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Feasibility Study Sites 2, 8, and 18 and Site Screening Area 14 Naval Weapons Station Yorktown Yorktown, Virginia

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Department of the Navy Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

Under The

LANTDIV CLEAN Program

Comprehensive Long-Term Environmental Action Navy

Baker

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Draft

FEASIBILITY STUDY
SITES 2, 8, AND 18, AND
SITE SCREENING AREA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CONTRACT TASK ORDER 0363

OCTOBER 31, 1998

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
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Comprehensive Long-Term
Environmental Action Navy

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LIST OF ACRONYMS AND ABBREVIATIONS

AET	apparent effects threshold
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
Baker	Baker Environmental, Inc.
BDAT	Best Demonstrated Available Technology
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
CBT	Chemical Biological Treatment
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	contaminant of concern
COPC	contaminant of potential concern
CT	central tendency
CTO	Contract Task Order
CWA	Clean Water Act
DCA	dichloroethane
DCE	dichloroethene
DNT	dinitrotoluene
DO	dissolved oxygen
DOD	Department of Defense
DoN	Department of the Navy
DOT	Department of Transportation
ECOC	ecological contaminants of concern
EOD	explosive ordnance demolition
ER-L	effects range - low
ER-M	effects range-median
ESQD	explosive safety quantity distance
FFA	Federal Facilities Agreement
FRG	Final Remediation Goal
FS	Feasibility Study
HEPA	high efficiency particulate air
HI	hazard index
HMX	octohydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HRSD	Hampton Roads Sanitation District
HTTD	high temperature thermal desorption
HQ	hazard quotient

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

IAS	Initial Assessment Study
ICR	incremental cancer risk
IGT	Institute of Gas Technology
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	Lowest Observable Adverse Effect Levels
LTTD	low temperature thermal desorption
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
msl	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEDED	Naval Explosives Development Engineering Department
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observable Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPW	net present worth
O&M	operation and maintenance
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PLF	powerline frequency
PMCL	Primary Maximum Contaminant Levels
POTW	publicly-owned treatment works
ppm	parts per million
PRAP	Proposed Remedial Action Plan
PRG	preliminary risk-based remediation goal
RA	risk assessment
RAA	remedial action alternative
RAB	Restoration Advisory Board
RBC	USEP Region III risk-based concentration
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RF	radio frequency
RGO	risk goal option
RI	Remedial Investigation
RL	remediation level
ROD	Record of Decision

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SMP	Site Management Plan
SSA	Site Screening Area
SVOC	semivolatile organic compound
TAL	Target Analyte List
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxic Characteristic Leaching Procedure
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TRC	Technical Review Committee
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UCL	upper confidence level
USEPA	United States Environmental Protection Agency
UXO	unexploded ordnance
VADEQ	Virginia Department of Environmental Quality
VGS	Virginia Groundwater Standard
VIMS	Virginia Institute of Marine Science
VISITT	Vendor Information System for Innovative Technologies
VOC	volatile organic compound
VWGS	Virginia Water Quality Standard
WPNSTA	Naval Weapons Station
µg/kg	micrograms per kilogram
µg/l	micrograms per liter

EXECUTIVE SUMMARY

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1.0 INTRODUCTION

On October 4, 1989, Naval Weapons Station Yorktown (WPNSTA Yorktown), Yorktown, Virginia was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) (54 Federal Register 41015, 1989). The location of WPNSTA Yorktown is shown on Figure 1-1. The United States Environmental Protection Agency (USEPA) Region III, the Virginia Department of Environmental Quality (VADEQ), and the United States Department of the Navy (DoN) then entered into a Federal Facilities Agreement (FFA) for WPNSTA Yorktown. The primary purpose of the FFA is to ensure that environmental impacts associated with past and present activities at WPNSTA Yorktown are thoroughly investigated, and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and the environment (FFA, 1994).

The Fiscal Year 1999-2000 Site Management Plan (SMP) for WPNSTA Yorktown, a primary document identified in the FFA, identifies sites requiring remedial investigation/feasibility study (RI/FS) activities and site screening areas (SSAs) requiring additional investigations. This report documents the FS conducted for Site 2 - Turkey Road Landfill, Site 8 - NEDED Explosives-Contaminated Wastewater Discharge Area, Site 18 - the Building 476 Discharge Area, and SSA 14 - the Building 537 Discharge to Felgates Creek at WPNSTA Yorktown.

Baker Environmental, Inc. (Baker) has prepared this FS under Contract Task Order (CTO)-0363 under the DoN's Atlantic Division Naval Facilities Engineering Command (LANTDIV) Comprehensive Long-Term Environmental Action Navy (CLEAN) program. The FS has been conducted in accordance with the requirements delineated in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for remedial actions (40 Code of Federal Regulations [CFR] 300.430). These NCP regulations were promulgated under CERCLA, commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. In addition, the USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988) was used as guidance in preparing this FS.

This FS has been based on data collected during the Round One RI conducted in 1992 (Baker/Weston, 1993a) and the Round Two RI conducted in 1996 and 1997 (Baker, 1998).

1.1 Purpose of the FS

The purpose of the FS for Sites 2, 8, 18, and SSA 14 is to identify remedial action alternatives (RAAs) that are protective of human health and the environment, attain Federal and state requirements that are applicable or relevant and appropriate (i.e., ARARs), and are cost-effective. In general, the FS process under CERCLA serves to ensure that appropriate remedial alternatives are developed and evaluated, so that relevant information concerning the remedial action options can be presented and an appropriate remedy selected.

The FS involves two major phases:

- Development and screening of RAAs including identifying Chemicals of Concern (COCs) and Areas of Concern (AOCs)
- Detailed analysis of RAAs

The first phase includes a review of the baseline risk assessment results contained in the Draft Remedial Investigation report (Baker, July 1988). From these results, remedial action objectives and final remediation goals (FRGs) are developed. Areas of concern and volumes of affected media are identified based on the location of contaminant detections which exceed the FRGs. ARARs are assembled as well as potential remedial action technologies and process options. Process options and remedial action tecnologies are combined to form RAAs for each site as part of phase one.

Section 121(b)(1) of CERCLA requires an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant. In addition, according to CERCLA, treatment alternatives should be developed ranging from an alternative that, to the degree possible, would eliminate the need for long-term management of alternatives, to alternatives which involve treatment that would reduce toxicity, mobility, or volume as their principal element. A containment option involving little or no treatment and a no-action alternative should also be developed.

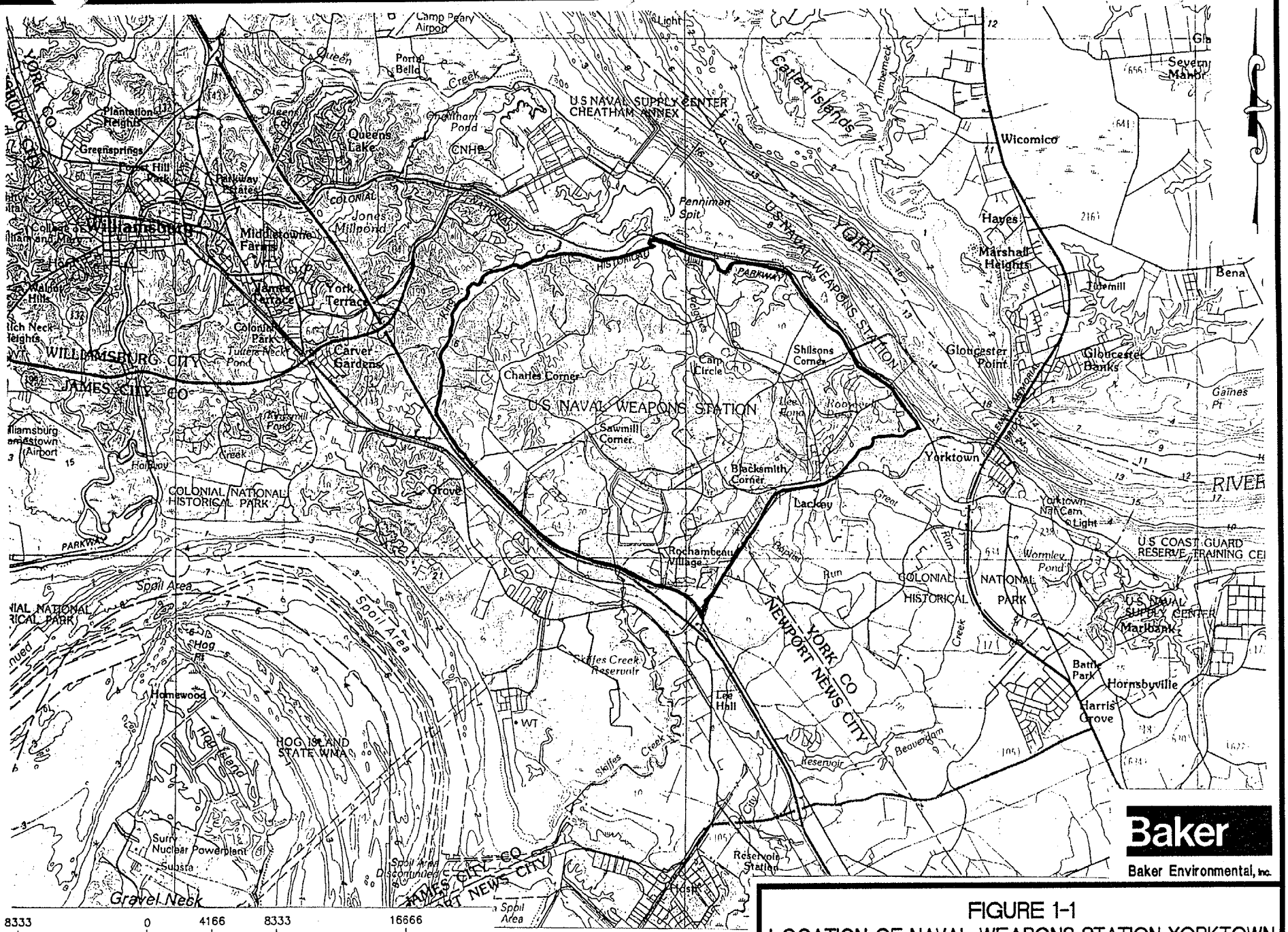
The second phase consists of a detailed analysis of each RAA at each site with respect to the nine evaluation criteria. These criteria address statutory requirements and preferences of CERCLA with respect to RAAs.

1.2 Organization of the FS

This FS report is organized into eight sections. Section 1.0 serves as the introduction. Section 2.0 contains background information for the sites and SSA, including the nature and extent of contamination. Section 3.0 presents the development of FRGs, and remedial action objectives. This section also includes the identification of ARARs. Section 4.0 presents the identification and preliminary screening of remedial action technologies and process options. Section 5.0 contains the development and preliminary screening of RAAs. Section 6.0 presents the criteria for the detailed analysis of RAAs. Section 7.0 presents an individual analysis and a comparative analysis of RAAs which is based on the set of evaluation criteria presented in Section 6.0. Section 8.0 concludes the FS with the references used for the entire report. Tables and figures are presented behind each appropriate section.

The appendices contain risk calculations, information used for the development of the RLs, vendor information, and cost estimate spreadsheets.

SECTION 1.0 FIGURES



SOURCE: U.S.G.S. 1:100,000-SCALE PLANIMETRIC MAP, WILLIAMSBURG, VIRGINIA, 1984.

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FIGURE 1-1
LOCATION OF NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

2.0 SITE BACKGROUND

This section presents background information pertaining to Sites 2, 8, and 18 and SSA 14. The information includes: site description and history; site features such as hydrology, hydrogeology, and land use; previous investigations; nature and extent of contamination; and baseline risk assessment (RA) results. Additional details of the site features can be found in the Round Two Remedial Investigation Report, Sites 2, 8, 18 and Site Screening Area 14, Naval Weapons Station Yorktown, Yorktown, Virginia (Baker, 1998).

2.1 Site-Specific Information

Site 2 lies in the center portion of WPNSTA Yorktown (also to be referred to as the Station) in a wetland area adjacent to the southern branch of Felgates Creek. Site 8 and SSA 14 lie in the north central portion of the Station along the eastern branch of Felgates Creek. Site 18 lies in the southeastern portion of the Station along a tributary leading to Lee Pond (Figure 2-1). Background information pertaining to each of the sites and the SSA are presented in the following subsections. In addition to a site description, the background information will include site history, surface water hydrology and drainage features, hydrogeology, and land use.

2.1.1 Site 2 - Turkey Road Landfill Information

2.1.1.1 Site Description and History of Site 2

Site 2 is a 3.75-acre former landfill area located east of Turkey Road in a wetland area adjacent to the southern branch of Felgates Creek (Figure 2-2). Currently, Site 2 is an open field with some tree cover. Access to the site is from Turkey Road. The site is situated between the forked headwaters (tributaries) of the southern branch of Felgates Creek. Figure 2-3 presents a site plan of the site. Recently, a series of trees were planted throughout the former landfill area as part of the Chesapeake Bay Initiative. This tree-planting initiative is designed to protect the Chesapeake Bay by vegetating the banks of water courses in the watershed.

Operations at the landfill reportedly began in the 1940s and ceased in 1981. Wastes disposed in this former landfill reportedly included mercury and carbon-zinc batteries, tree stumps and limbs,

construction rubble, missile hardware (e.g., wings, fins and power packs), electrical devices, and unidentified drums and/or tanks. An estimated 240 tons of waste was disposed during the period of use. Hard waste material (mine casings) was primarily identified along the tributaries to the southern branch of Felgates Creek. A removal action was conducted at Site 2 in 1994 to remove surface and near surface wastes from the area. Surface debris and UXO material included MK29 Depth Bombs, MK12 Practice Depth Charges, M-41A1 Frag Bombs, empty extender canisters, rockets and rocket launchers, MKZ5 mines, scrap metal and miscellaneous construction debris. The area was regraded and backfilled with an undisclosed amount of soil.

2.1.1.2 Surface Water Hydrology and Drainage Features at Site 2

Site 2 is situated on an elongated elevated plateau type feature. As shown on Figure 2-3, the eastern and western sides of the site are steep embankments that slope toward the tributaries. The northern portion of the site is a more gradual slope towards the marshy area and the tributaries. Elevations at the plateau portion of the site range from 12 to 17 feet mean sea level (msl). In the southern portion of the site, standing water in low lying areas accumulates after sustained periods of rain. Surface water runoff at the site is from the south (near the access road) to the north in a radial pattern away from the slightly higher middle area of the site toward the forked southern branch of Felgates Creek.

2.1.1.3 Hydrogeology of Site 2

The shallow subsurface portion of Site 2 is characterized by unconsolidated deposits of silty sand, silty clay, clayey silt, and marine shell fragments. This is generally consistent with the shallow hydrogeological framework described by Brockman (Brockman, et al., 1997). Collectively, these units form the shallow aquifer system. Unconsolidated deposits of medium-grained sand, clay, clayey silt, and silt with marine shell fragments encountered at all three sites identify the presence of the Cornwallis Cave confining unit and Cornwallis Cave aquifer.

The existing monitoring wells at Site 2 were installed within the shallow Cornwallis Cave aquifer. Groundwater was encountered at approximately 6 to 10 feet below ground surface (bgs). Groundwater level measurements were obtained from the existing and newly-installed monitoring wells. Potentiometric surface contours depicting the groundwater flow patterns at Site 2 as measured

on March 20, 1998 are presented on Figure 2-4. As shown on the figure, the groundwater flow at Site 2 is in a radial pattern from 2GW01 towards the tributaries of the southern branch of Felgates Creek.

Tidal studies were performed at Site 2. The studies were completed to determine if there was an interaction between the surface water adjacent to the sites and the groundwater beneath the site. The studies indicated that there is an interaction between the surface water and the groundwater as the tides fluctuate from high to low tide.

2.1.1.4 Land Use of Site 2

Site 2 is located within the restricted area of the Station and is located inside an area encumbered by the Explosive Safety Quantity Distance (ESQD) arc. Based on the current mission of the Station, this site area cannot be developed.

2.1.2 Site 8 - NEDED Explosives-Contaminated Wastewater Discharge Area Information

2.1.2.1 Site Description and History of Site 8

Site 8 is a 150-foot drainage ditch located along the east branch of Felgates Creek, approximately 1.5 miles from the confluence of the creek and the York River. Building 456 and its associated parking area are located to the east of the drainage ditch. SSA 14 is located south-southeast of the site. Figure 2-5 presents a map of the general area around Site 8. The proximity of SSA 14 to Site 8 is shown on this figure. Figure 2-6 presents a site plan of Site 8.

Site 8 received wastewater from the Naval Explosives Development Engineering Department (NEDED) complex (Building 456) from 1940 to 1975. The wastewater reportedly contained unspecified solvents, spent/neutralized acids, and nitramine compounds. In 1974, a carbon adsorption tower was installed adjacent to the drainage ditch (Figure 2-6) to treat the contaminated wastewater prior to being discharge into the drainage area. A National Pollutant Discharge Elimination System (NPDES) permit was granted by USEPA Region III to allow this discharge. In

1986, the effluent from the carbon adsorption tower was diverted to the sanitary sewer and ultimately to Hampton Roads Sanitation District (HRSD). Currently, the site has reverted to a natural drainage area.

2.1.2.2 Surface Water Hydrology and Drainage Features at Site 8

The topography of Site 8 is best described as a drainage basin (Figure 2-6). The drainage basin measures approximately 150 feet long. The drainage basin is approximately 10 feet wide at the top of the ditch (at the pipe outlet) and widens to over 80 feet as it approaches Felgates Creek. A small paved parking area for Building 456 is located immediately east of the drainage ditch. The drainage basin receives surface water runoff from the parking lot and the surrounding topography in addition to the storm water collection system that drains the area around Building 456.

2.1.2.3 Hydrogeology of Site 8

The existing monitoring wells at Site 8 were installed within the Yorktown-Eastover aquifer (upper and deeper portions of the aquifer). Groundwater level measurements were obtained from the existing and newly-installed monitoring wells. Potentiometric surface contours depicting the groundwater flow patterns at Site 8 as measured on March 20, 1998 are presented on Figure 2-7. The groundwater flow at Site 8 (Figure 2-7) is towards the west as it converges within the drainage basin and then flows toward the east branch of Felgates Creek.

Tidal studies were performed at Site 8. The studies were completed to determine if there was an interaction between the surface water adjacent to the site and the groundwater beneath the site. The tidal study at Site 8 consisted of two staff gauges and one piezometer. The staff gauges were installed within the eastern end of the drainage basin (8SG01) and in the western end of the drainage basin (8SG02) near the east branch of Felgates Creek. The piezometer (8PZ01) was installed on the north bank of the western portion of the drainage basin approximately 33 feet from staff gauge 8SG02. The results did not show a correlation between the tide oscillations and the groundwater fluctuations.

2.1.2.4 Land Use of Site 8

The drainage basin at Site 8 is generally inaccessible because of its topographic relief. In addition, Site 8 is located within the restricted area of the Station and is located inside an area encumbered by the ESQD arc. Based on the current mission of the Station, this site area cannot be developed. Explosive research and development is currently conducted within Building 456, which is adjacent to Site 8.

2.1.3 Site 18 - Building 476 Discharge Area Information

2.1.3.1 Site Description and History of Site 18

Site 18 is a 500-foot intermittent drainage ditch that located north of Building 476 (Figure 2-8). Building 476 is located along Old Williamsburg Road within an industrial area of the Station. The Site 18 drainage ditch discharges into a tributary to Lee Pond. Figure 2-8 presents a map of the general area around Site 8. Figure 2-9 presents a site plan of Site 18.

Site 18 was in use as a discharge area for approximately 20 years from the 1940s to the 1960s. The discharge material reportedly contained battery acid waste (consisting of hydrochloric acid or calcium hydroxide and dissolved metals such as lead, cadmium, nickel, and antimony). An estimated 100 to 200 pounds of metals may have been discharged. Battery acid waste no longer discharges from Building 476 into this drainage ditch.

2.1.3.2 Surface Water Hydrology and Drainage Features at Site 18

The general topography at Site 18 is typical of a drainage way. The highest elevation at the site (approximately 72 feet msl) is at the outlet of the 24-inch concrete pipe leading from Building 476. The site elevations slope to approximately 54 feet msl at the outlet of the drainage ditch to the tributary (Figure 2-9).

Surface water runoff is controlled by the drainage ditch that also receives storm water drainage from Building 476 and the surrounding area. The intermittent drainage ditch flows into a tributary that drains into a small pond near the camping and picnic area along Fig Tree Drive and eventually into Lee Pond.

2.1.3.3 Hydrogeology of Site 18

The existing monitoring wells at Site 18 were installed within the upper portion of the Cornwallis Cave aquifer. Groundwater was encountered at approximately 28 to 32 feet bgs. Potentiometric surface contours depicting the groundwater flow patterns at Site 18 as measured on March 20, 1998 are presented on Figure 2-10. The projected groundwater flow at the site is towards the northwest.

2.1.3.4 Land Use of Site 18

Site 18 is a wooded area. It is accessible to Station employees. An industrial area is located across the road that borders Site 18.

2.1.4 SSA 14 - Building 537 Discharge to Felgates Creek Information

2.1.4.1 Site Description and History of SSA 14

SSA14 consists of a storm water discharge pipe leading from Building 537 and the associated discharge area. As shown on Figure 2-5, SSA 14 is located south-southeast of Site 8. Like Site 8, the drainage area at SSA 14 discharges into the east branch of Felgates Creek. The SSA 14 discharge is upstream of the Site 8 discharge. SSA 14 occupies an area of approximately 0.4 acres (this includes the area of Building 537, the drainage area, and the marshy area leading to Felgates Creek).

Figure 2-11 presents a site plan of SSA 14. The discharge pipe has not been identified during the most recent investigations; therefore, the location of the pipe as presented on Figure 2-11 is approximated. Above the discharge pipe is an one-lane asphalt road which circles around the side of the hill. This road provides access to several underground concrete bunkers that are set into the hillside.

Nitramine-contaminated wastewater generated from Building 537 was reportedly discharged at SSA 14.

2.1.4.2 Surface Water Hydrology and Drainage Features at SSA 14

The topography of SSA 14 is typical of a drainage area located along a hillside. The highest elevations (approximately 25 feet msl) are near Building 537. The SSA decreases in elevation as the drainage area nears the marshy area and Felgates Creek. Surface water runoff drains from the area above the hillside which in turn drains through the SSA and then to Felgates Creek.

2.1.4.3 Hydrogeology of SSA 14

A groundwater flow map was not generated for SSA 14 because there is only one groundwater monitoring well at the SSA, but it is estimated that the flow would be toward the south towards Felgates Creek.

2.1.4.4 Land Use of SSA 14

SSA 14 is located within the restricted area of the Station and is located inside an area encumbered by the ESQD arc. Based on the current mission of the Station, this site area can not be developed. In addition, SSA 14 is located within an area where explosive research and development is currently conducted. The drainage area at SSA14 is generally inaccessible because of the topographic relief.

2.2 Previous Investigations

Previous investigation reports generated in conjunction with the continuing development of the Department of Defense (DoD) Installation Restoration Program (IRP) for Sites 2, 8, and 18, and SSA 14 include the following:

- Initial Assessment Study (IAS) Report (C. C. Johnson & Associates, Inc. and CH2M Hill, 1984)

- Confirmation Study Rounds One and Two Reports (Dames & Moore, 1986 and Dames & Moore, 1988)

- RI Interim Report (Versar, 1991)

- Focused Biological Sampling and Preliminary Risk Evaluation Report (Baker/Weston, 1993b)

- Round One RI Report (Baker/Weston, 1993a)

- Habitat Evaluation Report (Baker, 1995a)

- Final Closeout Report, Sites 2, 9, and SSA 4 - Mine Casing and Debris Removal Action (IT, 1995)

- Relative Risk Ranking System Data Collection Investigation Report - SSAs 9, 10, and 14 (Baker, 1995c)

- Round Two RI Report (Baker, 1998)

Summaries of these previous investigations are provided in the following subsections.

2.2.1 Initial Assessment Study

The purpose of the IAS (C. C. Johnson & Associates, Inc. and CH2M Hill, 1984) was to identify and assess sites at WPNSTA Yorktown posing a potential threat to human health and/or the environment due to contamination from past operations. A total of 19 potentially contaminated sites were identified based on information from historical records, aerial photographs, field inspections, and personnel interviews. Each site was evaluated for the type of contamination, migration pathways, and pollutant receptors. The IAS concluded that 15 of the 19 sites, including Sites 2, 8, and 18, were of sufficient potential threat to human health or the environment to warrant further investigations such as Confirmation Studies.

For Site 2, the IAS recommended the installation of monitoring wells and the collection of groundwater, surface water, and sediment samples. For Site 8, the IAS recommended the collection of soil, surface water, and sediment samples. For Site 18, the IAS recommended the collection of soil samples.

2.2.2 Confirmation Study and RI Interim Report

Two rounds of data were obtained during the Confirmation Study effort. The first round of sampling and analysis was documented in the "Confirmation Study Step IA (Verification), Round One" (Dames & Moore, 1986). The results of the second round of sampling and comparisons with appropriate regulatory standards were presented in the "Confirmation Study Step IA (Verification), Round Two" (Dames & Moore, 1988).

During the Round One Confirmation Study at Site 2, four monitoring wells were installed and three surface water and sediment samples were collected. Inorganics were detected in groundwater, surface water, and sediment. Volatile organic compounds (VOCs) were detected in the surface water, although at levels below criteria, and in the sediment. During Round Two activities four groundwater samples and three surface water and sediment samples were collected. Results were consistent with the results of the Round One analyses.

At Site 8, two soil samples and two surface water and sediment samples were collected during both the Round One and Round Two portions of the Confirmation Study. Inorganics and low levels of organics were detected in all media; many of the organics were laboratory contaminants and common pesticides.

At Site 18, two surface water and two sediment samples were collected during the Round One Confirmation Study, and three surface water and four sediment and soil samples were collected during the Round Two Confirmation Study. Organics, all of which were laboratory contaminants, were detected in surface water, soil, and sediment. Inorganics were also detected in all media; silver was the only inorganic detected above criteria in surface water.

The results of the Confirmatory Study field efforts were combined and summarized in the Draft RI Interim Report (Dames & Moore, 1989). This report was subsequently revised by Versar, Inc.

(Versar) in 1991 to incorporate comments from the former Technical Review Committee (TRC); now called a Restoration Advisory Board (RAB). The revised report is referred to as the RI Interim Report (Versar, 1991). The RI Interim Report recommended that further RI activities be completed at 14 of the 15 sites, including Sites 2, 8, and 18.

2.2.3 Focused Biological Sampling and Preliminary Risk Evaluation Report

The Focused Biological Sampling and Preliminary Risk Evaluation Report (Baker/Weston, 1993b) summarized the results of a limited biological tissue, surface water, and sediment sampling effort conducted in October 1992. The primary objective of the sampling program was to evaluate the potential human health risk associated with consumption of fish and shellfish taken from select waters within WPNSTA Yorktown, including Lee Pond, Roosevelt Pond, Felgates Creek, and Indian Field Creek.

Analytical results of the biota sampling indicated that contaminants from WPNSTA Yorktown have not bioaccumulated in significant quantities in the fish and shellfish of Lee Pond, Roosevelt Pond, Indian Field Creek, and Felgates Creek so as to pose a significant risk to the individuals who fish or harvest shellfish from those water bodies. The report noted that there was some uncertainty associated with the estimate of risk for fish and shellfish consumption because data were not available with which to assess potential human exposure to the explosives hexahydro-1,3,5-trinitro-1,3,5-thiazine (RDX) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX). Comprehensive human health and ecological risk assessment evaluations were recommended.

2.2.4 Round One RI Report

As recommended by the Confirmation Study (RI Interim Report), additional RI activities were conducted for several sites at WPNSTA Yorktown including Sites 2, 8, and 18. The Round One RI was conducted in 1992. The results of the Round One RI (Baker/Weston, 1993a) indicated that further investigation was needed at all sites that were studied to better define the nature and extent of contamination associated with each site. Data indicate that surface soil, subsurface soil, groundwater, surface water, and sediment have been potentially impacted by past site activities. A summary of the Round One RI conducted for Sites 2, 8, and 18 is presented below by site.

2.2.4.1 Site 2 Round One RI Results

The Round One RI at Site 2 consisted of groundwater, surface water, and sediment investigations. Figure 2-12 identifies the sampling locations. The results of the RI per media are summarized below.

Groundwater Sampling Results

One round of groundwater samples was collected from monitoring wells 2GW01, 2GW02, 2GW03, and 2GW04 at Site 2. The samples were analyzed for VOCs, semivolatile organic compounds (SVOCs), pesticides/ polychlorinated biphenyls (PCBs), nitramines (explosives), and inorganics. Only SVOCs, at low concentrations, were detected in the groundwater samples. Nitrate concentrations ranged from nondetect to 470 micrograms per liter (µg/L). No VOCs, explosives, pesticides, or PCBs were detected. The analytical results for organic compounds detected in groundwater at Site 2 are presented in Figure 2-13.

The inorganic analyses performed on the groundwater samples provided the following results:

- Unfiltered inorganic analysis of sample 2GW02-001 contained chromium (55 µg/L) and zinc (93.8 µg/L) concentrations above the state standards. The lead concentration (15.5 µg/L) exceeded the Federal action level. None of these compounds, however, were above the standards in the filtered inorganic sample for this monitoring well.

- Zinc exceeded the state standard in the unfiltered inorganic sample from monitoring well 2GW03, at a concentration of 67.1 µg/L; zinc was below standards in the filtered inorganic sample.

- The unfiltered inorganic sample 2GW04-001 contained concentrations of arsenic, chromium, and zinc above the state standard. Arsenic also was above the Federal standard, at a concentration of 110J µg/L. The "J " qualifier indicates that the reported sample concentration value has been estimated. Lead concentrations exceeded the Federal action level. Arsenic was the only inorganic detected above

standards in the filtered inorganic sample, at 74.8 μg/L; this concentration exceeded both the Federal standard (50 μg/L) and the state standard (50 μg/L).

- The unfiltered and filtered inorganic samples collected from monitoring wells 2GW02, 2GW03, and 2GW04 contained concentrations of several inorganics above Round One background levels.

The groundwater analytical results obtained during the Round One RI activities were consistent with those obtained during previous investigations.

Surface Water Sampling Results

Seven surface water stations were sampled during the Round One RI sampling activities: 2SW01 through 2SW07 (Figure 2-12). Figure 2-14 presents the analytical results for the organic compounds detected in surface water at Site 2. As shown on the figure, only common laboratory contaminants (e.g., di-n-butylphthalate, acetone, and bis[2-ethylhexyl]phthalate {BEHP}) were detected in the surface water samples. Explosives, pesticides, and PCBs were not detected in any of the surface water samples. Previous studies had indicated the presence of VOCs and pesticides, which were not confirmed in these analyses.

The inorganics analyses indicated the following:

- The unfiltered copper concentrations in samples 2SW01-001 and 2SW04-001 were above the state and Federal criteria. The filtered inorganic concentration of copper in sample 2SW04-001 also was above these levels.

- The unfiltered nickel concentration in sample 2SW02-001 was above the state and Federal criteria. The filtered inorganic concentrations in samples 2SW03-001, 2SW06-001, and 2SW07-001 were above the state and Federal salt water chronic levels.

Sediment Sampling Results

A total of nine sediment stations were sampled at Site 2: 2SD01 through 2SD09. Figure 2-15 presents the analytical results for the organic compounds detected in the sediment samples at Site 2. As shown on the figure, the majority of detections were common laboratory contaminants (e.g., toluene, 2-butanone, methylene chloride, and acetone). Pentachlorophenol was detected in one sample at a concentration of 350J micrograms per kilogram (µg/kg). The PCB Aroclor-1248 was detected in the sample collected from the 6- to 12-inch interval of sediment sampling station 2SD06 (110J µg/kg), but not in the 0- to 6-inch interval. The pesticide 4,4'-DDE was detected in the sample collected from the 0- to 6-inch interval of sediment station 2SD08 (2.9J µg/kg). The concentrations of Aroclor-1248 and 4,4'-DDE exceeded the National Oceanic and Atmospheric Administration (NOAA) effects range-low (ER-L) criteria.

A few of the inorganic concentrations exceeded the levels found in the site-specific Round One background sediment samples, especially in the 6- to 12-inch interval. Silver concentrations exceeded the NOAA effects range-median (ER-M) and apparent effects threshold (AET) criteria in five sediment samples collected from Site 2. Higher levels of inorganics were detected in the sediment samples analyzed during previous investigations.

Round One RI Conclusions for Site 2

Based on the results of the Round One RI for Site 2, groundwater does not appear to be impacted by organics. Inorganic concentrations were elevated above background levels. Surface water does not appear to be impacted by organics. In addition, inorganics detected were typical of background concentrations. In sediment, pentachlorophenol, Aroclor-1248, and 4,4'-DDE were each detected once. A few inorganic analyte concentrations exceeded background levels and/or other criteria. Higher levels of inorganics were detected in the sediment samples analyzed during previous investigations.

Based on the results of the Round One RI, a removal action to excavate and dispose of surficial waste and debris was recommended, followed by a risk evaluation.

2.2.4.2 Site 8 Round One RI

The Round One RI at Site 8 consisted of surface soil, groundwater, surface water, and sediment investigations. Figure 2-16 identifies the sampling locations. The following subsections present the analytical results for each medium sampled and the conclusions made for Site 8.

Surface Soil Sampling Results

Surface soil samples were collected from sample locations 8S03, 8S04, and 8S05. Figure 2-17 presents the analytical results for the organic compounds detected in the surface soil samples collected at Site 8. VOCs, including vinyl chloride, 1,2-dichloroethane (1,2-DCA); 1,2-dichloroethene (1,2-DCE); 1,1,2-trichloroethane (1,1,2-TCA); toluene; and 2-butanone were detected in samples 8S04-101 and 8S05-001 at concentrations less than 100 μg/kg. SVOCs, primarily polynuclear aromatic hydrocarbons (PAHs), were identified in the surface soil samples. Explosives (RDX and HMX) were detected in samples 8S03-001 and 8S04-101. Several pesticides were detected in sample 8S04-101. No PCBs were detected in the surface soil samples. The concentrations of inorganics were comparable to those found in Round One site-specific background surface soil samples.

Groundwater Sampling Results

One groundwater sample was obtained at Site 8 using a Hydropunch™ sampler at sample location 8HP01. Analysis of this sample provided the following results:

- VOCs, including acetone (5J μg/L), 1,1-DCE (2J μg/L), chloroform (3J μg/L), 1,1,1-TCA (45 μg/L), and trichloroethene (TCE; 15 μg/L) were present in groundwater. The concentration of TCE exceeded the Federal standard of 5 μg/L.

- Explosives (13 μg/L HMX and 64 μg/L RDX) also were detected in the groundwater.

- Nitrate was detected in the groundwater at a concentration of 1,000 μg/L.

- No SVOCs, pesticides, or PCBs were detected.

In the unfiltered inorganic sample, the concentrations of chromium (163 µg/L) and zinc (216 µg/L) exceeded the state standard. Chromium levels also were above the Federal standard, and the lead action level was exceeded. The beryllium concentration (4.5J µg/L) was above the Federal standard of 4 µg/L. Several unfiltered inorganic concentrations were above the Round One site-specific background levels. All of the concentrations in the filtered inorganic sample were below the standards and site-specific background levels.

Surface Water Sampling Results

Three surface water samples were collected from Site 8: 8SW01, 8SW03, and 8SW04. No VOCs, SVOCs, pesticides, PCBs, or explosives were detected in any of the surface water samples. Copper concentrations in the unfiltered inorganic sample from 8SW01 were above state and Federal criteria. The filtered inorganic concentrations were below these criteria. Lead and nickel exceeded the Federal salt water chronic level concentrations in the unfiltered inorganic sample 8SW03; nickel also was above the state standard. The filtered inorganic lead concentration, however, was below this standard. Copper and nickel concentrations in the unfiltered inorganic sample collected from 8SW04 were above the state and Federal salt water chronic levels. The filtered inorganic concentrations were below these standards. Low concentrations of some VOCs and SVOCs had been previously detected in the surface water collected at Site 8; these results were not duplicated during the Round One sampling activities. The surface water inorganic concentrations were consistent with those found in Round One site-specific background samples.

Sediment Sampling Results

Sediment samples were collected from three locations: 8SD01, 8SD01, and 8SD04. Figure 2-18 presents the analytical results for organic compounds detected in sediment at Site 8. The sediment samples did not contain explosives, pesticides, or PCBs. The only VOCs detected were acetone, methylene chloride, and carbon disulfide (common laboratory contaminants). 4-Methyl phenol was the only SVOC compound detected in any of the sediment samples. Inorganic concentrations were similar to those found in the Round One site-specific background sediments. Lead and zinc were detected at concentrations slightly above the NOAA low effects range criteria in sample 8SD03-001;

lead was also slightly above NOAA standards in sample 8SD04-002. Mercury exceeded the NOAA ER-M and Apparent Effects Threshold (AET) criteria in sample 8SD01-001. Previous investigations indicated the presence of other VOCs and SVOCs at low concentrations that were not detected in the Round One analyses.

Round One RI Conclusions for Site 8

Site 8 is a drainage ditch that received wastewater from the operation of Building 456. There is no longer any wastewater discharge to the ditch, which is inundated at high tide. The highest contaminant detections were the explosives HMX and RDX. These constituents were detected in two of three soil samples near the ditch at concentrations in the approximate range of 1,000 to 3,000 µg/kg. Explosives were not detected in sediment or surface water samples. The surface soil also contained numerous SVOCs and some VOCs, most of which were reported as estimated values, less than 200 µg/kg. The highest detected VOCs were DCE and TCE, collected at a soil sample location midway between Building 456 and Felgates Creek. Two soil samples were collected at that location (8S04), and the higher contaminant levels of TCE (32 µg/L) were found in the deeper soil sample.

VOCs and explosives were detected in the Hydropunch™ groundwater sample. Detected VOCs included TCA (45 µg/L) and TCE (15 µg/L) and explosives HMX (13 µg/L) and RDX (64 µg/L). No VOC contaminants were detected in surface water samples. Volatile contaminants (primarily common laboratory contaminants) were found in sediments but acetone also was present in upgradient samples.

Based on the Round One RI results, further soil sampling for explosives and VOCs was recommended to delineate the extent of contamination around 8S03 and 8S04. Installation of monitoring wells and collection of VOC, explosive, and inorganic samples to confirm the Hydropunch™ results and delineate the extent of contamination were also recommended.

2.2.4.3 Site 18 Round One RI

The Round One RI at Site 18 consisted of surface soil, groundwater, surface water, and sediment investigations. Figure 2-19 identifies the sampling locations. The following subsections present the analytical results for each medium sampled and the conclusions made for Site 18.

Soil Sampling Summary

Six soil samples were collected at Site 18: 18S05 through 18S10 and analyzed for inorganics. Analysis of these samples indicated that copper, zinc, and arsenic concentrations exceeded Round One site-specific background levels in several samples. These results confirm those obtained from previous investigations.

Groundwater Sampling Results

One groundwater sample was collected from Site 18 (from 18HP01)and was analyzed for unfiltered and filtered inorganic and hardness. Cadmium, chromium, lead, mercury, and zinc were present in the unfiltered inorganic sample at concentrations exceeding the state standard. The levels of unfiltered cadmium (12.6 µg/L) also exceeded the Federal standard. The concentration of unfiltered lead exceeded the Federal action level, and unfiltered beryllium (7.5J µg/L) exceeded the Federal standard. The filtered inorganic analysis showed concentrations of these inorganics below the above-referenced standards.

Surface Water Sampling Results

Five surface water samples were collected at Site 18 at the following sampling locations: 18SW01, 18SW02, 18SW04, 18SW05, and 18SW06 and analyzed for inorganics. The results show that there are no inorganic concentrations above the state or Federal criteria in the samples collected at downgradient station 18SW02 and upgradient station 18SW06. Copper and zinc concentrations were above the Federal salt water chronic levels in both the unfiltered and filtered inorganic samples collected from stations 18SW01, 18SW04, and 18SW05.

Sediment Sampling Results

Ten sediment samples were collected at Site 18 and analyzed for inorganics. Two sediment samples were collected from each of the following five sampling locations: 18SD01, 18SD02, 18SD04, 18SD05 and 18SD06. Beryllium was the only inorganic that was detected above site-specific background levels. The antimony concentrations in samples 18DS01-002 and 18SD06-002 exceeded the NOAA ER-L range criteria. The inorganic concentrations in sediment were similar to those found in previous investigations.

Round One RI Conclusions for Site 18

Soil contains arsenic and zinc at concentrations above Round One site-specific background levels at four sample locations, lead at two locations, and copper at three locations. Sediment samples in the drainage ditch also exceeded site-specific background inorganic concentrations for beryllium at one location. Copper and zinc in surface water exceeded the state and Federal criteria, but not at the farthest downstream sampling point or in the branch northeast of Building 476. Groundwater samples showed that no filtered samples contained inorganic concentrations that exceeded state or Federal criteria.

Based on the Round One RI results, it was recommended that a risk screening be conducted for Site 18 to confirm that no further actions are necessary for the site.

2.2.5 Habitat Evaluation Report

This section summarizes the results of the Habitat Evaluation (Baker, 1995b) that was conducted for the aquatic and terrestrial habitats at Sites 2, 8, and 18. Sites 2 and 8 are located in the Felgates Creek watershed and Site 18 is located in the Lee Pond watershed. Although SSA 14 was not specifically included in the Habitat Evaluation, it is located immediately upstream of Site 8.

2.2.5.1 Site 2 Habitat Evaluation Results

Four different habitats are present in the vicinity of Site 2. These include deciduous upland forest, an ecotone or transition zone along the edge of the disposal area, an open area on top of the disposal area, and wetlands along the tributaries to Felgates Creek.

Upland forest is present along Turkey Road and on the higher ground to the east and west of the site. Between the open area at Site 2 and the wetland, an ecotone or transition zone is present. This ecotone area includes a variety of trees, shrubs, woody vines, and herbaceous plants, none of which is dominant. Young trees and saplings in the ecotone are mixed with shrubs. Herbaceous annuals and perennials are also common in the ecotone, particularly along the edges of the open area.

The middle of the Site 2 area is an open field, which is kept roughly mowed. There are no trees, shrubs, or vines growing in this open area, and grasses are clearly dominant. These grasses are mixed with few herbaceous annuals or perennials, probably because the area is regularly mowed. Slender bush clover, field thistle, and blue mistflower were identified in the grassy, open area.

The wetland regime at Site 2 is somewhat complex. Wetlands are present along both tributaries to Felgates Creek that flank the disposal area and along Felgates Creek itself. These wetlands represent three different sub-habitats. The wetland to the south of the disposal area between Turkey Road and the rail line was formed when beavers dammed the eastern tributary of Felgates Creek. This wetland is classified as a palustrine, scrub shrub wetland. The wetland downstream of the palustrine scrub shrub wetland and the wetland to the west of the disposal area are both classified as palustrine forested wetlands. In these areas upland forest is present to the edges of the lower wetland areas, which can be delineated by topography and wetland vegetation. The wetlands along Felgates Creek are estuarine and consist primarily of tidal saltmarsh.

Because of the varied habitats present at Site 2, avifauna observed at the site was abundant and diverse. Sixteen different species of birds were identified during the habitat evaluation, even though field work was conducted in the afternoon. Evidence of four mammal species was also observed during the habitat evaluation.

2.2.5.2 Site 8 Habitat Evaluation Results

Two habitat types are present at Site 8, deciduous upland forest on the higher ground and mixed forest in the vicinity of the drainage way. Salt marsh, dominated by spartina, is also present beyond the drainageway in Felgates Creek.

Trees are dominant in the upland forest, although no species is clearly dominant. A mixed forest is present along the drainage way. The mixed forest also has a variety of species in the understory. In addition, six different woody vines are present in the understory at Site 8.

Although the drainageway is not officially classified as a wetland on the National Wetland Inventory (NWI) maps, wetland vegetation is present. The drainageway leads to an estuarine, intertidal, emergent wetland along Felgates Creek.

Only four birds were observed at Site 8, perhaps because the habitat evaluation was conducted in the late afternoon or because most migrants had already passed through the area when the habitat evaluation was conducted. Signs of two mammals were also observed. No reptiles or amphibians were noted at Site 8 during the habitat evaluation.

2.2.5.3 Site 18 Habitat Evaluation Results

Currently, Site 18 is a drainageway that appears to be a natural stream in some areas and an excavated trench in others. From the amount of erosion present in portions of the drainageway, a good deal of water appears to flow through the area during storms. During September, when the habitat evaluation was conducted, water was present in the drainageway.

Site 18 is surrounded by deciduous forest. The dominant species and makeup of the forest are dependent upon the topography. Upland species are present on the slopes and lowland species are present along the drainage ditch. Forbs found in the upland forest also occur in the lowland areas. In addition, wetland vegetation is present along the drainage way.

Avifauna were not abundant at Site 18, perhaps because the habitat was evaluated in late afternoon when birds are not as active as they are in the morning and in the evening. No mammals were

observed at the site, nor was any mammal sign noted. One reptile was found at the site. Adult green frogs were also observed living in the drainage ditch.

2.2.6 Final Closeout Report - Site 2 Removal Action

A removal action was conducted at Site 2 from September through December 1994 (IT, 1995). The main objectives of the removal action were to removal all surface and shallowly buried wastes from the designated areas at Site 2 and to restore the site to pre-removal action conditions. Based on historical photographs, waste disposal appears to have been limited to the perimeter of the site.

Wastes removed from Site 2 included large concrete masses, asphalt, high efficiency particulate air (HEPA) filter drums, scrap metal, empty drums, miscellaneous construction/demolition debris, batteries, and unexploded ordnance (UXO). All ordnance items were certified inert either by the UXO superintendent, were transferred to the NEDED laboratory on site and verified as inert, or were transferred off site by the Station explosive ordnance demolition (EOD) staff for final disposition.

Upon completion of the removal action, confirmatory soil sampling was completed at designated locations at Site 2. Forty samples (shown on Figure 2-20) were collected and the locations were field located through surveying. The confirmatory sampling was conducted to develop a database to be used for determining if further investigations or actions were needed at the site. Each sample was analyzed for the following parameters:

- Target Compound List (TCL) VOCs
- TCL SVOCs
- TCL pesticides/PCBs
- Nitramine compounds
- Target Analyte List (TAL) inorganics

The samples were collected after the excavation activities were completed and prior to any backfilling. Each sample that was collected from within a waste removal area was obtained from the base of the excavated area, at a depth of 0 to 6 inches. In addition, a number of designated samples were located outside the designated limits of excavation. In these cases, the samples were

taken from a 0- to 6-inch depth. If any backfill was required in the sample locations, the samples were taken prior to placement of any backfill materials.

As shown on Figure 2-20, VOCs were not detected in the confirmatory samples. SVOCs, predominantly PAHs, were detected in the majority of these samples. Low levels of a nitramine compound (4-amino-2,6-dinitrotoluene [DNT] at 0.76 μg/kg) were detected in one sample (02-SS-04). Aroclor-1254 was detected in five of the confirmation samples. Detected Aroclor-1254 concentrations ranged from 510 μg/kg to 6,200 μg/kg.

