documented on similar wastes;
- Obtain information on relative costs, applicability, removal efficiencies, O&M requirements, and implementability of the technologies; and
- Determine the testing requirements for conducting bench or pilot studies.

The decision to conduct treatability studies will ultimately be made by weighing the cost and time required to complete an investigation against the potential value of the information in resolving uncertainties associated with the selection of an alternative. Should treatability studies be required, a testing plan will be developed to identify the types of studies and their goals, the level of effort needed, and a schedule for completion. The data-management guidelines will be submitted to the Directorate of Safety, Health, and Environment at APG for review and approval and subsequent submittal to the EPA.

During the testing, all management and quality control review activities will be implemented to ensure the quality of the data. Upon completion of the testing, the results will be evaluated to assess the technologies with respect to the goals identified in the test plan. A report summarizing the testing program and its results will be presented in the final FS Report.

3.5 TASK 5: DETAILED ANALYSIS OF ALTERNATIVES

3.5.1 Subtask 5.1: Detailed Development of Remaining Alternatives

The detailed development of the alternatives remaining after the screening described above will provide the information needed to complete the final evaluation and selection of the preferred alternative. Examples of development information include the following:

- The components of treatment and disposal technologies will be described to provide an understanding of the features and functions of the technologies.
- Special engineering considerations required to implement an alternative will be identified (e.g., treatability studies for in-situ treatment, bench-scale testing for containment options, or pilot treatment facilities for on-site treatment).
- Proposed methods and costs, associated physical and legal issues, and compliance with ARARs will be discussed.
- Operation, maintenance, and monitoring requirements will be addressed (e.g., frequency, complexity, cost, and availability of labor and materials necessary for effective operations of the technologies).
- Alternatives involving off-site disposal that may impose special requirements for implementation will be addressed. The disposal needs and transportation plans, such as zoning clearances, local permits, and appropriate actions to comply with state and federal regulations, will be identified.
- Safety requirements for implementation of alternatives will address both off-site and on-site issues. Factors relative to the health and safety of site personnel, nearby populations, and the environment will be identified for both short-term and long-term operational periods.

3.5.2 Subtask 5.2: Evaluation of Alternatives against Regulatory Criteria

Nine evaluation criteria, some of which are related to human health evaluation and risk, have been developed under the CERCLA program to address statutory requirements, as well as additional technical and policy considerations that have proven to be important to the process of selecting among remedial alternatives. The criteria are (1) overall protectiveness; (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction of mobility, toxicity, or volume through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance. These evaluation criteria will be used to conduct a detailed analysis and to select an appropriate remedial action for each operable unit. The results of the evaluation will be arrayed so that alternatives can be compared and key trade-offs identified.

The first two criteria — overall protectiveness and compliance with ARARs — are considered *threshold* determinations and must be met before a remedy can be selected. Evaluation of the overall protectiveness of an alternative will focus on how well it will achieve protection over time and reduce site risks and how it will become part of the sitewide remedy.

To satisfy the relevant NCP remedy-selection criteria, an assessment of the overall protectiveness and attainment of ARARs will be developed for each alternative. That assessment will be intended to determine how well the risks posed by each pathway associated with the operable unit are eliminated, reduced, or controlled through treatment, engineered controls, or institutional controls. A detailed analysis of the environmental effects will not be conducted if those effects are not within the scope of the alternative under consideration. Factors that will be considered include (1) effects on environmentally sensitive areas, (2) compliance with regulations, (3) short- and long-term effects, and (4) irreversible commitment of resources. Any known or potential environmental problems previously identified that are not addressed by the remedial alternative will be clearly described.

The evaluation of overall protectiveness criteria will address the effects (both long- and short-term) of each alternative under consideration. Each alternative will be assessed with regard to how well it mitigates long-term exposure to any residual contamination and protects human health, both during and after completion of the remedial action. The assessment will describe the levels and characteristics of contaminants, potential exposure routes, and potentially affected populations. In general, the evaluation of each alternative will consider both the expected adverse effects and the beneficial effects, such as changes in the release of contaminants, resultant environmental conditions, improvements in the resources, and improvements in the biological environment.

The level of detail in this evaluation will depend on the degree of actual or potential damage to the environment providing the impetus for response. The level of detail must be adequate to compare the expected environmental benefits of different alternatives and to determine the effects of construction and operation. Because remedial activities may themselves have a wide range of environmental effects, findings will be presented in such a

way as to permit comparison of the environmental effects of the different alternatives on specific resources (e.g., hydrological, geological, biological, land use).

The associated mitigative measures to be implemented will be analyzed for any alternative that appears to have significant inevitable or irreversible environmental effects. The analysis will take into consideration the technology to be used, the associated cost, and the mitigating effects.

To determine if an alternative satisfies ARAR criteria, the effects of federal, state, and local requirements, regulations, and other institutional considerations relative to the design, operation, and timing of each alternative will be evaluated. These results will be presented as part of the *noncost* criteria analysis in the final report. All ARARs and other standards to be considered will be identified.

The next five criteria are primary *balancing* criteria: long-term effectiveness and permanence; reduction of mobility, toxicity, or volume through the use of treatment; short-term effectiveness; implementability; and cost. Risk will be an important factor in the analysis of effectiveness and permanence. The analysis will evaluate the residual risk at the site after response objectives have been met. The primary focus will be on effectiveness of the controls to manage risk posed by treatment residuals or any untreated wastes that may remain. The evaluation will also consider the potential impacts on human health and the environment if the remedy fails.

The last two criteria — state acceptance and community acceptance — are considered *modifying* criteria and do not include risk information. These criteria will be evaluated after public comments are received on the RI/FS reports and the proposed plan. The acceptance criteria will be addressed once a final decision is made and the record of decision (ROD) is being prepared.

The FS will satisfy the statutory requirements for the remedial actions that will be addressed in the ROD. Those provisions require that the remedial actions:

- Be protective of human health and the environment;
- Attain ARARs or provide grounds for invoking a waiver;
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practicable; and
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element (or provide an explanation as to why it does not).

Analyses of individual alternatives will include (1) a technical description that outlines the waste management strategy involved and identifies the key ARARs associated

with each alternative and (2) a discussion that profiles the performance of the alternative with respect to each of the evaluation criteria. After the individual analyses are complete, the alternatives will be compared and contrasted relative to each of the evaluation criteria.

3.6 TASK 6: COST ANALYSIS

The cost analysis for each alternative and its component technologies will include consideration of site-specific factors identified from available information and determined during development of the alternative. Common sources for these cost estimates include vendors, estimates for similar projects, and standard costing guidance documents. This evaluation will include the following factors: cost estimation (estimation of capital costs and O&M costs); present-worth analysis (calculation of annual costs and present worth on the basis of estimated costs); and summary of the costs of alternatives (summary of cost data, including total costs and distribution of costs over time).