Inorganics were detected in all confirmatory surface soil samples. Analytical results indicated that there is no contaminant source or discernible pattern of inorganic contamination. The majority of inorganic analytical results fell within Station background levels. Figure 2-21 presents the detected inorganic concentrations for aluminum, antimony, arsenic, cadmium, copper, iron, manganese, mercury, and thallium.

2.2.7 Relative Risk Ranking for SSA 14

A Relative Risk Ranking Data Collection Investigation was conducted at SSA 14 during late October 1995 (Baker, 1995c). The objective of this effort was to gather contaminant, pathway, and receptor information to be used in the DoN's Relative Risk Ranking System. Prior to this investigation, no samples had been collected at SSA 14.

Surface soil, surface water, and sediment samples were collected at SSA 14. All samples were analyzed for nitramine compounds. Explosives were detected in one surface soil (RDX and HMX), one surface water sample (HMX, RDX, and amino-dinitrotoluene [amino-DNTs]), and in one sediment sample (HMX).

Migration pathways and receptor factors were evaluation by media at SSA 14. Migration pathways were found to be evident (utilized pathways were clearly present) for groundwater, soils (human health), surface water (human health and ecological - freshwater), and sediment (human health and ecological - freshwater). Receptors for these media were identified as potentially being present at the site (potential receptor factor). Migration pathways were found to be confined (pathway is not

possible under existing site conditions) for surface water (ecological - marsh) and sediment (ecological - marsh). Receptors were precluded from exposure to the site (limited receptor factor).

2.2.8 Round Two RI

A Round Two RI (Baker, 1998) was conducted at Sites 2, 8, and 18 and SSA 14 to assess the nature and extent of contamination at the sites/SSA and to address any data gaps observed from the Round One RI. The Round Two RI field investigation for Sites 2, 8, and 18, and SSA 14 was conducted from August through September ~~1996 and from January~~ through February 1997.

A summary of the Round Two RI for Sites 2, 8, and 18, and SSA 14 is presented below. A more detailed discussion of the nature and extent of contamination at the sites and SSA with respect to the Round Two RI results will be presented in Section 2.6.

2.2.8.1 Site 2 Round Two RI Results Summary

The Round Two RI for Site 2 included the collection of subsurface soil, groundwater, surface water and sediment samples. No additional surface soil samples were collected since numerous surface soil samples were collected as part of the Removal Action.

During the Round Two RI, ten soil borings were advanced at Site 2 at locations 2SB01 through 2SB04, 2GW05, 2GW06, 2GW07, and 2SB08 through 2SB10 (Figure 2-22). Subsurface soil samples were collected from these soil borings/monitoring well borings. The samples were analyzed for TCL VOCs, TCL SVOCs, nitramine compounds, TCL pesticides/PCBs, TAL inorganics, total organic carbon (TOC), pH, and nitrate/nitrite. Select results of these analyses are shown on Figures 2-23 and 2-24 for organics and inorganics, respectively. With respect to organics, PAHs were detected in eight samples from five sample locations, and the PCB, Aroclor-1254 was detected in one sample.

Groundwater samples were collected from one existing monitoring well (2GW01) and the three newly-installed monitoring wells (2GW05, 2GW06, and 2GW07). Note that existing monitoring wells 2GW02, 2GW03 and 2GW04 could not be sampled during the Round Two RI; the monitoring wells had to be abandoned because they had been flooded. Groundwater samples were analyzed for

TCL organics (VOCs, SVOCs, pesticides/PCBs), nitramine compounds, TAL inorganics (total and dissolved), TOC, nitrate/nitrite, total dissolved solids (TDS), total suspended solids (TSS), bromide, chloride, orthophosphate, sulfate, and dissolved methane. Select results of these analyses are shown in Figure 2-25. With respect to organics, VOCs (1,2-DCE and vinyl chloride) were detected in one groundwater sample (2GW06-001).

Nine surface water/sediment sampling stations and three additional sediment stations were identified to characterize the tributaries to Felgates Creek that border Site 2 (Figure 2-26). The sampling stations included 2SW/SD01 through 2SW/SD09. The three additional sediment sampling stations included 2SD10, 2SD11, and 2SD12. All surface water and sediment samples were analyzed for TCL organics, nitramine compounds, TAL inorganics, cyanide, TOC, nitrate/nitrite, grain size (sediment only), total Kjeldahl nitrogen (TKN), ammonia, and pH (sediment pH was measured in the laboratory). In addition, analyses for pH, temperature, dissolved oxygen (DO), salinity, and specific conductivity were performed on surface water samples in the field immediately following sample collection. No organic compounds were detected in the surface water samples. Select analytical results are shown in Figure 2-27 for the detected inorganics in the surface water samples. Figure 2-28 shows the analytical results for the detected organics and select inorganics. With respect to organics, PAHs were detected in five of the sediment samples.

An aquatic ecological investigation was conducted at each of the nine surface water/sediment locations. These studies were used to assess potential ecological impacts to benthic macroinvertebrate and fish populations in Felgates Creek.

2.2.8.2 Site 8 Round Two RI Results Summary

Nine surface soil samples were collected at Site 8 from the 0- to- 6 inch bgs interval and analyzed for TCL VOCs, SVOCs, pesticides and PCBs, nitramine compounds, TAL inorganics, TOC, nitrate/nitrite, and pH. Selected samples were also analyzed for cation exchange capacity (CEC). The surface soil sampling locations correspond with each soil boring/monitoring well location: 8GW01, 8GW02, 8GW03, and 8SB04 through 8SB09. The surface soil samples were labeled 8SB01-00 through 8SB09-00. Surface soil sample locations are identified on Figure 2-29. Select analytical results (organic and inorganic) are shown in Figure 2-30. With respect to organics, PAHs were detected in two samples, PCBs detected in one sample and explosives detected in five samples.

Two subsurface soil samples were collected from each of the following soil borings: 8SB01, 8SB01A, 8SB02, 8SB03, and 8SB09. One subsurface soil sample was collected from just above the water table and a second subsurface soil sample was collected from a mid-point in the soil boring. In situations where groundwater water was encountered at depths of less than seven feet bgs, this mid-point sample was omitted. In addition, one sample was collected within the aquifer material at 8SB01. This sample (along with one collected above the water table) was analyzed for engineering parameters which included grain size (sieve/hydrometer), bulk density, and CEC to obtain information on the migration potential of contaminants at the site. All of the subsurface soil samples were analyzed for ~~TCL VOCs, SVOCs,~~ and pesticides/PCBs, nitramine compounds, TAL inorganics, cyanide, TOC, nitrate/nitrite, CEC, bulk density, grain size, and pH. Select analytical results are shown on Figure 2-31. With respect to organics, explosives were detected in one sample.

One round of groundwater samples was collected from the four newly-installed monitoring wells: 8GW01, 8GW01A, 8GW02, and 8GW03. Groundwater samples were analyzed for TCL organics, TAL inorganics (total and dissolved), TOC, nitrate/nitrite, TDS, TSS, bromide, chloride, orthophosphate, sulfate, and dissolved methane. Select analytical results are shown on Figure 2-32. With respect to organics, VOCs including TCE and 1,1-DCE and explosives including RDX and HMX were detected in all of the groundwater samples.

Due to their proximity, Site 8 and SSA 14 surface water/sediment and aquatic ecological investigations were combined in the Round Two RI. Six surface water/sediment sampling stations were identified to characterize the East Branch of Felgates Creek in this area (Figure 2-33): 8SW/SD01, 8SW/SD02, 8SW/SD03, A14SW/SD01, A14SW/SD02, and A14SW/SD03. All surface water and sediment samples were analyzed for TCL organics, nitramine compounds, TAL inorganics, TOC, cyanide, nitrate/nitrite, grain size (sediment only), and pH (sediment pH shall be measured in the laboratory). In addition, analyses for pH, temperature, DO, salinity, and specific conductivity were performed on surface water samples in the field immediately following sample collection. No organic compounds were detected in the surface water or sediment samples. Select analytical results are shown on Figures 2-34 and 2-35 for surface water and sediment inorganics, respectively.

An aquatic ecological investigation was conducted at each of the six surface water/sediment locations. These studies were used to assess potential ecological impacts to benthic macroinvertebrates and fish populations in the East Branch of Felgates Creek.

2.2.8.3 Site 18 Round Two RI Results Summary

Six surface soil samples were collected at Site 18. Three samples were collected from independent locations (18S11, 18S12, and 18S13 and from each of the three soil boring locations) later converted into monitoring wells (18GW01, 18GW02, and 18GW03). All of these samples were collected from the 0- to 6-inch bgs interval and were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, nitramine compounds, TAL inorganics, TOC, nitrate/nitrite, and pH. Two of the samples were analyzed for CEC. The sampling locations are shown on Figure 2-36. The three surface soil samples were identified as 18SS11, 18SS12, and 18SS13. This numbering scheme was developed to follow the Round One RI samples which ended with the designation 18SS10. The three surface soil samples collected in the soil boring locations were identified as 18SB01-00, 18SB02-00, and 18SB03-00. No organic compounds were detected in the surface soil samples. Select inorganic analytical results are shown on Figure 2-37.

Three soil borings (18GW01, 18GW02, and 18GW03) were advanced at Site 18 for collection of subsurface soil samples and installation of monitoring wells for groundwater sampling. Soil boring samples were analyzed for TCL organics, nitramine compounds, TAL inorganics, TOC, pH, and nitrate/nitrite. No organic compounds were detected in the subsurface soil samples. Select inorganic analytical results are shown on Figure 2-38.

One round of groundwater samples was collected from the three newly-installed monitoring wells at Site 18. Groundwater samples were analyzed for TCL organics, TAL inorganics (total and dissolved), TOC, nitrate, nitrite, TDS, TSS, bromide, chloride, orthophosphorous, sulfate, and dissolved methane. No organic compounds were detected in the groundwater samples. Select inorganic analytical results are shown in Figure 2-39.

Four surface water/sediment sampling stations were identified to characterize the area downstream of Site 18 as shown on Figure 2-40: 18SW/SD07 through 18SW/SD10. All surface water and sediment samples were analyzed for TCL organics, nitramine compounds, TAL inorganics, TOC,

nitrate/nitrite, cyanide, grain size (sediment only), and pH. In addition, analyses for pH, temperature, DO, salinity, and specific conductivity were performed on surface water samples in the field immediately following sample collection. No organic compounds were detected in the surface water samples. Select inorganic analytical results are shown on Figure 2-41 for surface water. Figure 2-42 shows the detected analytical results for organics and select inorganics for sediment. With respect to organics, PAHs and Aroclor-1254 were detected in sample 18SD07-01.

2.2.8.4 SSA 14 Round Two RI Results Summary

Four surface soil samples were collected at the soil boring/monitoring well locations (A14GW01, A14SB02, A14SB03, and A14SB04) from the 0- to 6-inch bgs interval. These samples were analyzed for TCL VOCs and SVOCs, TCL pesticides/PCBs, nitramine compounds, TAL inorganics, TOC, pH, CEC, and nitrate/nitrite. The four sampling locations are shown on Figure 2-43. The four surface soil samples were labeled A14SB01-00, A14SB02-00, A14SB03-00, and A14SS04-00. Select analytical results are shown on Figure 2-44. With respect to organics, PAHs were detected in two samples and an explosive (HMX) was detected in one sample. The detected HMX concentration was 1,700,000 µg/kg.

Four soil borings were advanced at the site and numbered A14SB01 through A14SB04. Three of the soil borings were located at the end of the discharge pipe on the stream bank of Felgates Creek to intercept contaminants that may have been discharged from the pipe. One soil boring was advanced upgradient of the discharge pipe (A14SB01) and then converted to a shallow monitoring well (A14GW01). Subsurface soil samples collected at SSA 14 were analyzed for TCL organics, nitramine compounds, TAL inorganics, TOC, and nitrate/nitrite. No organic compounds were detected in the soil samples. Select inorganic analytical results are shown on Figure 4-45.

One groundwater sample was collected from the newly-installed monitoring well at SSA 14. The groundwater sample was analyzed for TCL organics and TAL inorganics (total and dissolved), TOC, nitrate/nitrite, TDS, TSS, bromide, chloride, orthophosphate, sulfate, and dissolved methane. Select analytical results are shown on Figure 2-46. With respect to organics, VOCs and explosives were detected in the groundwater sample.

2.3 Nature and Extent of Contamination

A summary of the nature and extent of contamination at Sites 2, 8, and 18 and SSA 14 based on the results of the Round Two RI is presented below.

2.3.1 Nature and Extent of Contamination at Site 2

With respect to organic compounds, PAHs, a PCB compound, and a nitramine compound were detected in surface soil at Site 2 (based on the Removal Action confirmatory soil samples). PAHs were detected in the majority of the 40 confirmatory samples around the perimeter of the landfill area. PCBs were detected in five samples and a nitramine in one sample. There was no discernible pattern to the surface soil detections, which probably reflects the random nature of disposal at Site 2.

With respect to inorganic analytes detected in the confirmatory samples, arsenic, aluminum, antimony, cadmium, copper, iron, manganese, mercury, and thallium were detected in surface soil at Site 2. Iron and arsenic were most prevalent. Detections of inorganics in surface soil at Site 2 may result from disposal of metallic debris.

PAHs and a single detection of a PCB compound were noted in subsurface soil at Site 2. Detections occurred in a random pattern around the perimeter of the landfill. Because surface and subsurface soil samples were collected from different locations during different investigations, no comparisons can be made between surface and subsurface contamination.

Two VOCs (1,2-DCE and vinyl chloride) were identified in a single groundwater sample from the toe of the former landfill area. Thallium was detected in a majority of the groundwater samples; it often occurred with manganese and iron. Arsenic, barium, and aluminum were also detected. Generally, filtered and unfiltered groundwater results were consistent.

No organic compounds were detected in the Site 2 surface water samples. The only inorganic analytes detected included arsenic, beryllium, cadmium, and iron.

PAHs were detected in sediment at Site 2, primarily in a single location. This may reflect transport of PAH-contaminated soil from the former landfill area. Inorganics detected in the sediments were similar to those detected in surface soil, with one exception. Silver was noted in sediments from the

western tributary, but it is not related to Site 2; rather, it appears to originate upstream potentially from another SSA at the Station (i.e., SSA 10).

2.3.2 Nature and Extent of Contamination at Site 8

With respect to organic compounds, the surface soil at Site 8 was contaminated with PAHs, nitramines, and a single, relatively high detection of a PCB compound. The organic surface soil contamination was concentrated in the drainage way leading from Building 456 to Felgates Creek. Inorganic analytes were ~~detected in surface soil at~~ Site 8. Iron and arsenic were the most prevalent; aluminum was also widespread. Beryllium, chromium, manganese, and thallium were also detected. Explosives were detected in one subsurface soil sample. Inorganic detections were consistent with surface soil. Soil contamination appears to be confined to surface intervals at Site 8.

VOCs and nitramines were detected in all five groundwater samples collected at Site 8. Thallium was the most prevalent inorganic detected.

No organic compounds were detected in either the surface water or the sediment from the East Branch of Felgates Creek. Iron and arsenic were detected in all surface water samples, and antimony was detected in a majority of the surface water samples. Aluminum, iron, arsenic, beryllium, and manganese were detected in all sediment samples. Chromium was noted in a majority of the sediment samples. Based upon these results, organic contaminants from Site 8 (and SSA 14) do not appear to be affecting Felgates Creek.

2.3.3 Nature and Extent of Contamination at Site 18

No organic contaminants were detected in the surface or subsurface soil, the groundwater, or the surface water at Site 18. Iron and arsenic occurred in the surface soil samples; iron, arsenic, aluminum, chromium, manganese, and vanadium were detected in the subsurface soil samples. No inorganic analytes were detected in the filtered groundwater samples.

PAHs and a PCB compound were detected in a single sediment sample at Site 18. Since these compounds were not detected elsewhere on the site, they probably reflect the impact of the industrial area on sediments at Site 18.

Inorganic analytes detected in the sediments were similar to those detected in the surface soil, with the exception of thallium. Arsenic and iron were detected in all sediment samples; thallium was detected in the sediment samples collected from the deeper interval.

2.3.4 Nature and Extent of Contamination at SSA 14

PAHs and a single nitramine were found in the surface soil of the drainage way at SSA 14. However, no organic contamination was detected in the subsurface soil. Therefore, organic contamination appears to be confined to the surface. Iron and aluminum occurred in all surface soil samples; aluminum, arsenic, beryllium, iron, and thallium occurred in all of the subsurface soil samples.

VOCs and nitramines were detected in groundwater from the single monitoring well installed at SSA 14. Inorganics detected in the groundwater included arsenic, manganese, and thallium.

2.4 Baseline Risk Assessment Summary

A baseline human health RA and an ecological RA were conducted for Sites 2, 8, and 18, and SSA 14 under the Round Two RI. The human health RA conclusions were based on an evaluation of potential carcinogenic and noncarcinogenic risks. Carcinogenic risks in terms of incremental lifetime cancer risks (ICRs) were compared to USEPA's acceptable target risk range of 1.0×10^{-06} to 1.0×10^{-04}. Noncarcinogenic risks in terms of hazard indices (HIs) were compared to USEPA's acceptable value of 1.0.

With respect to ecological risks, the terrestrial environment was assessed on a screening of site soil concentrations against flora/fauna toxicity values. In addition, receptor models were calculated. The aquatic environment was assessed with a comparison to aquatic benchmark values (if available) and aquatic receptor modeling.

The following subsections summarize the results of these RAs for each site.

2.4.1 Risk Assessment Summary for Site 2

The only risk values in exceedence of USEPA acceptable target risk criteria for human health at Site 2 were estimated for future residents. Carcinogenic and noncarcinogenic risks estimated for the other potential receptors evaluated for the site were less than, or within the appropriate USEPA acceptable target risk criteria.

Future young child residents were evaluated for exposures to surface soil contaminants of potential concern (COPCs) at Site 2 as well as exposures to shallow groundwater under a beneficial use scenario. The total Site 2 ICR estimated for this receptor group was within USEPA's acceptable target ICR range; however, the total site HI (6.0) exceeded the target value of 1.0 due to ingestion of cadmium, iron, and Aroclor-1254 and dermal exposures to cadmium in surface soil. It should be noted that all hazard quotients (HQs) estimated for iron and Aroclor-1254 are less than 1.0; however, the individual HQs in both the ingestion and dermal contact scenario for cadmium were greater than 1.0. The total central tendency (CT) HI was also greater than unity (1.9); however, the CT scenario results demonstrated acceptable individual HI values for the ingestion and dermal contact with surface soil by future young children.

Future adult residents were evaluated for exposures to surface soil COPCs at Site 2 as well as exposures to shallow groundwater under a beneficial use scenario. The total Site 2 ICR estimated for this receptor group was within USEPA's acceptable target ICR range; however, the total site HI (1.6) exceeded the target value of 1.0 due to ingestion and dermal exposures to cadmium in surface soil. It should be noted that all individual HQs estimated for cadmium are less than unity. In addition, it should also be noted that an evaluation of the same scenarios under CT exposure assumptions yielded a total site HI of 0.47, which is an acceptable value since it is less than USEPA's acceptable target value of 1.0.

The terrestrial ecological RA conducted at Site 2 included the evaluation of surface soil samples. Surface soil concentrations of benzo(a)pyrene, aluminum, antimony, cadmium, chromium, cobalt, copper, iron, mercury, silver, thallium, vanadium, and zinc present potential risks to surface soil flora and fauna. In addition, soil concentrations of fluoranthene, phenanthrene, pyrene, Aroclor-1254, aluminum, antimony, cadmium, chromium, cobalt, copper, iron, lead, mercury, thallium, and vanadium pose potential risks to the higher trophic level terrestrial receptors. Of the contaminants

potentially posing a risk to the terrestrial environment, surface soil concentrations of benzo(a)pyrene, fluoranthene, phenanthrene, pyrene, Aroclor-1254, antimony, cadmium, cobalt, copper, lead, mercury, silver, thallium, and zinc were detected above background surface soil concentrations.

Surface water and sediment samples were assessed in the tidal freshwater aquatic ecological RA conducted in the Eastern Branch of Felgates Creek at Site 2. Surface water concentrations were not compared to surface water benchmark values because there were no benchmark values located for the tidal freshwater ecological contaminants of concern (ECOCs) identified. Based on conservative screening the following surface water contaminants were identified as potential risks to the aquatic environment: 2,4,6-trinitrotoluene (TNT), aluminum, copper, iron, manganese, and nickel. Of these contaminants, concentrations of TNT and copper were detected above the range of background concentrations for tidal freshwater streams.

2.4.2 Risk Assessment Summary for Site 8

At Site 8, the risk values in exceedence of USEPA acceptable risk criteria for human health were estimated for the current maintenance workers, future construction workers, and future residents. Carcinogenic and noncarcinogenic risks estimated for the other potential receptors evaluated for Site 8 were less than, or within the appropriate USEPA target risk criteria.

Current adult maintenance workers were evaluated for exposures to surface soil COPCs at SSA 14 and surface water and sediment COPCs for Site 8 and SSA 14. The total SSA 14 ICR estimated for this receptor group was within USEPA's acceptable target ICR range; however, the total site HI (1.9) exceeded the target value of 1.0 due to dermal exposures to HMX in the surface soil; ingestion and dermal exposures to antimony in surface water; and ingestion of iron in the sediment. However, since all HQs estimated for HMX, antimony, and iron were less than 1.0, and HMX, antimony, and iron HQs are not additive since they target different organs, no real adverse health effects are expected for this receptor subsequent to exposure although the total site HI exceeds 1.0.

Future adult construction workers were evaluated for exposures to subsurface soil COPCs at Site 8. The total Site 8 ICR estimated for this receptor group was within USEPA's acceptable target ICR range; however, the total site HI (1.3) exceeded the target value of 1.0 because of ingestion of iron

and arsenic in subsurface soil. However, since all HQs estimated for iron and arsenic are less than 1.0, and iron and arsenic HQs are not additive since they target different organs, no real adverse health effects are expected for this receptor subsequent to exposure, although the total site HI exceeds 1.0.

Future young child residents were evaluated for exposures to surface soil COPCs at Site 8 as well as exposures to shallow groundwater under a beneficial use scenario. The total site ICR estimated for this receptor was within USEPA's acceptable target risk range; however, the total site HI (5.1) exceeds USEPA's acceptable target value of 1.0. This exceedence was due primarily to surface soil accidental ingestion exposures of young children to iron and 4-amino-2,6-dinitrotoluene; dermal exposures to 4-amino-2,6-DNT in surface soil; and ingestion of amino-DNTs in the shallow groundwater. The individual HQ values for iron in the surface soil for the ingestion pathway and amino-DNTs in the shallow groundwater were greater than unity. It should be noted that an evaluation of the same scenarios under CT exposure assumptions yielded a total site HI of 3.0, and the individual HQ value for amino-DNTs in the ingestion scenario for shallow groundwater was still greater than unity.

Future adult residents were evaluated for exposures to surface soil COPCs at Site 8 as well as exposures to shallow groundwater under a beneficial use scenario. The total site ICR estimated for this receptor was within USEPA's acceptable target risk range; however, the total site HI (1.3) exceeded the corresponding USEPA acceptable target risk criteria. This exceedence was due primarily to surface soil accidental ingestion exposures to iron and 4-amino-2,6-DNT and dermal exposures to 4-amino-2,6-DNT in surface soil. It should be noted that all individual HQs estimated for this receptor are less than unity. In addition, it should also be noted that an evaluation of the same scenarios under CT exposure assumptions yielded a total site HI of 0.84, which is an acceptable value since it is less than USEPA's acceptable target value of 1.0.

Surface soil was assessed in the terrestrial ecological RA conducted at Site 8. Surface soil concentrations of RDX, aluminum, antimony, chromium, copper, iron, lead, mercury, thallium, vanadium, and zinc present potential risks to surface soil flora and fauna. Soil concentrations of Aroclor-1260, aluminum, antimony, chromium, copper, iron, lead, mercury, vanadium, and zinc pose potential risks to the higher trophic level terrestrial receptors. Of the contaminants posing a potential

risk at this site, concentrations of RDX, Aroclor-1260, aluminum, chromium, copper, lead, mercury, thallium, and zinc were detected above the range of background concentrations.

Surface water and sediment collected from the East Branch of Felgates Creek at Site 8/SSA 14 were evaluated in this ecological assessment. Surface water concentrations were not compared to surface water benchmark values because there were no benchmark values located for the tidal freshwater ECOCs identified. Based on conservative screening the following surface water contaminants were identified as potential risks to the aquatic environment: aluminum, iron, manganese, and nickel. Only concentrations of manganese were detected above the range of background tidal freshwater surface water concentrations.

2.4.3 Risk Assessment Summary for Site 18

At Site 18, the only risk values in exceedence of USEPA acceptable target risk criteria for human health were estimated for the future construction workers. Carcinogenic and noncarcinogenic risks estimated for all other receptors were less than, or within the appropriate USEPA target risk criteria.

Future adult construction workers were evaluated for exposures to subsurface soil COPCs at Site 18. The total Site 18 ICR estimated for this receptor group was within USEPA's acceptable target ICR range; however, the total site HI (2.0) exceeded the target value of 1.0 because of ingestion of iron and arsenic in subsurface soil. However, since all HQs estimated for iron and arsenic are less than 1.0, and iron and arsenic HQs are not additive since they target different organs, no real adverse health effects are expected for this receptor subsequent to exposure, although the total site HI exceeds 1.0.

Surface soil was assessed in the terrestrial ecological RA conducted at Site 18. Surface soil concentrations of aluminum, chromium, iron, mercury, and vanadium present potential risks to surface soil flora and fauna. Soil concentrations of aluminum, chromium, copper, iron, lead, mercury, and vanadium pose potential risks to the higher trophic level terrestrial receptors. Of the contaminants posing a potential risk to the terrestrial environment at Site 18, only one concentration of mercury was detected slightly above the range of background concentrations.

The aquatic environment at Site 18 was evaluated in this assessment. Surface water and sediment were assessed in the freshwater drainage way at Site 18. Surface water concentrations of aluminum, copper, and iron pose a potential risk to aquatic species inhabiting this drainage way. Surface water concentrations of aluminum and copper were detected above the range of background freshwater surface water concentrations.

Sediment concentrations of pyrene, alpha-chlordane, gamma-chlordane, Aroclor-1254, beryllium, and iron pose potential risks to benthic receptors at Site 18. Sediment concentrations of copper, iron, and lead demonstrated potential risks in the aquatic receptor models. Of the contaminants posing potential risks to the aquatic environment, sediment concentrations of pyrene, alpha-chlordane, gamma-chlordane, Aroclor-1254, copper, and iron exceeded background concentrations.

2.4.4 Risk Assessment Summary for SSA 14

At SSA 14, the only risk values in exceedence of USEPA acceptable target risk criteria for human health were estimated for the current maintenance workers, current and future recreational users and trespassers, and future residents. Carcinogenic and noncarcinogenic risks estimated for all other receptors were less than, or within the appropriate USEPA target risk criteria.

Current adult maintenance workers were evaluated for exposures to surface soil COPCs at SSA14 and surface water and sediment COPCs for Site 8 and SSA 14. The total SSA 14 ICR estimated for this receptor group was within USEPA's acceptable target ICR range; however, the total site HI (1.9) exceeded the target value of 1.0 due to dermal exposures to HMX in the surface soil; ingestion and dermal exposures to antimony in surface water; and ingestion of iron in the sediment. However, since all HQs estimated for HMX, antimony, and iron were less than 1.0, and HMX, antimony, and iron HQs are not additive since they target different organs, no real adverse health effects are expected for this receptor subsequent to exposure although the total site HI exceeds 1.0.

Current recreational users and trespassers were evaluated for exposures to surface soil COPCs at SSA 14 and surface water and sediment COCPs at Site 8 and SSA 14. The total site ICRs estimated for the adult recreational users and trespassers and the adolescent recreational users and trespassers were within USEPA's acceptable target ICR range; however, the total site HI (1.1 for the adult and

1.6 for the adolescent) exceeded the target value of 1.0 due to dermal exposure to HMX in surface soil. It should be noted that the individual HQ for dermal contact with HMX in surface soil for the adolescent receptor was greater than unity; therefore, adverse health effects may be expected for this receptor subsequent to exposure.

Future young child residents were evaluated for exposures to surface soil COPCs at SSA 14 as well as exposures to shallow groundwater under a beneficial use scenario. The total site ICR estimated for this receptor was within USEPA's acceptable target risk range; however, the total site HI (17) exceeds USEPA's acceptable target value of 1.0. This exceedence was due primarily to surface soil accidental ingestion exposures of young children to iron and HMX and dermal exposures to HMX in surface soil. The individual HQ values for iron in the surface soil for the ingestion pathway and HMX in surface soil for the ingestion and dermal contact pathways were greater than unity. It should be noted that an evaluation of the same scenarios under CT exposure assumptions yielded a total site HI of 8.2, and the individual HQ value for HMX in the ingestion and dermal contact scenarios for surface soil was still greater than unity.

Future adult residents were evaluated for exposures to surface soil COPCs at SSA 14 as well as exposures to shallow groundwater under a beneficial use scenario. The total site ICR estimated for this receptor was within USEPA's acceptable target risk range; however, the total site HI (6.1) exceeds USEPA's acceptable target value of 1.0. This exceedence was due primarily to dermal exposures to HMX in surface soil. The individual HQ value for HMX in surface soil for the dermal contact pathway was greater than unity. It should be noted that an evaluation of the same scenarios under CT exposure assumptions yielded a total site HI of 3.7, and the individual HQ value for HMX in the dermal contact scenario for surface soil was still greater than unity.

Surface water and sediment collected from the East Branch of Felgates Creek at Site 8/SSA 14 were evaluated in this ecological assessment. Surface water concentrations were not compared to surface water benchmark values because there were no benchmark values located for the tidal freshwater ECOCs identified. Based on conservative screening the following surface water contaminants were identified as potential risks to the aquatic environment: aluminum, iron, manganese, and nickel. Only concentrations of manganese were detected above the range of background tidal freshwater surface water concentrations.

Sediment concentrations of BEHP, beryllium, and copper pose potential risks to benthic receptors within Felgates Creek. In addition, sediment concentrations of aluminum, copper, and iron demonstrated potential risks in the aquatic receptor models. Of the contaminants posing potential risks to the aquatic environment, sediment concentrations of BEHP, beryllium, and copper exceeded background concentrations.

SECTION 2.0 FIGURES

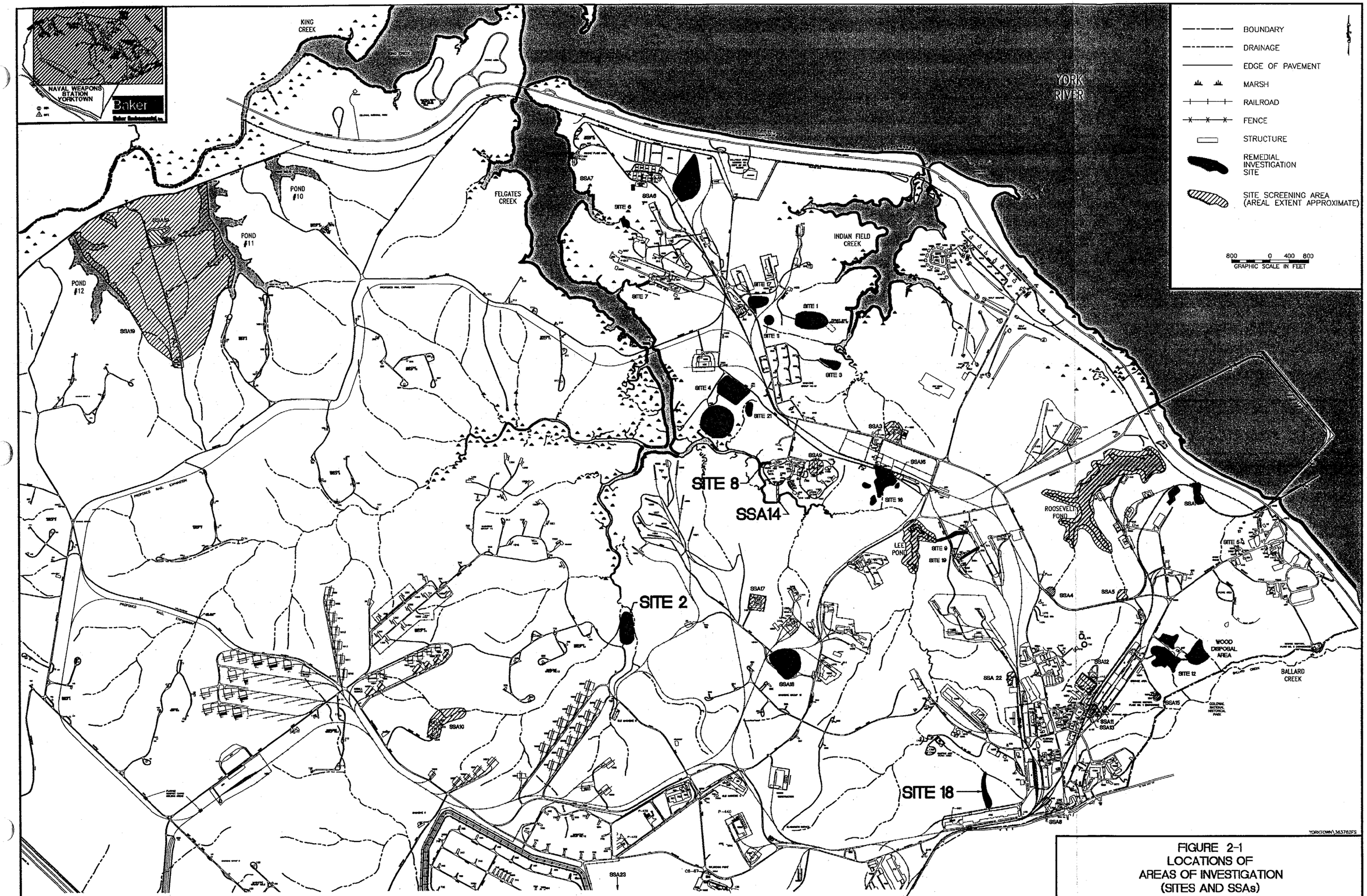
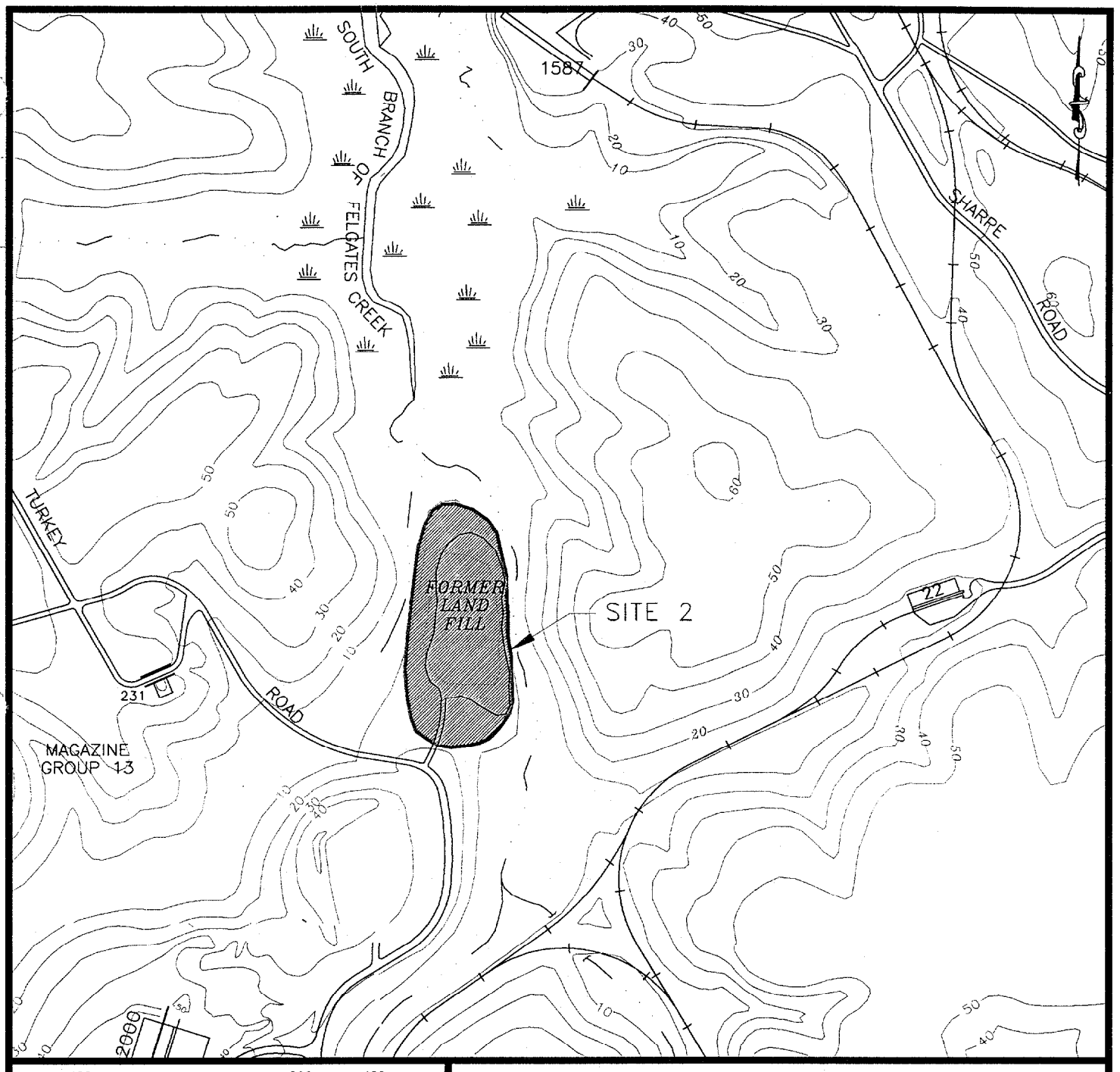


FIGURE 2-1
LOCATIONS OF
AREAS OF INVESTIGATION
(SITES AND SSAs)

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA

SOURCE: NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA.

01764F012



400 0 200 400

1 inch = 400 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

MARSH

FENCE

STRUCTURE

APPROXIMATE SITE BOUNDARY

10 GROUND SURFACE CONTOUR (FT., MSL)

363700FS

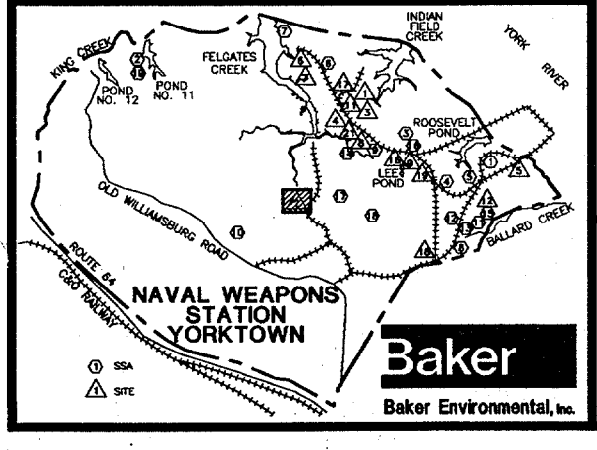
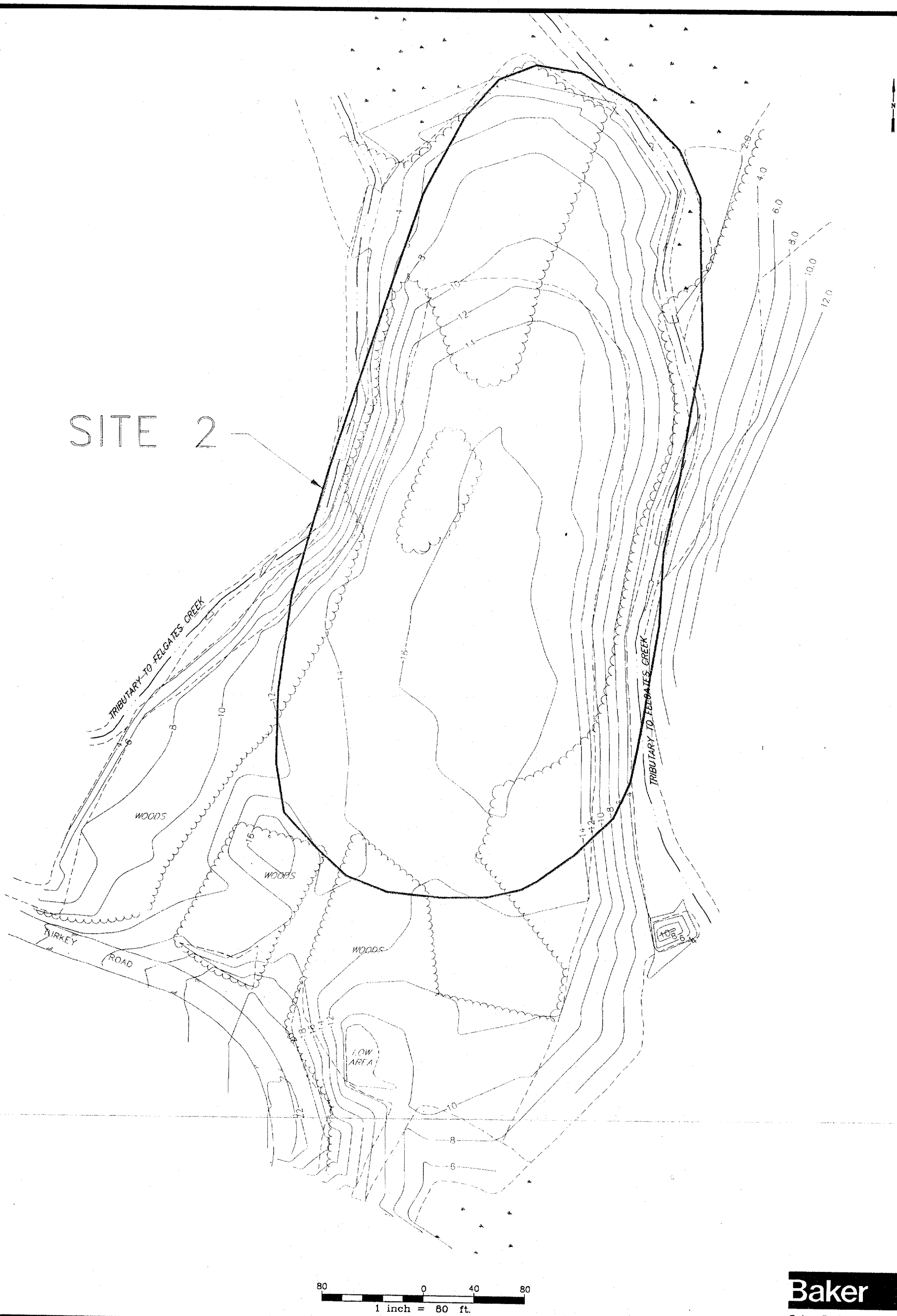


FIGURE 2-2
SITE VICINITY MAP
SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



363778FS

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LEGEND

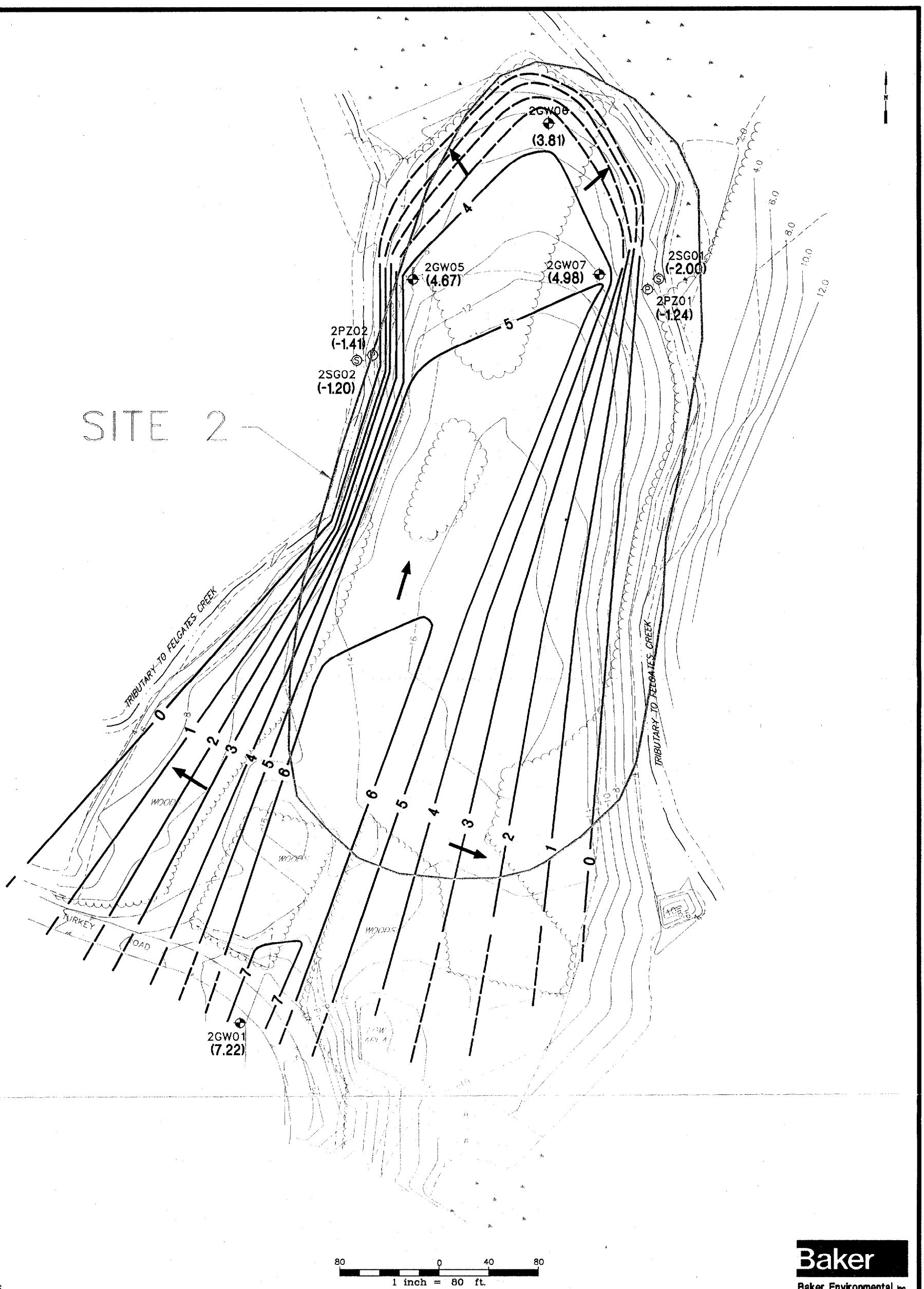
- TREE LINE
- 10 — GROUND SURFACE CONTOUR (FT., MSL)
- APPROXIMATE SITE BOUNDARY

SOURCE: MILLER-STEPHENSON AND ASSOCIATES, NOV. 1997.

FIGURE 2-3
DETAILED SITE MAP
SITE 2

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

01764FB2Z



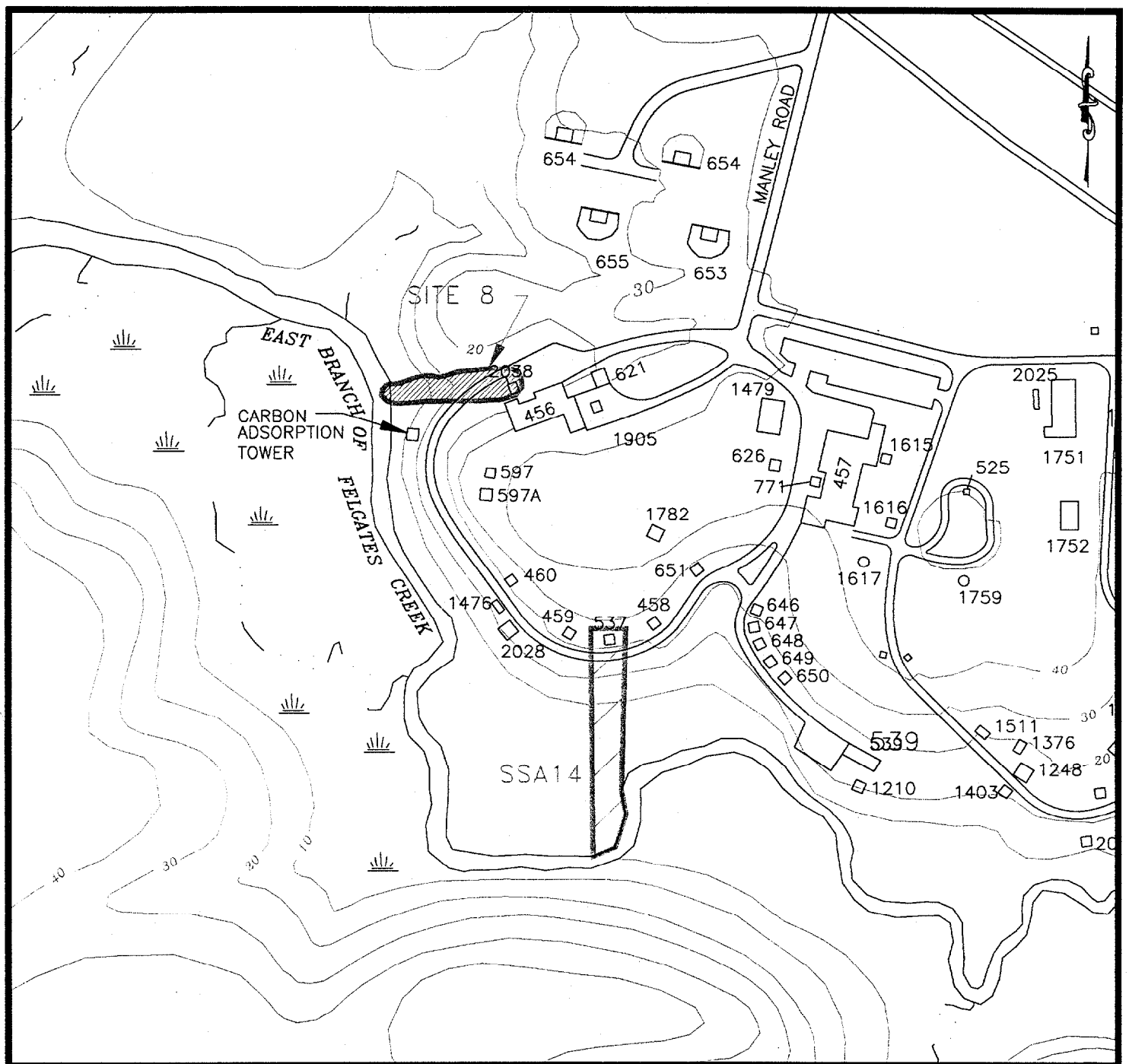
LEGEND

- 2GW01 – EXISTING MONITORING WELL (DAMES & MOORE 1986)
- 2GW05 – MONITORING WELL (BAKER 1997)
- —5— – GROUNDWATER CONTOUR LINE (ESTIMATED)
- — — – GROUNDWATER CONTOUR LINE (PROJECTED)
- → – GROUNDWATER FLOW DIRECTION
- (7.22) – GROUNDWATER ELEVATION, MEAN SEA LEVEL (MSL)
- – TREE LINE
- 2SG01 – STAFF GAUGE
- 2PZ01 – PIEZOMETER
- –10– – GROUND SURFACE CONTOUR (FT., MSL)

SOURCE: MILLER–STEPHENSON AND ASSOCIATES, NOV. 1997.

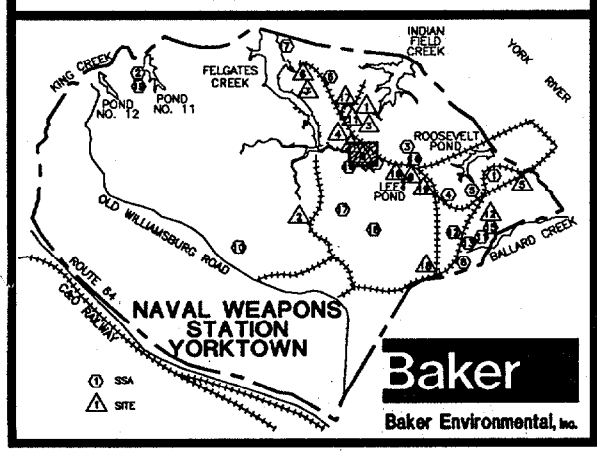
FIGURE 2-4
GROUNDWATER CONTOUR MAP
MARCH 20, 1997
SITE 2

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA



250 0 125 250

1 inch = 250 ft.



WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

MARSH

STRUCTURE

APPROXIMATE SITE BOUNDARY

10 GROUND SURFACE CONTOUR (FT., MSL)

363706FS

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FIGURE 2-5
SITE VICINITY MAP
SITE 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

363779FS

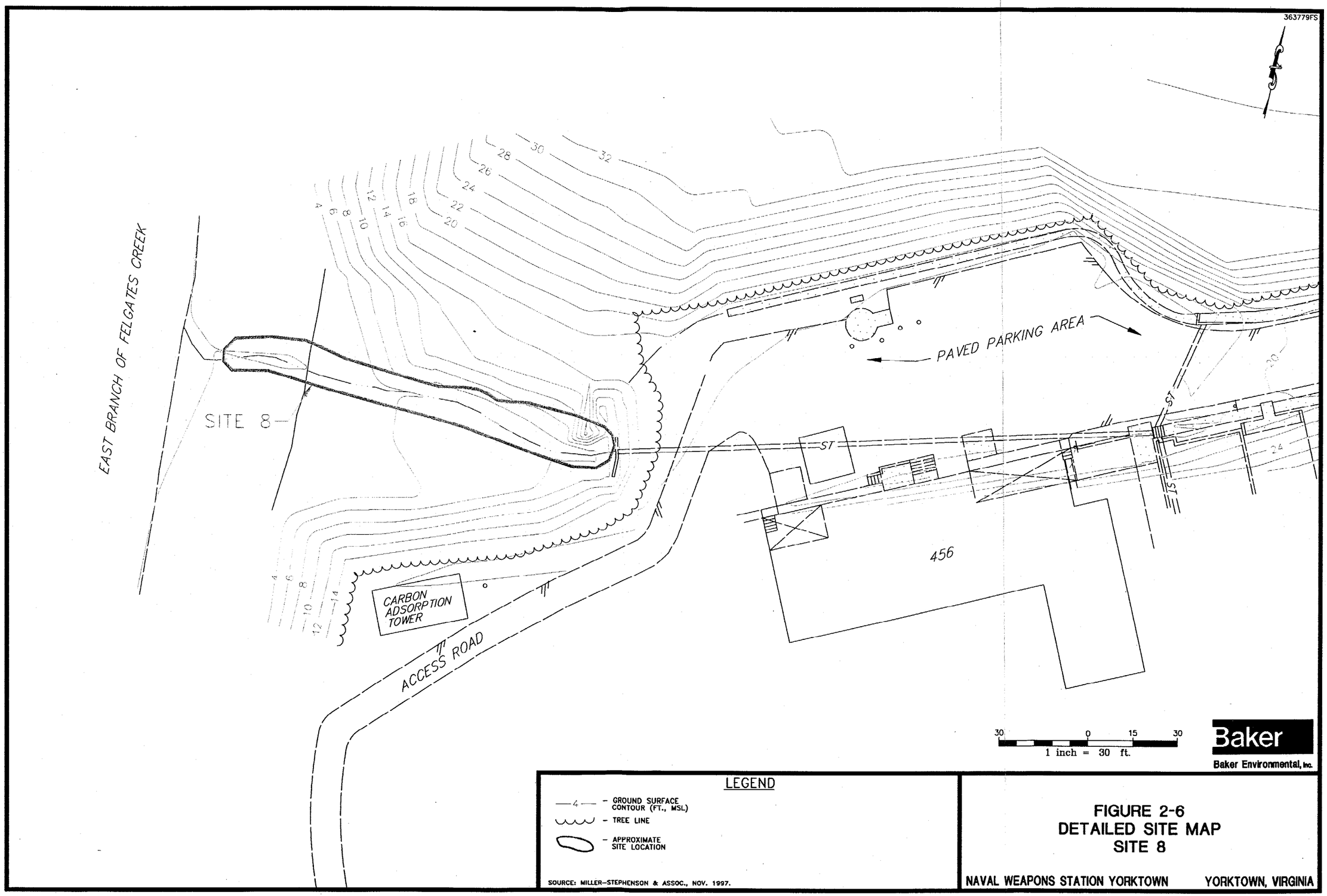
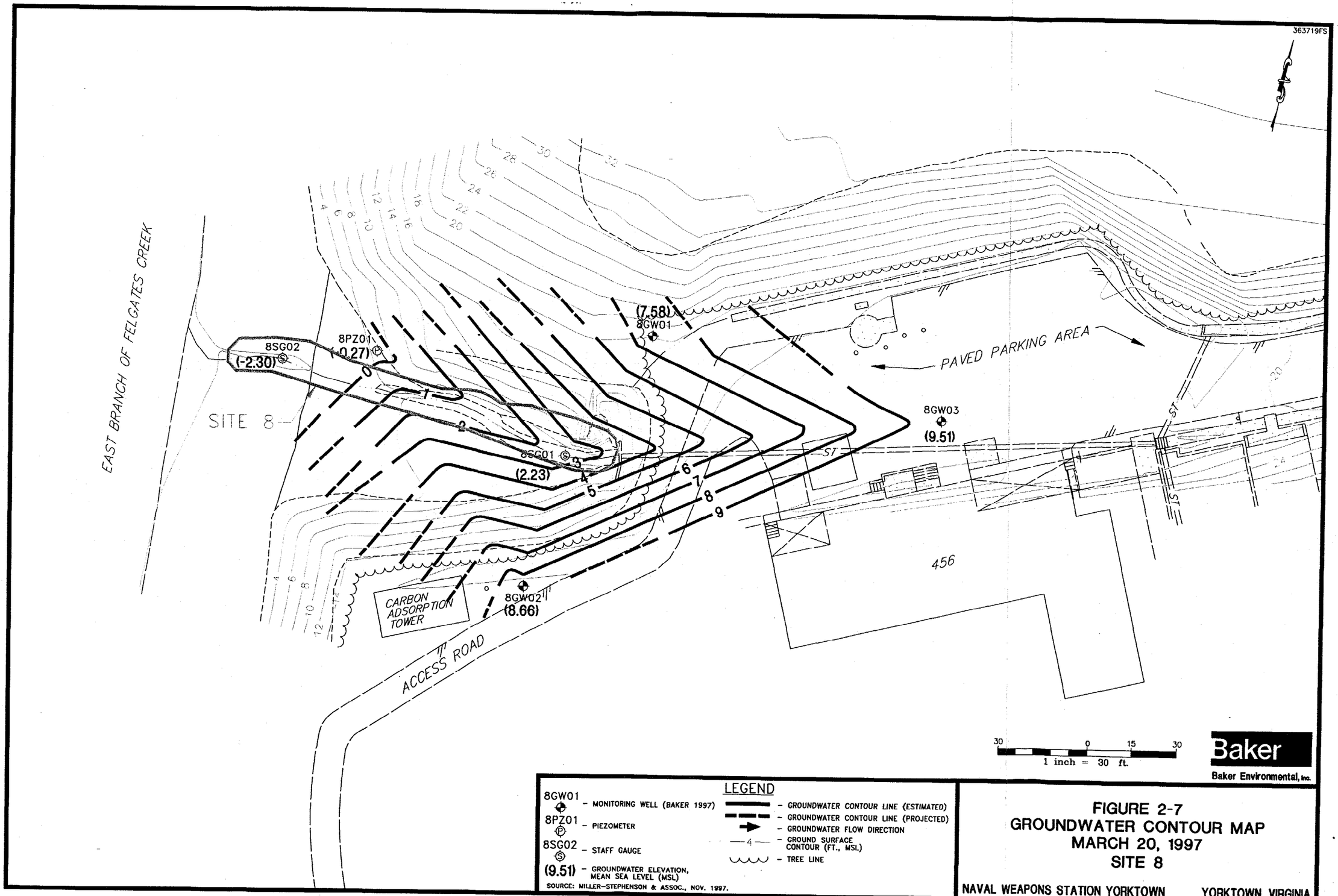
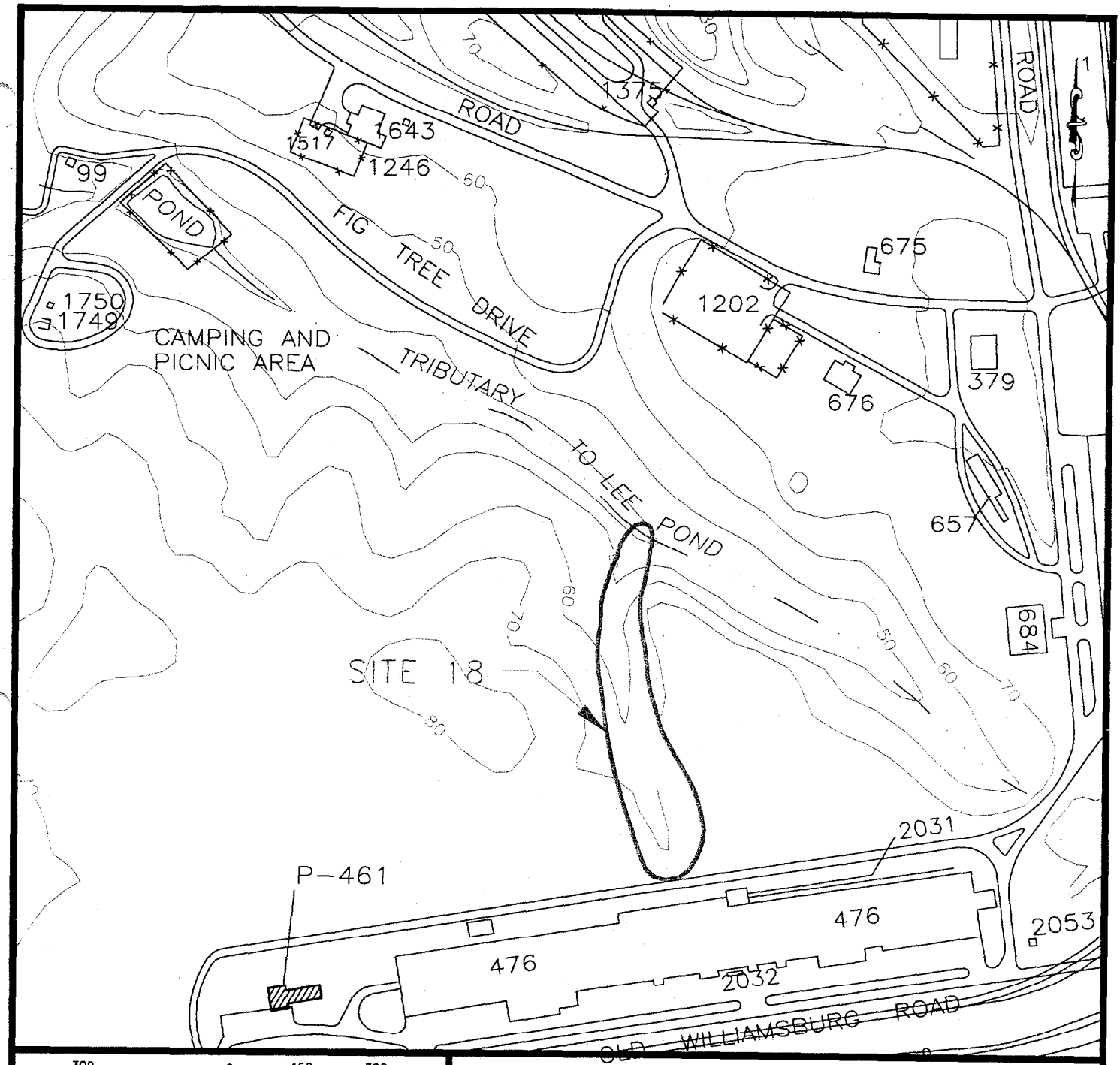


FIGURE 2-6
DETAILED SITE MAP
SITE 8

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

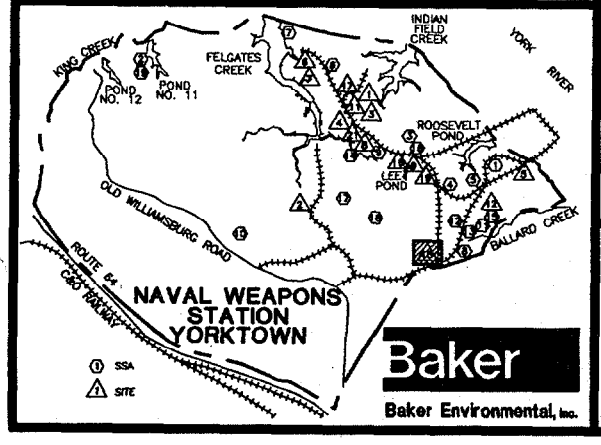
01764FB32


363719FS
EAST BRANCH OF FELGATES CREEK
SITE 8
8SG02
(-2.30)
8PZ01
(0.27)
8SG01
(2.23)
8GW01
(7.58)
8GW02
(8.66)
8GW03
(9.51)
PAVED PARKING AREA
CARBON ADSORPTION TOWER
ACCESS ROAD
456
ST
30 0 15 30
1 inch = 30 ft.
Baker
Baker Environmental, Inc.
LEGEND
8GW01 - MONITORING WELL (BAKER 1997)
8PZ01 - PIEZOMETER
8SG02 - STAFF GAUGE
(9.51) - GROUNDWATER ELEVATION, MEAN SEA LEVEL (MSL)
SOURCE: MILLER-STEPHENSON & ASSOC., NOV. 1997.
- GROUNDWATER CONTOUR LINE (ESTIMATED)
- GROUNDWATER CONTOUR LINE (PROJECTED)
- GROUNDWATER FLOW DIRECTION
- GROUND SURFACE CONTOUR (FT., MSL)
- TREE LINE
FIGURE 2-7
GROUNDWATER CONTOUR MAP
MARCH 20, 1997
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



300 0 150 300

1 inch = 300 ft.



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WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

FENCE

STRUCTURE

APPROXIMATE SITE BOUNDARY

50 GROUND SURFACE CONTOUR (FT., MSL)

363710FS

FIGURE 2-8
SITE VICINITY MAP
SITE 18

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

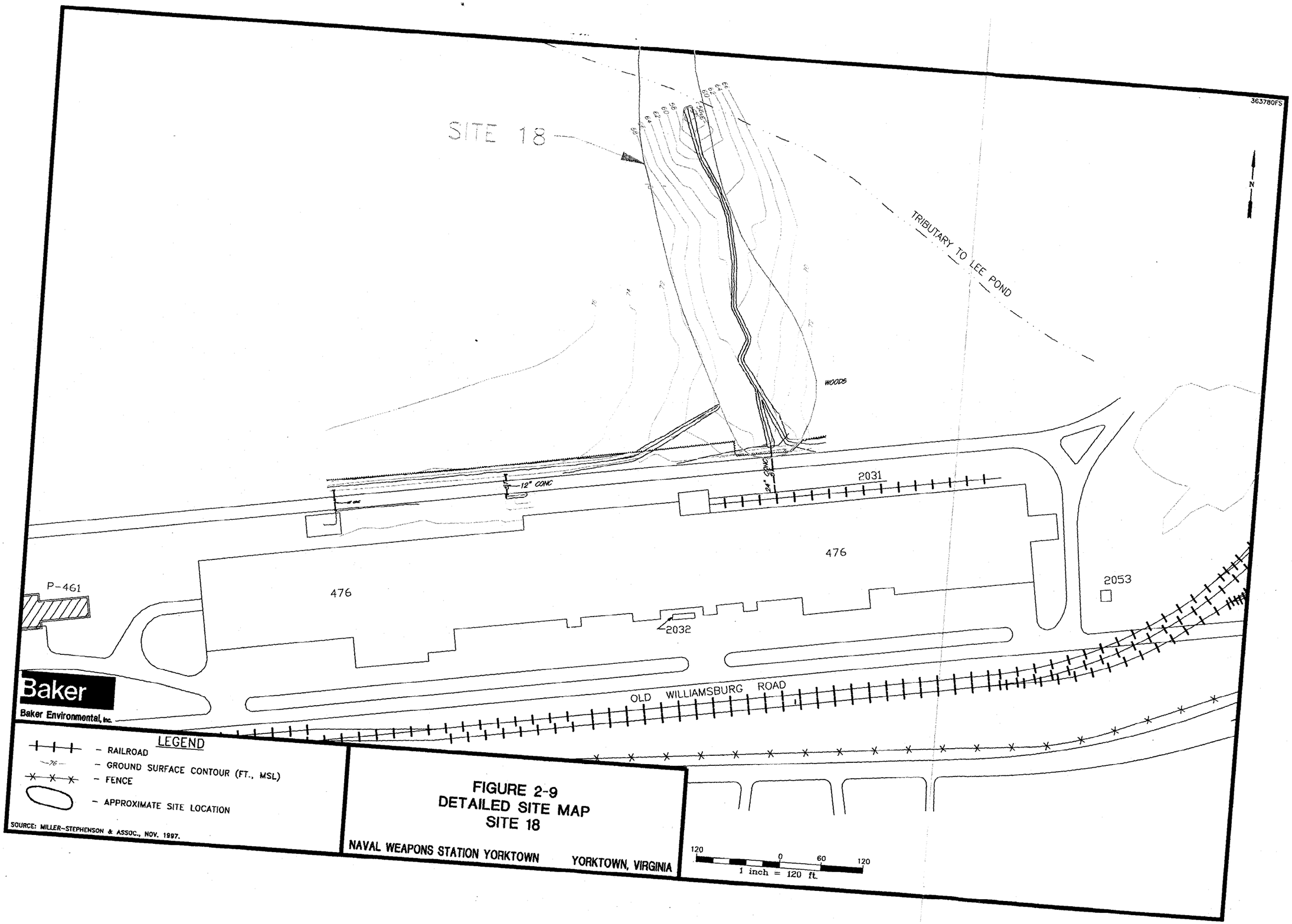


FIGURE 2-9
DETAILED SITE MAP
SITE 18

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

01764FR47

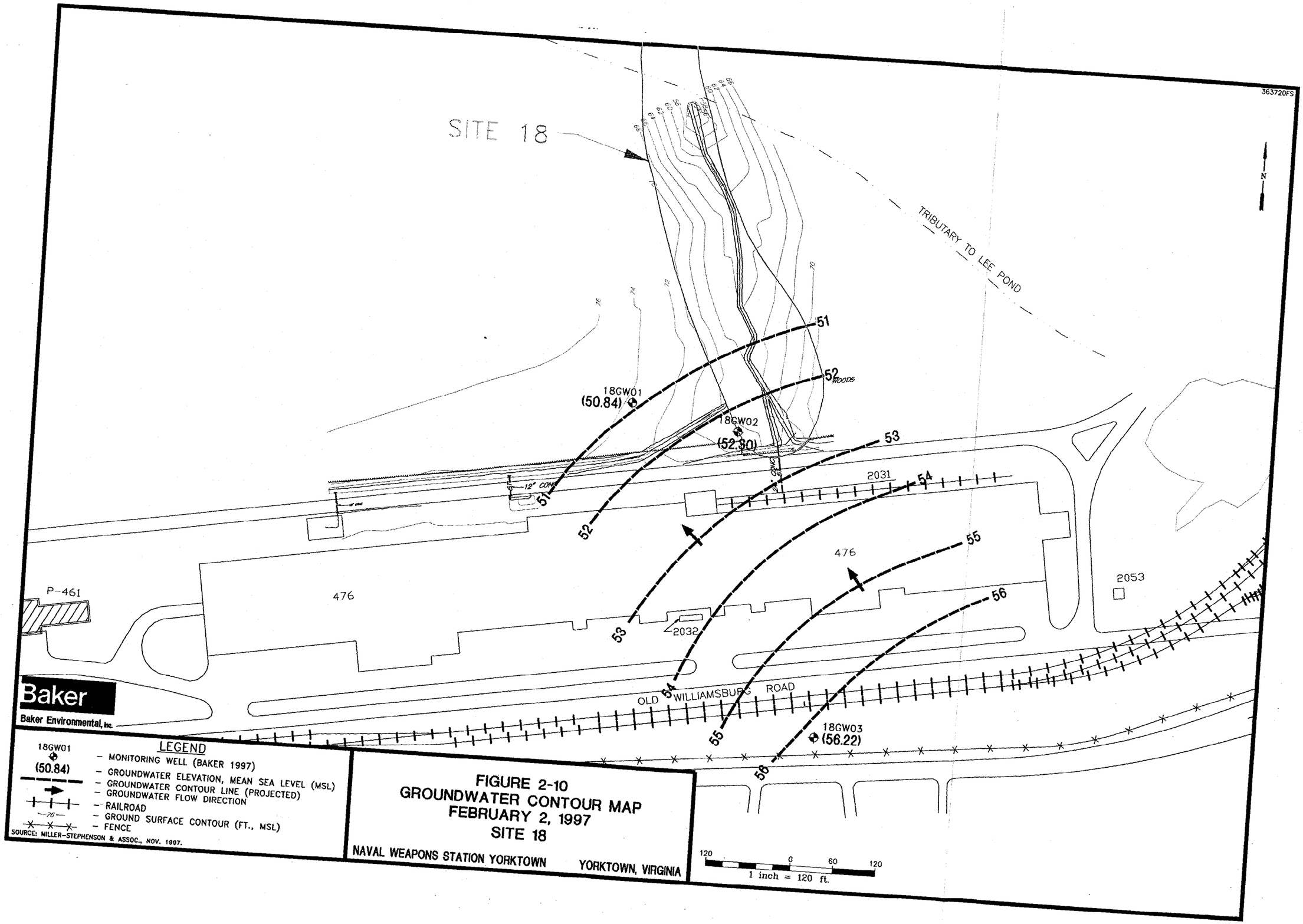
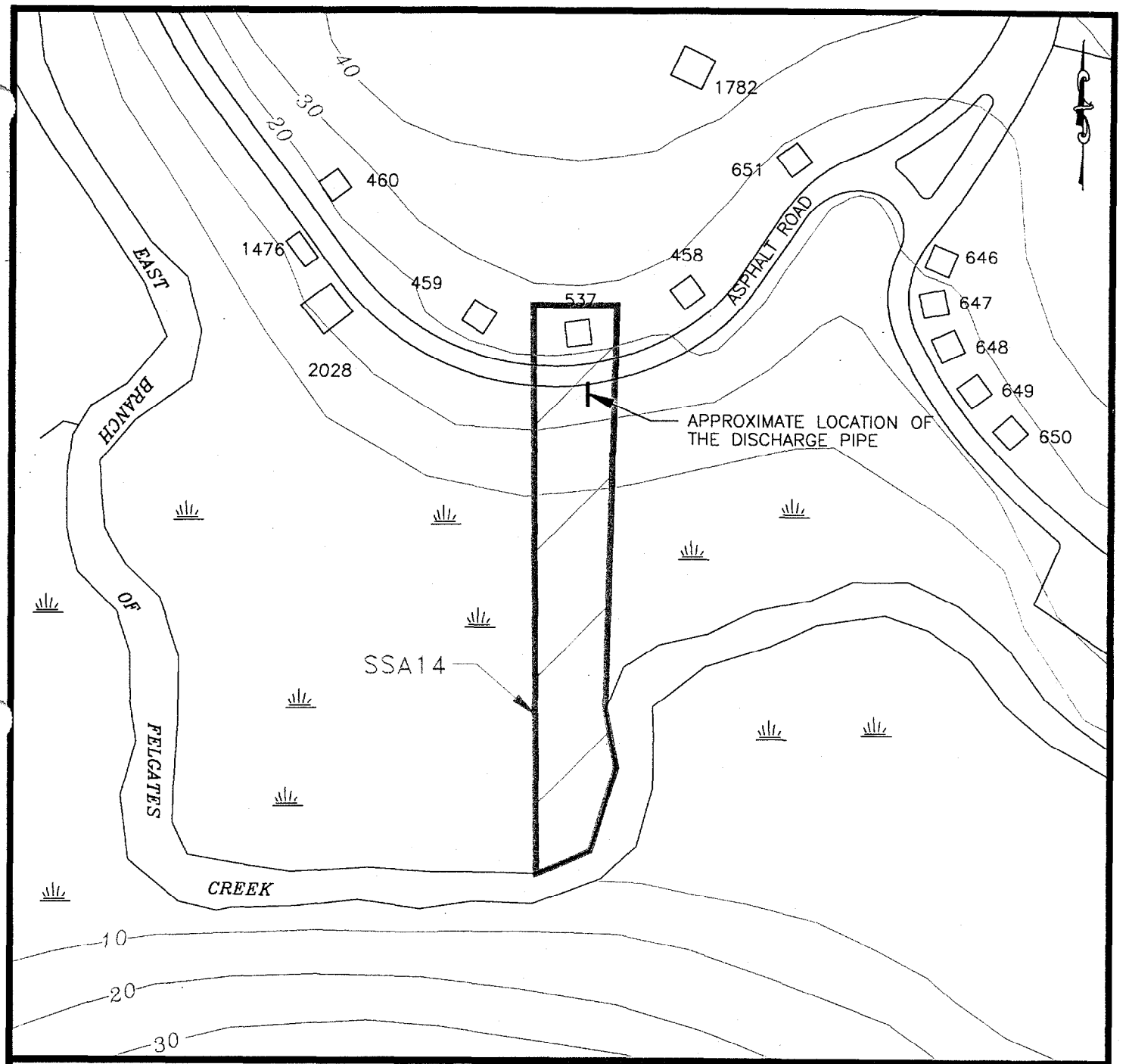


FIGURE 2-10
GROUNDWATER CONTOUR MAP
FEBRUARY 2, 1997
SITE 18

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



100 0 50 100

1 inch = 100 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

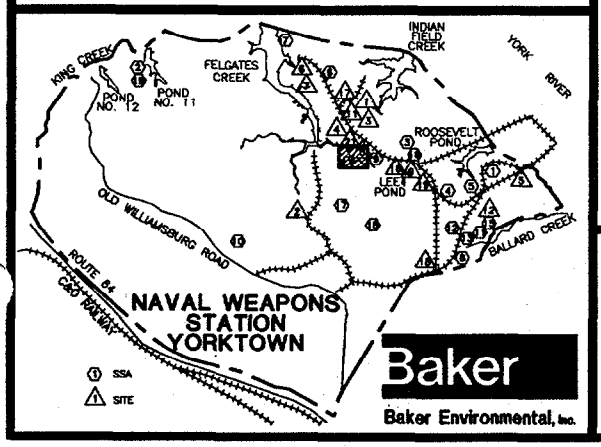
MARSH

STRUCTURE

APPROXIMATE SSA BOUNDARY

10 GROUND SURFACE CONTOUR (FT., MSL)

363781FS



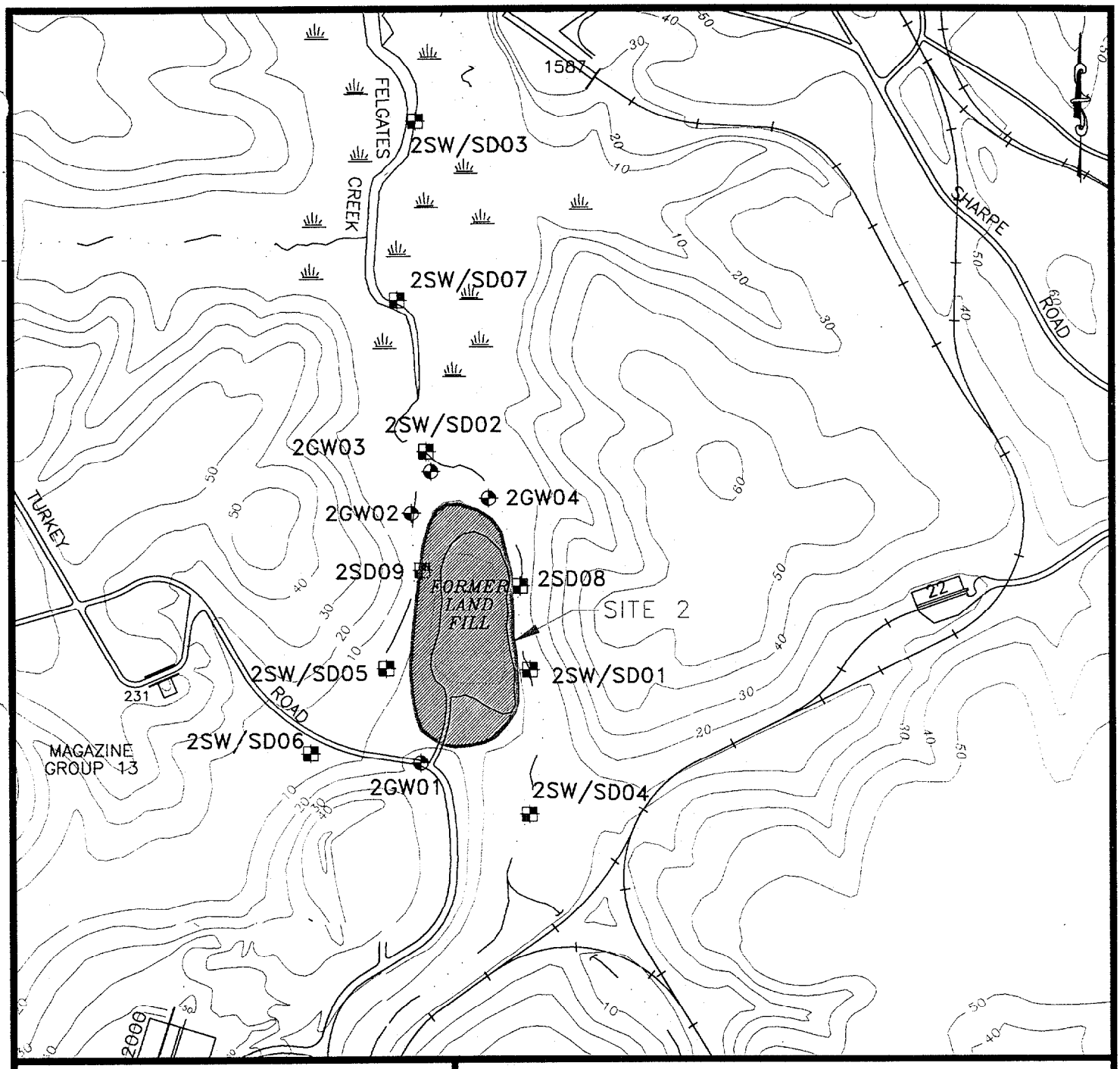
Baker

Baker Environmental, Inc.

FIGURE 2-11
SITE MAP
SSA 14

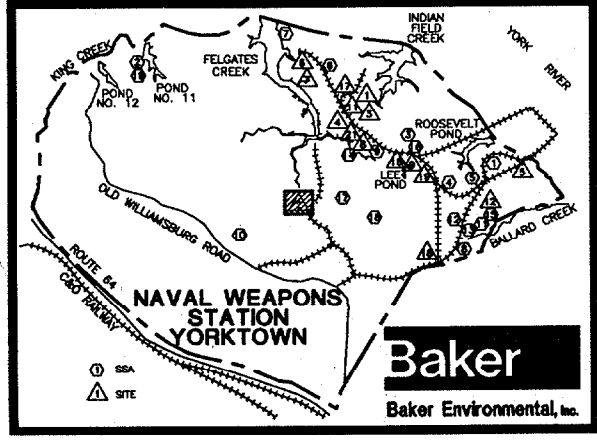
NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



400 0 200 400

1 inch = 400 ft.



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WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

MARSH

STRUCTURE

APPROXIMATE SITE BOUNDARY

2GW03 EXISTING MONITORING WELL LOCATION

2SW/SD04 ROUND ONE SURFACE WATER/SEDIMENT SAMPLING LOCATION

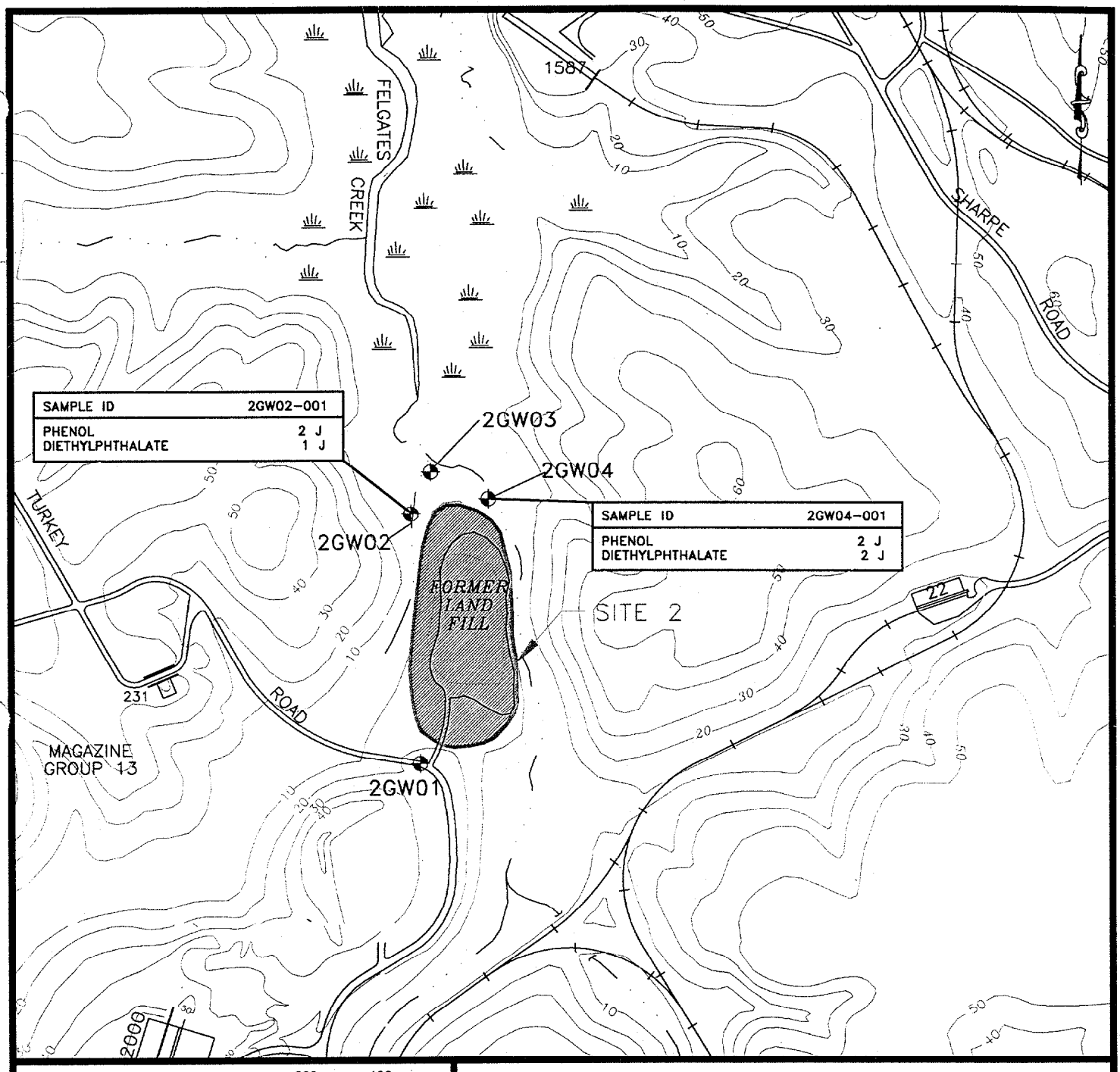
10 GROUND SURFACE CONTOUR (FT., MSL)

363701FS

FIGURE 2-12
ROUND ONE RI - SAMPLING LOCATIONS
SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



400 0 200 400

1 inch = 400 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

MARSH

RAILROAD

STRUCTURE

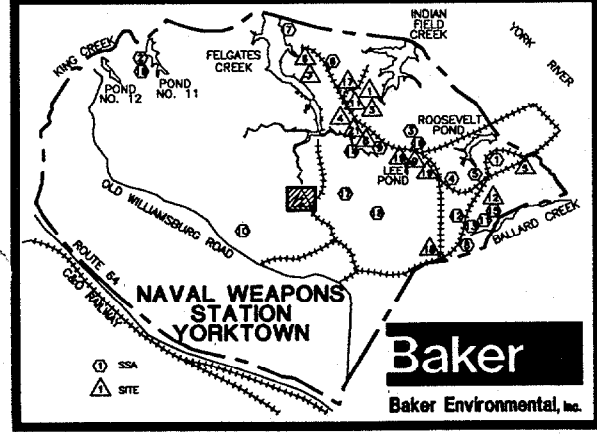
APPROXIMATE SITE BOUNDARY

2GW03 EXISTING MONITORING WELL LOCATION

10 GROUND SURFACE CONTOUR (FT., MSL)

NOTE: ANALYTICAL RESULTS REPORTED IN MICROGRAMS PER LITER (ug/L).

363702FS



Baker

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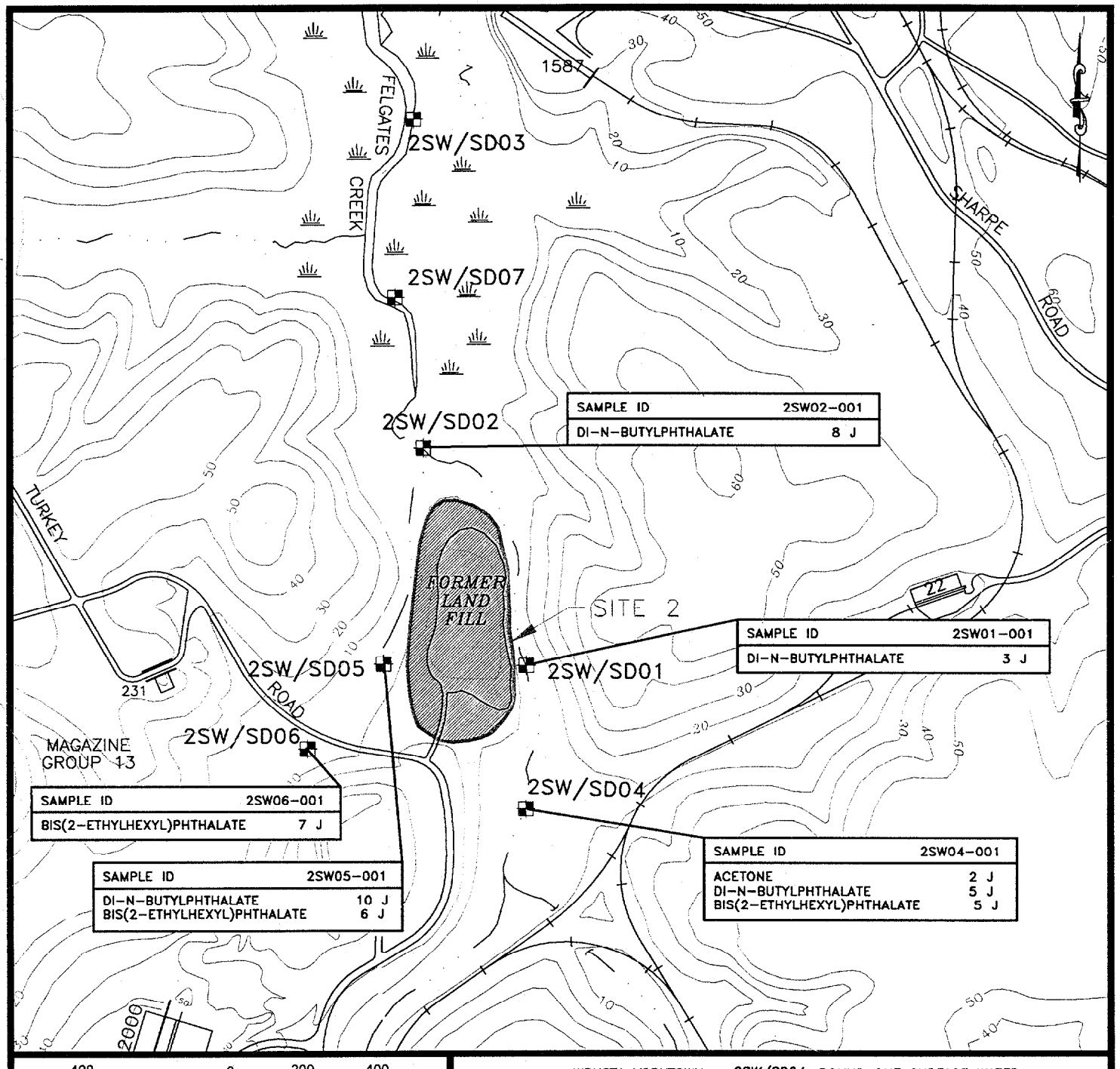
FIGURE 2-13
ROUND ONE RI - SELECT ANALYTICAL RESULTS FOR ORGANICS DETECTED IN GROUNDWATER SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



400 0 200 400

1 inch = 400 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

MARSH

STRUCTURE

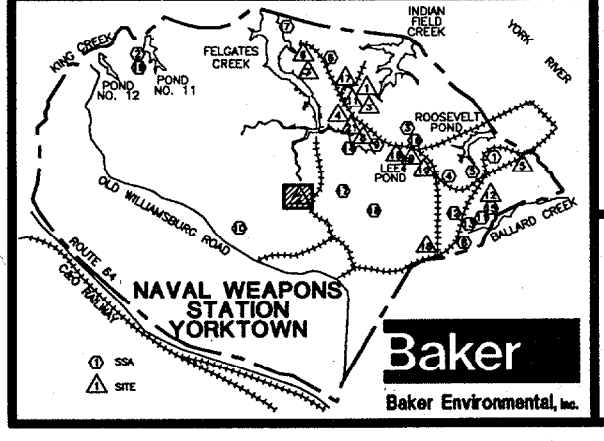
APPROXIMATE SITE BOUNDARY

2SW/SD04 ROUND ONE SURFACE WATER SAMPLING LOCATION

10 GROUND SURFACE CONTOUR (FT., MSL)

NOTE: ANALYTICAL RESULTS REPORTED IN MICROGRAMS PER LITER (ug/L).