3.6.1 Subtask 6.1: Capital Costs

Capital costs consist of direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for equipment, labor, and installation materials. Capital costs that must be increased in future years as part of the remedial action alternatives will be identified and noted for the year in which they will occur. Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities but that are required to complete the installation of the technologies constituting the alternative. The following are examples of direct and indirect capital costs:

- Construction — materials, labor, and equipment;
- Equipment — remedial action and service equipment;
- Land and site development — purchase of land and preparation of the site;
- Buildings and services — utility connections, process and nonprocess buildings, purchased services;
- Disposal — transporting and disposing of wastes;
- Engineering — administration, construction supervision, design, treatability testing;
- License and permits — administrative costs to obtain building and operating permits;
- Start-up — activities to ensure that the systems are operational; and

- Contingency fund — funds for unforeseen circumstances (e.g., weather, unexpected levels of contamination).

3.6.2 Subtask 6.2: Operating and Maintenance Costs

Operating and maintenance costs are postconstruction expenditures necessary to ensure the continued effectiveness of a remedial action. Typical O&M costs include the following:

- Labor — wages, salaries, training, and overhead;
- Maintenance materials and labor — routine maintenance and equipment replacement;
- Auxiliary materials and energy — chemicals, electricity, water, sewer, fuel;
- Purchased services — sampling, laboratory;
- Insurance, taxes, and licenses — accident and liability insurance, real estate taxes, technology license fees; and
- Periodic site reviews — required at least every five years as long as wastes are present.

3.6.3 Subtask 6.3: Present-Worth Analysis

Present-worth analysis will be used to evaluate expenditures that occur over different time periods by discounting all future costs to the present. A discount rate of 3% before taxes and after inflation will be assumed in the present-worth analysis. This rate represents the average rate of return on private investment. Costs in each planning year will be estimated in constant dollars, representing the general purchasing power at the time of construction. The period of performance will not exceed 30 years for the purpose of detailed feasibility analysis.

3.6.4 Subtask 6.4: Sensitivity Analysis

After the present-worth analysis of each alternative is completed, sensitivity analyses will be used to evaluate each cost for the effects of variations in assumptions. This analysis will assess how variations in specific assumptions about the design, implementation, operation, discount rate, and effective life of an alternative can affect its estimated cost. The sensitivity analysis will be used to optimize the design of an alternative, particularly when design parameters are interdependent (e.g., treatment plant capacity for contaminated groundwater and the length of the period of performance).

3.6.5 Subtask 6.5: Cost Analysis Summary

Data developed in the cost estimation and present-worth analysis will be used in a summary table to describe the alternative. To provide a common basis for comparison of costs, the following elements will be included in the summary: (1) total capital cost, (2) total cost of implementation, (3) present-worth costs, and (4) cash flow over the life of the alternative (including O&M costs and identification of future capital costs).

3.7 TASK 7: SELECTION OF PREFERRED ALTERNATIVE

To provide a basis for selection of a preferred alternative, the analysis of the alternatives will discuss the individual criteria assessment and include a comparative analysis to evaluate the relative performance of each alternative.

The individual alternative assessments will provide data on technology components, quantities of hazardous materials handled, time required for implementation, process sizing, implementation requirements, and assumptions. The significant ARARs for each alternative will be integrated into the discussion. A summary table will highlight the assessment of each alternative with respect to the nine evaluation criteria. The relative performances of the alternatives will be compared for each evaluation criterion. That analysis will include a discussion of the strengths and weaknesses of the alternatives (with respect to each criterion) and how reasonable variations of key uncertainties could change the expectations of relative performances. Substantive differences among alternatives will be identified.

The technology assessments and risk management judgments will be used to rank the alternatives and identify those alternatives projected to attain or exceed the requirements of the evaluation criteria. The comparative advantages and disadvantages of each alternative will be presented.

3.8 TASK 8: REPORT PREPARATION

An FS report will be prepared to document project activities carried out during implementation of the FS process for J-Field. The report will include an overview of the site background information and the compliance process and will summarize cleanup criteria derived from the baseline risk assessment. For each task, the report will outline the criteria used to perform the task and the rationale for the conclusions reached. Details of the FS report and other reporting requirements are discussed in Section 4.

4 REPORT PREPARATION

4.1 DRAFT FEASIBILITY STUDY REPORT

A draft FS report will be prepared by ANL to document all FS activities. Table 4.1 presents the general outline of the report; minor modifications may be made as appropriate. The contents of the report are discussed in the following sections. The current schedule for the preparation and submittal of all FS reports is provided in Appendix D of the RI Work Plan.

4.1.1 Section 1: Introduction

Section 1 will discuss the purpose and scope of the FS and the FS report. It will also provide an overview of the environmental compliance process for the project and describe the report organization.

4.1.2 Section 2: Site Background

Section 2 will present the site background relevant to the analysis of remedial action alternatives and management of the site, including (1) a brief description of the operational history and environmental setting of J-Field; (2) a summary of contamination, emphasizing key information from the RI report; (3) an overview of all environmental activities conducted at J-Field to date; and (4) a brief discussion of human health and environmental impacts that might occur in the absence of remedial action, using data from the baseline risk assessment (which includes an ecological risk assessment).

4.1.3 Section 3: Remedial Action Objectives

Section 3 will identify (1) the objectives of the remedial action at J-Field; (2) environmental standards, identified as ARARs; (3) the process for developing cleanup criteria; and (4) cleanup criteria for all contaminated media being remediated.

4.1.4 Section 4: Identification and Screening of Technologies

Section 4 will identify and screen potential response technologies for managing J-Field and the criteria used for the evaluation.

4.1.5 Section 5: Development and Screening of Preliminary Alternatives

Section 5 will document the development and screening of preliminary alternatives and the criteria used for combining sets of technologies into alternatives. It will present the

TABLE 4.1 Generalized Outline of FS Report

-
- 1 Introduction
 - 1.1 Background
 - 1.2 Purpose and Scope
 - 1.3 Overview of the Environmental Compliance Process
 - 1.4 Report Organization
 - 2 Site Background
 - 2.1 Site History
 - 2.2 Site Description
 - 2.2.1 Topography
 - 2.2.2 Soils and Geology
 - 2.2.3 Surface Water
 - 2.2.4 Groundwater
 - 2.2.5 Climate and Meteorology
 - 2.2.6 Ecology
 - 2.2.7 Land Use and Demography
 - 2.3 Nature and Extent of Contamination
 - 2.4 Environmental Activities at J-Field
 - 2.4.1 Remedial Investigation
 - 2.4.2 Baseline Risk Assessment
 - 2.4.3 Interim Action at the Toxic Burning Pits
 - 2.5 Summary of Site Risks
 - 2.5.1 Human Health Risk Assessment
 - 2.5.2 Ecological Risk Assessment
 - 3 Remedial Action Objectives
 - 3.1 Overall Remedial Action Objectives
 - 3.2 Environmental Standards and Guidelines
 - 3.3 General Process for Developing Cleanup Criteria
 - 3.4 Cleanup Criteria
 - 4 Identification and Screening of Technologies
 - 4.1 Criteria for Identifying and Screening Technologies
 - 4.2 Technology Identification and Screening
 - 4.3 Potentially Applicable Technologies
 - 5 Development and Screening of Preliminary Alternatives
 - 5.1 Criteria for Developing Preliminary Alternatives
 - 5.2 Identification of Preliminary Alternatives
 - 5.3 Criteria for Screening Alternatives
 - 5.4 Screening of Preliminary Alternatives
 - 5.5 Screening Summary and Identification of Final Alternatives

TABLE 4.1 (Cont.)

6 Detailed Analysis of Alternatives**6.1 Alternative 1**

- 6.1.1 Overall Protection of Human Health and the Environment
- 6.1.2 Compliance with ARARs
- 6.1.3 Long-Term Effectiveness
- 6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment
- 6.1.5 Short-Term Effectiveness
- 6.1.6 Implementability
- 6.1.7 Cost

7 Comparative Analysis of Alternatives**7.1 Threshold Criteria**

- 7.1.1 Overall Protection of Human Health and the Environment
- 7.1.2 Compliance with ARARs

7.2 Primary Balancing Criteria

- 7.2.1 Long-Term Effectiveness and Permanence
- 7.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment
- 7.2.3 Short-Term Effectiveness
- 7.2.4 Implementability
- 7.2.5 Cost

7.3 Comparative Summary**8 References****9 Agencies Contacted**

objective of the alternative (e.g., source control or mitigation of contaminant migration), identify key features, describe each alternative, and summarize the evaluation of the alternative. This section will also include (1) associated control, treatment, and disposal requirements; (2) special engineering, safety, and other features that affect the feasibility of the alternative; (3) operation, maintenance, and monitoring requirements; and (4) aspects of the contamination that the alternative will address.

4.1.6 Section 6: Detailed Analysis of Alternatives

Section 6 will present a detailed analysis of each alternative relative to the nine EPA evaluation criteria. The discussion of protectiveness and compliance with ARARs will focus on how well each alternative achieves protection over time and reduces risks identified for each operable unit. The technical discussion will focus on the effectiveness, implementability, and cost of each alternative. The discussion of modifying factors will present regulatory and community acceptance issues for each alternative and will address impacts of those issues on the selection of an alternative. The cost analysis will summarize the estimated costs for

each alternative, review the main cost items, and discuss other important considerations in the cost analysis. The cost analysis will also include (1) costing methodology; (2) capital costs; (3) operation and maintenance costs; (4) present-worth analysis; (5) phasing of the work and its impact on cost, as appropriate; and (6) distribution of costs over time.

4.1.7 Section 7: Comparative Analysis of Alternatives

Section 7 will present a comparative analysis of the alternatives, describing the relative strengths and weaknesses of the alternatives with respect to each of the nine evaluation criteria. The effects of variations in key uncertainties on the relative performance of the alternatives will also be discussed. A preferred alternative will be selected and described in detail.

Tables and figures will be used to summarize important features of the alternatives. The advantages and disadvantages of each alternative will be listed for comparison. The preferred alternative and the rationale for its selection will be presented at the end of the section. The discussion will include, as appropriate, (1) a review of what will and will not be accomplished by implementation of the preferred alternative; (2) special engineering considerations and studies required during the final design stage; (3) operating, maintenance, and monitoring requirements; (4) off-site disposal requirements and transportation plans; (5) safety requirements for implementation; and (6) integration of the alternative into the site-wide remedy.

4.2 OTHER REPORTS AND COMMUNICATIONS

4.2.1 Monthly Progress Reports

Monthly reports will be submitted to the Directorate of Safety, Health, and Environment in part to obtain input and agreement on the technologies considered. The reports will contain information about the following items:

- Status of work and the progress to date,
- Percentage of work completed and the status of the schedule,
- Problems encountered and the corrective actions taken,
- The activities in progress,
- The activities planned for the next reporting period,
- Changes in key project personnel,

- Budget information, and
- Projection of expenditures needed to complete the project.

These frequent communications will streamline the FS process and promote cost savings by providing technical reviewers with opportunities to comment early in the decision-making process — before a commitment is made to conduct in-depth study. Through these comments, the screening decisions, assembly of technologies into alternatives, and identification of data deficiencies will be developed with a broader scope of information.

4.2.2 Responsiveness Summary

The draft FS Report will be revised to incorporate comments received from the sponsor, the public, and regulatory agencies. A responsiveness summary will present the comments received and the actions taken to address the comments.

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6 LIST OF PREPARERS

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APPENDIX A:
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

TABLE A.1 State Regulations and To-Be-Considereds for J-Field

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks
COMAR 14.19, Chesapeake Bay Critical Area Commission — Development in the Critical Area Resulting from State and Local Agency Programs	Water, sediment, soil	Protection of the bay, and criteria for any development in the bay area.	Potentially applicable	Applies to Chesapeake Bay only. The bay borders the site to the south and may receive discharge from groundwater aquifers. Potential impacts will depend on the remedial actions.
Maryland Nonpoint Source Pollution Control Laws, <i>Annotated Code of Maryland</i> 4.1 and 4.2	Water-sheds	Construction includes soil movement, grading, transporting, or otherwise disturbing land. Any such action undertaken by a federal unit, including a sediment control plan, must be reviewed and approved by the Department.	Potentially applicable	Any excavation of soils may require compliance with this law.
COMAR 26.09.01 and 26.09.02	Sediment, storm water	Protection of areas for erosion and sediment control, along with maintaining pre-development runoff characteristics and reducing stream channel erosion, pollution, siltation and sedimentation, and local flooding.	Potentially applicable	Any remedial action must address these regulations.
COMAR 8.05	Wetlands	It is prohibited to fill, place, dump, or discharge any dirt, trash, or polluting substances; to drain, dredge, or remove soil; to destroy natural vegetation; or to substantially alter existing patterns of tidal flow without a permit.	Potentially relevant and appropriate	Any remedial action that would disturb wetlands may require consultation with the Water Resource Administration.

TABLE A.1 (Cont.)

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks																												
COMAR 26.04.01	Ground-water	For community water systems, pertinent MCLs for metals, chlorinated hydrocarbons, chlorophenoxys, total trihalomethanes, volatile organic chemicals, and radioactivity include: <table><thead><tr><th>Contaminant</th><th>MCL (mg/L)</th></tr></thead><tbody><tr><td>Arsenic</td><td>0.05</td></tr><tr><td>Benzene</td><td>0.005</td></tr><tr><td>Carbon tetrachloride</td><td>0.005</td></tr><tr><td>Cyanide</td><td>0.2</td></tr><tr><td>11DCE</td><td>0.007</td></tr><tr><td>Lead</td><td>0.05</td></tr><tr><td>Nitrate</td><td>10.0</td></tr><tr><td>Selenium</td><td>0.01</td></tr><tr><td>111TCE</td><td>0.2</td></tr><tr><td>TCLEE</td><td>0.005</td></tr><tr><td>TRCLE</td><td>0.005</td></tr><tr><td>Gross alpha</td><td>15 pCi/L</td></tr><tr><td>Gross beta from manmade radio-nuclides</td><td>50 pCi/L if strontium-90 is <8pCi/L</td></tr></tbody></table>	Contaminant	MCL (mg/L)	Arsenic	0.05	Benzene	0.005	Carbon tetrachloride	0.005	Cyanide	0.2	11DCE	0.007	Lead	0.05	Nitrate	10.0	Selenium	0.01	111TCE	0.2	TCLEE	0.005	TRCLE	0.005	Gross alpha	15 pCi/L	Gross beta from manmade radio-nuclides	50 pCi/L if strontium-90 is <8pCi/L	Potentially relevant and appropriate	The aquifers underlying the site are Type I Aquifers as defined by COMAR 26.08.02.09. These regulations for Type I aquifers state that disposal of wastes cannot cause the natural groundwater quality to exceed mandatory or recommended standards for drinking water as established by the MDE in COMAR 26.04.01. MCLs are applicable at the tap, but may be relevant and appropriate for aquifer remedial goals.
Contaminant	MCL (mg/L)																															
Arsenic	0.05																															
Benzene	0.005																															
Carbon tetrachloride	0.005																															
Cyanide	0.2																															
11DCE	0.007																															
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Gross beta from manmade radio-nuclides	50 pCi/L if strontium-90 is <8pCi/L																															