363703FS



Baker

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FIGURE 2-14
ROUND ONE RI - SELECT ANALYTICAL RESULTS FOR ORGANICS DETECTED IN SURFACE WATER SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

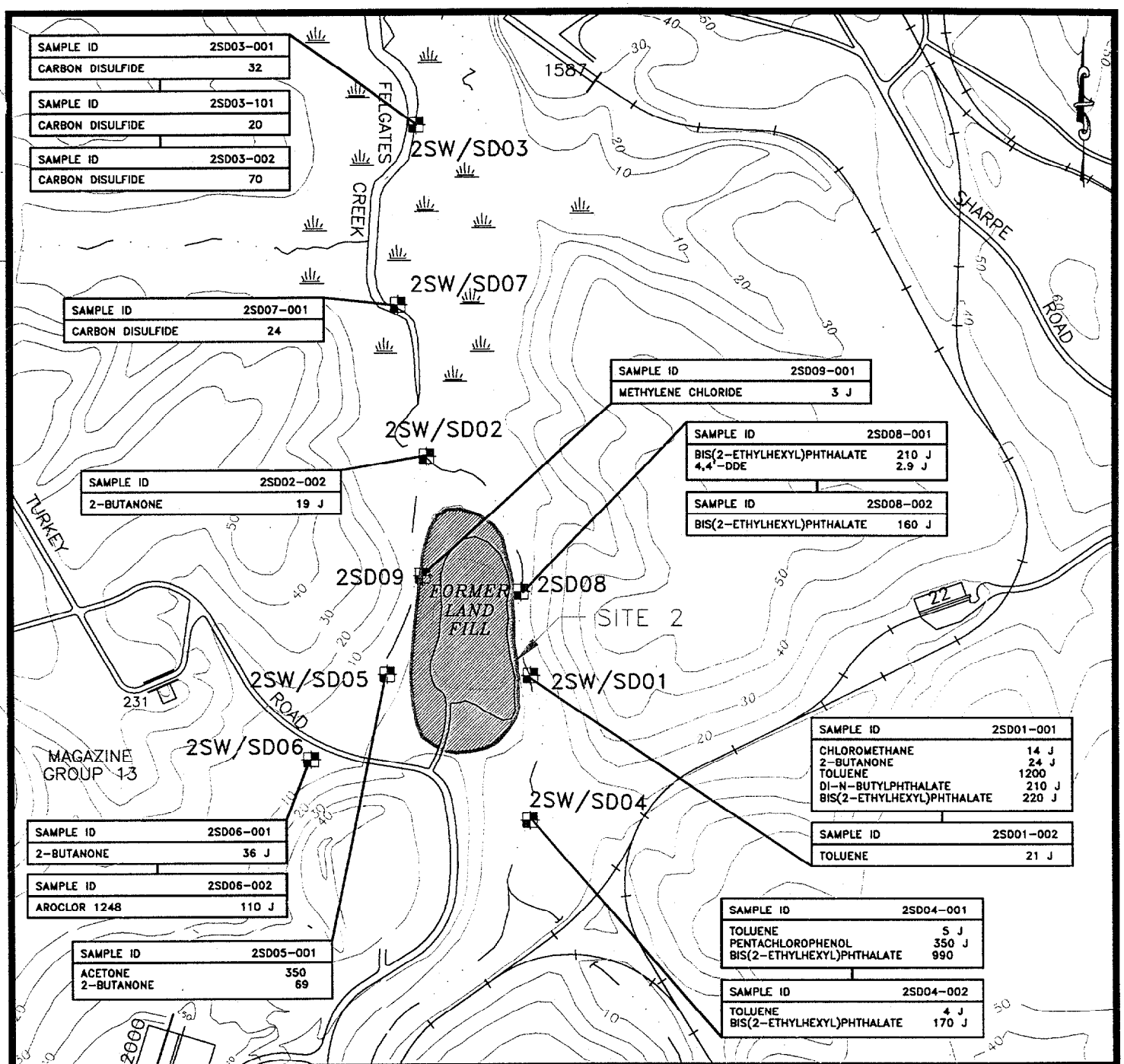
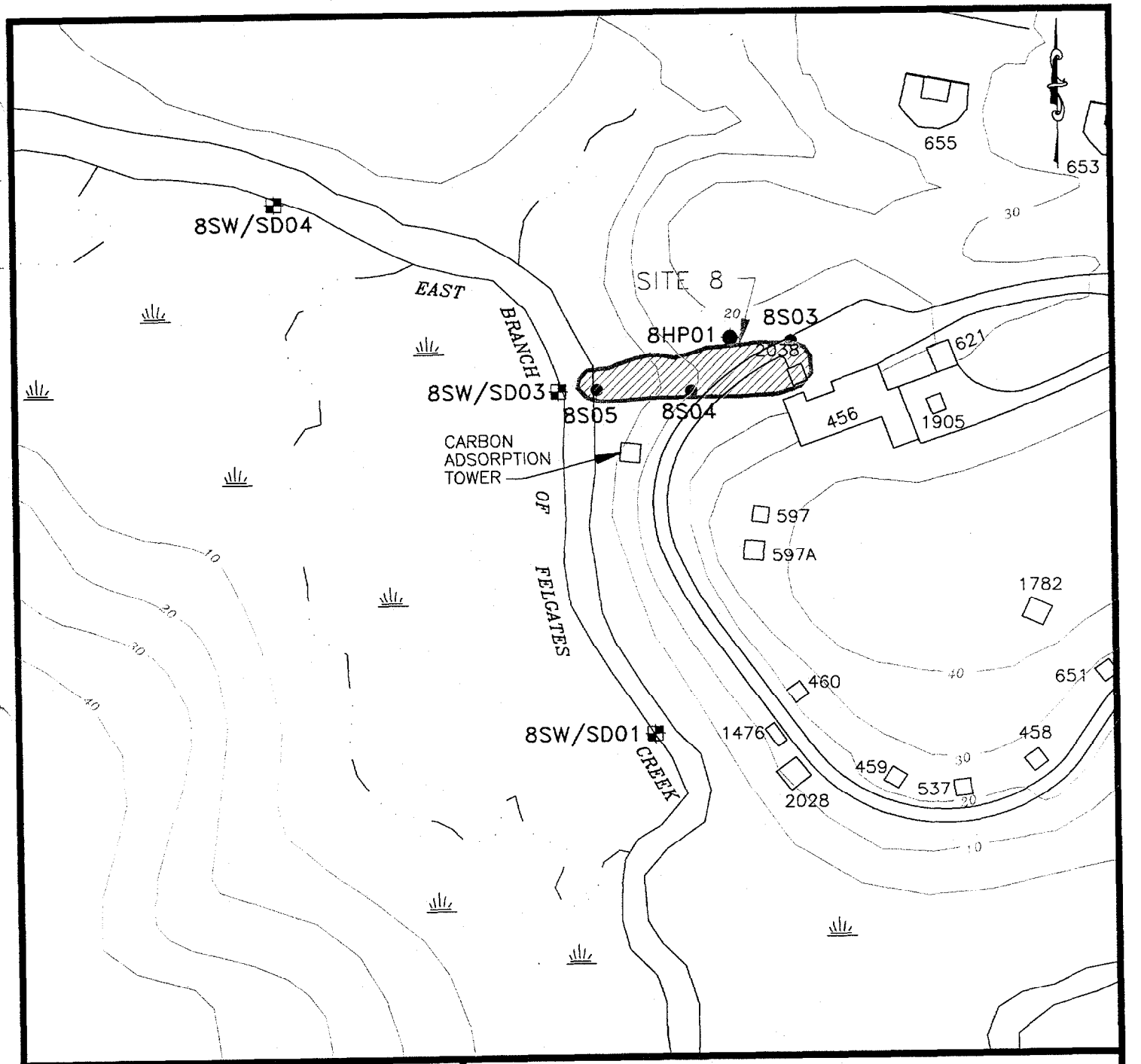


FIGURE 2-15
ROUND ONE RI - SELECT ANALYTICAL RESULTS FOR ORGANICS DETECTED IN SEDIMENT SITE 2

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA



150 0 75 150

1 inch = 150 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

MARSH

STRUCTURE

APPROXIMATE SITE BOUNDARY

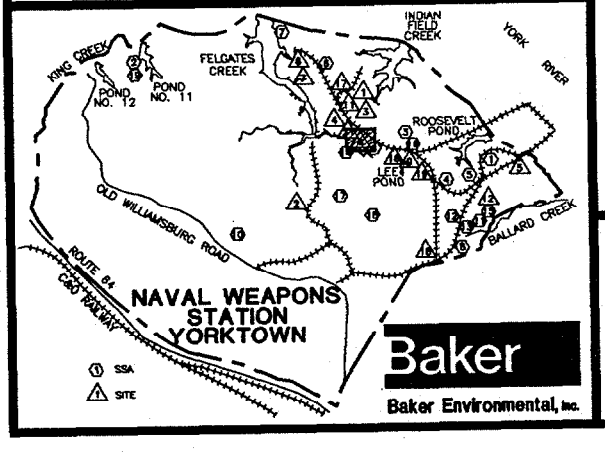
20 GROUND SURFACE CONTOUR (FT., MSL)

8SW/SD04 ROUND ONE SURFACE WATER/ SEDIMENT SAMPLING LOCATION

8S05 ROUND ONE RI SURFACE SOIL SAMPLE LOCATION

8HP01 HYDROPUNCH SAMPLE LOCATION

363764FS



Baker

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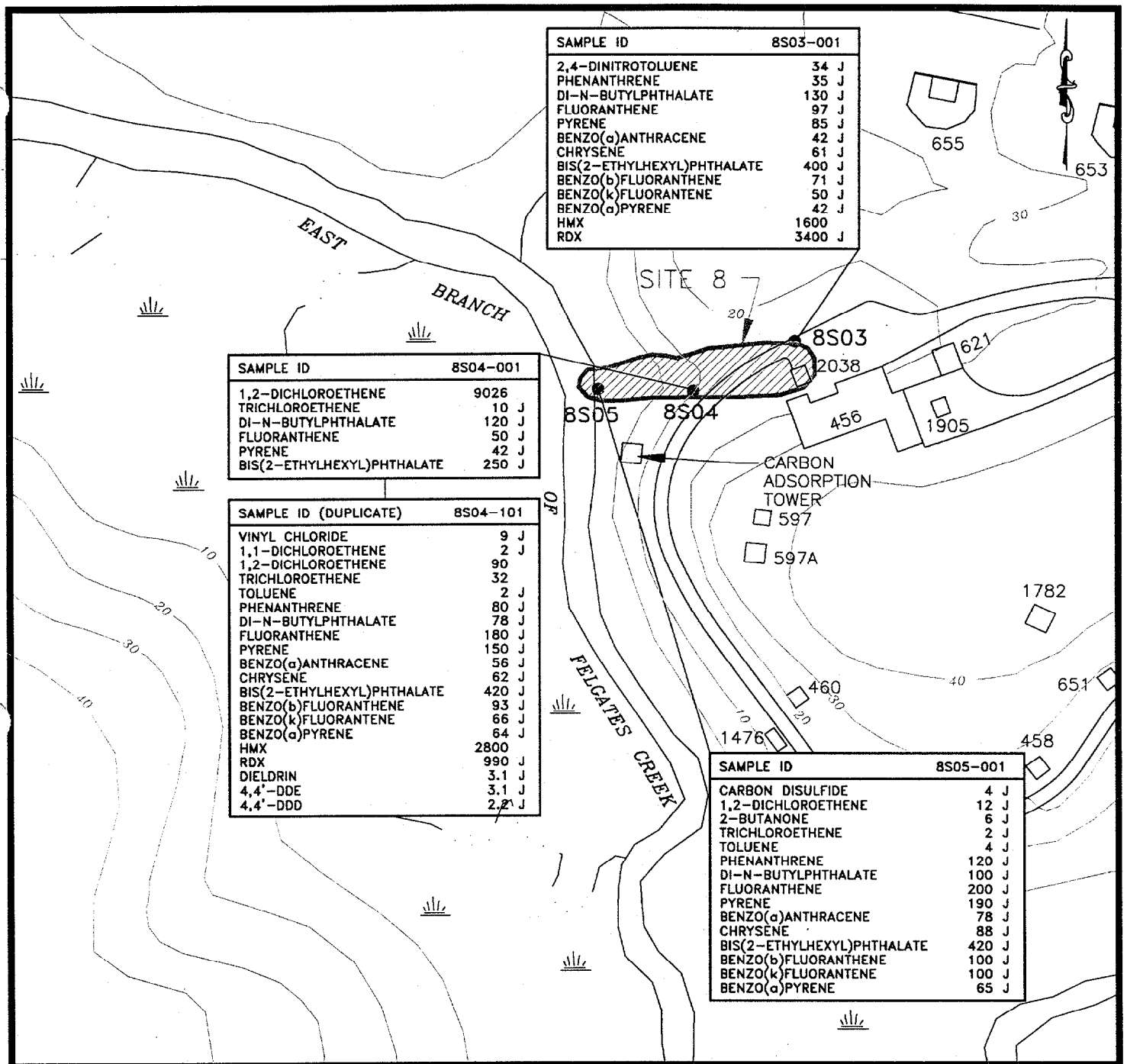
FIGURE 2-16
ROUND ONE RI - SAMPLING LOCATIONS
SITE 8

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



SAMPLE ID	8S03-001
2,4-DINITROTOLUENE	34 J
PHENANTHRENE	35 J
DI-N-BUTYLPHTHALATE	130 J
FLUORANTHENE	97 J
PYRENE	85 J
BENZO(a)ANTHRACENE	42 J
CHRYSENE	61 J
BIS(2-ETHYLHEXYL)PHTHALATE	400 J
BENZO(b)FLUORANTHENE	71 J
BENZO(k)FLUORANTENE	50 J
BENZO(a)PYRENE	42 J
HMX	1600
RDX	3400 J

SAMPLE ID	8S04-001
1,2-DICHLOROETHENE	9026
TRICHLOROETHENE	10 J
DI-N-BUTYLPHTHALATE	120 J
FLUORANTHENE	50 J
PYRENE	42 J
BIS(2-ETHYLHEXYL)PHTHALATE	250 J

SAMPLE ID (DUPLICATE)	8S04-101
VINYL CHLORIDE	9 J
1,1-DICHLOROETHENE	2 J
1,2-DICHLOROETHENE	90
TRICHLOROETHENE	32
TOLUENE	2 J
PHENANTHRENE	80 J
DI-N-BUTYLPHTHALATE	78 J
FLUORANTHENE	180 J
PYRENE	150 J
BENZO(a)ANTHRACENE	56 J
CHRYSENE	62 J
BIS(2-ETHYLHEXYL)PHTHALATE	420 J
BENZO(b)FLUORANTHENE	93 J
BENZO(k)FLUORANTENE	66 J
BENZO(a)PYRENE	64 J
HMX	2800
RDX	990 J
DIELDRIN	3.1 J
4,4'-DDE	3.1 J
4,4'-DDD	2.2 J

SAMPLE ID	8S05-001
CARBON DISULFIDE	4 J
1,2-DICHLOROETHENE	12 J
2-BUTANONE	6 J
TRICHLOROETHENE	2 J
TOLUENE	4 J
PHENANTHRENE	120 J
DI-N-BUTYLPHTHALATE	100 J
FLUORANTHENE	200 J
PYRENE	190 J
BENZO(a)ANTHRACENE	78 J
CHRYSENE	88 J
BIS(2-ETHYLHEXYL)PHTHALATE	420 J
BENZO(b)FLUORANTHENE	100 J
BENZO(k)FLUORANTENE	100 J
BENZO(a)PYRENE	65 J

150 0 75 150

1 inch = 150 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

MARSH

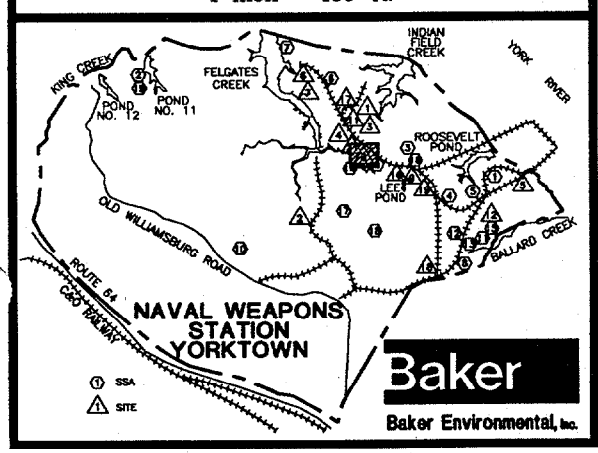
STRUCTURE

APPROXIMATE SITE BOUNDARY

20 GROUND SURFACE CONTOUR (FT., MSL)

8S05 ROUND ONE RI SURFACE SOIL SAMPLE LOCATION

363765FS



Baker

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FIGURE 2-17
ROUND ONE RI - SELECT ANALYTICAL RESULTS FOR ORGANICS DETECTED IN SURFACE SOIL SITE 8

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

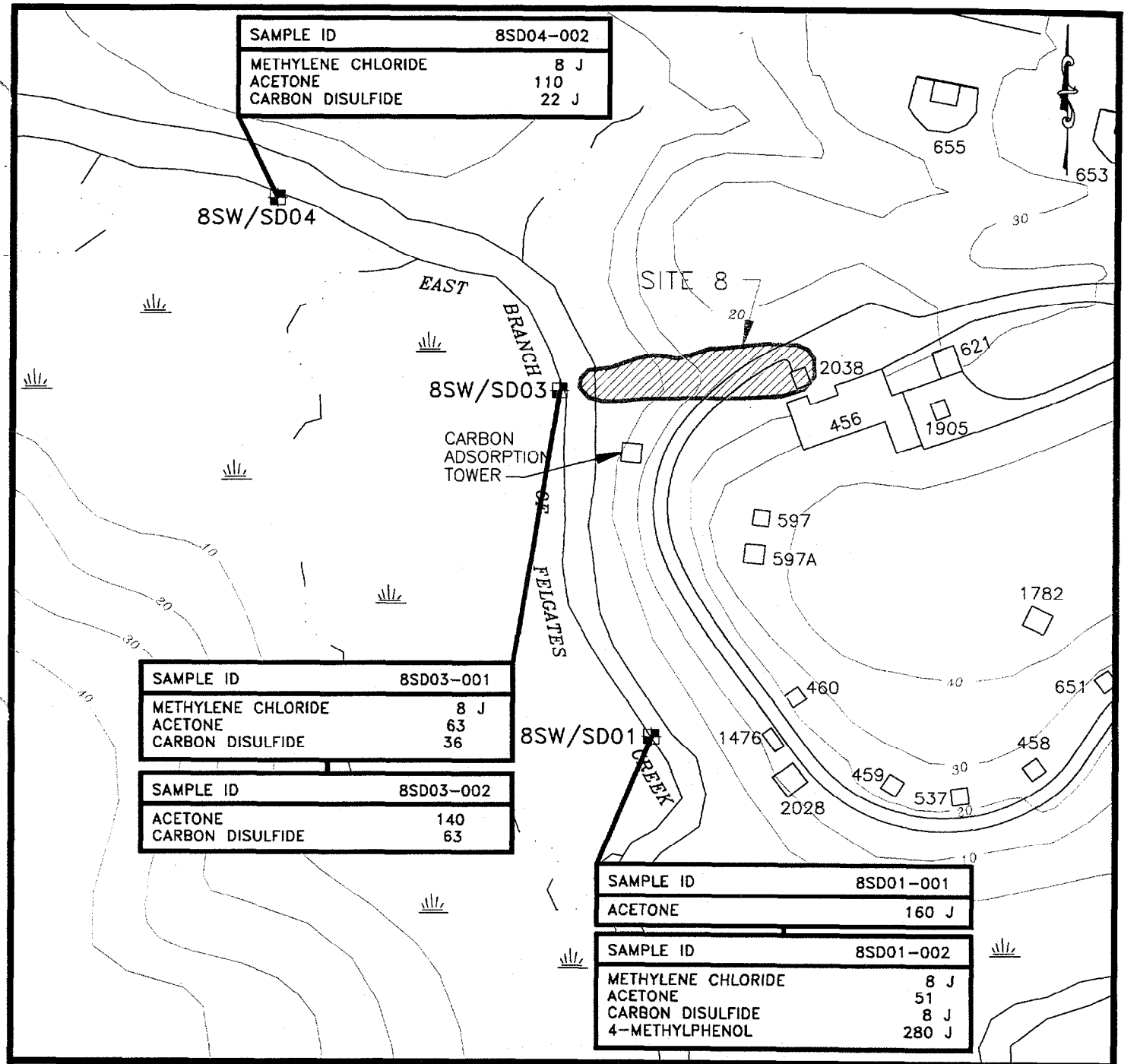
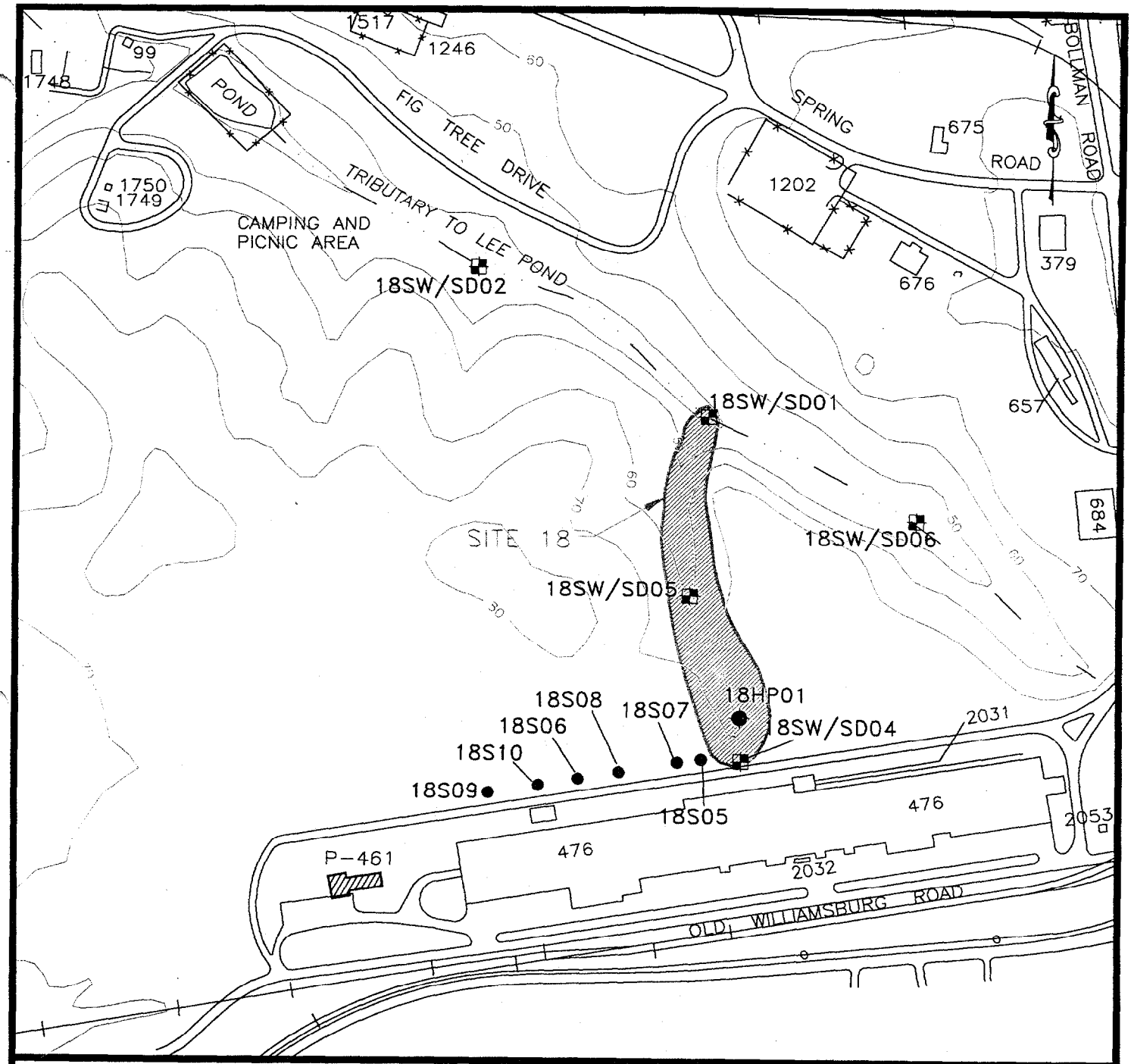


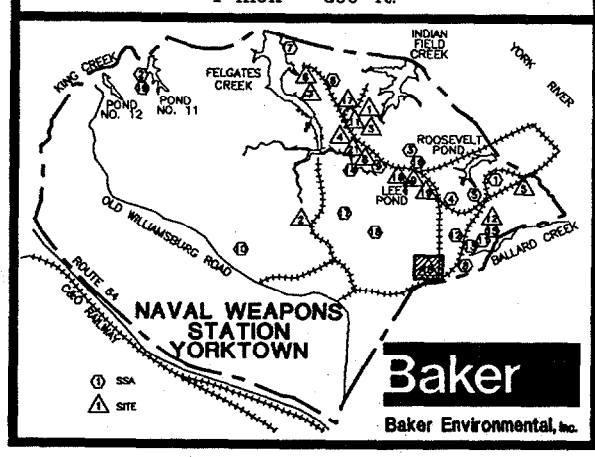
FIGURE 2-18
ROUND ONE RI - SELECT ANALYTICAL RESULTS FOR ORGANICS DETECTED IN SEDIMENT SITE 8

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA



300 0 150 300

1 inch = 300 ft.



Baker

Baker Environmental, Inc.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

FENCE

STRUCTURE

APPROXIMATE SITE BOUNDARY

18SW/SD02 ROUND ONE RI SURFACE WATER/ SEDIMENT SAMPLING LOCATION

18HP01 ROUND ONE RI HYDROPUNCH SAMPLE LOCATION

18S09 ROUND ONE RI SURFACE SOIL SAMPLE LOCATION

80 GROUND SURFACE CONTOUR (FT., MSL)

363767FS

FIGURE 2-19
ROUND ONE RI - SAMPLING LOCATIONS
SITE 18

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

SAMPLE NO.	02-SS-14
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	6600
BENZO(A)PYRENE	5500
BENZO(B)FLUORANTHENE	8100
BENZO(K)FLUORANTHENE	3500
CARBAZOLE	1500 J
CHRYSENE	6900
DIBENZO(A,H)ANTHRACENE	800 J
INDENO(1,2,3-CD)PYRENE	1600 J

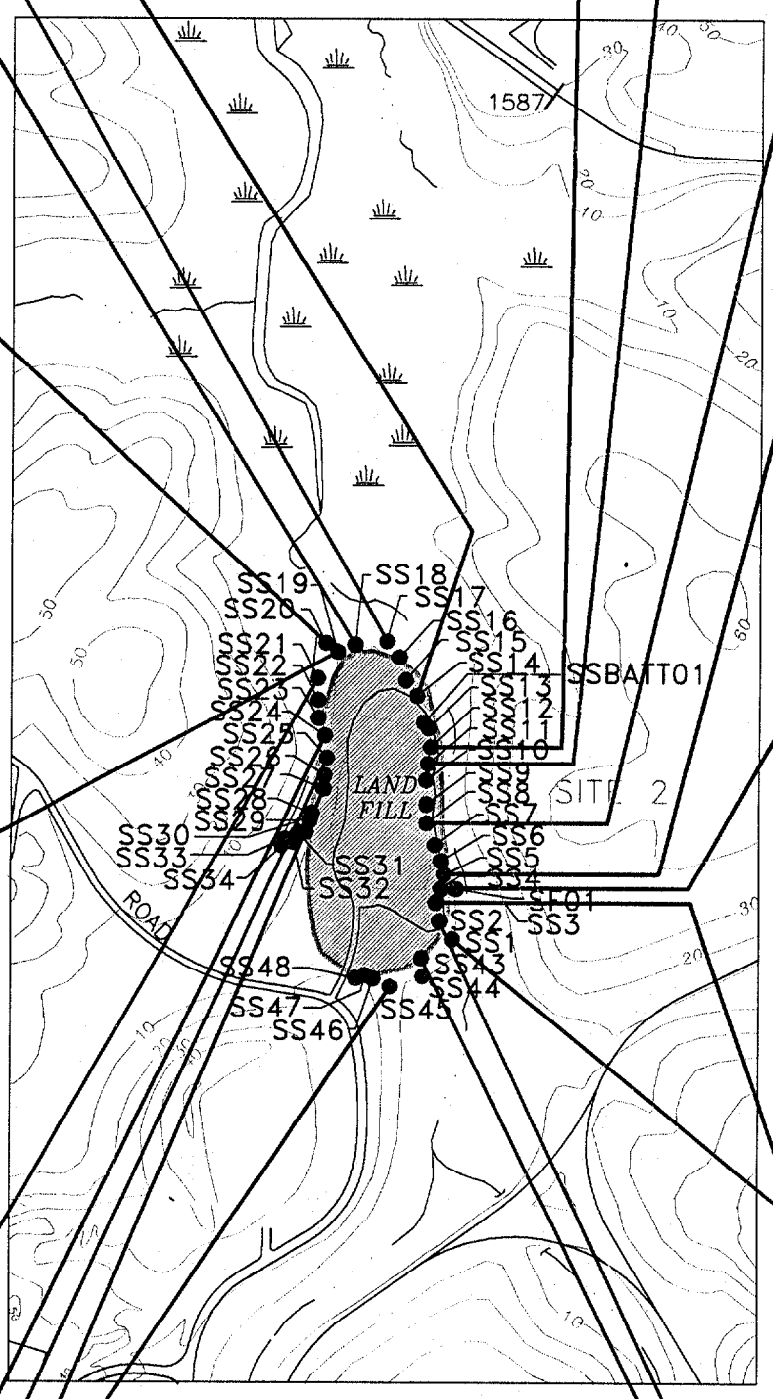
SAMPLE NO.	02-SS-12
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	2200
BENZO(A)PYRENE	1800
BENZO(B)FLUORANTHENE	2600
BENZO(K)FLUORANTHENE	1600
CARBAZOLE	370 J
CHRYSENE	2500
DIBENZO(A,H)ANTHRACENE	280 J
INDENO(1,2,3-CD)PYRENE	650 J
PESTICIDES/PCBs (ug/kg)	
AROCLOR-1254	510

SAMPLE NO.	02-SS-11
DATE SAMPLED	11/4/94
PESTICIDES/PCBs (ug/kg)	
AROCLOR-1254	1900

SAMPLE NO.	02-SS-17
DATE SAMPLED	11/14/94
PESTICIDES/PCBs (ug/kg)	
AROCLOR-1254	6200

SAMPLE NO.	02-SS-08
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	48000
BENZO(A)PYRENE	40000
BENZO(B)FLUORANTHENE	35000
BENZO(K)FLUORANTHENE	33000
CARBAZOLE	6600 J
CHRYSENE	50000
DIBENZO(A,H)ANTHRACENE	11000 J
INDENO(1,2,3-CD)PYRENE	28000

SAMPLE NO.	02-SS-18
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	2400
BENZO(A)PYRENE	2700
BENZO(B)FLUORANTHENE	3700
BENZO(K)FLUORANTHENE	1900
CARBAZOLE	670
CHRYSENE	2500
DIBENZO(A,H)ANTHRACENE	570
INDENO(1,2,3-CD)PYRENE	1300



SAMPLE NO.	02-SS-05
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	140 J
BENZO(A)PYRENE	360 J
BENZO(B)FLUORANTHENE	830
BENZO(K)FLUORANTHENE	440
CHRYSENE	580
DIBENZO(A,H)ANTHRACENE	170 J
INDENO(1,2,3-CD)PYRENE	670

SAMPLE NO.	02-SS-20
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	3400
BENZO(A)PYRENE	3000
BENZO(B)FLUORANTHENE	4100
BENZO(K)FLUORANTHENE	2400
CARBAZOLE	680 J
CHRYSENE	1600
DIBENZO(A,H)ANTHRACENE	480 J
INDENO(1,2,3-CD)PYRENE	1100 J

SAMPLE NO.	02-SS-04
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	730
BENZO(A)PYRENE	590
BENZO(B)FLUORANTHENE	660
BENZO(K)FLUORANTHENE	510
CARBAZOLE	140 J
CHRYSENE	840
DIBENZO(A,H)ANTHRACENE	230 J
INDENO(1,2,3-CD)PYRENE	410 J
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	0.76

SAMPLE NO.	02-SS-20D
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	1500
BENZO(A)PYRENE	1300
BENZO(B)FLUORANTHENE	1500
BENZO(K)FLUORANTHENE	1100
CARBAZOLE	320 J
CHRYSENE	1600
DIBENZO(A,H)ANTHRACENE	350 J
INDENO(1,2,3-CD)PYRENE	850

SAMPLE NO.	02-SS-19
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	2500
BENZO(A)PYRENE	2600
BENZO(B)FLUORANTHENE	3400
BENZO(K)FLUORANTHENE	2000
CARBAZOLE	840
CHRYSENE	2700
DIBENZO(A,H)ANTHRACENE	700
INDENO(1,2,3-CD)PYRENE	1700

SAMPLE NO.	02-SS-03
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	360 J
BENZO(A)PYRENE	380 J
BENZO(B)FLUORANTHENE	390 J
BENZO(K)FLUORANTHENE	240 J
CHRYSENE	440 J
DIBENZO(A,H)ANTHRACENE	110 J
INDENO(1,2,3-CD)PYRENE	270 J

SAMPLE NO.	02-SS-01
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	12000
BENZO(A)PYRENE	9600
BENZO(B)FLUORANTHENE	9600
BENZO(K)FLUORANTHENE	7200
CARBAZOLE	2000 J
CHRYSENE	13000
DIBENZO(A,H)ANTHRACENE	3400 J
INDENO(1,2,3-CD)PYRENE	6000

SAMPLE NO.	02-SS-21
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	6800
BENZO(A)PYRENE	6500
BENZO(B)FLUORANTHENE	8800
BENZO(K)FLUORANTHENE	4000
CARBAZOLE	1300 J
CHRYSENE	6900
DIBENZO(A,H)ANTHRACENE	960 J
INDENO(1,2,3-CD)PYRENE	2500 J

SAMPLE NO.	02-SS-45
DATE SAMPLED	11/15/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	850
BENZO(A)PYRENE	750
BENZO(B)FLUORANTHENE	850
BENZO(K)FLUORANTHENE	490
CARBAZOLE	210 J
CHRYSENE	930
DIBENZO(A,H)ANTHRACENE	110 J
INDENO(1,2,3-CD)PYRENE	260 J
PESTICIDES/PCBs (ug/kg)	
AROCLOR-1254	1500

SAMPLE NO.	02-SS-02
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	12000
BENZO(A)PYRENE	8600
BENZO(B)FLUORANTHENE	8500
BENZO(K)FLUORANTHENE	6900
CARBAZOLE	1000 J
CHRYSENE	13000
DIBENZO(A,H)ANTHRACENE	2300 J
INDENO(1,2,3-CD)PYRENE	5600

SAMPLE NO.	02-SS-24
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	3600
BENZO(A)PYRENE	2800
BENZO(B)FLUORANTHENE	4800
BENZO(K)FLUORANTHENE	2800
CARBAZOLE	570 J
CHRYSENE	4900
INDENO(1,2,3-CD)PYRENE	1100 J

SAMPLE NO.	02-SS-27
DATE SAMPLED	11/15/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	4100
BENZO(A)PYRENE	3500
BENZO(B)FLUORANTHENE	2500
BENZO(K)FLUORANTHENE	670 J
CARBAZOLE	1400 J
CHRYSENE	4000
DIBENZO(A,H)ANTHRACENE	440 J
INDENO(1,2,3-CD)PYRENE	1200 J

SAMPLE NO.	02-SS-43
DATE SAMPLED	11/15/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	4500
BENZO(A)PYRENE	3400
BENZO(B)FLUORANTHENE	4200
BENZO(K)FLUORANTHENE	2600
CARBAZOLE	2000 J
CHRYSENE	5000
DIBENZO(A,H)ANTHRACENE	540 J
INDENO(1,2,3-CD)PYRENE	1100 J
PESTICIDES/PCBs (ug/kg)	
AROCLOR-1254	1900

SAMPLE NO.	02-SS-25
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	910
BENZO(A)PYRENE	820
BENZO(B)FLUORANTHENE	1700
BENZO(K)FLUORANTHENE	780
CARBAZOLE	180 J
CHRYSENE	1600
DIBENZO(A,H)ANTHRACENE	130 J
INDENO(1,2,3-CD)PYRENE	400

400 0 200 400
1 inch = 400 ft.

Baker
Baker Environmental, Inc.

363782WP

LEGEND

SS1 SOIL SAMPLE LOCATION

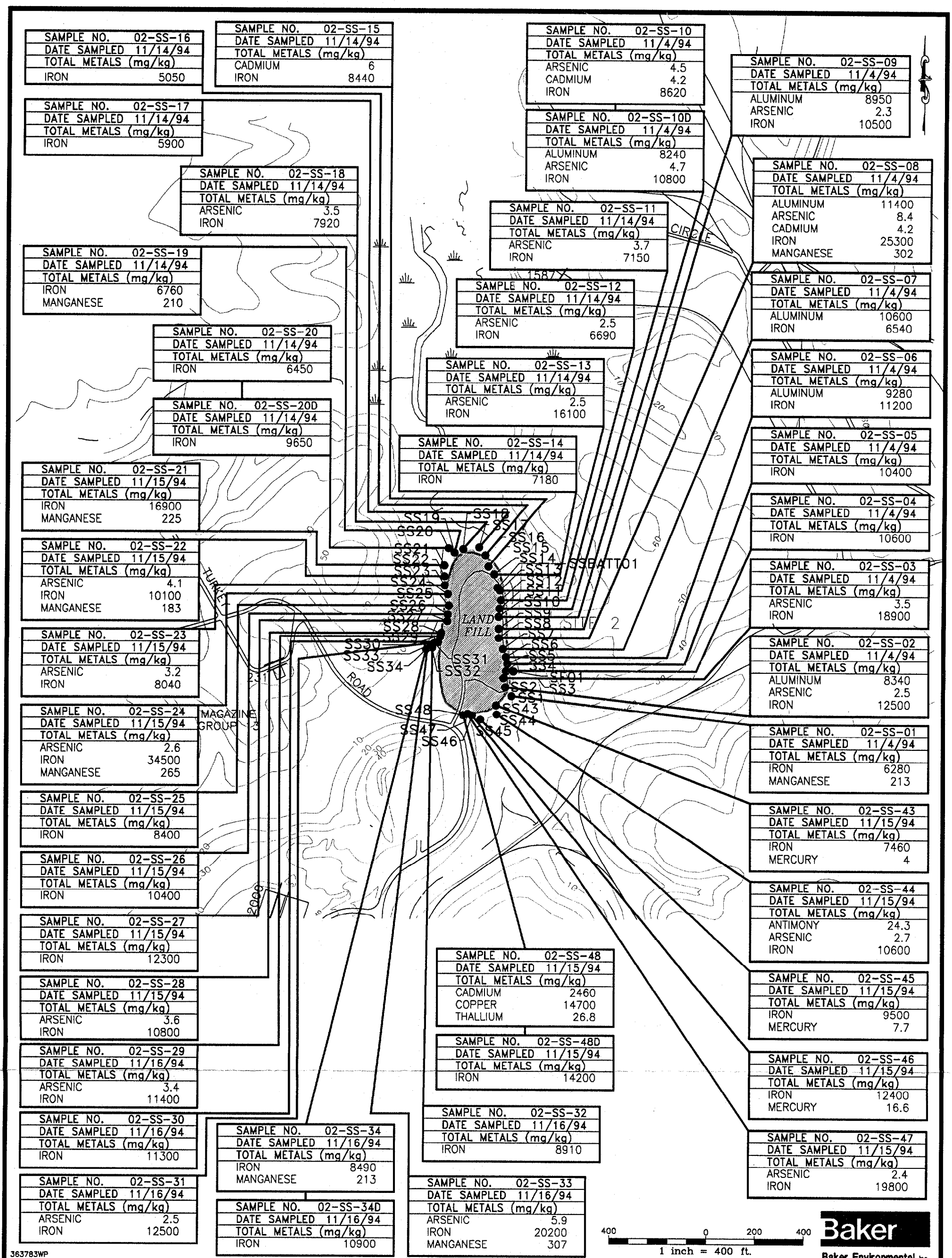
BOUNDARY
DRAINAGE
EDGE OF PAVEMENT
MARSH
RAILROAD
FENCE
STRUCTURE
REMEDIAL INVESTIGATION SITE

SOURCE: LANTDIV, OCT. 1991

FIGURE 2-20
SELECT ORGANIC CONTAMINANTS
IN SURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

01764FB52



LEGEND

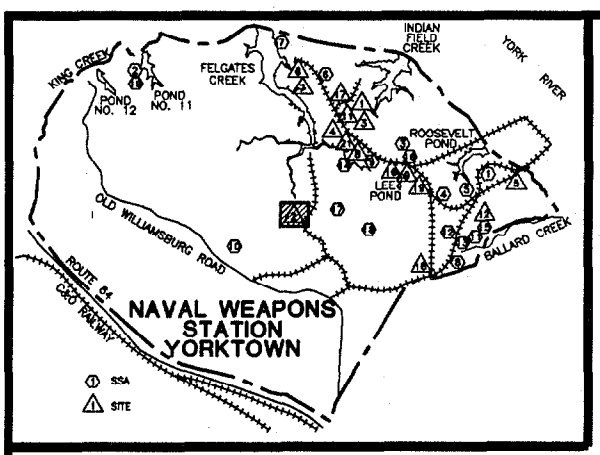
SS1 ● SOIL SAMPLE LOCATION

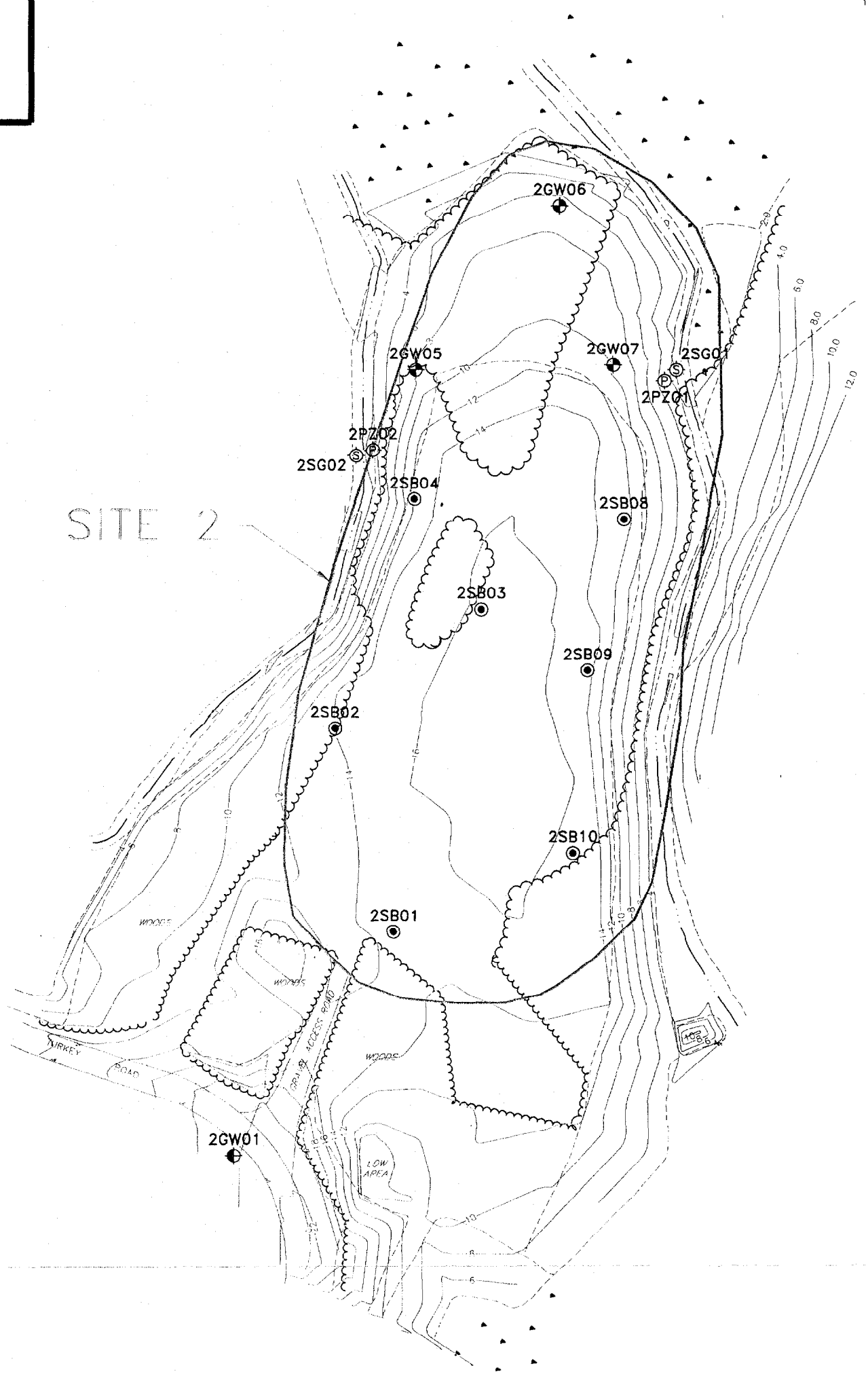
BOUNDARY
DRAINAGE
EDGE OF PAVEMENT
MARSH
RAILROAD
FENCE
STRUCTURE
REMEDIAL INVESTIGATION SITE

SOURCE: LANTDIV, OCT. 1991

FIGURE 2-21
SELECT INORGANIC CONTAMINANTS
IN SURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA





100 0 50 100
1 inch = 100 ft.