TABLE A.1 (Cont.)

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks	
COMAR 26.08.02	Water	Toxic Substance Criteria		These requirements are potentially applicable because water impacted by the site may be contaminating the Bush and Gunpowder rivers, as well as Chesapeake Bay. State water quality criteria are enforceable standards and, if more stringent than the Federal Water Quality Standards, are applicable. See Table 2.24.	
		Standard (µg/L)			
		Contaminant	Acute		Chronic
		Fresh Water			
		Aldrin-dieldrin	3		—
		DDT	1.1		0.001
		Endrin	0.18		0.0023
		Lead	82		3.2
		Mercury	2.4		0.012
		Nickel	1,400		160
		PCBs	2		0.014
		Toxaphene	0.73		0.002
		Tributyltin	—		0.026
		Zinc	120		110
		Salt Water			
		Aldrin-dieldrin	1.3		—
		DDT	0.13		0.001
		Endrin	0.037		0.0023
		Lead	140		5.6
		Mercury	2.1		0.025
		Nickel	75		8.3
		PCBs	10		0.03
		Toxaphene	0.21		0.0002
Tributyltin	—	0.010			
Zinc	95	86			

TABLE A.1 (Cont.)

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks												
		Water Quality Criteria Specific to Designated Use Classes I and II														
		<table><tr><th>Parameter</th><th>Criteria</th></tr><tr><td>Dissolved oxygen</td><td>>5 mg/L</td></tr><tr><td>Temperature</td><td>≤90°F (or the ambient temperature of the surface water, whichever is greater)</td></tr><tr><td>pH</td><td>6.5-8.5</td></tr><tr><td>Turbidity</td><td>≤150</td></tr><tr><td></td><td>≤50 (monthly average)</td></tr></table>	Parameter	Criteria	Dissolved oxygen	>5 mg/L	Temperature	≤90°F (or the ambient temperature of the surface water, whichever is greater)	pH	6.5-8.5	Turbidity	≤150		≤50 (monthly average)		
Parameter	Criteria															
Dissolved oxygen	>5 mg/L															
Temperature	≤90°F (or the ambient temperature of the surface water, whichever is greater)															
pH	6.5-8.5															
Turbidity	≤150															
	≤50 (monthly average)															
COMAR 26.08.03; 26.08.04.01	Water	<p>Prohibited toxic discharges:</p> <ol style="list-style-type: none">1. The discharge of any pollutant in toxic amounts including<ol style="list-style-type: none">a. substances that accumulate to toxic amounts during the expected life of organisms in the surface water, orb. substances that produce deleterious behavioral effects on the organisms.2. The discharge of any radiological, chemical, or biological warfare agent.3. The discharge of any waters in excess of 10,000 gal/d or the discharge of waste or wastewater regardless of volume without a discharge permit. Permit limits and technical requirements apply to the construction and operation of any facility for the discharge of wastes or wastewaters into the waters of the state.	Potentially applicable	"Discharge" is defined as the addition, introduction, spilling, or emitting of any pollutant to waters of the state; or, the placing of a pollutant in a location where it is likely to pollute the site. Pollutants have been and are continuing to be discharged to the two estuaries and to Chesapeake Bay; thus, the requirements are potentially applicable. If a new wastewater treatment plant is constructed at J-Field, permit limits and technical requirements would have to be met. If pump-and-treat wastewaters are taken to the O-Field treatment plant, permit modification may be necessary.												

TABLE A.1 (Cont.)

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks
COMAR 26.11.01, 26.11.03, and 26.11.06	Air	State-adapted national ambient air quality standards and guidelines must be met for PM-10 24-h, sulfur dioxide, nitrogen dioxide, and lead. For particulate matter from materials handling and construction, reasonable precautions must be taken to prevent matter from becoming airborne; e.g., use of water or chemicals for dust control during demolition. In addition, the treatment of waste containing VOCs may not be performed in a manner that results in evaporation of VOCs to the atmosphere greater than 20 lb/d.	Potentially relevant and appropriate	In the past, the site has been a source of emissions. Potential emissions may occur in the marshes where CWAs and UXO may exist and during emergency use of the TBP and WPP. The site is an unconfined source in what is termed an Area III (per 26.11.01, p. 139). Particulate matter must be controlled during demolition or other earth-moving activities. The treatment of VOC-contaminated soils and/or pump-and-treat operations may be sources of VOC emissions.
COMAR 26.11.15	Air	General requirements for the discharge of toxic air pollutants to the atmosphere. Also outlines procedures for requesting permits for discharge.	Potentially applicable	Potentially applicable to any emissions resulting from remedial actions, such as in-situ treatment and pump-and-treat actions. In addition, CWAs are listed as Class I Toxic Air Pollutants.
COMAR 26.11.21	Air	All worker protection requirements must be followed for asbestos contamination. Guidelines and standards require conditions and control features for asbestos abatement. Also, procedures are outlined for handling and disposing of asbestos.	Potentially applicable	During the remedial action, should the PB contain asbestos, the standards and guidelines will have to be met and followed. Also, asbestos may have been disposed of in one or more pits.
COMAR 26.04.04	Ground-water	General requirements for installing, constructing, operating, and abandoning wells.	Potentially applicable	Potentially applicable to the construction of wells during remedial action.

TABLE A.1 (Cont.)

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks
COMAR 26.04.07	Solid waste	General regulations for disposing of solid waste in a land-based unit, including procedures for closure and postclosure. Also, sites that act as a transfer station or processing facility for on-site disposal must follow these regulations.	Potentially applicable	Should the remedial action involve landfilling, transferring, and/or processing the waste (as defined by COMAR 26.04.07.02), these regulations must be followed.
COMAR 26.13.01.05	Hazardous waste	<p>These regulations identify and list hazardous waste, define hazardous waste, and present standards applicable to generators and transporters of hazardous waste. Also, standards are presented for owners and operators of hazardous waste treatment/storage/disposal facilities. Standards include groundwater protection and prohibition of OB/OD of waste explosives containing EPA hazardous wastes F020, 8021, F022, F023, F026, and F027. Maryland-listed acute hazardous wastes include the chemicals GA (tabun), GB (sarin), GD (soman), VX, L (lewisite), DM (adamsite), HD (sulfur mustard), T, waste military CWAs having any of these substances as their active or principal ingredient, or mixtures of any of these substances and any characteristic or listed hazardous waste. Maryland-listed hazardous waste from specific sources includes residues from the treatment of the above-listed wastes, except when treated at the following:</p> <ul style="list-style-type: none"> • U.S. Army APG/U.S. Army Chemical Research Development and Engineering Center; 	Potentially applicable	These requirements are applicable to any removal actions if the waste at the site meets the prerequisites for definition as characteristic or listed hazardous waste. Also, these requirements apply to groundwater contamination and dispersal of hazardous air pollutants.

TABLE A.1 (Cont.)

Potential ARAR	Medium	Requirements	Preliminary Determination	Remarks
		<ul style="list-style-type: none"> • U.S. Army Product Assurance Directorate, APG; or • U.S. Army APB/Medical Research Institute of Chemical Defense; 		
		<p>under the protocol, "To Support the Delisting of Decontaminated Liquid Chemical Surety Materials as Hazardous Waste from Specific Sources COMAR 26.13.02.167 and 26.13.02.18 K991-K999 and Residues from K991-K999" (U.S. Army Chemical Research Development and Engineering Center, APG, Md., 1988).</p>		

TABLE A.2 Federal Regulations and To-Be-Considereds for J-Field — Potential Contaminant-Specific Requirements

Potential ARARs	Contaminant	Medium	Requirements	Preliminary Determination	Remarks
Clean Air Act, as amended (42 USC 7401-7642); National Primary and Secondary Ambient Air Quality Standards (40 CFR Part 50)	Particulate matter	Air	For a major stationary source [see 40 CFR 52.2(b)(1)(i)(a)] that emits >250 tons/yr of any regulated pollutant or >100 tons/yr of a regulated pollutant for which the area is designated as nonattainment, PM-10 should not exceed a 24-h average concentration of 150 $\mu\text{g}/\text{m}^3$ or an annual arithmetic mean of 50 $\mu\text{g}/\text{m}^3$.	Potentially relevant and appropriate	These requirements do not apply directly to source-specific emissions; rather, they are national limitations on ambient concentrations. However, they will be addressed in controlling particulate emissions that could result from implementation of a remedial action.
	Lead	Air	As for the above conditions, the standard for lead and its compounds, as elemental lead, is 1.5 $\mu\text{g}/\text{m}^3$ maximum arithmetic mean averaged over one calendar quarter.	Potentially relevant and appropriate	These requirements do not apply directly to source-specific emissions; rather, they are national limitations on ambient concentrations. However, they will be addressed in controlling lead emissions that could result from implementation of a remedial action.
OSHA Standards, Occupational Health and Environmental Control [29 CFR 1910.95(g)]	Noise	Air	The permissible occupational exposure level for noise is 90 dBA (slow response) for an 8-h day; with decreasing times of exposure, the levels increase to 115 dBA per 15-min day.	Potentially applicable	These requirements are part of an employee protection law (rather than an environmental law) with which all CERCLA response actions should comply. Because this compliance is directly required, as promulgated in the NCP, these requirements are not subject to evaluation for attainment or waiver as part of the ARAR process. However, they constitute requirements for worker protection with which any remedial action will comply.

TABLE A.2 (Cont.)

Potential ARARs	Contaminant	Medium	Requirements	Preliminary Determination	Remarks
TSCA, as amended (15 USC 2607-2629, PL 94-469, et seq.); Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions [40 CFR Part 761(g)]	PCBs	Soil	For spills of materials contaminated with >50 ppm PCBs in unrestricted- access areas (e.g., residential areas), soil within the spill area must be excavated and backfilled with soil containing <1 ppm PCBs. Contaminated soil may be decontaminated to 10 ppm by weight by excavating a minimum of 10 in. and backfilling with soil containing <1 ppm PCBs. For spills at outdoor electrical substations, the soil must be cleaned to 25 ppm by weight (as for other restricted-access areas) or to 50 ppm by weight with posting of a visible notice.	Potentially relevant and appropriate	Any such spills at the site would have preceded the effective date of this requirement; hence, it is not applicable. However, it may be considered relevant and appropriate to the remedial action.
Safe Drinking Water Act (42 USC 300G, PL 93-523); National Primary Drinking Water Regulations [40 CFR Part 141(b)(g)]; National Secondary Drinking Water Regulations (40 CFR Part 143)	Any	Water	See 40 CFR Parts 141 and 143 for MCLs and secondary MCLs for drinking water delivered directly to the ultimate user of a public water system.	Potentially relevant and appropriate	These requirements are potentially relevant and appropriate because contaminated aquifers under the site have potential use for drinking water. Also, proposed rules (54 FR Part 97 and 53 FR Part 160) for MCLs and secondary MCLs should be considered (although levels set at 0 do not apply at CERCLA action sites), and are potentially relevant and appropriate regulations when promulgated.

TABLE A.2 (Cont.)

Potential ARARs	Contaminant	Medium	Requirements	Preliminary Determination	Remarks
Federal Water Pollution Control Act, Clean Water Act (33 USC 1251-1376); Water Quality Criteria (40 CFR Part 122)	Any	Water	Concentration limits for a long list of contaminants in surface water are specified for the protection of human health and aquatic life. See Table 2.24.	To be considered	Federal water quality criteria are nonenforceable guidelines used by states and the federal government to set water quality standards for surface water; however, they may be relevant and appropriate if the water concerned is a public water supply or if fishing is also included in the state's designated use of the waters concerned. If a state has promulgated a numerical water quality standard for a given contaminant, the state standard rather than the federal water quality criteria would be relevant and appropriate.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes [40 CFR 261(c)(d)]	Any	Solid waste	A waste must be evaluated to determine whether it is a hazardous waste, i.e., either a listed waste or a characteristic waste. A characteristic waste is determined by its (1) ignitability, (2) corrosivity, (3) reactivity, or (4) leachability, as defined by TCLP for several contaminants.	Potentially applicable	This requirement is applicable to the characterization and management of site waste. One or two samples have shown the presence of leachable lead. Further characterization is ongoing.