363711FS

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LEGEND

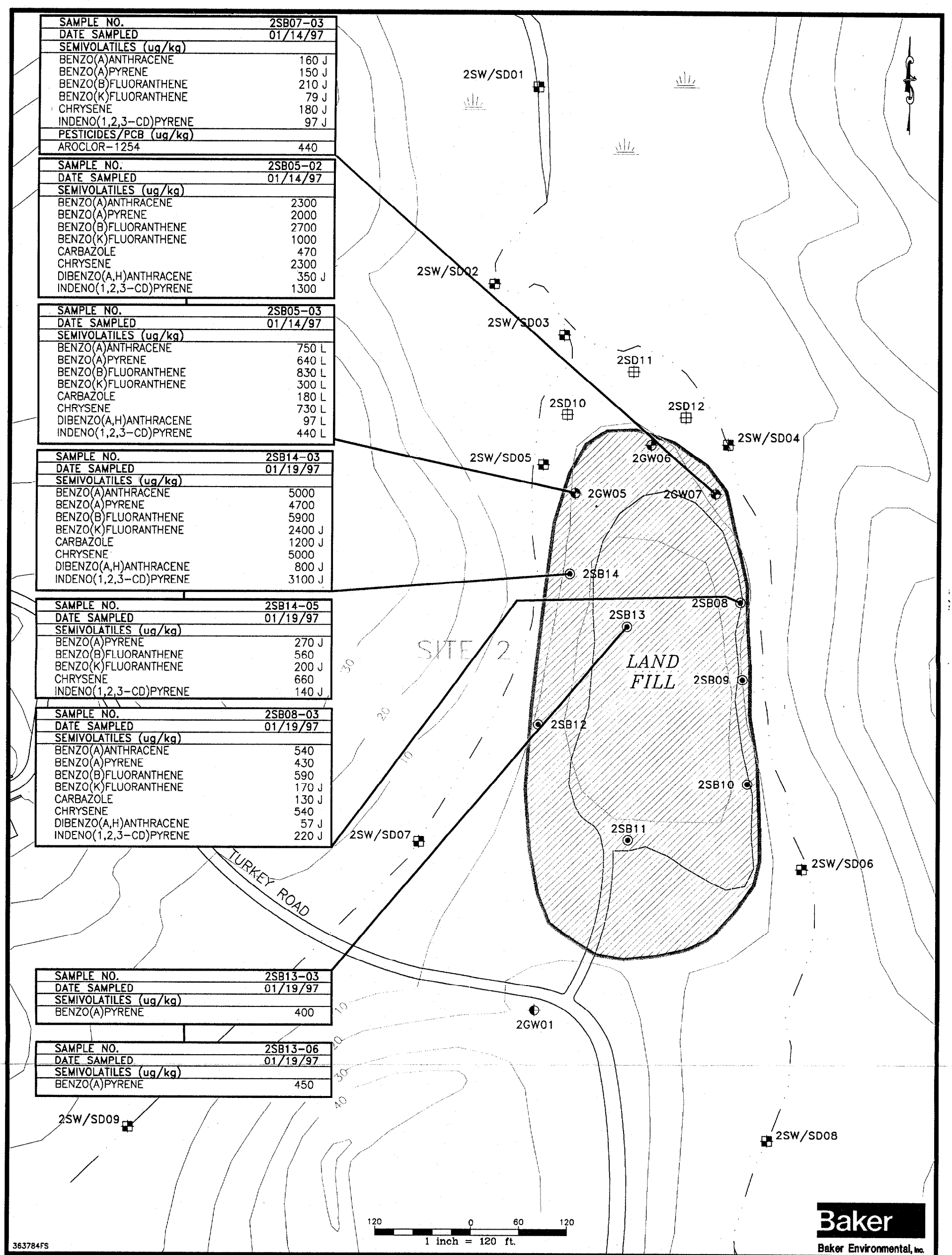
- 2GW01 – EXISTING MONITORING WELL
- 2GW05 – MONITORING WELL (BAKER 1997)
- 2SB01 – SOIL BORING
- 2SG01 – STAFF GAUGE LOCATION
- 2PZ01 – PIEZOMETER LOCATION
- TRIBUTARY TO FELGATES CREEK
- TREE LINE
- MARSH
- GROUND SURFACE CONTOUR (FT., MSL)
- APPROXIMATE SITE BOUNDARY

SOURCE: LANTDIV, 1991

FIGURE 2-22
ROUND TWO RI SOIL BORING AND MONITORING WELL LOCATIONS SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



SAMPLE NO.	2SB07-03
DATE SAMPLED	01/14/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	160 J
BENZO(A)PYRENE	150 J
BENZO(B)FLUORANTHENE	210 J
BENZO(K)FLUORANTHENE	79 J
CHRYSENE	180 J
INDENO(1,2,3-CD)PYRENE	97 J
PESTICIDES/PCB (ug/kg)	
AROCLOR-1254	440

SAMPLE NO.	2SB05-02
DATE SAMPLED	01/14/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	2300
BENZO(A)PYRENE	2000
BENZO(B)FLUORANTHENE	2700
BENZO(K)FLUORANTHENE	1000
CARBAZOLE	470
CHRYSENE	2300
DIBENZO(A,H)ANTHRACENE	350 J
INDENO(1,2,3-CD)PYRENE	1300

SAMPLE NO.	2SB05-03
DATE SAMPLED	01/14/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	750 L
BENZO(A)PYRENE	640 L
BENZO(B)FLUORANTHENE	830 L
BENZO(K)FLUORANTHENE	300 L
CARBAZOLE	180 L
CHRYSENE	730 L
DIBENZO(A,H)ANTHRACENE	97 L
INDENO(1,2,3-CD)PYRENE	440 L

SAMPLE NO.	2SB14-03
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	5000
BENZO(A)PYRENE	4700
BENZO(B)FLUORANTHENE	5900
BENZO(K)FLUORANTHENE	2400 J
CARBAZOLE	1200 J
CHRYSENE	5000
DIBENZO(A,H)ANTHRACENE	800 J
INDENO(1,2,3-CD)PYRENE	3100 J

SAMPLE NO.	2SB14-05
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	270 J
BENZO(B)FLUORANTHENE	560
BENZO(K)FLUORANTHENE	200 J
CHRYSENE	660
INDENO(1,2,3-CD)PYRENE	140 J

SAMPLE NO.	2SB08-03
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	540
BENZO(A)PYRENE	430
BENZO(B)FLUORANTHENE	590
BENZO(K)FLUORANTHENE	170 J
CARBAZOLE	130 J
CHRYSENE	540
DIBENZO(A,H)ANTHRACENE	57 J
INDENO(1,2,3-CD)PYRENE	220 J

SAMPLE NO.	2SB13-03
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	400

SAMPLE NO.	2SB13-06
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	450

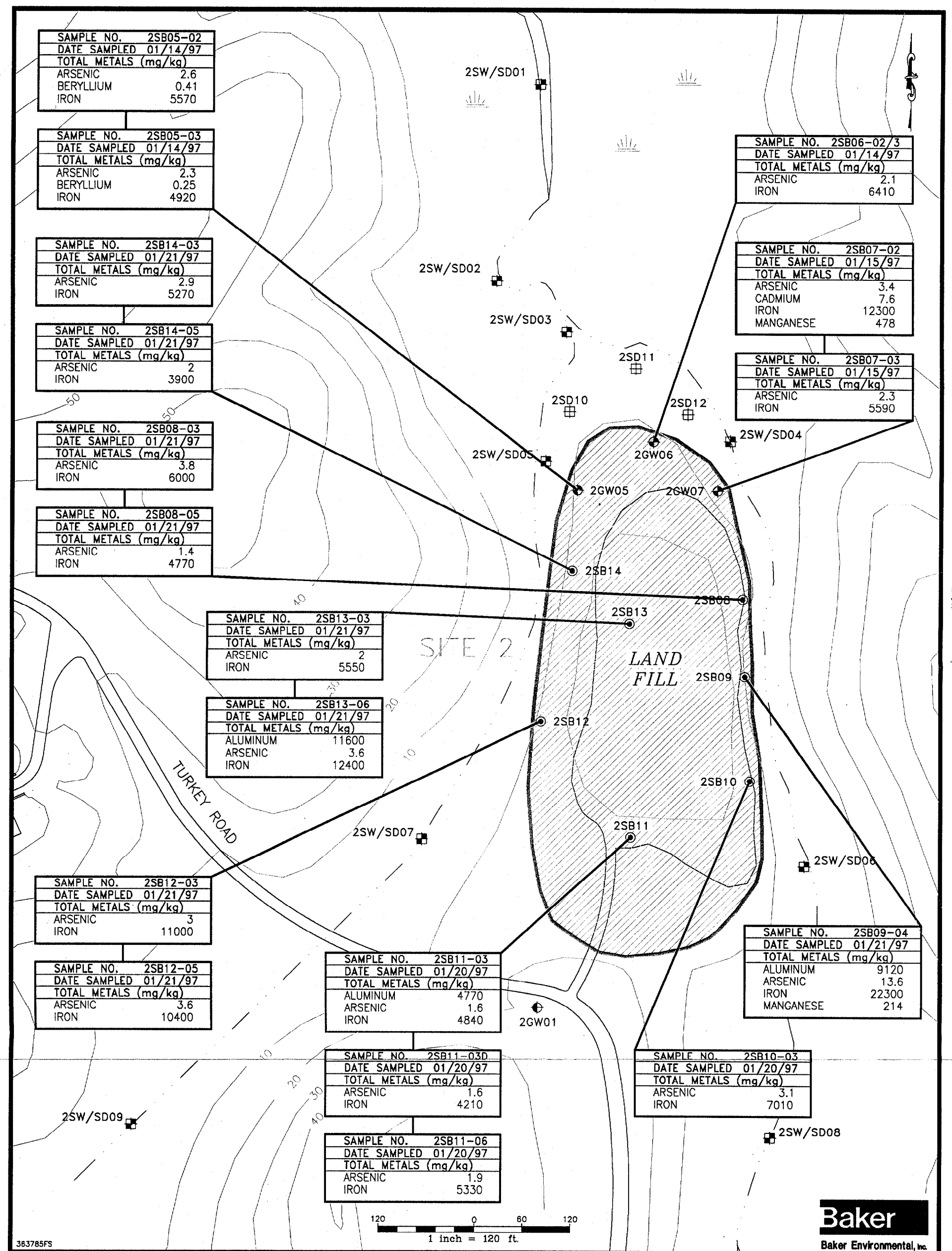
LEGEND

- 2GW01 – EXISTING MONITORING WELL (DAMES & MOORE 1986)
- 2GW05 – MONITORING WELL (BAKER 1997)
- 2SB01 – SOIL BORING
- 2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997
- 2SG01 – STAFF GAUGE LOCATION
- 2PZ01 – PIEZOMETER LOCATION

SOURCE: LANTDIV, 1991

FIGURE 2-23
SELECT ORGANIC CONTAMINANTS
IN SUBSURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



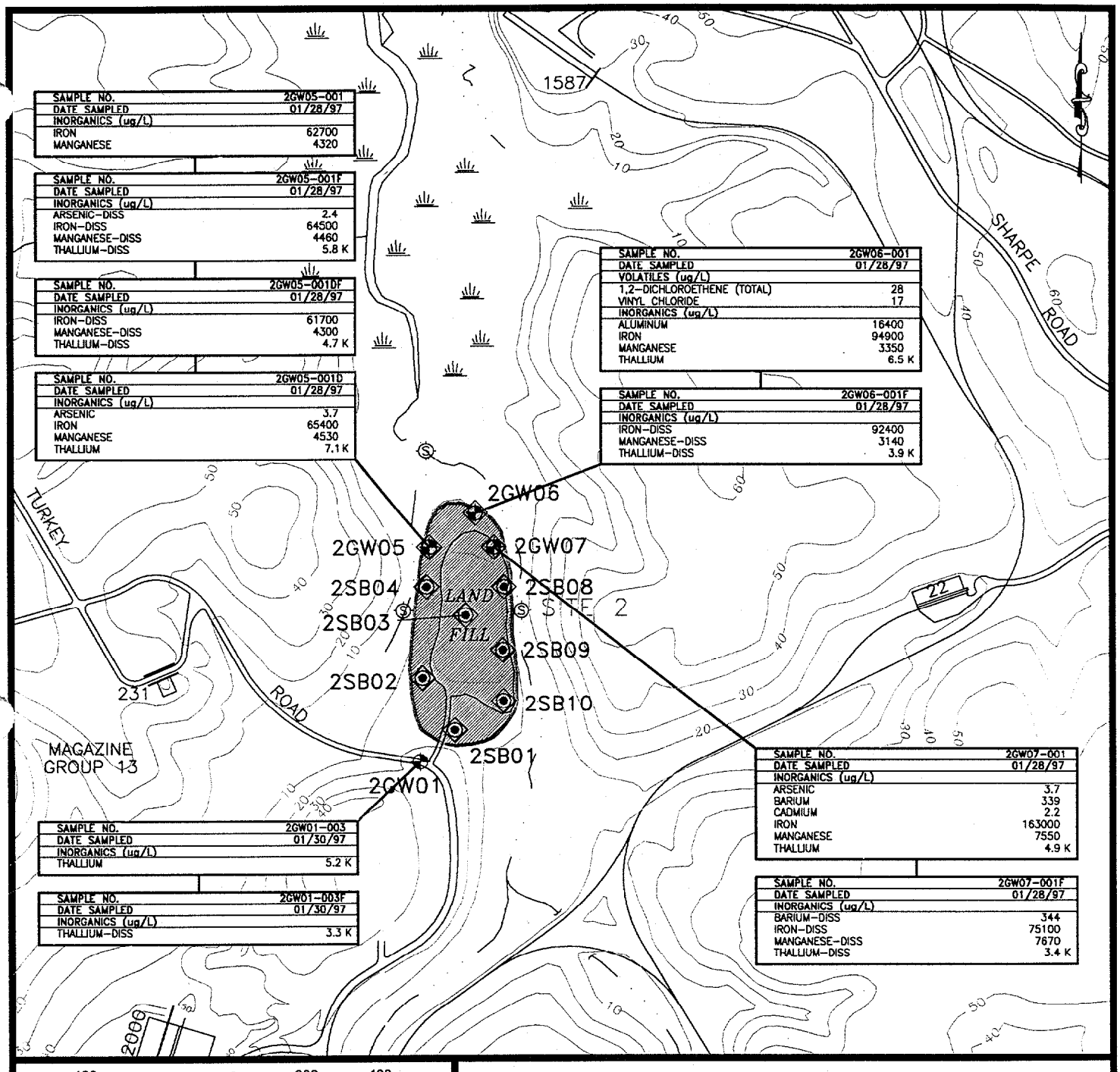
LEGEND

- 2GW01 – EXISTING MONITORING WELL (DAMES & MOORE 1986)
- 2GW05 – MONITORING WELL (BAKER 1997)
- 2SB01 – SOIL BORING
- 2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997
- 2SG01 – STAFF GAUGE LOCATION
- 2PZ01 – PIEZOMETER LOCATION

SOURCE: LANTDIV, 1991

FIGURE 2-24
SELECT INORGANIC CONTAMINANTS
IN SUBSURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	2GW05-001
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
IRON	62700
MANGANESE	4320

SAMPLE NO.	2GW05-001F
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
ARSENIC-DISS	2.4
IRON-DISS	64500
MANGANESE-DISS	4460
THALLIUM-DISS	5.8 K

SAMPLE NO.	2GW05-001DF
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
IRON-DISS	61700
MANGANESE-DISS	4300
THALLIUM-DISS	4.7 K

SAMPLE NO.	2GW05-001D
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
ARSENIC	3.7
IRON	65400
MANGANESE	4530
THALLIUM	7.1 K

SAMPLE NO.	2GW06-001
DATE SAMPLED	01/28/97
VOLATILES (ug/L)	
1,2-DICHLOROETHENE (TOTAL)	28
VINYL CHLORIDE	17
INORGANICS (ug/L)	
ALUMINUM	16400
IRON	94900
MANGANESE	3350
THALLIUM	6.5 K

SAMPLE NO.	2GW06-001F
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
IRON-DISS	92400
MANGANESE-DISS	3140
THALLIUM-DISS	3.9 K

SAMPLE NO.	2GW07-001
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
ARSENIC	3.7
BARIUM	339
CADMIUM	2.2
IRON	163000
MANGANESE	7550
THALLIUM	4.9 K

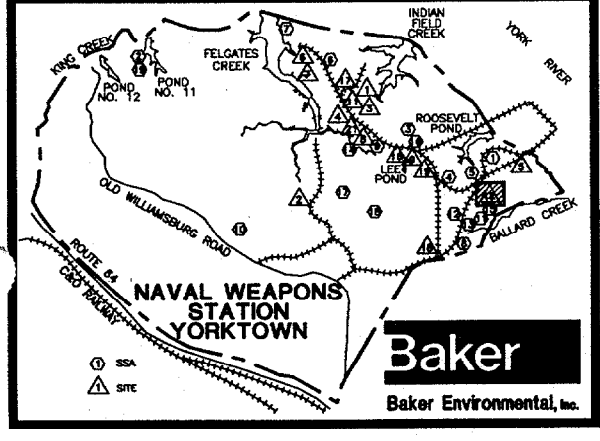
SAMPLE NO.	2GW07-001F
DATE SAMPLED	01/28/97
INORGANICS (ug/L)	
BARIUM-DISS	344
IRON-DISS	75100
MANGANESE-DISS	7670
THALLIUM-DISS	3.4 K

SAMPLE NO.	2GW01-003
DATE SAMPLED	01/30/97
INORGANICS (ug/L)	
THALLIUM	5.2 K

SAMPLE NO.	2GW01-003F
DATE SAMPLED	01/30/97
INORGANICS (ug/L)	
THALLIUM-DISS	3.3 K

400 0 200 400

1 inch = 400 ft.



BOUNDARY
DRAINAGE
EDGE OF PAVEMENT
MARSH
RAILROAD
FENCE
STRUCTURE
REMEDIAL INVESTIGATION SITE

2GW01 ROUND ONE MONITORING WELL LOCATION

2GW07 ROUND TWO SOIL BORING/ MONITORING WELL LOCATION

SOIL BORING LOCATION

STAFF GAUGE LOCATION

363786FS

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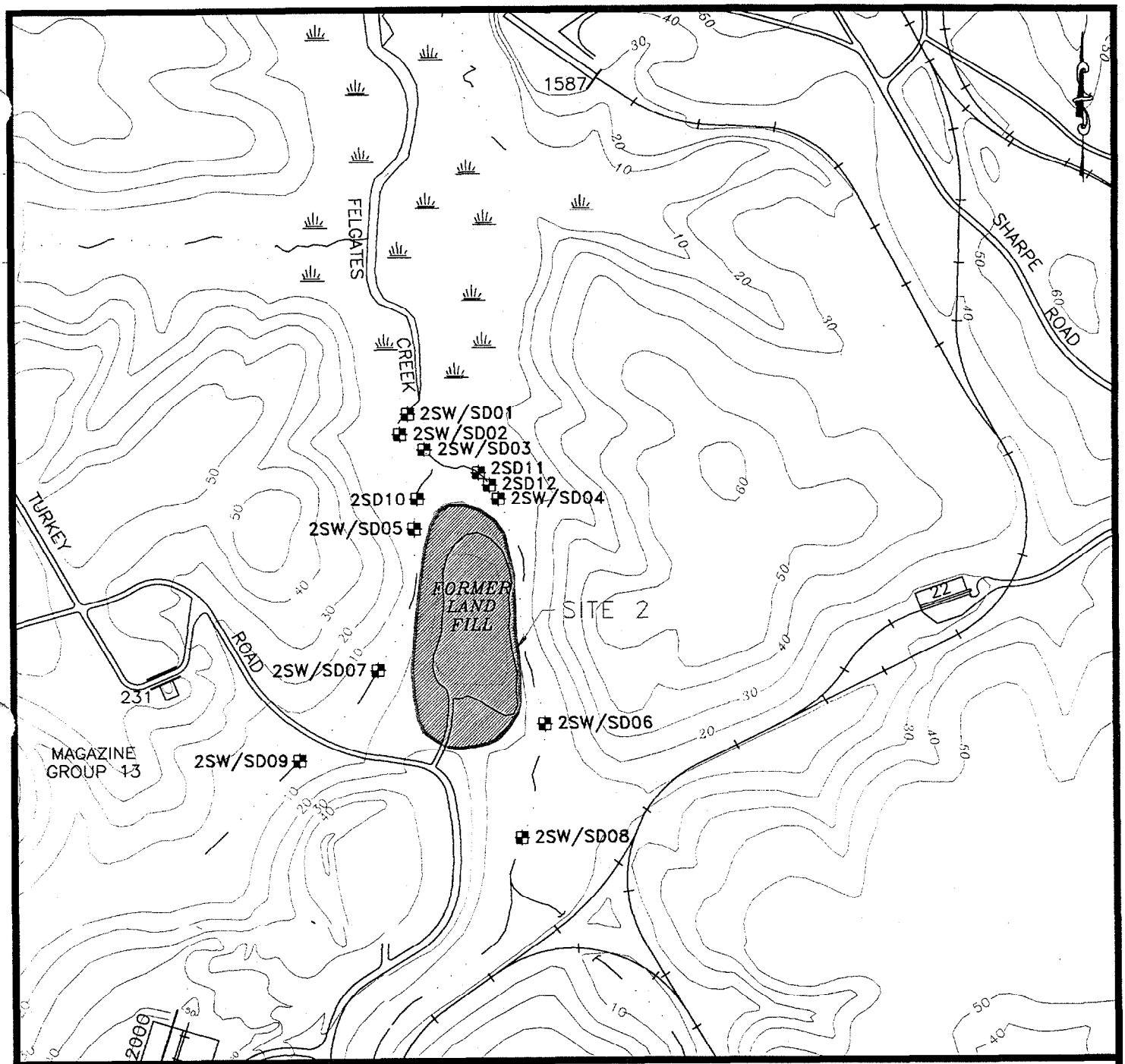
FIGURE 2-25
SELECT ORGANIC AND INORGANIC CONTAMINANTS IN GROUNDWATER
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



400 0 200 400

1 inch = 400 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

MARSH

RAILROAD

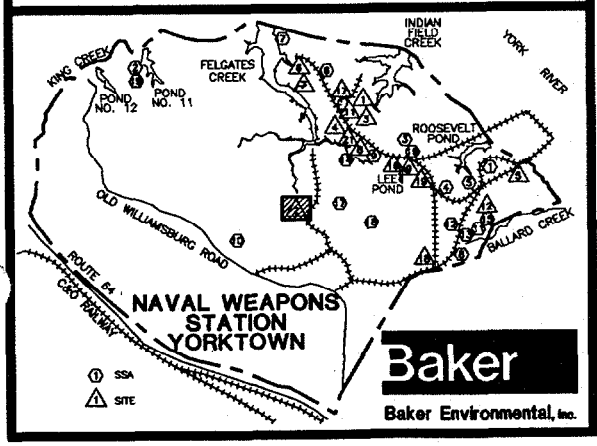
STRUCTURE

APPROXIMATE SITE BOUNDARY

2SW/SD08 SURFACE WATER/SEDIMENT/ BIOTA SAMPLE LOCATIONS

10 GROUND SURFACE CONTOUR (FT., MSL)

363712FS



Baker

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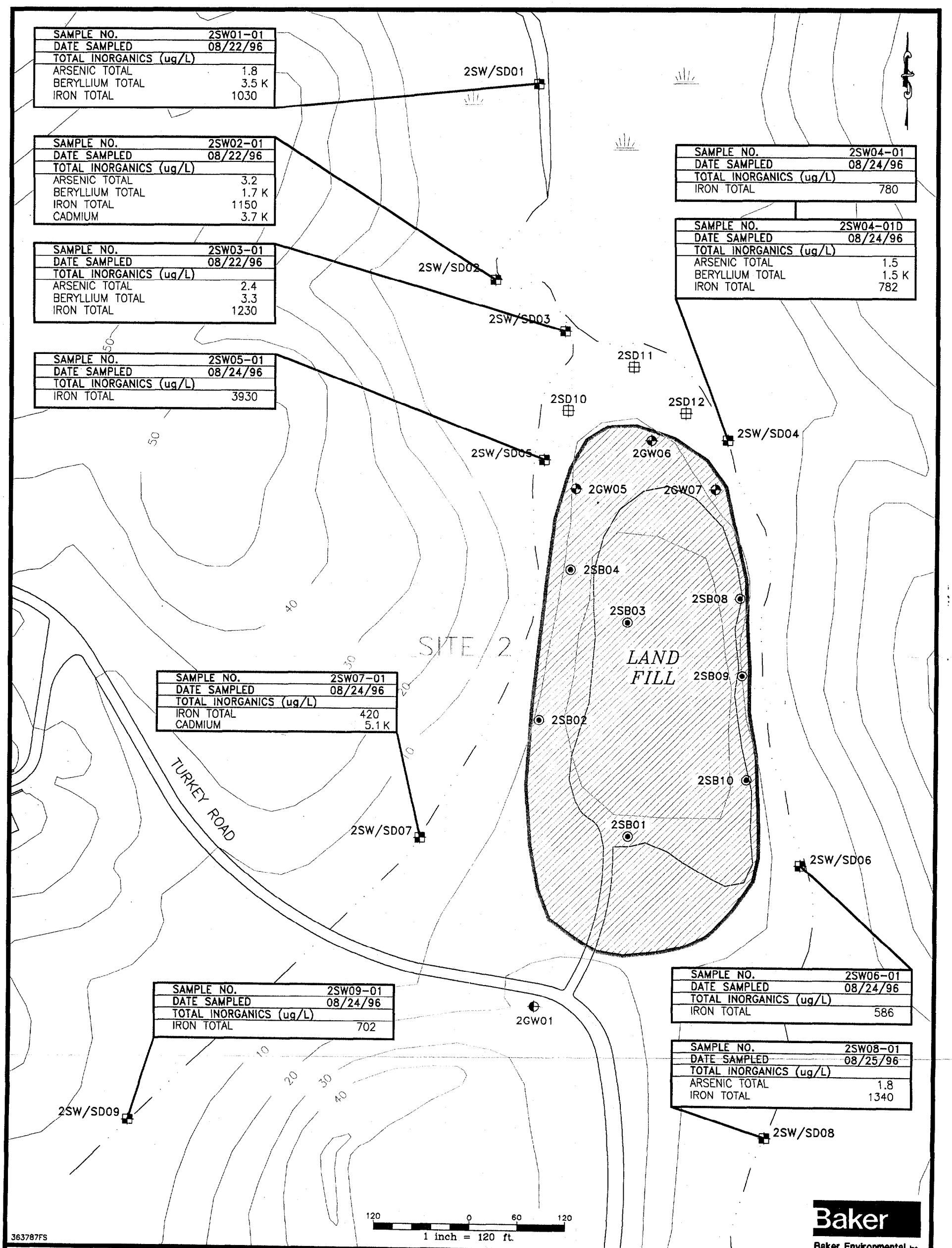
FIGURE 2-26
ROUND TWO RI SURFACE WATER/SEDIMENT/ BIOTA SAMPLE LOCATIONS SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



LEGEND

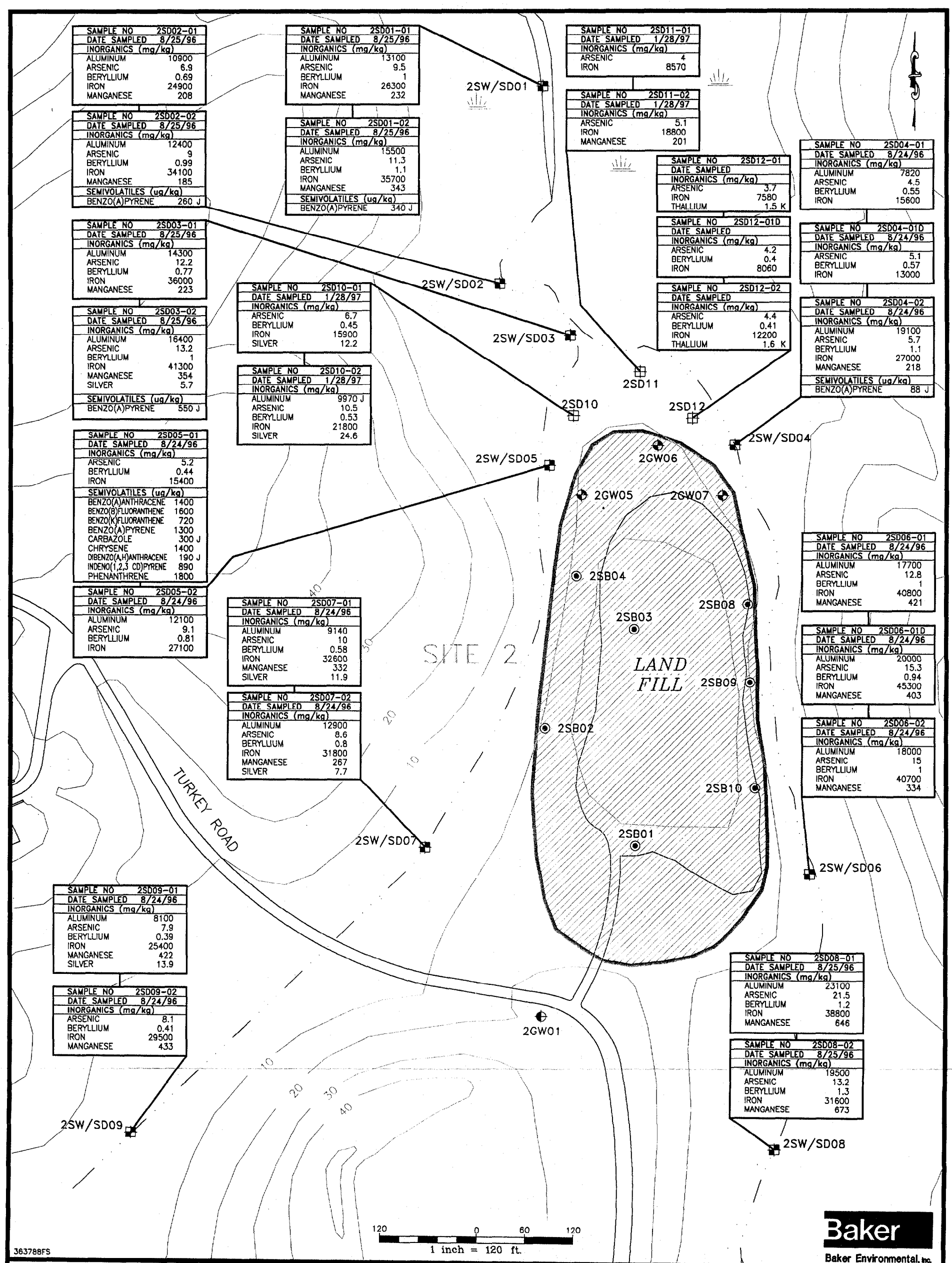
- 2GW01 – EXISTING MONITORING WELL (DAMES & MOORE 1986)
- 2GW05 – MONITORING WELL (BAKER 1997)
- 2SB01 – SOIL BORING
- 2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997
- 2SG01 – STAFF GAUGE LOCATION
- 2PZ01 – PIEZOMETER LOCATION

SOURCE: LANTDIV, 1991

FIGURE 2-27
SELECT INORGANIC CONTAMINANTS
IN SURFACE WATER
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

01764FB6Z



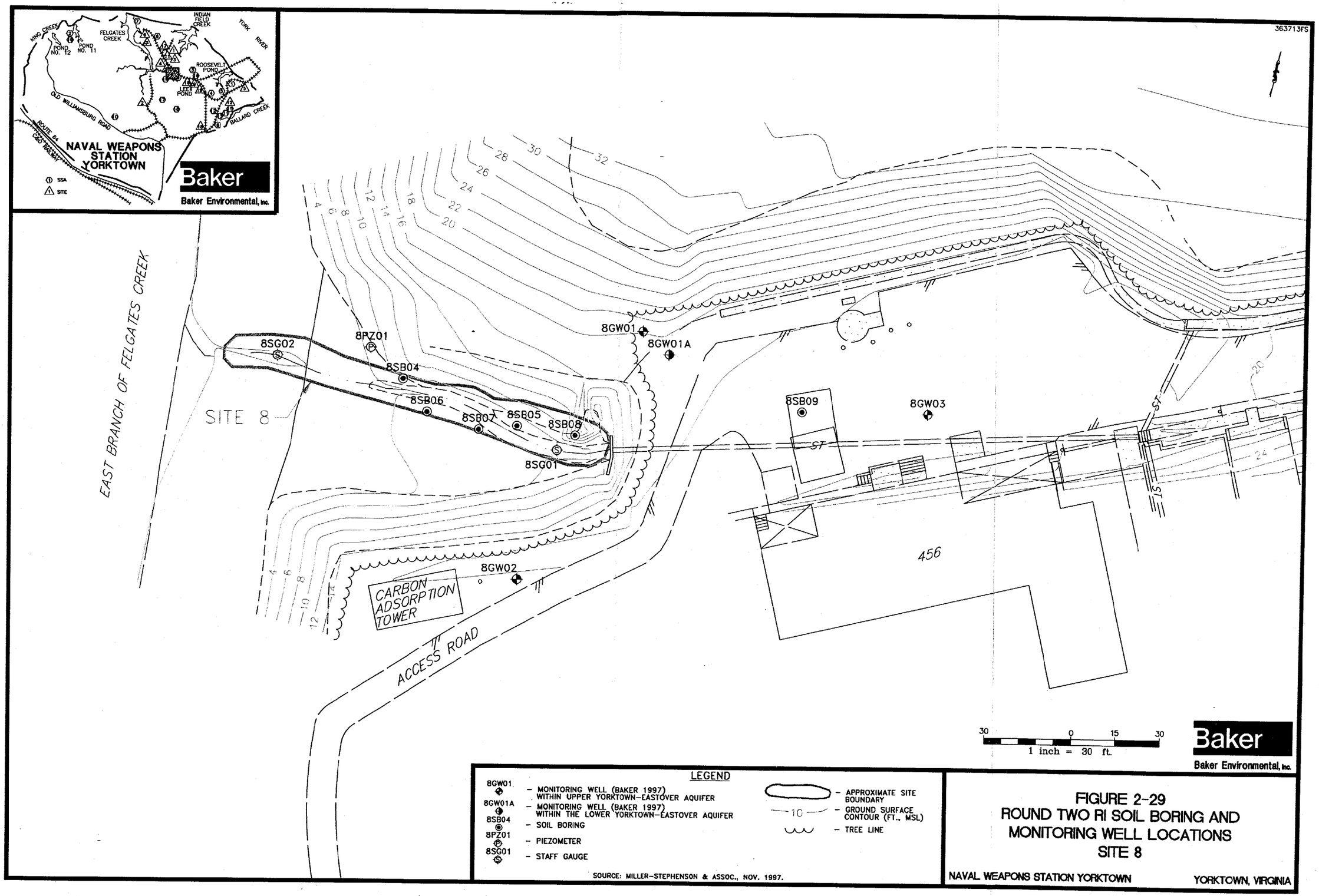
LEGEND

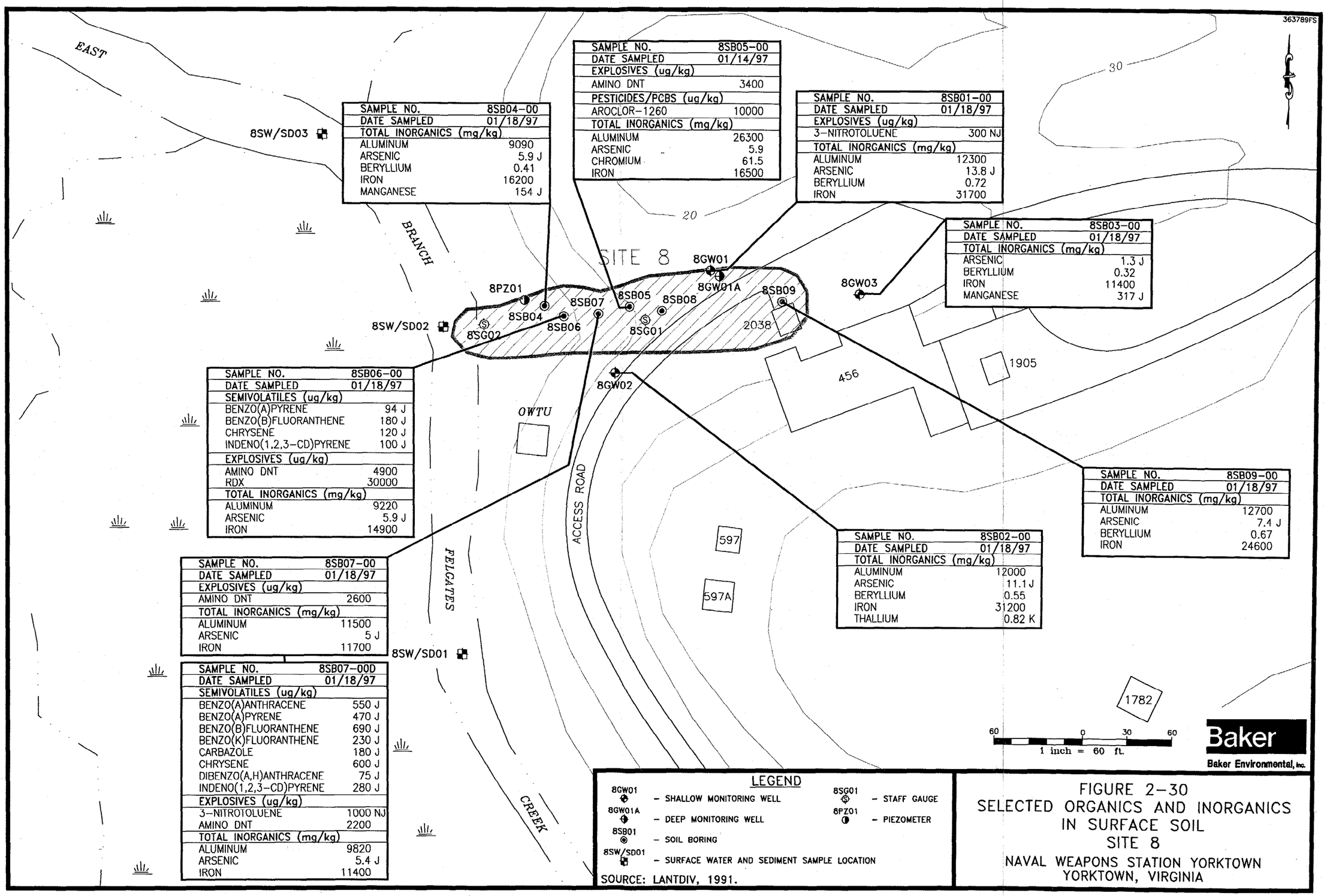
- 2GW01 – EXISTING MONITORING WELL (DAMES & MOORE 1986)
- 2GW05 – MONITORING WELL (BAKER 1997)
- 2SB01 – SOIL BORING
- 2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997
- 2SG01 – STAFF GAUGE LOCATION
- 2PZ01 – PIEZOMETER LOCATION

SOURCE: LANTDIV, 1991

FIGURE 2-28
SELECT ORGANIC AND INORGANIC CONTAMINANTS IN SEDIMENT
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA


363713FS
KING CREEK
POND NO. 12
POND NO. 11
FELGATES CREEK
INDIAN FIELD CREEK
YORK RIVER
ROOSEVELT POND
LEET POND
OLD WILLIAMSBURG ROAD
ROUTE 64
C&O RAILWAY
BALLARD CREEK
NAVAL WEAPONS STATION YORKTOWN
SSA
SITE
Baker
Baker Environmental, Inc.
EAST BRANCH OF FELGATES CREEK
SITE 8
8SG02
8PZ01
8SB04
8SB06
8SB07
8SB05
8SB08
8SG01
8GW01
8GW01A
8SB09
8GW03
8GW02
CARBON ADSORPTION TOWER
ACCESS ROAD
456
ST
30
28
26
24
22
20
18
16
14
12
10
8
6
4
32
30 0 15 30
1 inch = 30 ft.
Baker
Baker Environmental, Inc.
LEGEND
8GW01 – MONITORING WELL (BAKER 1997) WITHIN UPPER YORKTOWN–EASTOVER AQUIFER
8GW01A – MONITORING WELL (BAKER 1997) WITHIN THE LOWER YORKTOWN–EASTOVER AQUIFER
8SB04 – SOIL BORING
8PZ01 – PIEZOMETER
8SG01 – STAFF GAUGE
– APPROXIMATE SITE BOUNDARY
10 – GROUND SURFACE CONTOUR (FT., MSL)
– TREE LINE
SOURCE: MILLER–STEPHENSON & ASSOC., NOV. 1997.
FIGURE 2-29
ROUND TWO RI SOIL BORING AND MONITORING WELL LOCATIONS
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	8SB04-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9090
ARSENIC	5.9 J
BERYLLIUM	0.41
IRON	16200
MANGANESE	154 J

SAMPLE NO.	8SB05-00
DATE SAMPLED	01/14/97
EXPLOSIVES (ug/kg)	
AMINO DNT	3400
PESTICIDES/PCBS (ug/kg)	
AROCLOR-1260	10000
TOTAL INORGANICS (mg/kg)	
ALUMINUM	26300
ARSENIC	5.9
CHROMIUM	61.5
IRON	16500

SAMPLE NO.	8SB01-00
DATE SAMPLED	01/18/97
EXPLOSIVES (ug/kg)	
3-NITROTOLUENE	300 NJ
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12300
ARSENIC	13.8 J
BERYLLIUM	0.72
IRON	31700

SAMPLE NO.	8SB03-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.3 J
BERYLLIUM	0.32
IRON	11400
MANGANESE	317 J

SAMPLE NO.	8SB06-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	94 J
BENZO(B)FLUORANTHENE	180 J
CHRYSENE	120 J
INDENO(1,2,3-CD)PYRENE	100 J
EXPLOSIVES (ug/kg)	
AMINO DNT	4900
RDX	30000
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9220
ARSENIC	5.9 J
IRON	14900

SAMPLE NO.	8SB09-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12700
ARSENIC	7.4 J
BERYLLIUM	0.67
IRON	24600

SAMPLE NO.	8SB02-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12000
ARSENIC	11.1 J
BERYLLIUM	0.55
IRON	31200
THALLIUM	0.82 K

SAMPLE NO.	8SB07-00
DATE SAMPLED	01/18/97
EXPLOSIVES (ug/kg)	
AMINO DNT	2600
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11500
ARSENIC	5 J
IRON	11700

SAMPLE NO.	8SB07-00D
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	550 J
BENZO(A)PYRENE	470 J
BENZO(B)FLUORANTHENE	690 J
BENZO(K)FLUORANTHENE	230 J
CARBAZOLE	180 J
CHRYSENE	600 J
DIBENZO(A,H)ANTHRACENE	75 J
INDENO(1,2,3-CD)PYRENE	280 J
EXPLOSIVES (ug/kg)	
3-NITROTOLUENE	1000 NJ
AMINO DNT	2200
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9820
ARSENIC	5.4 J
IRON	11400

FIGURE 2-30
SELECTED ORGANICS AND INORGANICS
IN SURFACE SOIL
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

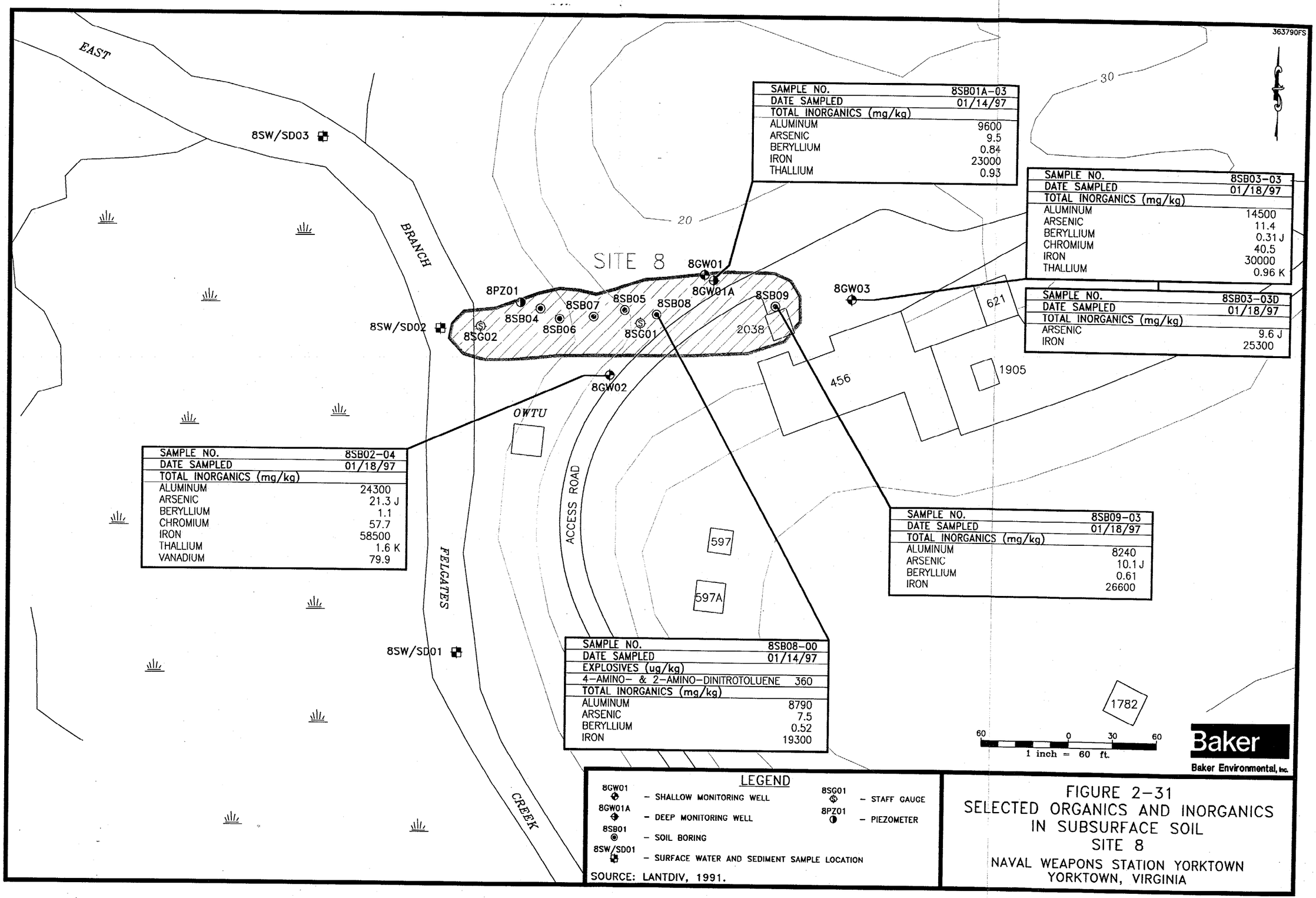
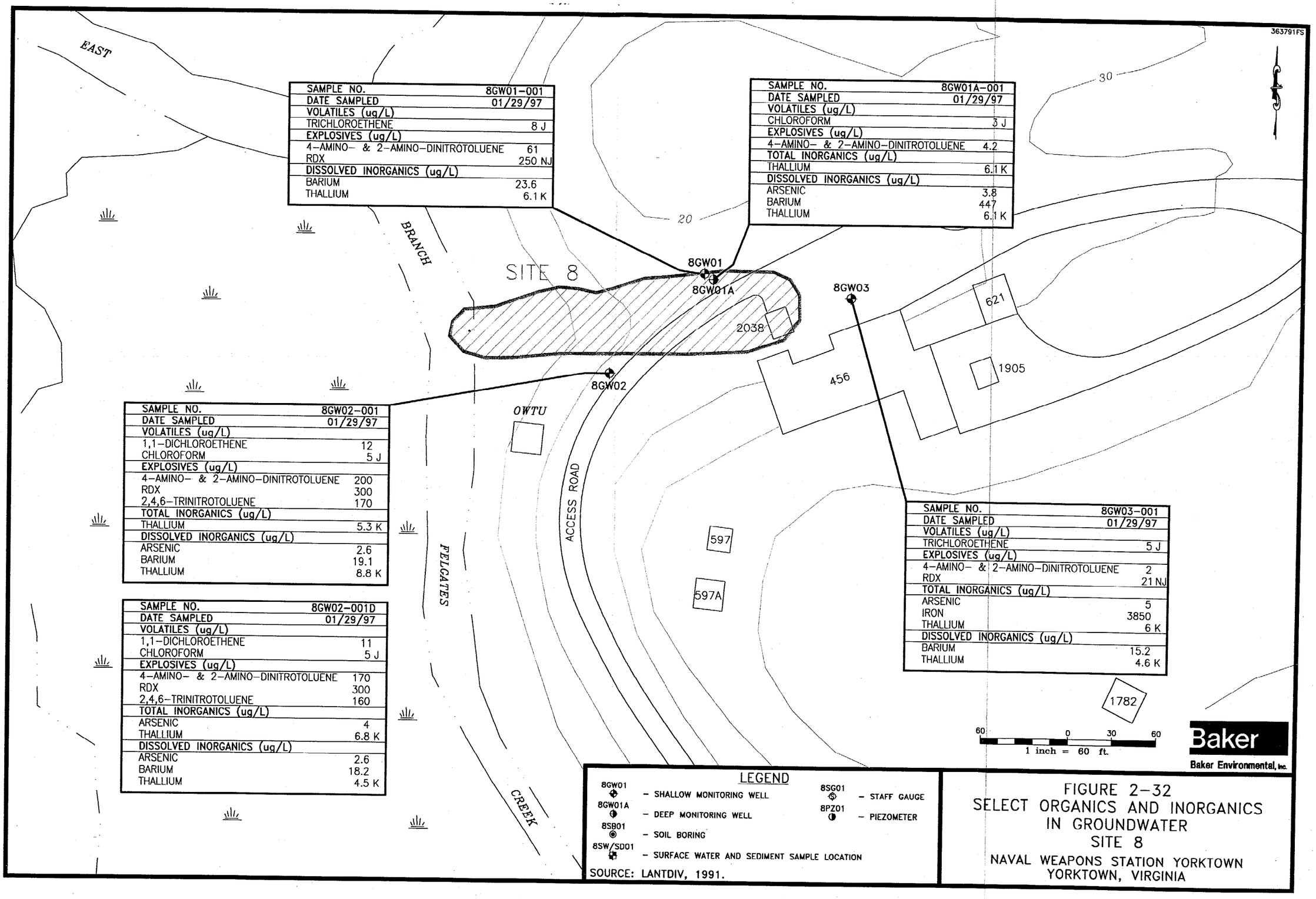