TABLE A.3 Federal Regulations and To-Be-Considereds for J-Field — Potential Location-Specific Requirements

Potential ARARs	Location	Requirements	Preliminary Determination	Remarks
Antiquity Act, Historic Sites Act [16 USC 431-433, 16 USC 461-467, 40 CFR 6.301(a)]	Land	Cultural resources, such as historic buildings and sites and natural landmarks, must be preserved on federal land to avoid adverse impacts.	Potentially applicable	Should the J-Field site be identified as a cultural resource, the requirement could be potentially applicable during a remedial action.
National Historic Preservation Act, as amended [16 USC 470, et seq., 40 CFR 6.301(b), 36 CFR Part 800]	Land	The effect of any federally assisted undertaking must be taken into account for any district, site, building, structure, or object included in or eligible for the <i>National Register of Historic Places</i> .	Potentially applicable	Should such a property be identified, the requirement would be potentially applicable during a remedial action.
Archaeological and Historic Preservation Act [16 USC 469, 40 CFR 6.301(c), PL 93-291, 88 Stat. 174]	Land	Prehistorical, historical, and archaeological data that might be destroyed as a result of a federal, federally assisted, or federally licensed activity or program must be preserved.	Potentially applicable	Should such data be identified, the requirement would be potentially applicable during a remedial action.
Archaeological Resources Protection Act [16 USC 470(a)]	Land	A permit must be obtained if an action on public or Native American lands could affect archaeological resources.	Potentially applicable	Should such resources be identified, the requirement would be potentially applicable during a remedial action.
Protection and Enhancement of the Cultural Environment (EO 11593, 40 CFR 6.301)	Land	Historic, architectural, archaeological, and cultural resources must be preserved, restored, and maintained, and must be evaluated for inclusion in the <i>National Register of Historic Places</i> .	Potentially applicable	Should such resources be identified, the requirement would be potentially applicable during a remedial action.
Endangered Species Act, as amended [16 USC 1531-1543, 50 CFR 17.402, 40 CFR 6.302(h)]	Any	Federal agencies must ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify any critical habitat.	Potentially applicable	Should such species or habitat exist, the requirement would be potentially applicable during a remedial action.

TABLE A.3 (Cont.)

Potential ARARs	Location	Requirements	Preliminary Determination	Remarks
Fish and Wildlife Coordination Act [14 USC 441-444, 40 CFR 4.302(a)]	Any	Adequate protection of fish and wildlife resources is required when any federal department or agency proposes or authorizes any modification (e.g., diversion or channeling) of any stream or other water body or any modification of areas affecting any stream or other water body.	Potentially applicable	Should modification of any stream or any other water bodies or areas affecting water bodies be required during a remedial action, the requirement would be potentially applicable.
Floodplain Management (EO 11988)	Floodplain	Federal agencies must avoid, to the maximum extent possible, any adverse impacts associated with direct and indirect development of a floodplain.	Potentially applicable	The site is within the 100-year floodplain.
Protection of Wetlands (EO 11990)	Wetlands	Federal agencies must avoid, to the extent possible, any adverse impacts associated with the destruction or loss of wetlands and the support of new construction in wetlands if a practicable alternative exists.	Potentially applicable	Wetlands exist in the affected area.

TABLE A.4 Federal Regulations and To-Be-Considereds for J-Field — Potential Action-Specific Requirements

Potential ARARs	Action	Requirements	Preliminary Determination	Remarks
Hazardous Material Transportation Act, as amended (49 USC 1801-1812); Solid Wastes (40 CFR Part 263)	Transportation	Generic requirements are established, as are procedures for transporting hazardous waste, for minimizing the environmental impacts of spills or releases of hazardous materials.	Potentially applicable	These requirements are not part of an environmental law and hence are not subject to evaluation for attainment or waiver as part of the ARAR process. However, they could be pertinent to any remedial action in which hazardous waste is transported off-site. In this case, the pertinent requirements (e.g., for spill response) would be addressed during implementation.
Noise Control Act, as amended; Noise Pollution and Abatement Act (42 USC 4901, et seq.)	Detonation, heavy equipment usage	The public must be protected from noises (e.g., that could result from remedial action activities) that jeopardize health or welfare.	Potentially applicable	This requirement is potentially applicable if during a remedial action any detonation of UXO occurs and heavy equipment is used.
OSHA Standards for Hazardous Waste Operations and Emergency Response (29 CFR Part 1910)	Waste management	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In addition, procedures are established for hazardous waste operations, including decontamination and drum/container handling (e.g., for radioactive waste, asbestos, and PCBs).	Potentially applicable	These requirements are parts of an employee protection law (rather than an environmental law) with which all CERCLA response actions should comply. Because this compliance is directly required, as promulgated in the NCP, these requirements are not subject to evaluation for attainment or waiver as part of the ARAR process. However, they constitute requirements for worker protection with which a remedial action will comply.

TABLE A.4 (Cont.)

Potential ARARs	Action	Requirements	Preliminary Determination	Remarks
TSCA, as amended (15 USC 2607-2629, PL 94-469, et seq.); Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761 Subpart A)	PCB testing	Inspection and testing are required for material contaminated with PCBs.	Potentially applicable	This requirement may be applicable to characterization of site waste for PCBs.
TSCA, as amended (15 USC 2607-2629, PL 94-499, et seq.) Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761 Subpart D)	PCB storage and disposal	When material contaminated with PCBs >50 ppm is stored, the facility used for storage must be marked as such and must not be located in a 100-year floodplain. PCBs may not be stored for more than 1 year before disposal. Disposal of material contaminated with PCBs >50 ppm requires either incineration or chemical waste landfilling at EPA-approved facilities.	Potentially relevant and appropriate	These requirements are potentially relevant and appropriate because disposal of material from the site that may be contaminated with PCBs may be included in the scope of the remedial action.

TABLE A.4 (Cont.)

Potential ARARs	Action	Requirements	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Hazardous Wastes [40 CFR 264(b-e)]	Waste treatment, storage, and disposal	General requirements are established for treatment, storage, and disposal (TSD) facility location, design, and inspection; waste compatibility determination; emergency contingency plans; preparedness plans; recordkeeping; reporting; and worker training. Location requirements include (1) facilities must not be located within 61 m (200 ft) of an active fault and (2) facilities located in a 100-year floodplain must be constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially applicable	These requirements are potentially applicable because storage, treatment, or disposal, as defined under RCRA, may be included in the scope of a remedial action. In addition, the ongoing OB/OD activities at J-Field will mean that Subpart X, Miscellaneous Units, could be a key ARAR. Soil storage over 90 days before treatment or off-site shipment must meet these general requirements (containment buildings [40 CFR 264 Subpart DD] or waste piles [40 CFR 264 Subpart L]). Soil washing, as a treatment activity, must meet these general requirements (40 CFR 264 Subpart X). Storage of wastewater from pump-and-treat activities in tanks for over 90 days must meet these general requirements (40 CFR 264 Subpart J). Such storage tanks would also have to meet new VOC emission standards at TSD facilities (59 FR 62,896, Dec. 6, 1994; 40 CFR Part 264 Subpart CC). Any facility, whether storage or treatment, must meet the requirements for closure (40 CFR 264 Subpart G).

TABLE A.4 (Cont.)

Potential ARARs	Action	Requirements	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Hazardous Wastes (40 CFR 264 Subpart F)	Waste disposal	A groundwater monitoring system must be maintained for an SWMU. The concentration of a hazardous constituent in the uppermost aquifer beneath a regulated unit is not to exceed the existing background concentration or a listed maximum concentration if higher than the background level, or an alternate concentration limit, unless an exemption is granted. See 40 CFR Part 264 for organic and inorganic parameter requirements.	Potentially applicable	These requirements are potentially applicable if the scope of a remedial action includes maintaining or capping an SWMU.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Hazardous Wastes (40 CFR 264 Subpart I)	Waste storage	Containers used to store hazardous waste must be closed and in good condition.	Potentially applicable	These requirements may be applicable to the remedial action, container storage, and transportation of site waste that meets the prerequisites for definition as characteristic hazardous waste.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Land Disposal Restrictions (40 CFR 268 Subpart C); Land Disposal Restrictions for Newly Identified and Listed Hazardous Wastes and Hazardous Soil, Proposed Rules (58 FR 48092, Sept. 14, 1993)	Waste disposal	The land disposal of certain hazardous waste (e.g., contaminated soil and debris) without proper treatment is restricted, unless a treatability variance is appropriate. Such treatment must attain levels achievable by the "best demonstrated available technologies" for each hazardous constituent in the listed waste.	Potentially applicable	These requirements are potentially applicable for any remedial action at J-Field that includes disposal or any consolidation of site waste into a new disposal or storage area. The proposed rules may impose different land disposal restriction (LDR) treatment standards on contaminated soils. Also, see below for the applicability of LDRs for placement of excavated soils in corrective action management units.

TABLE A.4 (Cont.)

Potential ARARs	Action	Requirements	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Hazardous Wastes (40 CFR 264 Subpart S)	Waste Disposal	For the purpose of implementing a RCRA corrective action, placement of remediation wastes into an EPA-designated corrective action management unit does not constitute land disposal and the LDRs and minimum technology requirements for TSD facilities do not apply.	Potentially applicable	These requirements could be applicable to the placement of the excavated soils before treatment or off-site disposal or to the capping of areas of contaminated soil without excavation or treatment.
CERCLA, as amended (42 USC 6901, et seq.)	Waste Disposal	Wastes may only be shipped to off-site facilities that are in compliance with all applicable RCRA requirements, particularly certification that the receiving unit has no releases of hazardous constituents to the environment.	Potentially applicable	These requirements apply to any shipments of hazardous wastes to off-site TSD facilities, including excavated soils.

APPENDIX B:

IDENTIFICATION OF POTENTIAL AREAS OF CONCERN AT J-FIELD

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B.1 INTRODUCTION

This appendix describes the methodology used to identify the potential areas of concern (PAOCs) at J-Field, documents the PAOCs on the basis of historical photograph analysis, and reports the results of the PAOC inspections performed April 12-15, 1994, and May 11, 1994.

The methodology used to select the PAOCs is described in Section B.2. The PAOCs are documented and the site inspection results presented in Section B.3. The PAOCs are divided into three groups. One group contains sites that are not associated with the eight AOCs, the second group includes sites associated with the identified AOCs, and the third group includes all craters at J-Field. The PAOCs in the first group could become new AOCs in the future if sampling and analysis indicated contamination were present. The PAOCs in the second group will be incorporated into their corresponding AOCs for study in the Remedial Investigation. The third group, fieldwide craters, will be addressed in the Ecological Risk Assessment Work Plan.

B.2 METHODOLOGY FOR IDENTIFYING PAOCs

The PAOCs were designated on the basis of information from two sources: (1) the 1986 RFA (Nemeth 1989), which includes a review of archival information and personnel interviews; and (2) analysis of historical aerial photographs. The photographic analysis involved a brief review of aerial photographs dated 1951, 1957, 1960, 1970, and 1981 (Nemeth 1989) and a detailed analysis of aerial photographs dated 1965 and 1968 (U.S. Army 1965; USGS 1968). The identified PAOCs include areas that show man-made features (such as clearing areas, geometric patterns, and ground scarring), and structures (such as buildings, trenches, storage areas, and roads) on aerial photographs. Their locations are shown in Figure B.1.

The PAOCs identified were inspected in the field April 12-15, 1994, and May 11, 1994. Large-scale (approximately 1 in.:400 ft) aerial photographs from 1965 were used in the field. Features that may reflect previous human activities such as soil piles, metal, and other man-made debris; structure ruins; bomb craters; road tracks; and shallow depressions of regular shape were recorded. The condition of vegetation within and around a PAOC was also documented. On the basis of these features and aerial photographic interpretation, an attempt was made (when possible) to determine the nature of the past activities on each PAOC.

FIGURE B.1 Locations of PAOCs at J-Field

B.3 FIELD INSPECTION RESULTS

A total of 17 PAOCs have been inspected. They are Site X1, Areas A to D, two suspected storage areas associated with the Toxic Burning Pits (TBP) area and the White Phosphorous Burning Pits (WPP) area, four suspected burning areas (two near the WPP and two near the Prototype Building), one suspected filled trench (near the South Beach Trench area), one clearing near the southwest corner of the Prototype Building, one suspected disposal area (southwest of the TBP area), the craters of J-Field, one demolition area (southeast of the TBP area), and one ruins site (east of the WPP area). The locations and features of these PAOCs are shown in Figure B.1 and described in the following sections.

For discussion purposes the PAOCs are separated into three groups: those not associated with AOCs (Section B.3.1), those that are (Section B.3.2), and craters (Section B.3.3). Within each group, the PAOCs are described sequentially based on their locations, from north to south.

B.3.1 PAOCs Not Associated with AOCs

B.3.1.1 Site X1

Site X1 is in the northwestern part of J-Field, about 300 ft southwest of the intersection of Rickett's Point Road and the access road to the Ford's Point Firing Position. In 1965 aerial photographs, the site was a cleared area with a size of about 120 by 100 ft. An access road starting from Rickett's Point Road ended at the site. The access road bed is still discernable in the field today.

The site includes two ruins subsites about 100 ft apart. Collapsed concrete columns are present on the ground at each subsite. Both subsites are surrounded by a ridge of soil piles. The vegetation is much younger within the subsites than in the surrounding areas. A brick wall foundation is visible on the ground in the eastern subsite. A small drum emerges among a soil pile in the western ruin. No bomb craters are found near this site.

Three very shallow depressions with ponded water were identified. All are near the access road. The first shallow depression is about 100 ft from the entrance of the access road and is perpendicular to the road. The second and third depressions are parallel to the access road and are near the first one. Each depression seems to be rectangular and about 6 ft wide. They may represent filled trenches. Site X1 has been present since as early as 1951 (Nemeth 1989). Its use is not known.

B.3.1.2 Area A

Located in the northern part of J-Field, Area A is characterized by grids of linear features and two water-filled trenches, as they appeared on aerial photographs. The access road to the Ford's Point Firing Station dissects the central part of the site. When inspected

in the field, the site was swampy. The grid pattern shown on aerial photographs is caused by grids of drainage commonly used to drain wetlands in this region.

One S-shaped trench and one straight trench are present within the drainage grid. The S-shaped trench is located immediately adjacent to the road and is separated from the straight trench by a dirt pile. Both trenches are about 6-7 ft wide. No scrap metal has been found nearby on the ground surface. The past use of the trenches is unclear.

About 400 ft west of the S-shaped trench is an old building site. A small shack appears there in 1965 aerial photographs. The ground now is scattered with a few glass bottles and ceramic sherds. Soil piles surround the site. A prominent, straight, long drainage about 3 ft wide extends from behind the site to the swamp north of J-Field. This drainage is readily noticeable in aerial photographs.