FIGURE 2-31
SELECTED ORGANICS AND INORGANICS IN SUBSURFACE SOIL
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

363791FS



SAMPLE NO.	8GW01-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	8 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	61
RDX	250 NJ
DISSOLVED INORGANICS (ug/L)	
BARIUM	23.6
THALLIUM	6.1 K

SAMPLE NO.	8GW01A-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
CHLOROFORM	3 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	4.2
TOTAL INORGANICS (ug/L)	
THALLIUM	6.1 K
DISSOLVED INORGANICS (ug/L)	
ARSENIC	3.8
BARIUM	447
THALLIUM	6.1 K

SAMPLE NO.	8GW02-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
1,1-DICHLOROETHENE	12
CHLOROFORM	5 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	200
RDX	300
2,4,6-TRINITROTOLUENE	170
TOTAL INORGANICS (ug/L)	
THALLIUM	5.3 K
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2.6
BARIUM	19.1
THALLIUM	8.8 K

SAMPLE NO.	8GW02-001D
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
1,1-DICHLOROETHENE	11
CHLOROFORM	5 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	170
RDX	300
2,4,6-TRINITROTOLUENE	160
TOTAL INORGANICS (ug/L)	
ARSENIC	4
THALLIUM	6.8 K
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2.6
BARIUM	18.2
THALLIUM	4.5 K

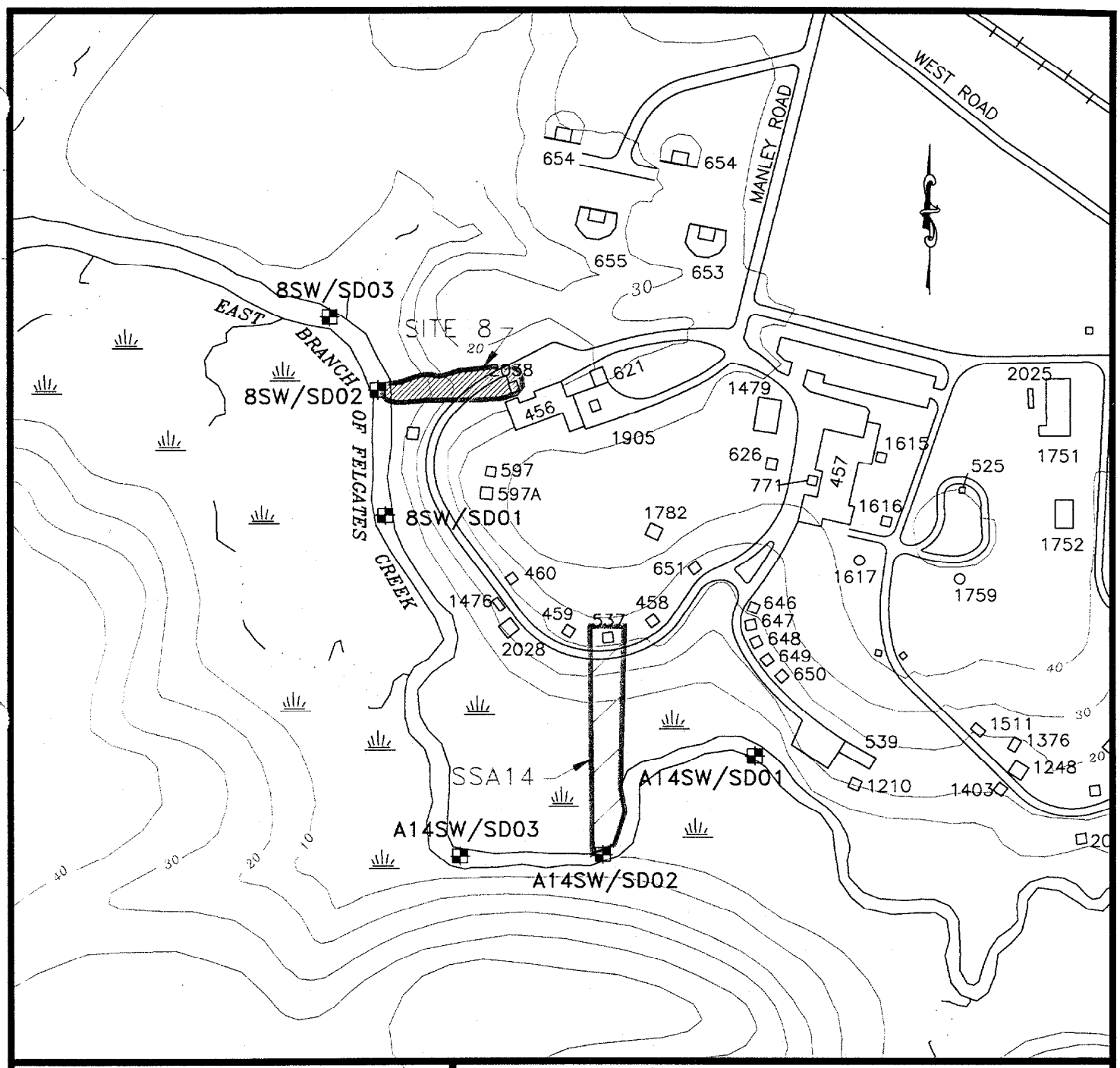
SAMPLE NO.	8GW03-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	5 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	2
RDX	21 NJ
TOTAL INORGANICS (ug/L)	
ARSENIC	5
IRON	3850
THALLIUM	6 K
DISSOLVED INORGANICS (ug/L)	
BARIUM	15.2
THALLIUM	4.6 K

LEGEND

- 8GW01 – SHALLOW MONITORING WELL
- 8GW01A – DEEP MONITORING WELL
- 8SB01 – SOIL BORING
- 8SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 8SG01 – STAFF GAUGE
- 8PZ01 – PIEZOMETER

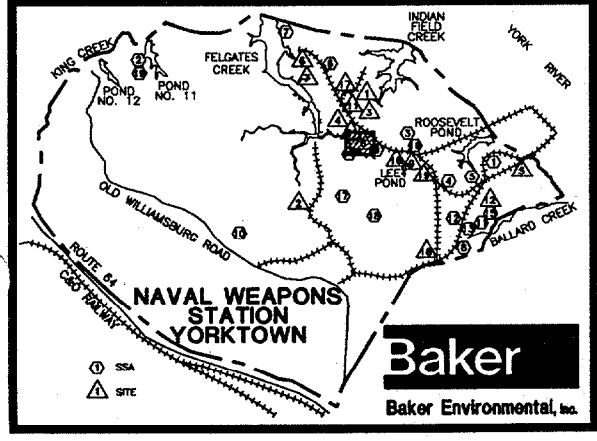
SOURCE: LANTDIV, 1991.

FIGURE 2-32
SELECT ORGANICS AND INORGANICS IN GROUNDWATER
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



250 0 125 250

1 inch = 250 ft.



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WPNSTA YORKTOWN BOUNDARY
DRAINAGE
EDGE OF PAVEMENT
MARSH
RAILROAD
STRUCTURE
APPROXIMATE SITE BOUNDARY
APPROXIMATE SSA BOUNDARY

8SW/SD02 SURFACE WATER/SEDIMENT/ BIOTA SAMPLE LOCATION

10 GROUND SURFACE CONTOUR (FT. MSL)

363717FS

FIGURE 2-33
ROUND TWO RI SURFACE WATER/SEDIMENT/ BIOTA SAMPLE LOCATIONS SITE 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

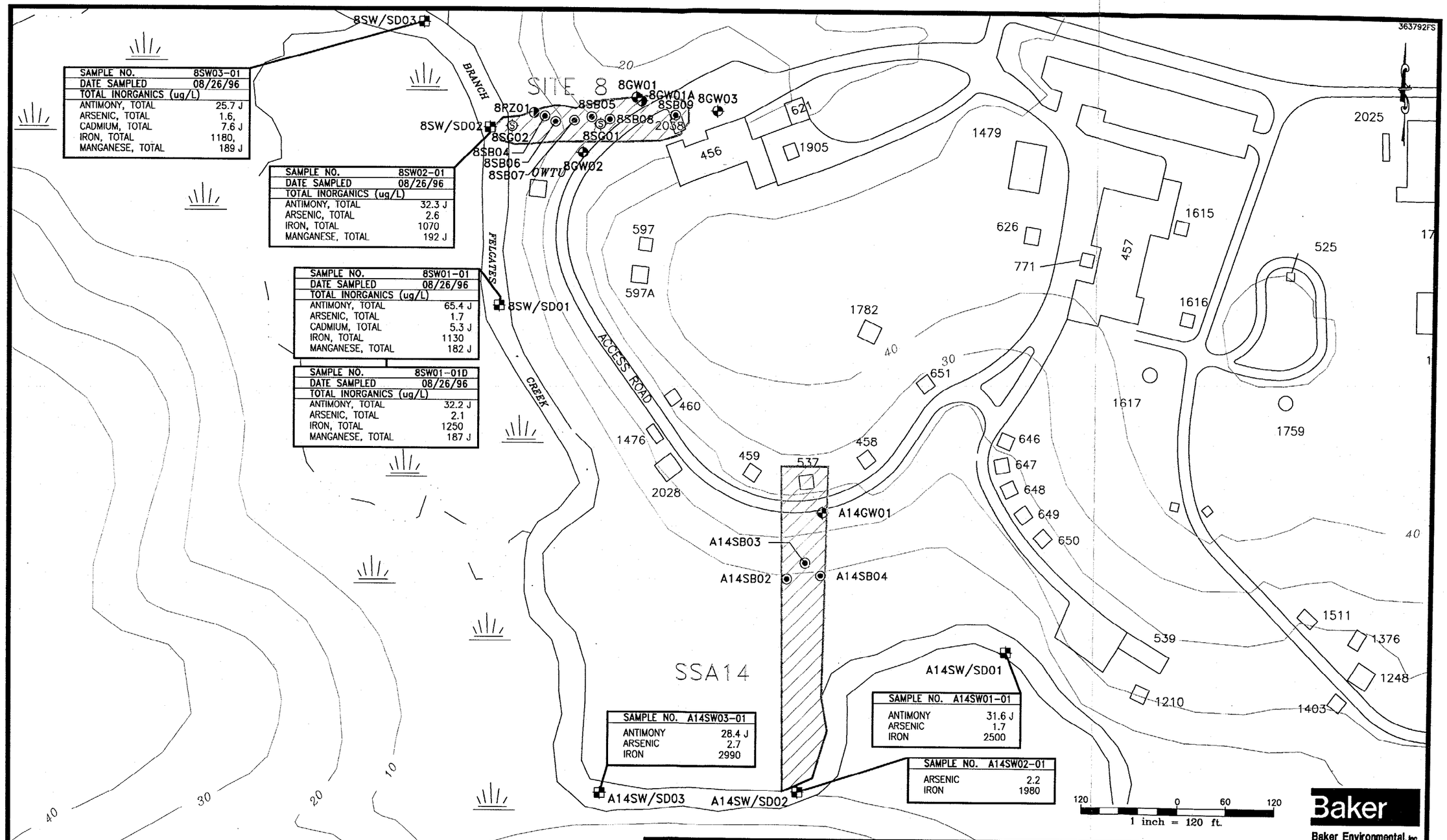
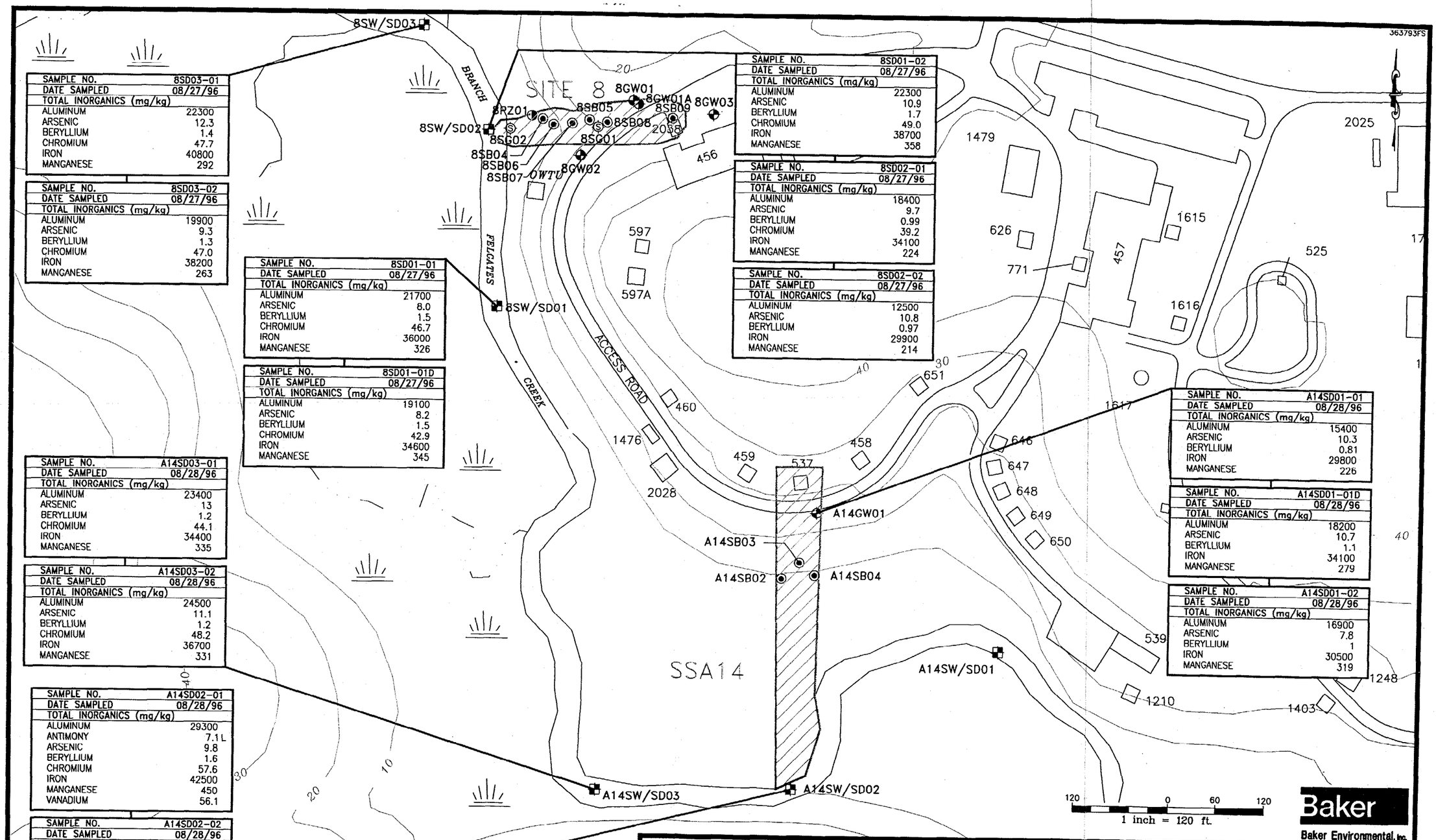


FIGURE 2-34
SELECTED INORGANICS
IN SURFACE WATER
SITE 8 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	8SD03-01
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	22300
ARSENIC	12.3
BERYLLIUM	1.4
CHROMIUM	47.7
IRON	40800
MANGANESE	292

SAMPLE NO.	8SD03-02
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	19900
ARSENIC	9.3
BERYLLIUM	1.3
CHROMIUM	47.0
IRON	38200
MANGANESE	263

SAMPLE NO.	8SD01-01
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	21700
ARSENIC	8.0
BERYLLIUM	1.5
CHROMIUM	46.7
IRON	36000
MANGANESE	326

SAMPLE NO.	8SD01-01D
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	19100
ARSENIC	8.2
BERYLLIUM	1.5
CHROMIUM	42.9
IRON	34600
MANGANESE	345

SAMPLE NO.	8SD01-02
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	22300
ARSENIC	10.9
BERYLLIUM	1.7
CHROMIUM	49.0
IRON	38700
MANGANESE	358

SAMPLE NO.	8SD02-01
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	18400
ARSENIC	9.7
BERYLLIUM	0.99
CHROMIUM	39.2
IRON	34100
MANGANESE	224

SAMPLE NO.	8SD02-02
DATE SAMPLED	08/27/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12500
ARSENIC	10.8
BERYLLIUM	0.97
IRON	29900
MANGANESE	214

SAMPLE NO.	A14SD01-01
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	15400
ARSENIC	10.3
BERYLLIUM	0.81
IRON	29800
MANGANESE	226

SAMPLE NO.	A14SD01-01D
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	18200
ARSENIC	10.7
BERYLLIUM	1.1
IRON	34100
MANGANESE	279

SAMPLE NO.	A14SD01-02
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	16900
ARSENIC	7.8
BERYLLIUM	1
IRON	30500
MANGANESE	319

SAMPLE NO.	A14SD03-01
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	23400
ARSENIC	13
BERYLLIUM	1.2
CHROMIUM	44.1
IRON	34400
MANGANESE	335

SAMPLE NO.	A14SD03-02
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	24500
ARSENIC	11.1
BERYLLIUM	1.2
CHROMIUM	48.2
IRON	36700
MANGANESE	331

SAMPLE NO.	A14SD02-01
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	29300
ANTIMONY	7.1 L
ARSENIC	9.8
BERYLLIUM	1.6
CHROMIUM	57.6
IRON	42500
MANGANESE	450
VANADIUM	56.1

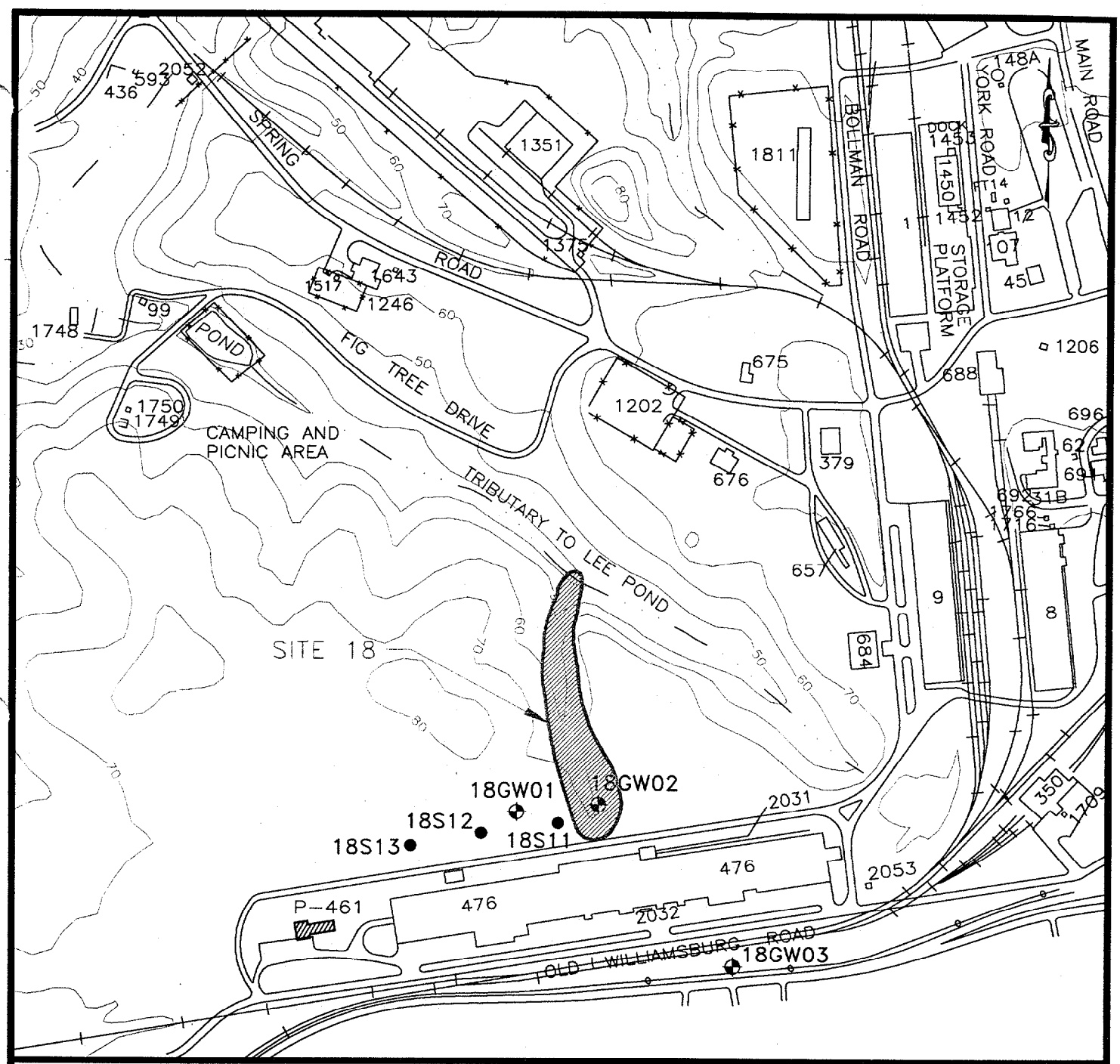
SAMPLE NO.	A14SD02-02
DATE SAMPLED	08/28/96
TOTAL INORGANICS (mg/kg)	
ALUMINUM	20500
ARSENIC	10.7
BERYLLIUM	1.3
CHROMIUM	43.9
IRON	36200
MANGANESE	335

LEGEND

- 8GW01 – SHALLOW MONITORING WELL
- 8GW01A – DEEP MONITORING WELL
- 8SB01 – SOIL BORING
- 8SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 8SG01 – STAFF GAUGE
- 8PZ01 – PIEZOMETER

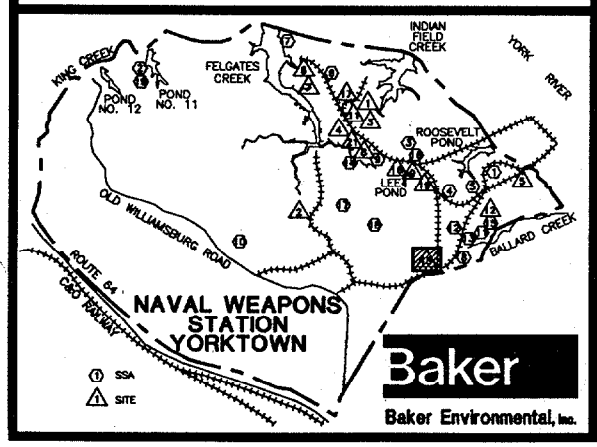
SOURCE: LANTDIV, 1991.

FIGURE 2-35
SELECTED INORGANICS
IN SEDIMENT
SITE 8 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



400 0 200 400

1 inch = 400 ft.



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WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

FENCE

STRUCTURE

APPROXIMATE SITE BOUNDARY

18S09 SURFACE SOIL SAMPLE LOCATION

18GW01 SOIL BORING/ MONITORING WELL LOCATION

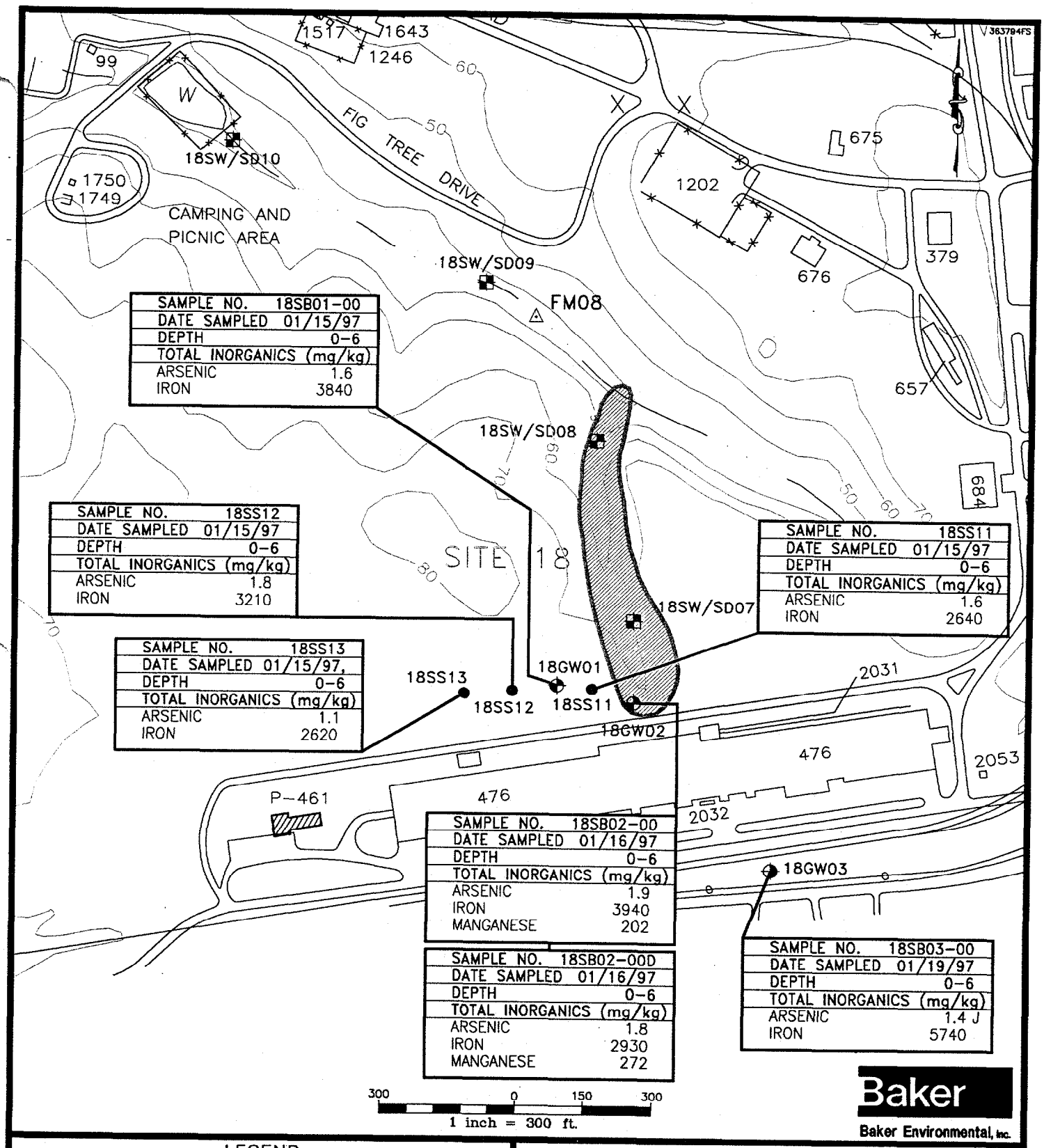
80 GROUND SURFACE CONTOUR (FT., MSL)

363714FS

FIGURE 2-36
ROUND TWO RI SOIL AND GROUNDWATER SAMPLING LOCATIONS
SITE 18

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



LEGEND

18GW01 – SHALLOW MONITORING WELL (BAKER 1997)

18GW03 – DEEP MONITORING WELL (BAKER 1997)

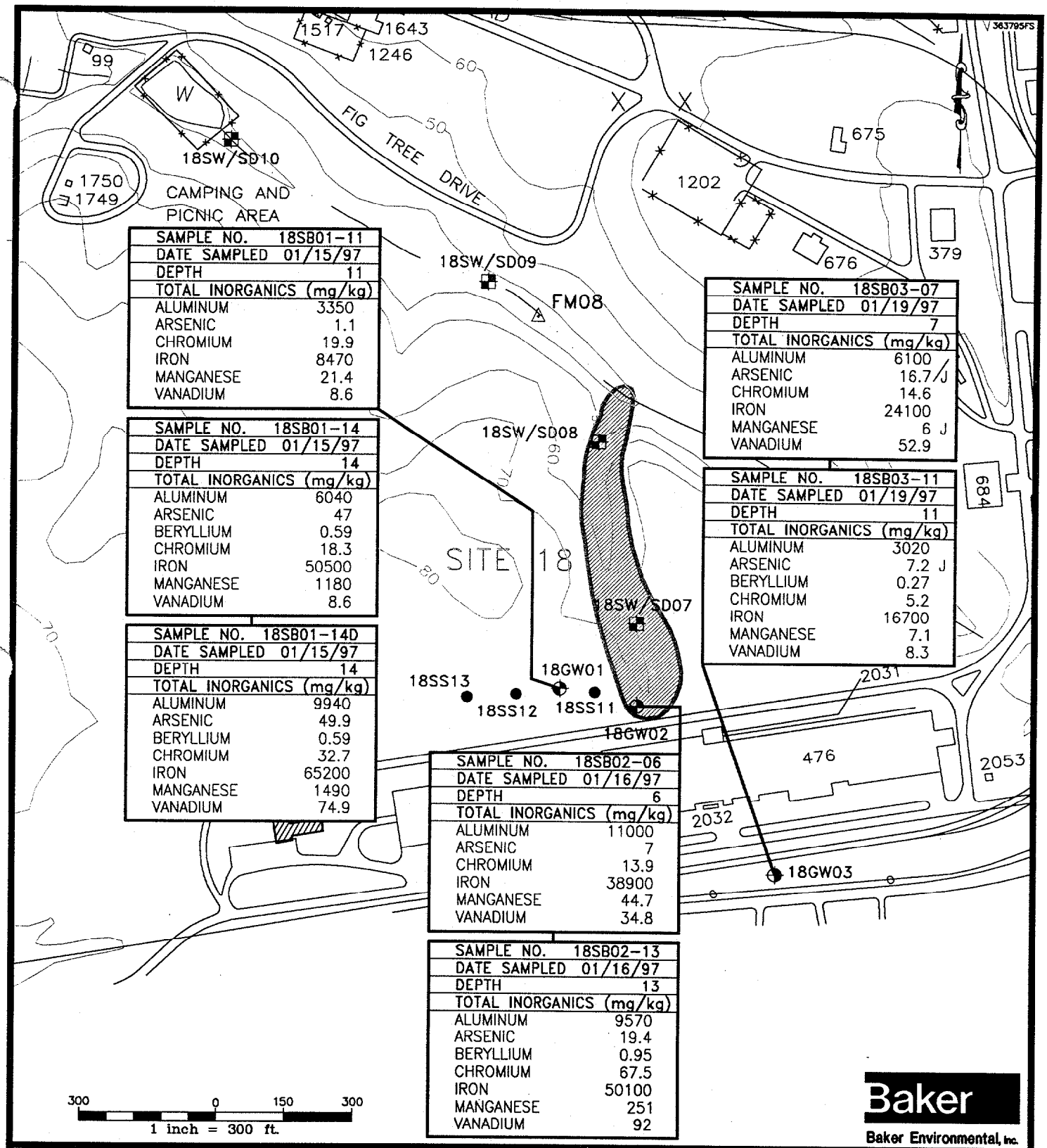
18SS11 – SURFACE SOIL SAMPLING LOCATION

18SW/SD07 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-37
SELECTED INORGANICS IN
SURFACE SOIL
SITE 18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	18SB01-11
DATE SAMPLED	01/15/97
DEPTH	11
TOTAL INORGANICS (mg/kg)	
ALUMINUM	3350
ARSENIC	1.1
CHROMIUM	19.9
IRON	8470
MANGANESE	21.4
VANADIUM	8.6

SAMPLE NO.	18SB01-14
DATE SAMPLED	01/15/97
DEPTH	14
TOTAL INORGANICS (mg/kg)	
ALUMINUM	6040
ARSENIC	47
BERYLLIUM	0.59
CHROMIUM	18.3
IRON	50500
MANGANESE	1180
VANADIUM	8.6

SAMPLE NO.	18SB01-14D
DATE SAMPLED	01/15/97
DEPTH	14
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9940
ARSENIC	49.9
BERYLLIUM	0.59
CHROMIUM	32.7
IRON	65200
MANGANESE	1490
VANADIUM	74.9

SAMPLE NO.	18SB02-06
DATE SAMPLED	01/16/97
DEPTH	6
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11000
ARSENIC	7
CHROMIUM	13.9
IRON	38900
MANGANESE	44.7
VANADIUM	34.8

SAMPLE NO.	18SB02-13
DATE SAMPLED	01/16/97
DEPTH	13
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9570
ARSENIC	19.4
BERYLLIUM	0.95
CHROMIUM	67.5
IRON	50100
MANGANESE	251
VANADIUM	92

SAMPLE NO.	18SB03-07
DATE SAMPLED	01/19/97
DEPTH	7
TOTAL INORGANICS (mg/kg)	
ALUMINUM	6100
ARSENIC	16.7 J
CHROMIUM	14.6
IRON	24100
MANGANESE	6 J
VANADIUM	52.9

SAMPLE NO.	18SB03-11
DATE SAMPLED	01/19/97
DEPTH	11
TOTAL INORGANICS (mg/kg)	
ALUMINUM	3020
ARSENIC	7.2 J
BERYLLIUM	0.27
CHROMIUM	5.2
IRON	16700
MANGANESE	7.1
VANADIUM	8.3

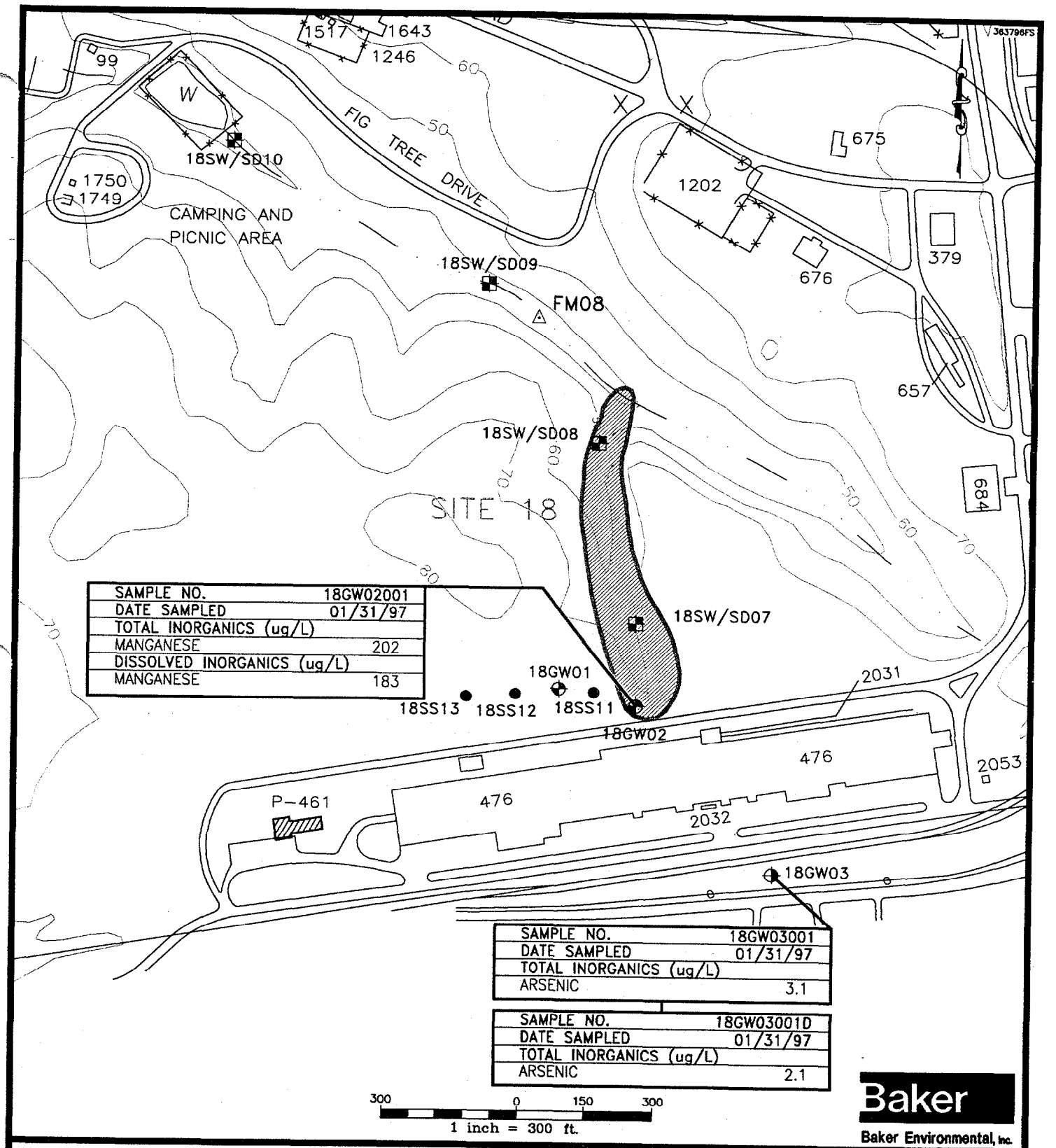
LEGEND

- 18GW01 – SHALLOW MONITORING WELL (BAKER 1997)
- 18GW03 – DEEP MONITORING WELL (BAKER 1997)
- 18SS11 – SURFACE SOIL SAMPLING LOCATION
- 18SW/SD07 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-38
SELECTED INORGANICS IN
SUBSURFACE SOIL
SITE 18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	18GW02001
DATE SAMPLED	01/31/97
TOTAL INORGANICS (ug/L)	
MANGANESE	202
DISSOLVED INORGANICS (ug/L)	
MANGANESE	183

SAMPLE NO.	18GW03001
DATE SAMPLED	01/31/97
TOTAL INORGANICS (ug/L)	
ARSENIC	3.1

SAMPLE NO.	18GW03001D
DATE SAMPLED	01/31/97
TOTAL INORGANICS (ug/L)	
ARSENIC	2.1

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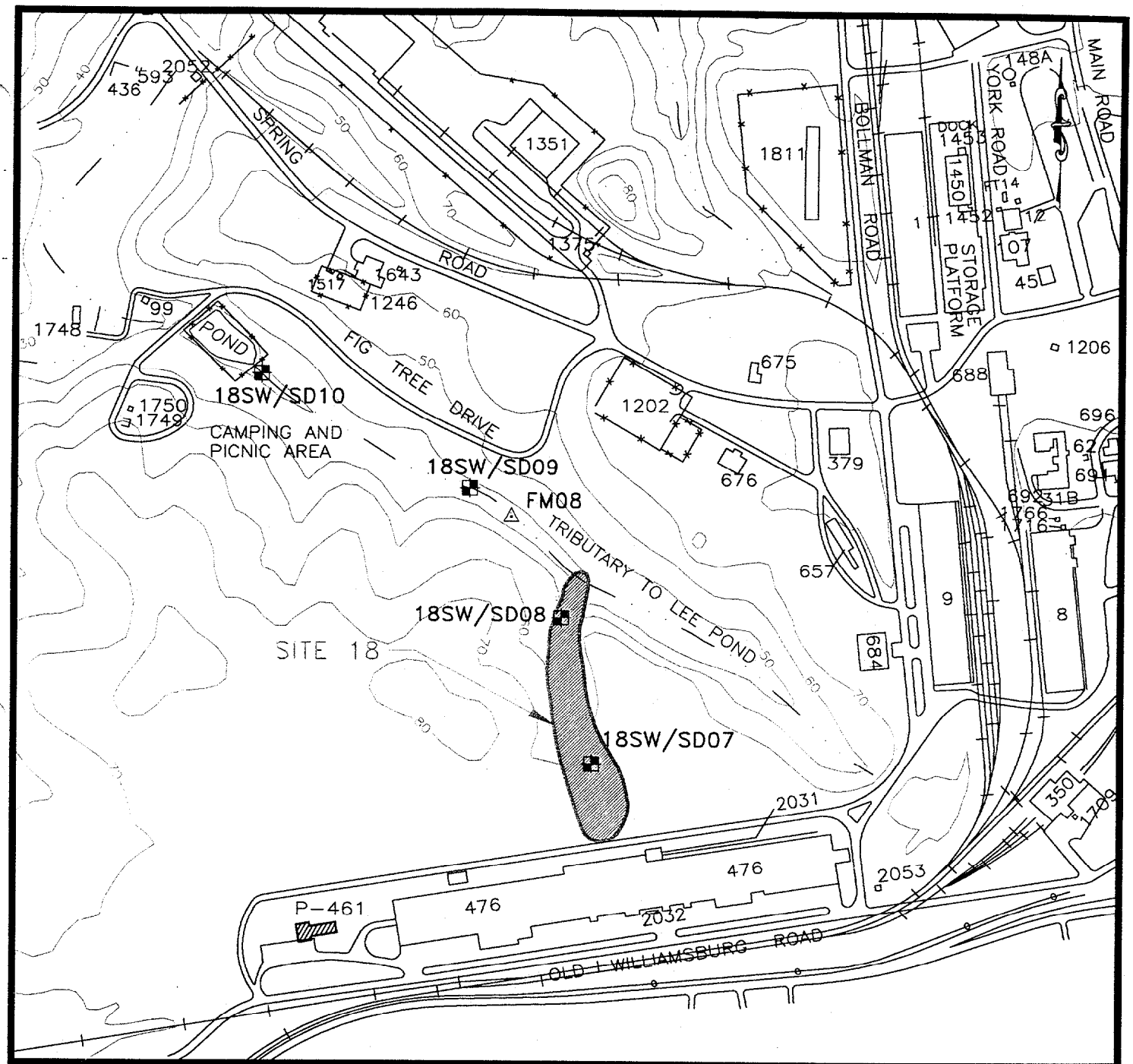
LEGEND

- 18GW01 – SHALLOW MONITORING WELL (BAKER 1997)
- 18GW03 – DEEP MONITORING WELL (BAKER 1997)
- 18SS11 – SURFACE SOIL SAMPLING LOCATION
- 18SW/SD07 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

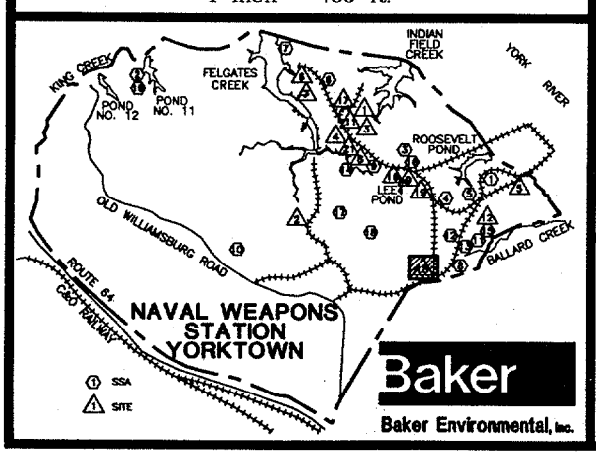
FIGURE 2-39
SELECTED INORGANICS
IN GROUNDWATER
SITE 18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



400 0 200 400

1 inch = 400 ft.