B.3.1.3 Area B (Ford's Point Firing Station)

Area B is a large open area at the eastern end of an access road in the northern part of J-Field and near the Bush River. It is also referred to Ford's Point Firing Station. Aerial photographs show that the site has existed since as early as 1951. The site is covered with reed grass (*Phragmites*). Concrete slabs are piled up near the shore of the Bush River, probably protecting the shore from erosion. Near the southern part of the site a pile of concrete chunks embedded with hollow pipes is present. Soil mounds are present near the western boundary of the site. Two small scrap drums were found on the ground surface near the soil mounds. The past use of the site is not known.

B.3.1.4 Area C

Area C is a ruin site near the entrance of the access road to Ford's Point Firing Station. Aerial photographs from 1965 show two buildings near the intersection of the access road and Rickett's Point Road, and a wall near the eastern part of the site. The buildings were destroyed before 1968, as indicated in later aerial photographs. In the field, remnants of a standing concrete wall and bricks are left on the ground surface. Bomb craters are visible near the site. The destroyed buildings probably were used for access control to the Ford's Point Firing Station, while the concrete wall in the eastern part of the site was probably a test site for bombing structures.

B.3.1.5 Ruins Site Across Road from WPP

A ruins site located across Rickett's Point Road from the WPP includes two building ruins, two connected artificial ponds, four retaining wall structures, and a suspected filled trench. These features are discernable in the 1965 aerial photographs. The western part of the site, where the two building ruins are located, was flooded when the site was inspected.

The site was used for munitions testing in World War II. Bomb craters are common, especially near the four retaining wall structures. Probably due to bombing, only remnants of buttressed columns and partially destroyed steel-reinforced walls remain in the field. No visible metal scrap has been found on the ground surface. The ruin buildings are in the eastern part of the site. One is a steel-reinforced concrete building, and the other is a steel-reinforced brick building. Circular-shaped scars are common on the building's outside walls. Two small ponds connected by a ditch are near the southern part of the site. One of the ponds is rectangular in shape, the other is irregularly shaped. The past use of the ponds is not known.

A suspected filled trench, about 7-8 ft wide, was identified in an area about 80 ft southeast of the ruin buildings. It is partially ponded with water. The suspected filled trench extends southeast for more than 100 ft. Traces of road bed are discernable near its end. The roads connect to Rickett's Point Road. A steel tube with a cylinder built inside was found next to a pile of soil between the filled trench and the two building ruins. The past use of the trench is not clear.

A dark-toned area appears in the southwestern part of the site in the 1965 aerial photographs. This area was inspected in the field and was found to be flat and covered with vegetation that is younger than in the surrounding area. No scrap metal was found on the ground surface. The previous use of this area is unknown.

B.3.1.6 Area D

Area D, located about 400 ft east of the ruins site, is a flooded swamp area. The area has a dark tone in aerial photographs and is dotted with many craters. No road extends to this site. The site probably was used for targeting.

B.3.2 PAOCs Associated with AOCs

B.3.2.1 Storage Area of WPP

The suspected storage area, about 30 by 20 ft, is in the southeastern corner of the WPP AOC and about 40 ft west of Rickett's Point Road. Some materials are shown on the ground surface in the 1965 aerial photographs. The storage area was observed in the field to be surrounded by piles of soil.

B.3.2.2 Suspected Burning Area near Northwestern Corner of WPP

This site is in the northwestern corner of the WPP AOC and is covered with reed grass. The 1965 aerial photographs show three suspected burning areas clustered together on this site. Each area was circular in shape, with a diameter about 30 ft, and appeared as a dark-toned area in the aerial photographs. Mounds of soil were observed in the field to be

piled near its northern boundary. A few pieces of scrap metal were scattered nearby. The specific past use of the site is not known.

B.3.2.3 Suspected Burning Area near Southwestern Corner of WPP

This area appeared as a demolition area in aerial photographs. By the shore of Gunpowder River and at the southwestern corner of the WPP AOC, the area is covered by abundant shells of small arms, grenade caps, 50-caliber shells, and melted glass. Away from the shore, most of the area is covered by reeds (*Phragmites*). Judging from field observations, this site likely was used for small ammunition demolition.

B.3.2.4 Suspected Burning Area near Northeastern Corner of Prototype Building

This area appeared in the 1965 aerial photographs as an oval-shaped clearing with three small structures in its western portion. The area is covered with grasses today. The three structures probably were grills. Only one of the structures, with a size of 3 by 3 ft, is still in the field. Pieces of silver-like melted metals and charcoals are still visible in the grill. The original clearing area is free from metallic objects. The previous use of the site is unknown.

B.3.2.5 Clearing near Southwestern Corner of Prototype Building

This area was shown as a clearing in aerial photographs as early as 1951. No scrap metal was found near the site when it was inspected. There is no evidence to suggest that management or disposal of wastes was carried out at this site.

B.3.2.6 Suspected Burning Area near Southwestern Portion of Prototype Building

The area appears as a demolition ground in aerial photographs. The site is about 200 ft west of the Prototype Building and near the edge of the woods. Its southern boundary is marked by piles of soil, and its northern boundary is marked by tall reeds and shallow ponded water. Very few trees grow on the site. A rusty empty drum and a belt-shaped piece of scrap metal were found on the ground surface.

B.3.2.7 Western Trench of South Beach Trench Area

This suspected trench is filled, and it is located about 40 ft west of the current South Beach Trench. In aerial photographs, the western trench is oriented east-west and extends more than 300 ft. Some waste was observed in its central and eastern portions. The central

portion of the trench was once accessible by a road from the south. The filled trench is still discernable in the field. Small drums and cans are scattered in the woods nearby.

B.3.2.8 Storage Area of TBP Area

Located near the southeastern corner of the TBP area and by the edge of the woods, the storage area is a fenced area about 30 by 30 ft. In the 1965 aerial photographs, drums were shown being unloaded from a truck and moved through a track to the storage area. This area probably was used for temporary storage before wastes were disposed in the TBP area.

B.3.2.9 Suspected Disposal Area near Southwestern Portion of TBP Area

Located in the southwestern portion of the TBP area, this site is shown cleared of nearly all vegetation in late 1950s aerial photographs. In 1965 aerial photographs, soil in the western part of the site is pushed out to the south into the marsh. In the field, the site is covered with reed grass with a few old trees. Near its northern edge, a square pit, about 4 by 4 ft and made of steel, emerges from the ground. The pit is filled with sand. No scrap metals, except for a barbed wire next to an old tree, were seen on the ground surface. The specific use of the site is unknown.

B.3.2.10 Demolition Area near Southeastern Portion of TBP Area

Documented in the RFA (Nemeth 1989), this site was used for demolition of high-explosive munitions. The site was active in as early as 1965, as seen in aerial photographs. Piles of scrap metals and soils are common on the ground near the site, especially near the marsh.

B.3.3 Craters

Numerous craters are distributed across J-Field. The craters are visible in large-scale historical aerial photographs and in the field. Many of these craters fill with water in the spring.

B.4 REFERENCES

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