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WPNSTA YORKTOWN BOUNDARY

DRAINAGE

RAILROAD

FENCE

STRUCTURE

APPROXIMATE SITE BOUNDARY

18SW/SD02 SURFACE WATER/SEDIMENT SAMPLING LOCATION

FM08 STREAM FLOW-MEASUREMENT STATION

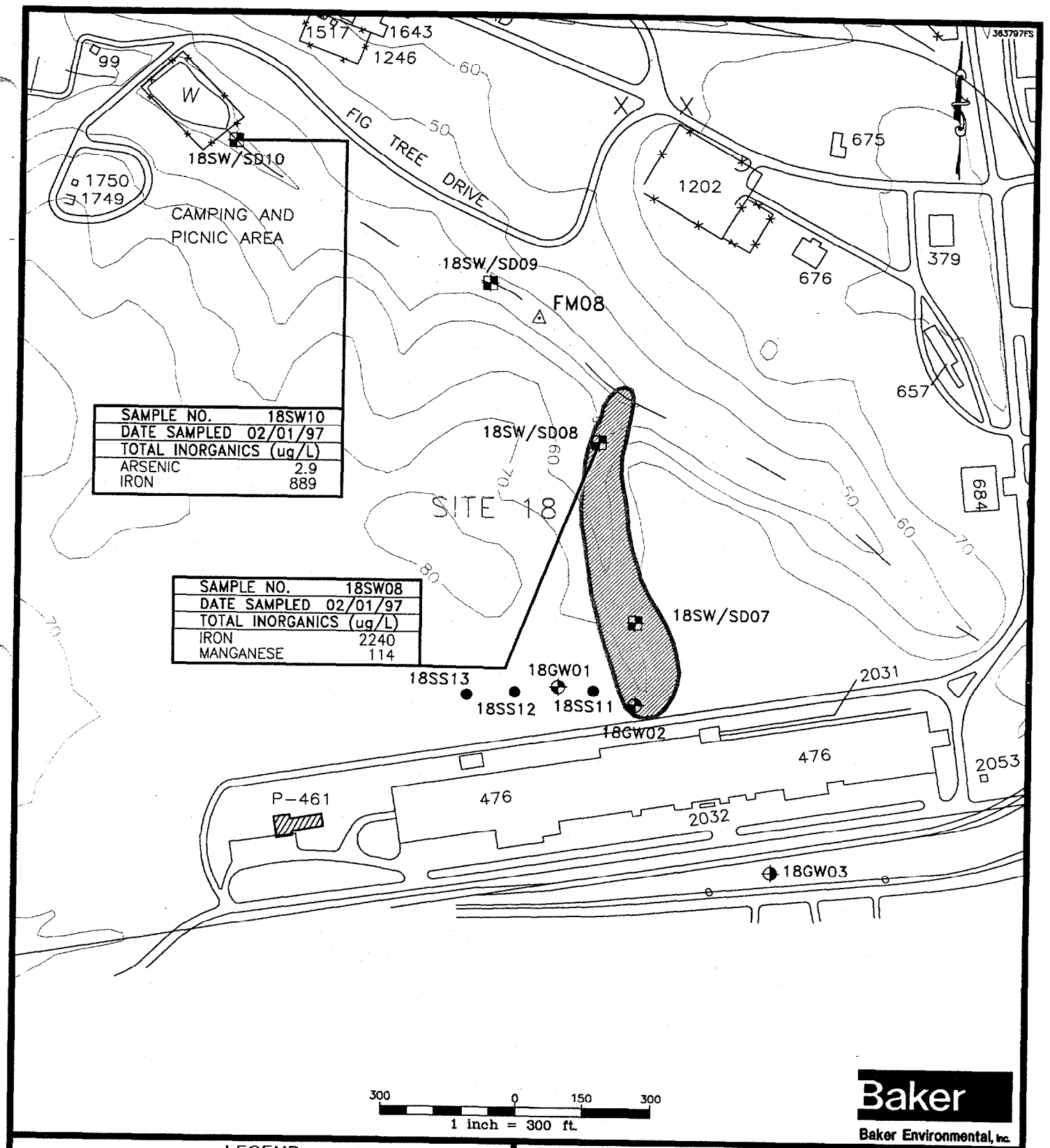
80 GROUND SURFACE CONTOUR (FT., MSL)

363715FS

FIGURE 2-40
ROUND TWO RI SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SITE 18

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



SAMPLE NO.	18SW10
DATE SAMPLED	02/01/97
TOTAL INORGANICS (ug/L)	
ARSENIC	2.9
IRON	889

SAMPLE NO.	18SW08
DATE SAMPLED	02/01/97
TOTAL INORGANICS (ug/L)	
IRON	2240
MANGANESE	114

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LEGEND

18GW01 – SHALLOW MONITORING WELL (BAKER 1997)

18GW03 – DEEP MONITORING WELL (BAKER 1997)

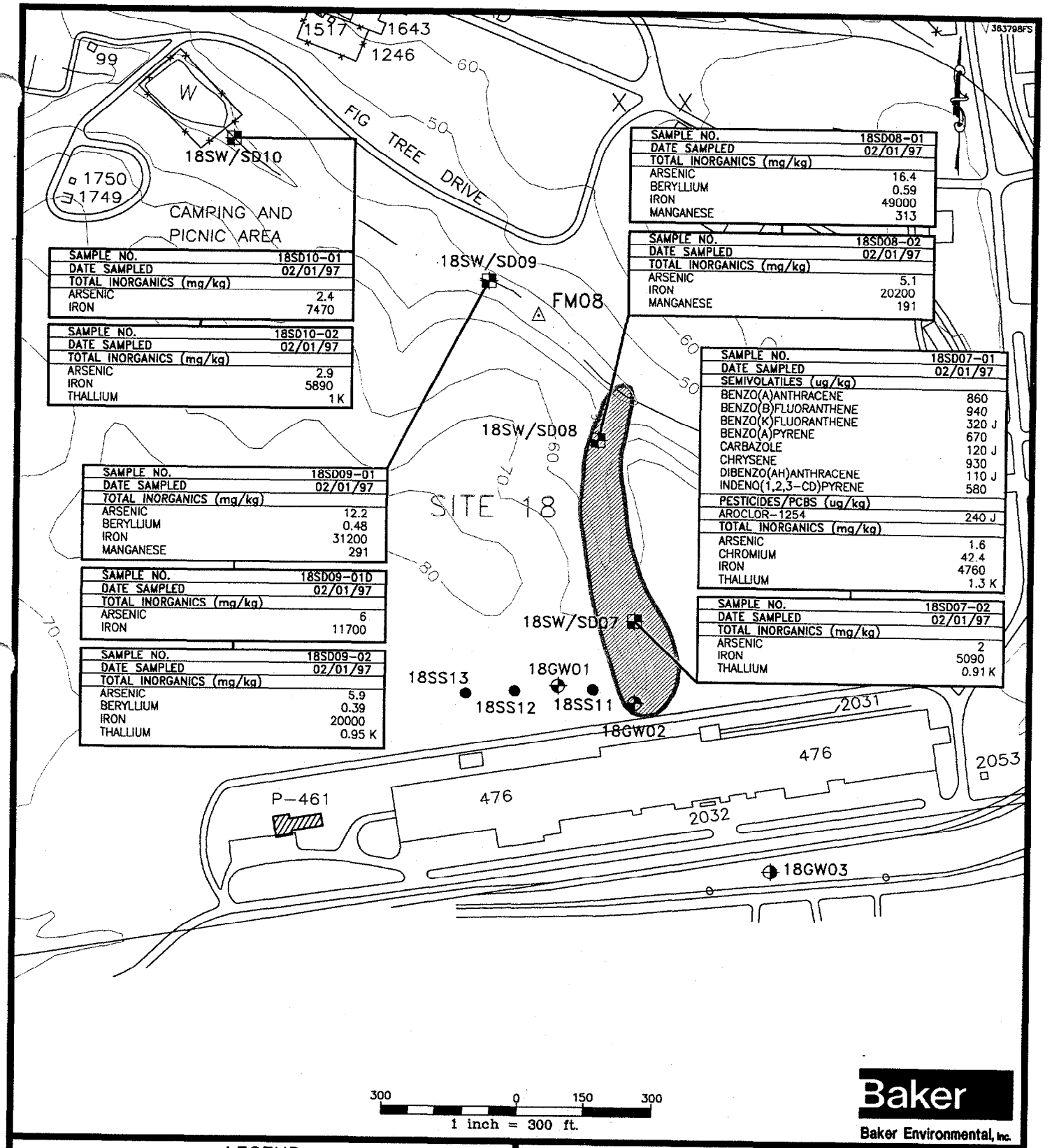
18SS11 – SURFACE SOIL SAMPLING LOCATION

18SW/SD07 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-41
SELECTED INORGANICS IN
SURFACE WATER
SITE 18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	18SD10-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	2.4
IRON	7470

SAMPLE NO.	18SD10-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	2.9
IRON	5890
THALLIUM	1 K

SAMPLE NO.	18SD09-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	12.2
BERYLLIUM	0.48
IRON	31200
MANGANESE	291

SAMPLE NO.	18SD09-01D
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	6
IRON	11700

SAMPLE NO.	18SD09-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	5.9
BERYLLIUM	0.39
IRON	20000
THALLIUM	0.95 K

SAMPLE NO.	18SD08-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	16.4
BERYLLIUM	0.59
IRON	49000
MANGANESE	313

SAMPLE NO.	18SD08-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	5.1
IRON	20200
MANGANESE	191

SAMPLE NO.	18SD07-01
DATE SAMPLED	02/01/97
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	860
BENZO(B)FLUORANTHENE	940
BENZO(K)FLUORANTHENE	320 J
BENZO(A)PYRENE	670
CARBAZOLE	120 J
CHRYSENE	930
DIBENZO(AH)ANTHRACENE	110 J
INDENO(1,2,3-CD)PYRENE	580
PESTICIDES/PCBS (ug/kg)	
AROCLOR-1254	240 J
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.6
CHROMIUM	42.4
IRON	4760
THALLIUM	1.3 K

SAMPLE NO.	18SD07-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
ARSENIC	2
IRON	5090
THALLIUM	0.91 K

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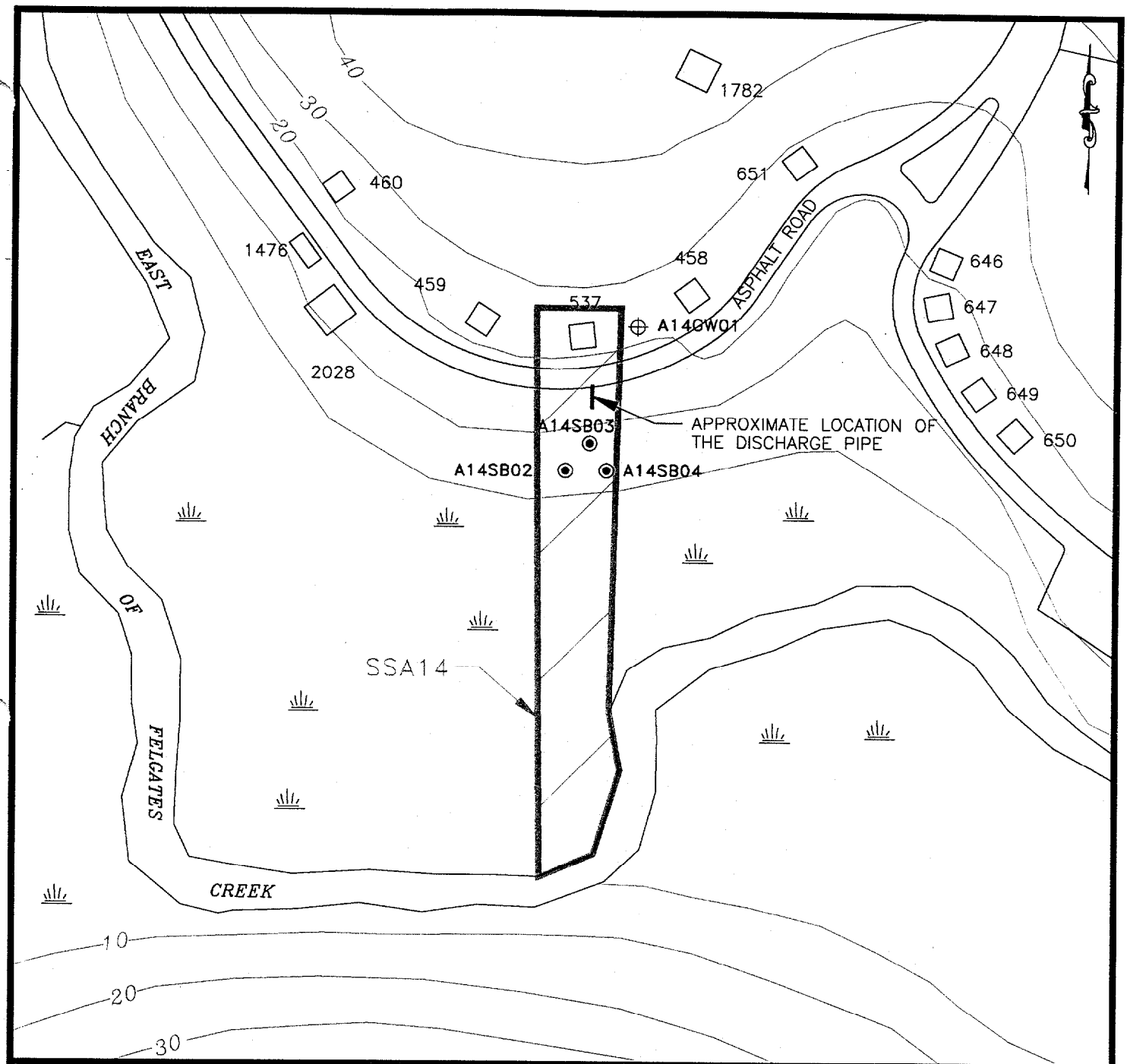
LEGEND

18GW01 – SHALLOW MONITORING WELL (BAKER 1997)
18GW03 – DEEP MONITORING WELL (BAKER 1997)
18SS11 – SURFACE SOIL SAMPLING LOCATION
18SW/SD07 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-42
SELECTED ORGANICS AND INORGANICS IN SEDIMENT
SITE 18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



100 0 50 100

1 inch = 100 ft.

WPNSTA YORKTOWN BOUNDARY

DRAINAGE

MARSH

STRUCTURE

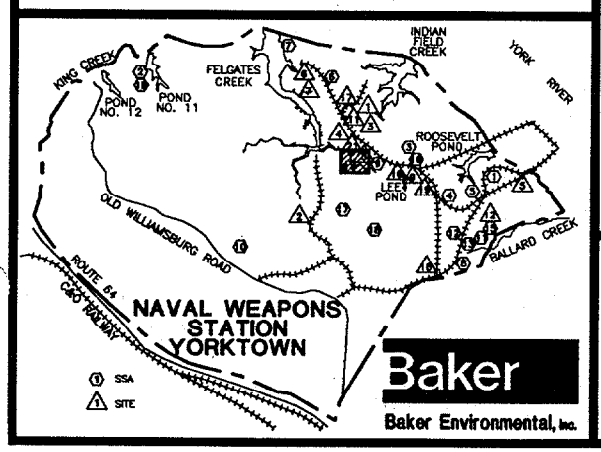
APPROXIMATE SSA BOUNDARY

SOIL BORING LOCATION

MONITORING WELL LOCATION

10 GROUND SURFACE CONTOUR (FT., MSL)

363716FS



Baker

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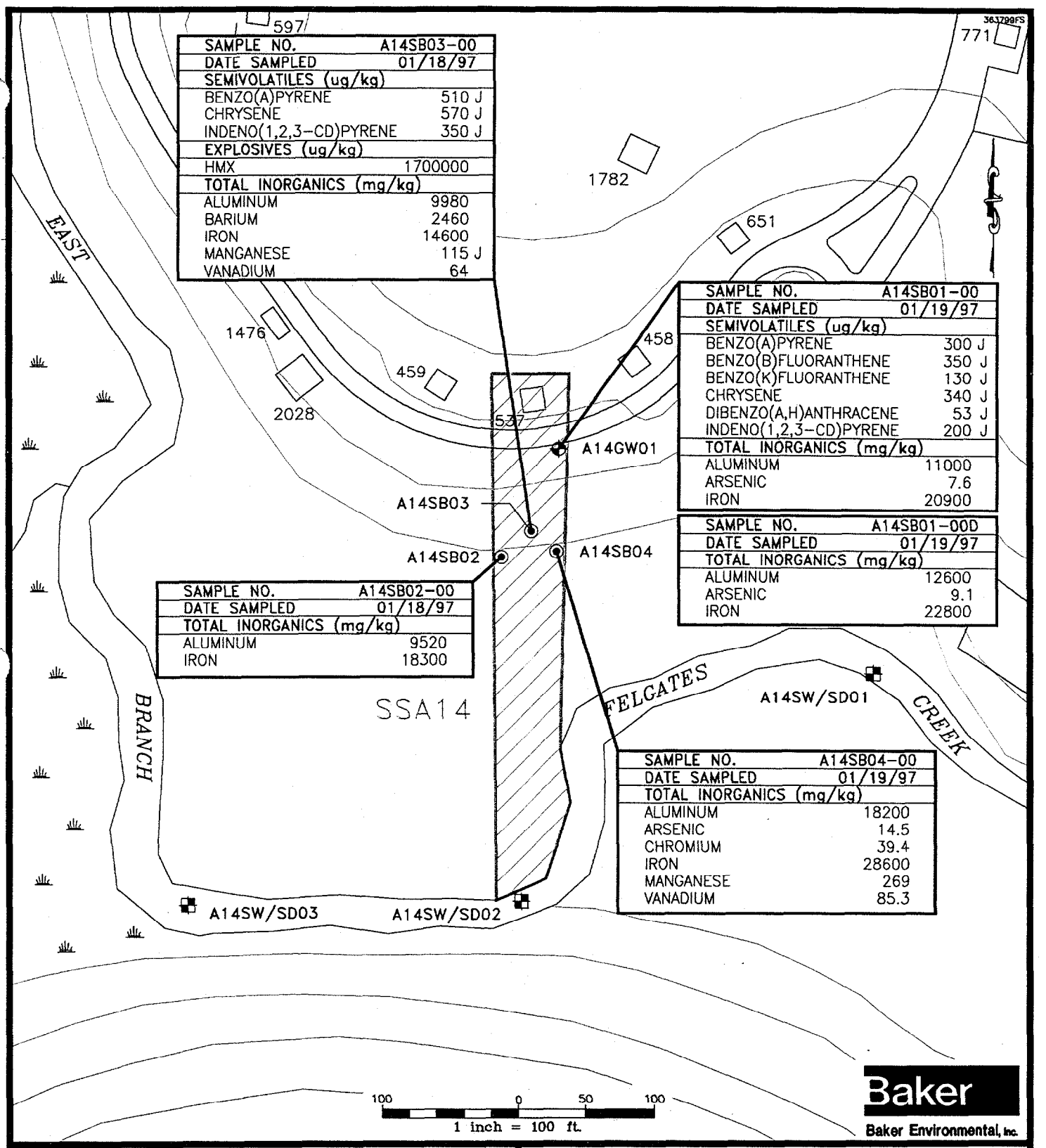
FIGURE 2-43
ROUND TWO RI SOIL BORING AND MONITORING WELL LOCATIONS
SSA 14

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA



SAMPLE NO.	A14SB03-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	510 J
CHRYSENE	570 J
INDENO(1,2,3-CD)PYRENE	350 J
EXPLOSIVES (ug/kg)	
HMX	1700000
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9980
BARIUM	2460
IRON	14600
MANGANESE	115 J
VANADIUM	64

SAMPLE NO.	A14SB01-00
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	300 J
BENZO(B)FLUORANTHENE	350 J
BENZO(K)FLUORANTHENE	130 J
CHRYSENE	340 J
DIBENZO(A,H)ANTHRACENE	53 J
INDENO(1,2,3-CD)PYRENE	200 J
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11000
ARSENIC	7.6
IRON	20900

SAMPLE NO.	A14SB01-00D
DATE SAMPLED	01/19/97
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12600
ARSENIC	9.1
IRON	22800

SAMPLE NO.	A14SB02-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9520
IRON	18300

SAMPLE NO.	A14SB04-00
DATE SAMPLED	01/19/97
TOTAL INORGANICS (mg/kg)	
ALUMINUM	18200
ARSENIC	14.5
CHROMIUM	39.4
IRON	28600
MANGANESE	269
VANADIUM	85.3

LEGEND

A14GW01 – MONITORING WELL (BAKER 1997)

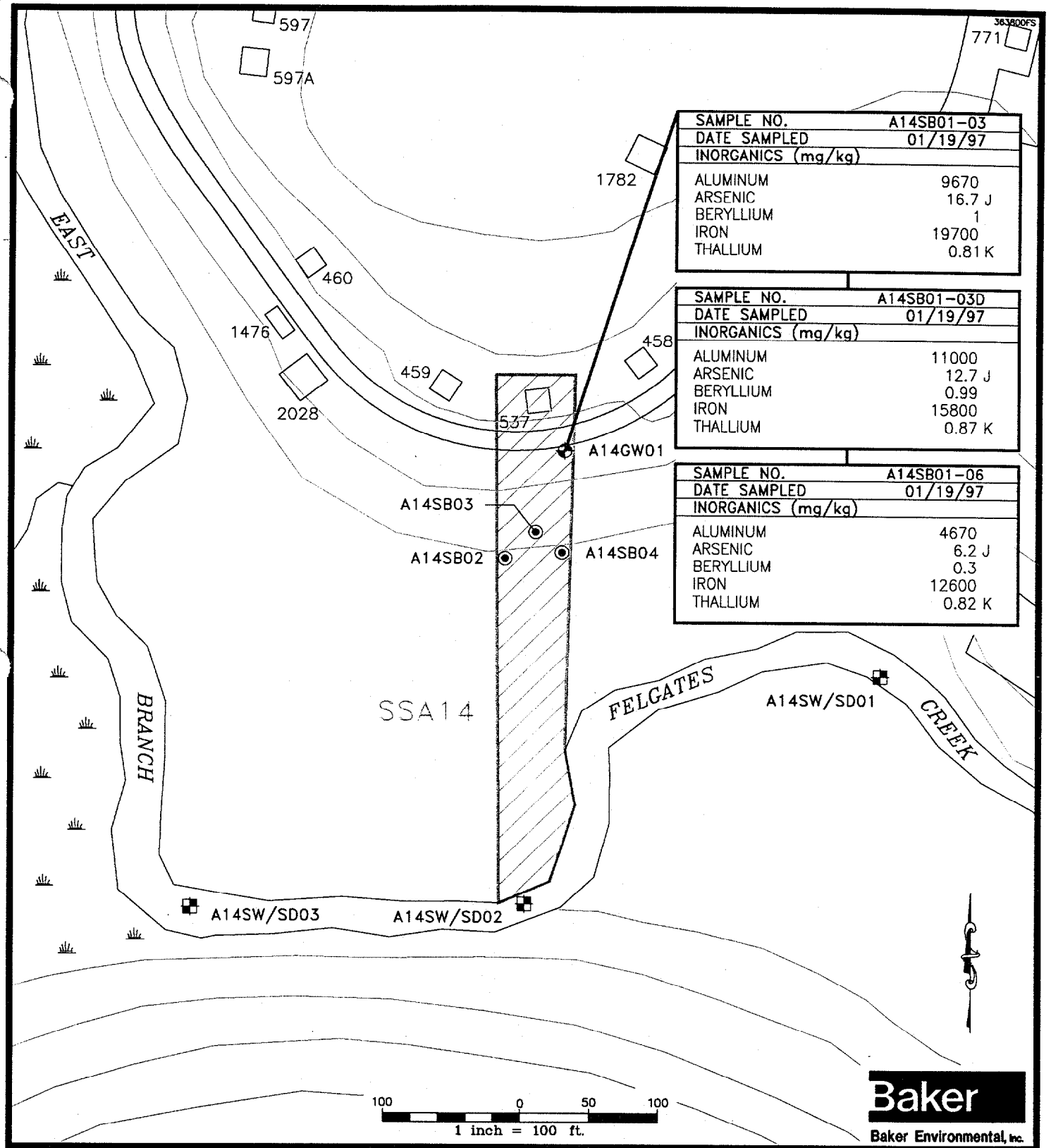
A14SB02 – SOIL BORING

A14SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-44
SELECTED ORGANICS AND INORGANICS IN SURFACE SOIL
SITE SSA-14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



LEGEND

A14GW01 – MONITORING WELL (BAKER 1997)

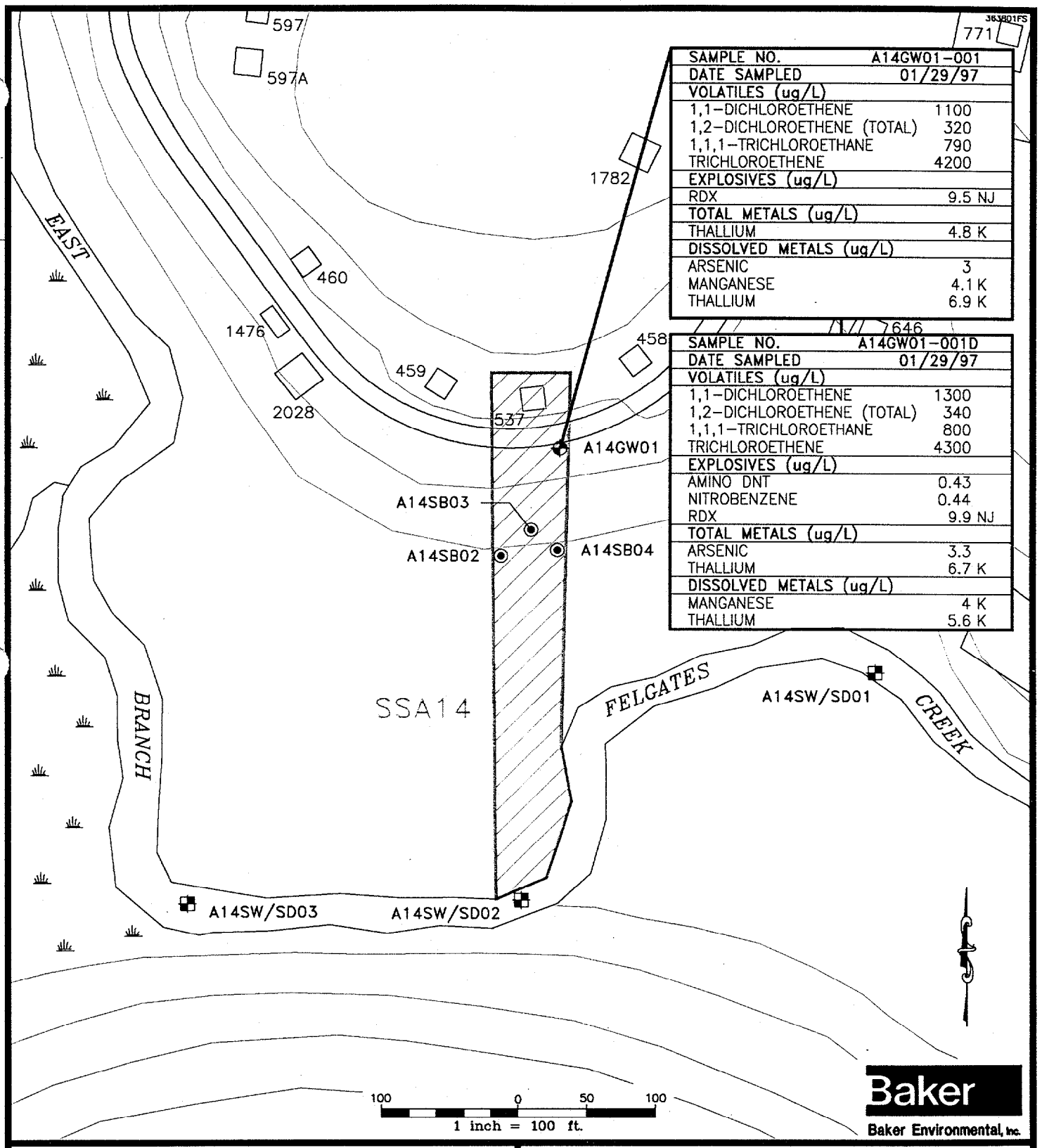
A14SB02 – SOIL BORING

A14SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-45
SELECTED INORGANICS
IN SUBSURFACE SOIL
SITE SSA-14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	A14GW01-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
1,1-DICHLOROETHENE	1100
1,2-DICHLOROETHENE (TOTAL)	320
1,1,1-TRICHLOROETHANE	790
TRICHLOROETHENE	4200
EXPLOSIVES (ug/L)	
RDX	9.5 NJ
TOTAL METALS (ug/L)	
THALLIUM	4.8 K
DISSOLVED METALS (ug/L)	
ARSENIC	3
MANGANESE	4.1 K
THALLIUM	6.9 K

SAMPLE NO.	A14GW01-001D
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
1,1-DICHLOROETHENE	1300
1,2-DICHLOROETHENE (TOTAL)	340
1,1,1-TRICHLOROETHANE	800
TRICHLOROETHENE	4300
EXPLOSIVES (ug/L)	
AMINO DNT	0.43
NITROBENZENE	0.44
RDX	9.9 NJ
TOTAL METALS (ug/L)	
ARSENIC	3.3
THALLIUM	6.7 K
DISSOLVED METALS (ug/L)	
MANGANESE	4 K
THALLIUM	5.6 K

LEGEND

A14GW01 – MONITORING WELL (BAKER 1997)

A14SB02 – SOIL BORING

A14SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

SOURCE: LANTDIV, 1991.

FIGURE 2-46
SELECTED ORGANICS AND INORGANICS IN GROUNDWATER
SITE SSA-14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

3.0 REMEDIATION GOALS AND REMEDIAL ACTION OBJECTIVES

This section evaluates the results of the baseline RAs and determines whether it is necessary to remediate environmental media at Sites 2, 8, and 18 and SSA 14. If remediation is necessary, all pertinent Federal and Commonwealth of Virginia standards and criteria will be evaluated in a manner consistent with the results of the baseline RAs to ensure that the selected remedy is adequately protective of human health and the environment. If Federal and/or Commonwealth of Virginia standards and criteria are not available, or are not adequately protective because of multi-chemical mixtures or multiple exposure pathways, risk-based remediation goals will be derived. These criteria and goals will be evaluated to determine contaminants of concern (COCs) and areas of concern (AOCs) for which RAAs can be developed.

3.1 Media and Contaminants of Concern

The following section identifies the media of concern and COCs for Sites 2, 8, and 18, and SSA 14 with respect to the results of the human health and ecological RAs developed in the RI.

3.1.1 Media and Contaminants of Concern Determined by the Human Health Risk Assessment

COPCs for human health were identified in the RI for each site and each media by comparing the concentrations of contaminants on site to Federal and state criteria. The COPCs are presented by media in Tables 3-1 through 3-5 and were used in the human health RA for each site. The following paragraphs present summaries of the human health RA for each site.

No unacceptable carcinogenic human health risks were identified for any media at Sites 2, 8, and 18, or SSA 14.

The human health RA determined that potential unacceptable noncarcinogenic human health risks were posed by ingestion and dermal contact with surface soil contaminated with cadmium at Site 2. At Site 8, unacceptable noncarcinogenic risks were also identified due to ingestion of surface soil contaminated with iron, and ingestion of groundwater contaminated with amino-DNTs. Ingestion

and dermal contact with surface soil contaminated with HMX and iron was determined to pose an unacceptable noncarcinogenic risk as SSA 14.

No unacceptable human health risks were identified at Site 18 for any media.

3.1.2 Media and Contaminants of Concern Determined by the Ecological Risk Assessment

The ECOCs identified in the RI are presented in the following sections by area. Only contaminants detected over benchmark toxicity values or generating risk in the receptor models are discussed.

3.1.2.1 Site 2 - Turkey Road Landfill

Terrestrial Environment

PAHs, Aroclor-1254, and inorganics were the primary ECOCs detected at Site 2 (Table 3-6). The following ECOCs detected in surface soil exceeded flora/fauna toxicity benchmark values or demonstrated risks in the terrestrial models: benzo(a)pyrene, fluoranthene, phenanthrene, pyrene, Aroclor-1254, aluminum, antimony, cadmium, chromium, cobalt, copper, iron, lead, mercury, silver, thallium, vanadium, and zinc. Soil concentrations of aluminum, chromium, iron, lead, and vanadium were detected at concentrations similar to Station-wide background surface soil concentrations. Soil concentrations of benzo(a)pyrene, silver, and zinc exceed soil flora and fauna values, but did not produce unacceptable risks in the terrestrial uptake models. Antimony was detected in only one surface soil sample at a concentration that was not significantly greater than background concentrations.

Based on this information, the surface soil at Site 2 is a medium of concern due to concentrations of fluoranthene, phenanthrene, pyrene, Aroclor-1254. Inorganics including cadmium, cobalt, copper, mercury, and thallium were detected above Station-wide background concentrations at levels that produce unacceptable ecological risks.

Aquatic Environment

As presented on Table 3-7, PAHs, TNT, and inorganics were the primary ECOCs detected in the aquatic habitat at Site 2. There are no benchmark values currently available to evaluate the estuarine surface water. Only concentrations of TNT were detected above off-Station background surface water concentrations.

Benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, phenanthrene, aluminum, beryllium, iron, selenium, and silver were detected ~~above toxicity benchmark~~ values or demonstrated risks in the aquatic models. Sediment concentrations of aluminum, beryllium, copper, iron, manganese, and selenium were detected at concentrations below off-Station background sediment concentrations. Sediment concentrations of benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, phenanthrene, and selenium exceed sediment benchmark values, but did not produce unacceptable risks in the aquatic uptake models.

Based on this evaluation, sediment is a medium of concern at Site 2 because to concentrations of silver exceed toxicity values and produce unacceptalbe receptor risks.

3.1.2.2 Site 8 - NEDED Explosives- Contaminated Wastewater Discharge Area

The aquatic environment at Site 8 was evaluated with the aquatic environment at SSA 14 due to the close proximity of these two areas. The aquatic evaluation is presented in Section 3.1.4.

Terrestrial Environment

Aroclor-1260, RDX, and inorganics were the primary ECOCs detected in the terrestrial habitat at Site 8 (Table 3-8). Aroclor-1260, RDX, aluminum, antimony, chromium, copper, iron, lead, mercury, thallium, vanadium, and zinc exceeded flora/fauna toxicity benchmark values or produced unacceptable risks in the terrestrial models. Soil concentrations of aluminum, antimony, iron, and vanadium were detected at concentrations similar to Station-wide background surface soil concentrations. Soil concentrations of RDX and thallium exceed soil flora and fauna values, but did not produce unacceptable risks in the terrestrial uptake models.

Surface soil at Site 8 is, therefore, a medium of concern because concentrations of Aroclor-1260, chromium, copper, lead, mercury, and zinc.

3.1.2.3 Site 18 - Building 476 Discharge Area

Terrestrial Environment

Aluminum, chromium, copper, iron, lead, mercury, and vanadium exceeded soil flora/fauna toxicity benchmark values or demonstrated ~~risks in the terrestrial~~ models (Table 3-9). Soil concentrations of the inorganic ECOCs were detected at concentrations similar to Station-wide background surface soil concentrations. As a result, the surface soil at Site 18 is not an ecological medium of concern.

Aquatic Environment

PAHs, pesticides, inorganics were the primary potential ECOCs detected in the aquatic habitat at Site 18. Aluminum, copper, and iron exceeded toxicity benchmark values (Table 3-10). Of these inorganics, concentrations of aluminum and iron were detected at similar concentrations to Station background surface water concentrations.

Surface water is, therefore, retained as a medium of concern at Site 18 because of concentrations of copper that exceeded background and produce unacceptable risks to aquatic receptors.

Sediment concentrations of pyrene, alpha-chlordane, gamma-chlordane, Aroclor-1254, beryllium, iron, and lead exceeded benchmark toxicity values or demonstrated risks in the aquatic models. Sediment concentrations of aluminum, beryllium, and lead were detected below Station background sediment concentrations. Of the ECOCs detected above background, concentrations of pyrene, alpha-chlordane, gamma-chlordane, and Aroclor-1254 exceed benchmark toxicity values, but do not pose unacceptable risk in aquatic uptake models.

Based on this evaluation, sediment at Site 18 is an ecological medium of concern because of concentrations of copper and iron detected above background that produce unacceptable risks to aquatic receptors.

3.1.2.4 SSA 14 - Building 537 Discharge to Felgates Creek

The terrestrial summary presented below pertains to SSA 14 surface soil. The aquatic summary presented in Section 3.1.4.2 pertains to both Site 8 and SSA 14.

Terrestrial Environment

HMX and inorganics were the primary ECOCs detected in the terrestrial habitat at SSA 14 (Table 3-11). HMX, aluminum, antimony, barium, chromium, copper, iron, lead, mercury, silver, thallium, vanadium, and zinc exceeded soil flora/fauna toxicity benchmark values or demonstrated risks in the terrestrial models. Soil concentrations of aluminum, antimony, chromium, iron, lead, mercury, thallium, and zinc were detected at concentrations similar to Station-wide background surface soil concentrations. Concentrations of silver and thallium exceeded benchmark toxicity values, but did not pose unacceptable risks in terrestrial uptake models.

Surface soil at SSA 14 is therefore retained as a medium of concern because of HMX, barium, copper, lead, mercury, and zinc detected above background that produce unacceptable risk to terrestrial receptors.

Aquatic Environment

Inorganics were the primary ECOCs detected in the aquatic habitat at Site 8/SSA 14 (Table 3-12). There are currently no benchmark values available to evaluate the estuarine surface water. Surface water concentrations of inorganics detected in surface water are similar to Station background surface water concentrations. Therefore, surface water is not a medium of concern at Site 8/SSA 14.

BEHP, aluminum, beryllium, copper, and iron were detected above sediment toxicity benchmark values or demonstrated risks in the aquatic models. Sediment concentrations of aluminum, beryllium, copper, iron, and nickel were similar to Station background. The four concentrations of BEHP detected in the sediment do not appear to be site related but are likely detected because of sampling or laboratory contamination. Therefore, the sediment at Site 8/SSA 14 will not be addressed in this FS.

3.1.3 Summary of Media and Contaminants of Concern

Based on the previous discussion, COPCs that were identified for human health risk are as follows:

- Site 2 - cadmium in surface soil
- Site 8 - iron in surface soil
  - amino-DNTs in groundwater
- Site 18 - no COPCs identified
- SSA 14 - HMX and iron in surface soil

The ECOCs that were identified based on ecological risk are as follows:

- Site 2 - fluoranthene, phenanthrene, pyrene, Aroclor-1254, cadmium, cobalt, copper, mercury, thallium in surface soil
  - silver in sediment
- Site 8 - Aroclor-1260, chromium, copper, lead, mercury, zinc in surface soil
- Site 18 - copper in surface water
  - copper and iron in sediment
- SSA 14 - HMX, barium, copper, lead, mercury, zinc in surface soil

These contaminants will now be considered COCs for further evaluation in this report.

3.2 Definition and Identification of ARARs/TBCs

An evaluation of ARARs is the first step in the identification of remediation goals. ARARs should be addressed consistently with the results of the baseline RA and should ensure that a selected remedy attains a degree of cleanup that assures the protection of human health and the environment. This section provides an explanation of Federal and state (Commonwealth of Virginia) criteria that apply to those media deemed to pose unacceptable human health risks or adverse ecological effects identified in the baseline RA. In addition to ARARs, other advisories, criteria, or guidance to-be-considered (TBC) will be evaluated. TBCs may also be useful in developing remedies for Sites 2, 8, and 18, and SSA 14. ARARs and TBCs for Sites 2, 8, and 18, and SSA 14 will be defined and evaluated in the following subsections.

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs." ARARs are derived from both Federal and State laws.

3.2.1 Definition of ARARs and TBCs

Definitions of ARARs, as well as TBCs, are given below:

- Applicable Requirements are cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited (appropriate) to the particular site. Requirements must be relevant and appropriate to be an ARAR of this type.

- TBCs are non-promulgated, non-enforceable guidelines or criteria that may be useful for establishing a cleanup level or for designing the remedial action, especially when no ARARs exist or they are not sufficiently protective. Examples of TBCs include USEPA Drinking Water Health Advisories and Secondary Maximum Contaminant Levels (SMCLs).

Section 121(d)(4) of CERCLA allows the selection of a remedial alternative that will not attain all ARARs if any of six conditions for a waiver of ARARs exist. These conditions include: 1) the remedial action is an interim measure whereby the final remedy will attain the ARAR upon completion; 2) compliance will result in greater risk to human health and the environment than other options; 3) compliance is technically impracticable; 4) an alternative remedial action will attain the equivalent of the ARAR; 5) for State requirements, the state has not consistently applied the requirement in similar circumstances; and 6) compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of CERCLA money for response at other facilities.

Subsection 121(d) of CERCLA also requires that remedies comply with Federal and state substantive requirements that qualify as ARARs. Federal, state, or local permits do not need to be obtained for removal or remedial actions implemented on site but their substantive requirement must be obtained. "On site" is interpreted by the USEPA to include the areal extent of contamination and all suitable areas in reasonable proximity to the contamination necessary for implementation of the response action.

There are three categories of ARARs: chemical-specific, location-specific, and action-specific. They are based on the manner in which they are applied. Many requirements are combinations of the different ARAR categories. An explanation of each of the ARAR categories follows.

- Chemical-Specific ARARs: Health- or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

- Location-Specific ARARs: Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of a site. Examples of this type of ARAR include Federal and state siting laws for hazardous waste facilities and sites on the National Register of Historic Places.

- Action-Specific ARARs: Refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act (CWA) for discharges to publicly-owned treatment works (POTWs) are examples of action-specific ARARs.

3.2.2 Identification of Potential ARARs and TBCs

3.2.2.1 Chemical-Specific ARARs

There are no chemical-specific ARARs established for the surface soil and/or sediment COPCs/ECOCs for Sites 2, 8 and 18, or SSA 14. Potential TBCs for surface soil are the USEPA Region III risk-based concentrations (RBCs) for human health. Potential TBCs for sediment are the Sediment Screening Values (effects range - median), and USEPA Region III RBCs for human health. A potential TBC is the Toxic Substances Control Act which establishes action levels for PCBs in soils.

ECOCs were identified for each media based on the chemical-specific screening levels. If a contaminant exceeded a screening level it was identified as an ECOC and then compared to a benchmark value (preferably No Adverse Effects Levels [NOAELs]) to identify potential risks to ecological receptors.

Human health site-specific risk-based RGOs developed in Section 3.3 for each medium will be used for comparison criteria. Potential chemical-specific ARARs and TBCs are presented in Table 3-13. Please note that the citations listed on Table 3-13 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

3.2.2.2 Location-Specific ARARs

Potential location-specific ARARs identified for Sites 2, 8 and 18, and SSA 14 are listed on Table 3-14. An evaluation determining the applicability of these location-specific ARARs with

respect to these sites/SSA is also presented on the table. Based on this evaluation, specific sections of the following acts/standards are considered as ARARs/TBCs for Sites 2, 8 and 18, and SSA 14:

- National Historic Preservation Act
- National Archaeological and Historical Preservation Act
- Protection of Archaeological Resources
- Groundwater Protection Strategy
- Executive Order 11990, Protection of Wetlands
- Clean Water Act Section 404
- Virginia Wetlands Regulations

Please note that the citations listed on Table 3-14 should not be interpreted to indicate that the entire citation is a potential ARAR. The citation listing is provided on the table as a general reference.

3.2.2.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated following the development of alternatives since they are dependent on the type of action being considered. Therefore, at this step in the FS process, potential action-specific ARARs have only been identified and not evaluated for Sites 2, 8 and 18, and SSA 14. A set of potential action-specific ARARs is listed on Table 3-15. These ARARs are based on RCRA, CWA, SDWA, and Department of Transportation (DOT) requirements. Note that the citations listed on Table 3-15 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided on the table as a general reference.

Action and location-specific ARARs will be evaluated after the RAAs have been identified for these sites/SSA. Additional action-specific ARARs may also be identified and evaluated at that time.

3.3 Human Health Risk-Based Preliminary Remediation Goals

When ARARs or TBCs are not available for a chemical or an environmental medium, or ARARs and TBCs are not sufficiently protective of human health and the environment, risk-based remediation goals must be developed for media presenting unacceptable risks. The methodology used to derive the preliminary risk-based remediation goals (PRGs) for Sites 2, 8 and 8, and SSA 14 was obtained

from USEPA's Risk Assessment Guidance for Superfund, Parts A and B (USEPA, 1989 and USEPA, 1991). For noncarcinogenic effects, PRGs were calculated for significant human exposure pathways that target an HI of 1.0. Contaminant concentrations in a given medium that are less than a corresponding PRG indicate that systemic health effects will not occur subsequent to exposure for even sensitive populations. For carcinogenic effects, risk-based PRGs were calculated for target ICR levels of 1×10^{-06} (one additional cancer occurrence in one million), and 1.0×10^{-04} (one additional cancer occurrence in ten thousand) that would be expected to result from exposure to a potential carcinogen over a lifetime, from all significant exposure pathways for a given medium.

Carcinogenic PRGs goals were derived by apportioning the target ICR value by the number of carcinogenic contaminants in a given medium (if necessary). Based on the NCP (40 CFR 300.430), acceptable exposure levels, for known or suspected carcinogens, are generally concentrations that represent an ICR between 1.0×10^{-04} and 1.0×10^{-06}, with the latter representing USEPA's point of departure.

Three steps were involved in deriving the PRGs for Sites 2, 8 and 18, and SSA 14. These steps include a consideration of: (1) the environmental medium and potential for exposure, (2) the most significant exposure parameters, and (3) a consideration of potential human receptors and subsequent adverse effects associated with exposure. The equations included calculations of total potential intake from a given medium and were based on identified exposure pathways and associated parameters.

The PRG calculations for human health are presented in Appendix A. PRGs were calculated for the following receptors and routes of exposure:

Site	Media	Receptor
Sites 2 and 8, SSA 14	surface soil	future commercial/industrial worker
		future adult resident
		future child resident
		future adult trespasser
		future adolescent trespasser

Site 8	groundwater	future adult resident
		future child resident

No PRG calculations were made for Site 18 because no human health risk was identified at this site. Human health PRGs for each COPC for each medium of concern were selected from the USEPA Region III RBCs, or the carcinogenic or non-carcinogenic PRGs for the future commercial/industrial worker scenario for each site. This scenario is the most likely future use of Sites 2, 8 and 18 and SSA 14. The human health PRGs selected for each COPC and medium are presented in Tables 3-16 through 3-19. Specifically, Table 3-16 presents the PRGs for surface soil at Site 2; Table 3-17 presents the PRGs for surface soil at Site 8; Table 3-18 presents the PRGs for groundwater at Site 8; and Table 3-19 presents the PRGs for surface soil at SSA 14.

3.4 Ecological Preliminary Remediation Goals

Ecological PRGs were selected for each ECOC for each media of concern from screening levels, established effects ranges, benchmark concentrations, or concentrations derived from receptor uptake models. The ecological PRGs selected are presented in Tables 3-20 through 3-26. The models upon which these goals are based are presented in Appendix A.

3.5 Final Remediation Goals

Final Remediation Goals (FRGs) were developed in four stages. In the first stage, human health and ecological PRG values were derived and compared against each other and remediation goal (RG) was selected that will reasonably protect human health and the environment. The RGs are presented on Tables 3-27 through 3-30, for each site/SAA, respectively. Figures presenting the COPCs/ECOCs that exceed the RGs for each site are presented in Appendix B.

In the second stage, the actual concentrations of the COPCs/ECOCs were compared against the background concentrations (as presented in Tables 3-16 through 3-26). Those contaminants whose maximum concentrations are below the background levels were not considered further in this FS. The COPCs/ECOCs eliminated from further discussion include:

Site	Media	COPC/ECOC Eliminated
Site 2	surface soil	arsenic, aluminum, manganese
Site 8	surface soil	arsenic, manganese
	groundwater	dissolved arsenic, dissolved barium
Site 18	surface soil	none
SSA 14	surface soil	aluminum, arsenic, barium*, chromium*, manganese

* Maximum barium and chromium concentrations were above but very close to the background concentrations. Therefore, they were eliminated from further discussion in this FS.

In the third stage, the RGs were compared against the actual contaminant concentration of the remaining COPCs/ECOCs for each site. Contaminants whose maximum concentrations are below the corresponding RGs are not considered further in this FS. The COPCs/ECOCs eliminated from further discussion are the following:

Site	Media	COPC/ECOC Eliminated
Site 2	surface soil	4-amino-2,6-DNT, antimony, cadmium, copper, iron, thallium
	sediment	none
	surface water	TNT
Site 8	surface soil	4-amino-2,6-DNT, aluminum, chromium, copper, iron, thallium
	groundwater	chloroform, TCE, TNT, dissolved thallium

Site 18	surface water	none
	sediment	none
SSA 14	surface soil	total carcinogenic PAHs, iron, thallium, vanadium

In the fourth stage, the RGs of the remaining COPCs/ECOCs were compared against the anthropogenic background concentrations for WPNSTA Yorktown. Some contaminants had PRG values ~~that were below the~~ corresponding anthropogenic background level instead of the selected PRG. These include lead in surface soil at Site 8 and copper and lead in surface soil at SSA 14.

Regarding PCBs, the FRGs for PCB contaminants (Aroclor-1254 and Aroclor-1260) are based on the Toxic Substances Control Act (TSCA) residential guideline (1 milligram per kilogram [mg/kg]) for surface soil instead of the human health based RGO (as presented in Appendix A). As discussed previously, human health PRGs were calculated for the future industrial worker. These levels are 1.31 mg/kg for Site 2, and 0.99 mg/kg for Site 8. Ecological PRGs for PCBs are 0.21 mg/kg for Site 2 and Site 8. USEPA guidance (USEPA, 1990a) includes action levels that can be considered in PCB contaminated site remediation. Action levels for protection of different receptors and land use scenarios are presented below:

Land Use	**PCB Action Level**
Residential	1 mg/kg
Industrial	10 - 25 mg/kg
Ecological	1 - 2 mg/kg

The most likely future use of Sites 2 and 8 is limited recreational use. However, due to ecological concerns, an FRG for PCB contaminated soil of 1 mg/kg has been selected. This level will adequately protect both human health and the environment.

This process of FRG development indicated that copper in surface water and iron in sediment at Site 18 should be included in the final set of contaminants of concern (COCs). However, the surface water sample for which copper exceeded the FRG was a duplicate sample. No copper was detected in the original sample. Therefore, copper will not be considered a COC for Site 18 surface water.

The maximum concentration of iron in sediment at Site 18 is on the same order of magnitude as, and is not statistically greater than the FRG. Further, actual screening levels are not available for iron in sediment. Therefore, the ecological PRG which was selected for iron in sediment was based on an Apparent Effects Threshold (AET) which is associated with uncertainty. This value is only 700 mg/kg lower than the freshwater stream background concentration which was ultimately selected as the FRG for these reasons, iron will not be considered a COC for Site 18 sediment. Based on the above discussion, there are no COCs for Site 18.

The final lists of COCs for each site are presented in Tables 3-31 through ~~3-34~~ with the selected FRG, and the basis for its selection. The final COCs for each site are as follows:

Site	Media	Final COC
Site 2	surface soil	carcinogenic PAHs, total PAHs, Aroclor-1254, cobalt, mercury
	surface water	none
	sediment	silver
Site 8	surface soil	carcinogenic PAHs, Aroclor-1260, RDX, lead, mercury, zinc
	groundwater	1,1-DCE, 4-amino-2,6-DNT, RDX
Site 18	None	None
SSA 14	surface soil	HMX, copper, lead, mercury, zinc

Figures showing COCs that exceed the FRGs for each site are presented in Appendix C.

3.6 Identification of Site Areas of Concern

In this section of the FS, AOCs are delineated for Sites 2, 8, and 18 and SSA 14 for each medium of concern based on the FRGs that were developed for each site in the previous section.

3.6.1 Site 2 Areas of Concern

Surface soil and sediment were media of concern at Site 2. The COC for sediment is related to activities at an upgradient source (SSA 10 - Building 28 X-Ray Facility Tank Drain Field). Therefore, this medium will be addressed through further study under the site screening process for SSA 10.

Surface soil COCs for Site 2 are carcinogenic PAHs, total PAHs, Aroclor-1254, cobalt, and mercury. AOCs for the organic and inorganic contaminants are shown on Figures 3-1 and 3-2. Much of the perimeter of Site 2 is located in woody or marshy areas, or located along steep banks of tributaries to Felgates Creek.

The surface soil samples were collected from 0 to 6 inches from the perimeter of the landfill. Assuming the areas identified on Figures 3-1 and 3-2 are contaminated one foot in depth, the combined volume of the Site 2 organic and inorganic AOCs is approximately 785 cubic yards.

It should be noted that some sample locations in the inorganic and organic AOCs overlap. Therefore, some surface soil is contaminated with both inorganic and organic COCs.

3.6.2 Site 8 Areas of Concern

Surface soil and groundwater were identified as media of concern at Site 8. Groundwater COCs include 1,2-DCE, 4-amino-DNT, and RDX. The extent of groundwater contamination cannot be adequately determined based on the available data. Therefore, further study of the Site 8 groundwater will be conducted and addressed in a separate FS.

Surface soil COCs include carcinogenic PAHs, Aroclor-1260, RDX, lead, mercury, and zinc. The surface soil AOC for organics and inorganics is shown on Figure 3-3. The surface soil samples were collected from 0 to 6 inches deep. The contaminated area in the drainage way at Site 8 is approximately 55 feet long by 15 feet wide (825 square feet). Assuming that one foot of soil would require remediation, 30 cubic yards of surface soil would require remediation.

3.6.3 Site 18 Areas of Concern

Because there are no COCs identified for Site 18, there is no AOC at this site.

3.6.4 SSA 14 Areas of Concern

Surface soil was identified as the only medium of concern at SSA 14. The COCs include HMX, copper, lead, mercury, and zinc. The surface soil AOC for organics and inorganics is shown on Figure 3-4. The surface soil samples were collected from 0 to 6 inches deep. The area of concern is approximately 1,500 square feet. Assuming that one foot of soil would require remediation, approximately 70 cubic yards of contaminated soil will require remediation.

3.7 Remedial Action Objectives

The following remedial action objectives have been developed for each site:

- *Site 2:* Mitigate direct contact by human and ecological receptors with surface soil contaminated with PAHs, Aroclor-1254, cobalt, and mercury.

- *Site 8:* Mitigate direct contact by human and ecological receptors with surface soil contaminated with PAHs, Aroclor-1260, RDX, lead, mercury, and zinc.

- *Site 18:* None

- *SSA 14:* Mitigate direct contact by human and ecological receptors with surface soil contaminated with HMX, copper, lead, mercury, and zinc.

SECTION 3.0 TABLES

Table 3-1
Identification of Surface Soil Contaminants of Potential Concern
Sites 2, 8, and 18 and SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

Human Health Contaminant of Potential Concern	USEPA Region III Residential Criteria	Site 2	Site 8	Site 18	SSA 14
Semivolatiles (mg/kg)					
Carbazole	32,000	X	X		X
Benzo(a)anthracene	880	X	X		X
Chrysene	88,000	X	X		X
Benzo(b)fluoranthene	880	X	X		X
Benzo(k)fluoranthene	8,800	X	X		X
Benzo(a)pyrene	88	X	X		X
Indeno(1,2,3-cd)pyrene	880	X	X		X
Dibenz(a,h)anthracene	88	X	X		X
PCBs (µg/kg)					
Aroclor-1254	320	X			
Aroclor-1260	320		X		
Nitramines (µg/kg)					
4-Amino-2,6-Dinitrotoluene	470	X			
Amino-DNTs	470		X		
HMX	390,000				X
RDX	5,800		X		
Inorganics (mg/kg)					
Aluminum	7,800	X	X		X
Antimony	3.1	X			
Arsenic (c/n)	0.43/2.3	X	X	X	X
Barium	550				X
Cadmium	3.9	X			
Chromium	39		X		X
Copper	310	X			
Iron	2,300	X	X	X	X
Manganese	180	X	X	X	X
Mercury	2.3	X			
Thallium	0.63	X	X		X
Vanadium					X

Notes:

mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram
X = Exceeds USEPA Region III Residential Criteria

Table 3-2
Identification of Subsurface Soil Contaminants of Potential Concern
Sites 2, 8, and 18, and SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

Human Health Contaminant of Potential Concern	USEPA Region III Residential Criteria	Site 2	Site 8	Site 18	SSA 14
Semivolatiles (µg/kg)					
Carbazole	32,000	X			
Benzo(a)anthracene	880	X			
Chrysene	88,000	X			
Benzo(b)fluoranthene	880	X			
Benzo(k)fluoranthene	8,800	X			
Benzo(a)pyrene	88	X			
Indeno(1,2,3-cd)pyrene	880	X			
Dibenz(a,h)anthracene	88	X			
Inorganics (mg/kg)					
Aluminum	7,800	X	X	X	X
Antimony	3.1				
Arsenic (c/n)	0.43/2.3	X	X	X	X
Barium	550				
Beryllium	16			X	
Cadmium	3.9	X			
Chromium	39		X	X	
Copper	310				
Iron	2,300	X	X	X	X
Manganese	180	X	X	X	
Mercury	2.3				
Thallium	0.63	X	X		X
Vanadium			X	X	

Notes:

mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram
X = Exceeds USEPA Region III Residential Criteria

Table 3-3
Identification of Shallow Groundwater Contaminants of Potential Concern
Sites 2, 8, and 18, and SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

Human Health Contaminant of Potential Concern	Federal MCL	USEPA Region III Tapwater COC Value	Virginia PMCLs	Site 2	Site 8	Site 18	SSA 14
Volatiles (µg/L)							
Vinyl Chloride	2	0.019	2	X			
1,1-Dichloroethene	7	0.044	7		X		X
1,2-Dichloroethene	70	5.5	--	X			X
Chloroform	100	0.15	--		X		
1,1,1-Trichloroethane	200	54	200				X
Trichloroethene	5	1.6	5		X		X
Nitramines (µg/L)							
Amino-Dinitrotoluenes	--	0.22	--		X		X
Nitrobenzene	--	0.34	--				X
RDX	--	0.61	--		X		X
2,4,6-Trinitrotoluene	--	2.2	--		X		
Total Inorganics (µg/L)							
Aluminum	--	3,700	--	X			
Arsenic	50	0.045	50	X	X	X	X
Barium	2,000	260	1,000	X	X		
Cadmium	5	1.8	10	X			
Iron	--	1,100	--	X	X		
Manganese	--	84	--	X			
Thallium	2	0.29	--	X	X		X
Dissolved Inorganics (µg/L)							
Arsenic	50	0.045	50	X	X		X
Barium	2,000	260	1,000	X	X		
Iron	--	1,100	--	X			
Manganese	--	84	--	X		X	
Thallium	2	0.29	--	X	X		X

Notes:

µg/kg = micrograms per kilogram
MCL = Maximum Contaminant Level
COC = Contaminant of Concern
PMCL = Primary Maximum Contaminant Level
X = Exceeds comparative criteria

Table 3-4
Identification of Surface Water Contaminants of Potential Concern
Sites 2, 8, and 18, and SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

Human Health Contaminant ofPotential Concern	Federal Criteria			Virginia Water Quality Standards		Site 2	Site 18	Site 8 and SSA 14
	WQS Water and Organisms	WQS Organisms Only	USEPA Region III Tapwater COC Value	Public Water Supplies	All Other Surface Waters			
Inorganics (Total) (µg/L)								
Antimony	14	4,300	1.5	--	--			X
Arsenic (c)	0.018	0.14	0.045	50	--	X	X	X
Beryllium	0.0076	0.131	0.73	--	--	X		
Cadmium	10	--	1.8	16	170	X		X
Iron	300	--	1,100	300	--	X	X	X
Manganese	50	100	84	50	--	X	X	X

Notes:

µg/kg = micrograms per kilogram
WQS = Water Quality Standard
COC = Contaminant of Concern
X = Exceeds comparative criteria

Table 3-5
Identification of Sediment Contaminants of Potential Concern
Sites 2, 8, and 18, and SSA 14
Naval Weapons Station, Yorktown
Yorktown, Virginia

Human Health Contaminant of Potential Concern	SSV ER-M	Residential Soil COC	Site 2	Site 18	Site 8 and SSA 14
Semivolatiles (µg/kg)					
Phenanthrene	1,500	310,000	X	X	
Carbazole	9,600	32,000	X	X	
Benzo(a)anthracene	1,600	880	X	X	
Chrysene	2,800	88,000	X	X	
Benzo(b)fluoranthene	9,600	880	X	X	
Benzo(k)fluoranthene	9,600	8,800	X	X	
Benzo(a)pyrene	1,600	88	X	X	
Indeno(1,2,3-cd)pyrene	9,600	880	X	X	
Dibenz(a,h)anthracene	260	88	X	X	
Pesticides (µg/kg)					
Aroclor-1254	180	320		X	
Inorganics (mg/kg)					
Aluminum	--	7,800	X		X
Antimony	--	3.1			X
Arsenic (c/n)	70	0.43/2.3	X	X	X
Chromium	370	39		X	X
Iron	--	2,300	X	X	X
Manganese	--	180	X	X	X
Silver	3.7	39	X		
Thallium	--	0.63	X	X	
Vanadium	--	55			X

Notes:

µg/kg = micrograms per kilogram
mg/kg = milligrams per kilograms
SSV = sediment screening valves
ER-M = effects range-median
COC = Contaminant of Concern
X = Exceeds comparative criteria

TABLE 3-6

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED
ECOLOGICAL CONTAMINANTS OF CONCERN
SITE 2
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Background Soil Range[1] (mg/kg)	Site Samples Detected Above Background	Flora Max. HQ	Fauna Max. HQ	Species with the Highest HQ[2]	Modeled HQ Value
Semivolatiles								
Benzo(a)pyrene	40	37/43	0.14J-0.18J	22	NE	1.60	Shrew	0.62
Fluoranthene	90	37/43	0.12J-0.43	21	NE	0.33	Shrew	1.50
Phenanthrene	79	30/43	ND	30	NE	0.79	Shrew	1.51
Pyrene	84	36/43	0.16J-0.32J	22	NE	NE	Shrew	1.25
PCBs								
Aroclor-1254	6.2	9/44	ND	9	0.16	NE	Shrew	4.73
Inorganics								
Aluminum	14,200	44/44	1,960-24,100	0	284.00	23.67	Shrew	240
Antimony	24.3	1/44	2L-11L	1	48.60	NE	Shrew	42.5
Cadmium	15.7	20/44	1.2J-1.5	15	3.93	0.79	Shrew	41.8
Chromium	25.1	43/44	2.6-33.5	0	25.10	167.33	Shrew	30.0
Cobalt	168	1/44	0.88J-6.7J	1	84.00	1.68	Robin	26.3
Copper	14,700	23/44	1.2J-24.4	4	1,470	2,940	Robin	440
Iron	34,500	44/44	1,440-46,400	0	NE	172.50	Fox	17.4
Lead	7-44	43/44	2.1-43.1	1	0.88	0.09	Robin	10.7
Mercury	16.6	17/44	0.05J	17	553.30	332.00	Robin	30.2

TABLE 3-6 (Continued)

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED
ECOLOGICAL CONTAMINANTS OF CONCERN
SITE 2
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Background Soil Range[1] (mg/kg)	Site Samples Detected Above Background	Flora Max. HQ	Fauna Max. HQ	Species with the Highest HQ[2]	Modeled HQ Value
Silver	12.5	1/44	1J-2.1J	1	62.50	0.25	Shrew	0.42
Thallium	26.8	1/44	ND	1	268.00	NE	Fox	7.67
Vanadium	50.2	41/44	5.2J-64.7	0	25.10	2.51	Shrew	6.68
Zinc	504	44/44	3.2KJ-48.4	21	10.10	5.04	Robin	0.77

Notes:

Highlighted areas represent hazard quotients greater than one.
[1] Station-wide and anthropogenic background soil
[2] Least conservative receptor models

HQ Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE Not Evaluated (lack of NOAEL or LOAEL)
NA Not Applicable
ND Not Detected
NOAEL No Observed Adverse Effect Level
LOAEL Lowest Observed Adverse Effect Level
J Analyte was positively identified, value is estimated
K Estimated value, biased high
L Estimated value, biased low
mg/kg milligrams per kilogram

TABLE 3-7

SUMMARY OF AQUATIC RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN SITE 2 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Surface Water					Sediment					Species with the Highest HQ[2]	HQ
	Maximum Concentration (µg/L)	No. of Positive Detects/ No. of Samples	Tidal Freshwater Stream Background Surface Water (µg/L)[1]	Site Samples Detected Above Background	Surface Water Maximum HQ*	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Tidal Freshwater Stream Background Sediment (mg/kg)[1]	Site Samples Detected Above Background	Sediment Maximum HQ		
Semivolatiles												
Benzo(g,h,i)perylene	ND	NA	ND	NA	NA	0.81J	2/20	ND	2	1.21	Bass	0.02
Indeno(1,2,3-cd)pyrene	ND	NA	ND	NA	NA	0.89	2/20	ND	2	1.48	Bass	0.02
Phenanthrene	ND	NA	ND	NA	NA	1.8	4/20	ND	4	1.29	Bass	0.03
Nitramines												
2,4,6-Trinitrotoluene	0.14J	1/10	ND	1	NE	ND	NA	ND	NA	NA	NA	NA
Inorganics												
Aluminum	1,280	10/10	171J-5,600	0	NE	23,100	20/20	1,510-40,500	0	NA	Heron	2.11
Beryllium	NA	NA	ND	NA	NA	1.3	20/20	0.55J-1.6J	0	3.61	NA	NA
Copper	9.7	1/10	5.6J-6.7J	0	NE	17.9	20/20	3.7J-43.1	0	NA	Heron	0.0002
Iron	3,930	10/10	289J-6,650	0	NE	45,300	20/20	3,060-46,000	0	1.68	Heron	5.12
Manganese	282J	10/10	33.1-379	0	NE	673	20/20	7.4-1,980	0	0.61	Heron	0.01
Nickel	21.9K	3/10	19.8-55.5K	0	NE	NA	NA	NA	NA	NA	NA	NA
Selenium	ND	NA	NA	NA	NA	1.1K	5/20	0.46L-1.5L	0	1.10	Heron	0.04
Silver	ND	NA	ND	NA	NA	13.9	8/20	2.2J	5	3.76	NA	NA

Notes

Highlighted areas represent hazard quotients greater than one.
* Surface water hazard quotients were not calculated for the tidal freshwater ecological contaminants of concern due to a lack of benchmark values.
(1) Off-station background stations located in Taskinas and Timberneck Creeks
(2) Least conservative receptor models

TABLE 3-7 (Continued)

SUMMARY OF AQUATIC RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN SITE 2 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

HQ	Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE	Not Evaluated (lack of NOAEL or LOAEL)
NA	Not Applicable (not a contaminant of concern in this media)
ND	Not Detected
NOAEL	No Observed Adverse Effect Level
LOAEL	Lowest Observed Adverse Effect Level
J	Analyte was positively identified, value is estimated
L	Estimated value, biased low
K	Estimated value, biased high
µg/l	micrograms per liter
mg/kg	milligrams per kilogram

TABLE 3-8

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED
ECOLOGICAL CONTAMINANTS OF CONCERN
SITE 8
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Background Soil Range[1] (mg/kg)	Site Samples Detected Above Background	Flora Max. HQ	Fauna Max. HQ	Species with the Highest HQ[2]	Modeled HQ Value
PCBs								
Aroclor-1260	10	1/9	ND	1	0.25	NA	Shrew	47.1
Nitramines								
RDX	30	1/9	ND	1	300.0	0.06	Shrew	0.26
Inorganics								
Aluminum	26,300	9/9	1,960-24,100	1	526.0	43.80	Shrew	386
Antimony	2.6L	6/9	2L-11L	0	5.20	NE	Shrew	3.12
Chromium	61.5	9/9	2.6-33.5	1	61.50	410.0	Shrew	76.1
Copper	68.4	9/9	1.2J-24.4	4	6.84	13.68	Robin	18.8
Iron	31,700	9/9	1,440-46,400	0	NE	159.0	Robin	29.5
Lead	129	9/9	2.1-43.1	4	2.58	0.26	Robin	23.0
Mercury	0.91	5/9	0.05J	5	30.30	18.20	Robin	9.71
Thallium	1.2K	2/9	ND	2	12.00	NE	Shrew	0.27
Vanadium	44.8	9/9	5.2J-64.7	0	22.40	2.24	Shrew	10.3
Zinc	249	9/9	3.2KJ-48.4	6	4.98	2.49	Robin	1.11

TABLE 3-8 (Continued)

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN
SITE 8
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Notes:

Highlighted areas represent hazard quotients greater than one.
(1) Station-wide and anthropogenic background soil
(2) Least conservative receptor models

HQ	Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE	Not Evaluated (lack of NOAEL or LOAEL)
NA	Not Applicable
ND	Not Detected
J	Analyte was positively identified, value is estimated
K	Estimated value, biased high
L	Estimated value, biased low
mg/kg	milligrams per kilogram

TABLE 3-9

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Background Surface Soil Range[1] (mg/kg)	Site Samples Detected Above Background	Flora Maximum HQ	Fauna Maximum HQ	Species with the Highest HQ[2]	Modeled HQ Value
Inorganics								
Aluminum	6,670	7/7	1,960 - 24,100	0	133.40	11.12	Shrew	136
Chromium	6.7	7/7	2.6 - 33.5	0	6.70	44.67	Shrew	10.4
Copper	3.2	7/7	1.2J - 24.4	0	NE	NE	Robin	1.41
Iron	5,740	7/7	1,440 - 46,400	0	NE	28.70	Robin	5.58
Lead	39.7	7/7	2.1 - 43.1	0	0.79	0.08	Shrew	8.17
Mercury	0.07	1/7	0.05J	1	2.33	1.40	Robin	1.10
Vanadium	18.5	7/7	5.2J - 64.7	0	9.25	0.93	Shrew	4.20

Notes:

Highlighted areas represent hazard quotients greater than one.

[1] Station-wide and anthropogenic background soil
[2] Least conservative receptor models

HQ Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE Not Evaluated (lack of NOAEL or LOAEL)
NOAEL No Observed Adverse Effect Level
LOAEL Lowest Observed Adverse Effect Level
J Analyte was positively identified, value is estimated
mg/kg milligrams per kilogram

TABLE 3-10

SUMMARY OF AQUATIC RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN SITE 18 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Surface Water					Sediment					Species With Hightest HQ[2]	Modeled HQ Values
	Maximum Concentration (µg/L)	No. of Positive Detects/ No. of Samples	Surface Water HQ	Off-Station Freshwater Stream Background Surface Water (µg/L)[1]	Site Samples Detected Above Background	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Sediment HQ	Off-Station Freshwater Stream Background Sediment (mg/kg)[1]	Site Samples Detected Above Background		
Semivolatiles										NA		
Di-n-Butylphthalate	2J	1/5	0.003	ND	1	ND	NA	NA	ND		Heron	0.0001
Pyrene	ND	NA	NA	ND	NA	2.6	3/9	1.00	ND	3	Bass	0.053
Pesticides/PCBs										1		
alpha-Chlordane	ND	NA	NA	ND	NA	0.0087L	1/9	1,450	ND		Heron	0.0001
gamma-Chlordane	ND	NA	NA	ND	NA	0.00016J	1/9	26.67	ND	1	Heron	0.0001
Aroclor-1254	ND	NA	NA	ND	NA	0.24J	2/9	1.33	ND	2	Bass	0.293
Inorganics												
Aluminum	1,350	5/5	2.93	94.4 - 1,050	1	6,020	9/9	NA	482K - 17,700J	0	Heron	0.52
Beryllium	ND	NA	NA	ND	NA	0.59	3/9	1.64	0.28J - 0.99J	0	NE	NE
Copper	58.9	3/5	15.50	5J	1	64	9/9	0.24	1J-6.3J	3	Heron	1.28
Iron	2,240	5/5	14.18	630 - 2,500J	0	49,000	9/9	1.81	329 - 27,700J	2	Heron	3.38
Lead	NA	NA	NA	NA	0	90.6	9/9	0.2	1.8L-381L	0	Heron	1.47

Notes

Highlighted areas represent hazard quotients greater than one.
[1] Off-station background stations located in Taskinas and Timberneck Creeks
[2] Least conservative receptor models

TABLE 3-10 (Continued)

SUMMARY OF AQUATIC RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN SITE 18 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

HQ	Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE	Not Evaluated (lack of NOAEL or LOAEL)
NA	Not Applicable (not a contaminant of concern in this media)
ND	Not Detected
NOAEL	No Observed Adverse Effect Level
LOAEL	Lowest Observed Adverse Effect Level
J	Analyte was positively identified, value is estimated
L	Estimated value, biased low
K	Estimated value, biased high
µg/l	micrograms per liter
mg/kg	milligrams per kilogram

TABLE 3-11

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN
SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Background Surface Soil Range[1] (mg/kg)	Flora HQ	Fauna HQ	Species with the Highest HQ[2]	Modeled HQ Value
Nitramines							
HMX	17,000	3/5	ND	NE	340.0	Fox	654
Inorganics							
Aluminum	18,200	5/5	1,960 - 24,100	364.00	30.3	Shrew	389
Antimony	1.1L	1/5	9.2L - 11L	2.20	NE	Shrew	1.97
Barium	2,460	5/5	4.2J-80.2	49.20	NE	Shrew	126
Chromium	39.4	5/5	2.6 - 33.5	39.40	263	Shrew	74.9
Copper	113	5/5	1.2J-24.4	11.30	22.60	Robin	20.7
Iron	28,600	5/5	1,440 - 46,400	NE	143.0	Robin	33.0
Lead	124	5/5	2.1 - 43.1	2.48	0.25	Robin	21.3
Mercury	0.29	2/5	0.05J	9.67	5.80	Robin	4.54
Silver	2	1/5	1J-2.1J	10.00	0.33	Shrew	0.07
Thallium	1.8K	2/5	ND	18.00	NE	Shrew	0.40
Vanadium	85.3	5/5	5.2J - 64.7	42.7	4.27	Shrew	15.3
Zinc	318J	5/5	3.2KJ - 48.4	6.36	3.18	Robin	1.31

Notes:

Highlighted areas represent hazard quotients greater than one.
[1] Least conservative receptor models
[2] Background range presented includes Station-wide and anthropogenic background sample results for all soil classifications

HQ Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE Not Evaluated (lack of NOAEL or LOAEL)
NA Not Applicable (not a surface soil ecological contaminant of concern)
ND Not Detected

TABLE 3-11 (Continued)

SUMMARY OF TERRESTRIAL RISK AND ASSOCIATED ECOLOGICAL CONTAMINANTS OF CONCERN
SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

NOAEL	No Observed Adverse Effect Level
LOAEL	Lowest Observed Adverse Effect Level
J	Analyte was positively identified, value is estimated
K	Estimated value, biased high
L	Estimated value, biased low
mg/kg	milligrams per kilogram

TABLE 3-12

SUMMARY OF AQUATIC RISK
SITE 8/SSA 14 - EAST BRANCH OF FELGATES CREEK
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Surface Water					Sediment					Species with the Highest HQ[2]	Modeled HQ Value
	Maximum Concentration (µg/L)	No. of Positive Detects/ No. of Samples	Surface Water HQ*	Off-Station Tidal Freshwater Stream Background Surface Water [1] (µg/L)	Site Samples Detected Above Background	Maximum Concentration (mg/kg)	No. of Positive Detects/ No. of Samples	Sediment HQ	Off-Station Tidal Freshwater Stream Background Sediment [1] (mg/kg)	Site Samples Detected Above Background		
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ND	NA	NA	ND	NA	6.2	4/14	4.77	0.29J	3	Heron	0.04
Inorganics												
Aluminum	1,990	7/7	NE	171J-5,600	0	29,300	14/14	NA	1,510-40,500	0	Heron	3.63
Beryllium	ND	NA	NA	ND	NA	1.7	14/14	4.72	0.55J-1.6J	1	NE	NE
Copper	ND	NA	NA	5.6J-6.7J	NA	45.7J	14/14	0.17	3.7J-43.1	1	Heron	1.22
Iron	2,990	7/7	NE	289J-6,650	0	42,500	14/14	1.57	3,060-46,000	0	Heron	6.95
Manganese	405J	7/7	NE	38.1J-379	1	NA	NA	NA	NA	0	Heron	0.006
Nickel	9K	1/7	NE	19.8K-55.5K	0	21.7	14/14	0.42	9.3K-55.2	0	NE	NE

Notes:

Highlighted areas represent hazard quotients greater than one.
* Surface water hazard quotients were not calculated for the tidal freshwater ecological contaminants of concern due to a lack of benchmark values.
[1] Off-station background stations located in Taskinas and Timberneck Creeks
[2] Least conservative receptor models

HQ	Hazard Quotient (equivalent to benchmark divided by maximum concentration)
NE	Not Evaluated (lack of NOAEL or LOAEL)
NA	Not Applicable (not a contaminant of concern in this media)
NOAEL	No Observed Adverse Effect Level
LOAEL	Lowest Observed Adverse Effect Level
J	Analyte was positively identified, value is estimated
L	Estimated value, biased low
K	Estimated value, biased high
µg/l	microgram per liter
mg/kg	milligrams per kilogram

TABLE 3-13

SUMMARY OF THE POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18, AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
FEDERAL/CONTAMINANT-SPECIFIC ARARs/TBCs			
Safe Drinking Water Act (42 USC 300[f]) Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant.	Not applicable to Sites 2, 8, and 18 or SSA 14. Relevant and appropriate in developing cleanup goals for contaminated groundwater and surface water that may potentially be used as a potable water supply.	The aquifer system underlying Sites 2, 8, and 18 and SSA 14 does not provide a potable water supply. Therefore, MCLs will not be considered as an ARAR.
Clean Water Act (CWA), 33 USC 1251 et seq	Guidelines to assess acute and chronic toxic effects in aquatic organics for surface water bodies. Also, included criteria for protection of human health from ingestion of water and aquatic organisms or from ingestion of organisms alone.	ARAR/TBC	Will be applicable for surface water bodies and groundwater discharge to surface water.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	Not an applicable TBC requirement.	The aquifer system underlying Sites 2, 8, and 18 and SSA 14 does not provide a potable water supply.
Safe Drinking Water Act (42 USC 300[f]) National Secondary Drinking Water Regulations (SMCLs) 40 CFR 143, excluding 143.5(b)	Non enforceable Federal contaminant levels intended as guidelines for the aesthetic qualities of public water systems.	Not an applicable TBC requirement.	The aquifer system underlying Sites 2, 8, and 18 and SSA 14 does not provide a potable water supply.
Resource Conservation and Recovery Act (RCRA), 40 CFR Sections 261.21, 261.22(a)(1), 261.23, 261.24(a)(1), and 261.100	Provides definition of RCRA hazardous waste, applicable for determining whether waste is hazardous.	ARAR/TBC	May be applicable if hazardous waste is generated at Sites 2, 8, and 18 or SSA 14.

TABLE 3-13 (Continued)

SUMMARY OF THE POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18, AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
Toxic Substances Control Act (TSCA), 40 CFR 761.60, excluding 761.60(a)(B and D), 761.60(a)(3)(iii)(3), 761.60(e), 761.60(f); 761.65(a and b); 761.65 (c) except 761.65(c)(9); 761.65(e)(6)(ii and iii); 761.65(e)(7 and 8); 761.79(15 USC 2601, et seq/)	Applicable for wastes (soils, sludges, or dredged material) contaminated with PCBs at concentrations greater than 50 parts per million (ppm)	TBC	Applicable at Sites 2 and 8 for soils contaminated with PCBs at concentrations greater than 1 ppm, the "clean soil" action level.
Clear Air Act (CAA), 40 USC 7401 et seq.	National Ambient Air Quality Standards: Primary and secondary standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).		May need to monitor air at and around the sites during remediation to ensure compliance with standards.
STATE OR REGIONAL/CONTAMINANT-SPECIFIC ARARs/TBCs			
Virginia Drinking Water Standards - PMCLs-Primary Maximum Contaminant Levels (Bureau of National Affairs, December 1994)	Establishes drinking water standards for the Commonwealth	Not applicable to Sites 2, 8, and 18 or SSA 14. Relevant and appropriate in developing cleanup goals for contaminated groundwater and surface water that may potentially be used as a potable water supply.	The aquifer system underlying Sites 2, 8, and 18 and SSA 14 is not a potable water supply.
Virginia Anti-Degradation Policy for Groundwater (VR 680-21-04)	Establishes groundwater standards for State Anti-degradation Policy for Groundwater (VR 680-21-04.2).	ARAR	Applicable to the groundwater aquifer system at Sites 2, 8, and 18 and SSA 14.
Virginia Water Quality Standards (VR 680-21-01.14	Guidelines to assess acute and chronic toxic effects in aquatic organics for surface water bodies. Also, included criteria for protection of human health from ingestion of water and aquatic organisms or from ingestion of organisms alone.	TBC	Applicable for surface water bodies and groundwater discharge to surface water.

TABLE 3-13 (Continued)

SUMMARY OF THE POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18, AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
Virginia Drinking Water Standards-SMCLs-Secondary Maximum Contaminant Levels (Bureau of National Affairs, December 1994)	Non-enforceable guidelines to protect the aesthetic qualities of drinking water such as taste or odor.	Not an applicable TBC requirement.	The aquifer system underlying Sites 2, 8, and 18 and SSA 14 is not a potable water supply.
Virginia Board of Health Waterworks Regulations (VR 355-28-004)	Standards for protection of health of consumers using public drinking water supplies. Establishes MCLs for given contaminants.	Not an applicable TBC requirement.	The aquifer system underlying Sites 2, 8, and 18 and SSA 14 is not a potable water supply.
Virginia Hazardous Waste Management Regulations, VR 672-10-01	Provides definition of RCRA hazardous waste, applicable for determining whether waste is hazardous.	ARAR/TBC	May be applicable is hazardous waste is generated at Sites 2, 8, and 18 or SSA 14.
Virginia Air Pollution Control Regulations, VR 120-03	Ambient Air Quality Standards: Primary and secondary standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).		Will need to monitor air at and around the sites to ensure compliance with standards.

TABLE 3-14

POTENTIAL LOCATION-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
FEDERAL/LOCATION-SPECIFIC			
The Endangered Species Act of 1973 (16 USC 1531) (40 CFR Part 502)	Requires action to conserve endangered and threatened species and their critical habitats.	Not applicable.	There are no known endangered species at Sites 2, 8, and 18 or SSA 14.
National Historic Preservation Act (32 CFR Parts 229 and 229.4; 43 CFR Part 171; and 36 CFR Part 800)	Develops procedures for the protection of archaeological and historical resources.	ARAR	Applicable to any excavation on site. If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and Commonwealth archaeologists. Also may be applicable to historical buildings.
National Archaeological and Historical Preservation Act (36 CFR 65)	Develops procedures for the protection of archaeological and historical resources.	ARAR. Applicable to any excavation on site. If excavation presents any alteration of terrain that threatens significant scientific, prehistoric, historic, or archaeologic data.	Archaeologically significant areas are not present at the sites/SSA.
Protection of Archaeological Resources (32 CFR Parts 229 and 229.4; 43 CFR Parts 107 and 171.1-5)	Develops procedures for the protection of archaeological and historical resources.	ARAR. Applicable to any excavation on site. If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and Commonwealth archaeologists.	Archaeologically significant areas are not present at the sites/SSA.

TABLE 3-14 (Continued)

POTENTIAL LOCATION-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
Groundwater Protection Strategy	EPA policy to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater: Class 1 - Special Ground Waters Class 2 - Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses Class 3 - Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use	TBC	The groundwater in the shallow aquifer system at the sites/SSA should be considered a Class 3.
Executive Order 1988. Protection of Floodplains; 40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Actions taken should avoid adverse effects, minimize potential harm, restore, and preserve natural and beneficial values.	Not applicable	The sites/SSA are not located within a floodplain.
Executive Order 11990, Protection of Wetlands; 40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Action to minimize the destruction, loss, or degradation of wetlands.	ARAR	Wetlands are present near the sites and could potentially be impacted by remedial response actions.
Clean Water Act, Section 404; 40 CFR 230.10; 40 CFR 231 (231.1, 231.2, 231.7, 231.8)	Action to prohibit discharge of dredged or fill material into wetland without permit.	ARAR	This requirement is an ARAR if discharge of dredged or fill material to a wetland is planned as part of remedial response action.
RCRA Location Requirements, 40 CFR 264.18	Places limitations on where on-site storage, treatment, or disposal of RCRA hazardous wastes may occur.	ARAR	If RCRA hazardous wastes are present at Sites 2, 8, and 18 or SSA 14, hazardous wastes will be handled and disposed of accordingly.

TABLE 3-14 (Continued)

POTENTIAL LOCATION-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
STATE/LOCATION-SPECIFIC			
Virginia Wetlands Regulations (VR 450-01-0051)	Regulates activities that impact wetlands.	ARAR.	Activities that could impact wetlands will comply with regulations.
Virginia Endangered Species Act and Virginia Board of Game and Inland Fisheries; Code of Virginia Sections 29.1-563 et seq. and 29-100 et seq.	Action to conserve endangered species or threatened species, including consultation with the Board of Game and Inland Fisheries.	Not applicable	There are no known endangered species at Sites 2, 8, and 18 or SSA 14.

TABLE 3-15

POTENTIAL ACTION-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
FEDERAL/ACTION-SPECIFIC			
DOT Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.	Remedial actions may include off-site treatment and disposal.
Resource Conservation and Recovery Act (RCRA) Subtitle C	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable to remedial actions involving treatment, storage, or disposal of hazardous waste.	Remediation may involve treatment, storage, or disposal of hazardous waste.
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Applicable in determining waste classification.	Remediation may involve contaminants that are considered listed wastes.
Treatment, Storage, and Disposal (TSD) of Hazardous Waste (40 CFR Parts 262-265, 266)	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable in the event that wastes on site are classified as hazardous.	TSD activities related to hazardous waste will comply with regulations.
Manifest Systems, Recordkeeping, and Reporting (40 CFR Part 264, Subpart E)	Regulates manifest systems related to hazardous waste treatment, storage, and disposal.	Applicable to remedial actions where hazardous waste is generated or transported.	Remedial actions may include off-site disposal or treatment.
Releases from Solid Waste Management Units (40 CFR Part 264, Subpart F)	Regulates releases from solid waste management units.	All solid waste management units on site shall comply with requirements.	Groundwater protection standards apply to solid waste management units.
Use and Management of Containers (40 CFR Part 264, Subpart I)	Regulates use and management of containers being stored at all hazardous waste facilities.	Applicable to containers stored on site.	Remedial actions may generate containerized waste. Investigation-derived waste (IDW) is containerized.
Toxic Substances Control Act (TSCA) (15 USC 2601 et seq) (40 CFR portions of Part 761)	Regulates management and disposal of PCB contaminated materials.	ARAR/TBC	Remedial activities may generate PCB contaminated wastes.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous pollutants, such as vinyl chloride, benzene, trichloroethylene, dichlorobenzene, asbestos, and other hazardous substances. Considered for any source that has the potential to emit 10 tons of any hazardous air pollutant or 25 tons of a combination of hazardous air pollutants per year.	Applicable to releases or potential releases of hazardous pollutants. Remedial actions may result in release of hazardous air pollutants. The treatment design would include air emissions control equipment as required to comply with NESHAPs.	The release of hazardous air pollutants at Sites 2, 8, and 18 and SSA 14 is not anticipated.

TABLE 3-15 (Continued)

POTENTIAL ACTION-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
FEDERAL/ACTION-SPECIFIC (Continued)			
National Ambient Air Quality Standards (NAAQS) (40 CFR 50)	Standards for the following six criteria pollutants: particulate matter; sulfur dioxide; carbon monoxide; ozone; nitrogen dioxide; and lead. The attainment and maintenance of these standards are required to protect the public health and welfare.	TBC	The release of criteria air pollutants are not anticipated at Sites 2, 8, and 18 and SSA 14.
Control of Air Emissions from Air Strippers at Superfund Groundwater Sites (OSWER Directive 9355.0-02)	Guidance that establishes criteria as to whether air emission controls are necessary for air strippers. A maximum 3 lbs/hr or 15 lbs/day or 10 tons/yr of VOC emissions is allowable; air pollution controls are recommended for any emissions in excess of these quantities.	TBC	Applicable if the alternative includes air stripping.
OSHA Requirements (29 CFR Parts 1910, 1926, and 1940)	Provides regulations for workers safety and health to be followed during all construction and operation of remedial activities.	TBC	Applicable to all workers engaged in on-site field activites.
STATE/ACTION-SPECIFIC			
Virginia Solid Waste Management Regulations (VR 672-20-10)	Regulates the disposal of solid wastes.	Applicable for solid (nonhazardous) waste.	Remedial actions could include off-site disposal of nonhazardous waste.
Virginia Hazardous Waste Regulations (VR 72-30-1 and VR 672-10-1, Part VII)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.	Remedial actions may include off-site treatment and disposal.
Virginia Hazardous Waste Management Regulations (VR 672-10-1)	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable to remedial actions involving treatment, storage, or disposal of hazardous waste.	Remediation may include treatment, storage, or disposal of hazardous waste.
Identification and Listing of Hazardous Waste (VR 672-10-1, Part III)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Applicable in determining waste classification.	
Manifest Systems, Recordkeeping, and Reporting (VR 672-10-1, Part X, Section 10.4)	Regulates manifest systems related to hazardous waste treatment, storage, and disposal.	Applicable to remedial actions where hazardous waste is generated or transported.	Remedial actions may include off-site disposal or treatment.

TABLE 3-15 (Continued)

POTENTIAL ACTION-SPECIFIC ARARs AND TBCs
SITES 2, 8, AND 18 AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Citation	Requirement	Consideration in the FS	Comments
STATE/ACTION-SPECIFIC (continued)			
Releases from Solid Waste Management Units (VR 672-10, Part X, Section 10.5)	Regulates releases from solid waste management units.	All solid waste management units on site shall comply with requirements.	Groundwater protection standards apply to solid waste management units.
Use and Management of Containers (VR 672-10, Part X, Section 10.8)	Regulates use and management of containers being stored at all hazardous waste facilities.	Applicable to containers stored on site.	Remedial actions may generate containerized waste. Investigation-derived waste (IDW) is containerized.
Virginia Stormwater Management Regulations (VR 215-02-00) and Virginia Erosion and Sediment Control Regulations (VR 625-02-00)	Regulates stormwater management and erosion/ sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities.	Activities during construction will comply with the Virginia Storm Water Management Program. A sediment and erosion control plan will be submitted to LANTDIV for approval.
Virginia Water Quality Standards (VR 680-21-00)	Surface water quality standards based on water use and criteria class of surface water.	Applicable to remedial actions requiring discharge to surface water.	May be considered an ARAR if discharges to surface water are part of remedial activities.
Virginia Ambient Air Quality Standards (VAAQS) (VR 120-03-01)	Primary and secondary air quality standards for particulate matter, sulfur oxides, carbon monoxide, nitrogen dioxide, and lead.	Potentially applicable for remedial actions requiring discharge to the atmosphere.	Air emissions from a remedial treatment facility will be monitored to comply with the substantive requirements of VAAQS provided by VADEQ.
Virginia Emission Standards for Toxic Pollutants (VR 120-01)	Establishes acceptable limits for toxic pollutants by applying a 1/40 correction factor to the occupational standard Threshold Limit Value-Ceiling (TLV-Ceiling).	These standards are applicable requirements for remedial actions requiring discharge to the atmosphere.	To be used during remedial design to determine whether air emissions from a remedial treatment facility will not exceed air emission standards.
Virginia Pollution Discharge Elimination System (VPDES) (VR 680-14-01) Regulation and Virginia Water Protection Permit Regulations (VR 680-15-01)	Regulated point-source discharges through the VPDES permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	Applicable to discharge of treated water to surface water.	May be an ARAR if point source discharges into surface water are part of remedial activities.

TABLE 3-16

HUMAN HEALTH PRGs FOR SURFACE SOIL
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Human Health							Background[5]	**PRG Value**
	RBC	Future Residents[4]			Future Commercial/Industrial Worker				
		HI	$1x10^{-4}$	$1x10^{-6}$	HI	$1x10^{-4}$	$1x10^{-6}$		
Organics (mg/kg)									
Total Carcinogenic PAHs[1]	88[2]	--	3[2]	0.03[2]	--	22[2]	0.22[2]	NA	**0.22**
PCBs (mg/kg)									
Aroclor-1254	0.32	--	13	0.13	--	131	1.31	NA	**1.31**
Explosives (mg/kg)									
4-Amino-2,6-Dinitrotoluene	0.47	2	--	--	37	--	--	NA	**1.31**
Inorganics (mg/kg)									
Aluminum	7,800	71,085	--	--	3,052,569	--	--	1,960-19,900	**3,052,569**
Antimony	3.1	28	--	--	1,221	--	--	9.2L-11L	**1,221**
Arsenic	0.43/2.3[3]	22	19	0.19	998	207	2.07	0.46L-63.9	**2.07**
Cadmium	3.9	434	--	--	11,008	--	--	1.2J-24.4	**11,008**
Copper	310	3,027	--	--	146,909	--	--	1.2J-24.4	**146,909**
Iron	2,300	21,325	--	--	915,771	--	--	1,440-19,900	**915,771**
Manganese	180	1,284	--	--	39,895	--	--	7.6L-491	**39,895**
Thallium	0.63	6	--	--	244	--	--	ND	**244**

Notes:
(1) Total carcinogenic PAHs include benzo(a)anthracene, benso(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and carbazole.
(2) Carcinogenic risk for benzo(a)pyrene only
(3) carcinogenic/noncarcinogenic
(4) Most conservative value for either an adult or child receptor.
(5) Based on combined Station-wide and anthropogenic background concentrations

HI - Hazard Index
NA - Not Applicable
ND - Not Detected
PAH - Polynuclear Aromatic Hydrocarbon
RBC - Risk Based Concentration
mg/kg - milligrams per kilogram
PRG - Preliminary Risk-Based Remediation Goal

TABLE 3-17

HUMAN HEALTH PRGs FOR SURFACE SOIL
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Human Health							Background[5]	PRG Value
	RBC	Future Residents[4]			Future Commercial/Industrial Worker				
		HI	$1x10^{-4}$	$1x10^{-6}$	HI	$1x10^{-4}$	$1x10^{-6}$		
Organics (mg/kg)									
Total Carcinogenic PAHs[1]	88[2]	--	2[2]	0.02[2]	--	17[2]	0.17[2]	NA	**0.17**
PCBs (mg/kg)									
Aroclor-1260	0.32	--	10	0.1	--	99	0.99	NA	**0.99**
Explosives (mg/kg)									
4-Amino-2,6-Dinitrotoluene	0.47	2	--	--	37	--	--	NA	**37**
RDX	5.8	111	98	0.98	2572	546	5.46	NA	**5.46**
Inorganics (mg/kg)									
Aluminum	7,800	71,085	--	--	3,052,569	--	--	1,960-19,200	**3,052,569**
Arsenic	0.43/2.3[3]	22	14	0.14	998	155	1.55	0.46L-63.9	**1.55**
Chromium	39	355	--	--	15,263	--	--	2.6-18.3	**15,263**
Iron	2,300	21,325	--	--	915,771	--	--	1,440-19,900	**915,771**
Manganese	180	1,284	--	--	39,895	--	--	7.6L-491	**39,895**
Thallium	0.63	6	--	--	244	--	--	ND	**244**

Notes:

(1) Total carcinogenic PAHs include benzo(a)anthracene, benso(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and carbazole.

(2) Carcinogenic risk for benzo(a)pyrene only

(3) carcinogenic/noncarcinogenic

(4) Most conservative value for either an adult or child receptor.

(5) Based on combined Station-wide and anthropogenic background concentrations

HI - Hazard Index

NA - Not Applicable

ND - Not Detected

PAH - Polynuclear Aromatic Hydrocarbon

RBC - Risk Based Concentration

mg/kg - milligrams per kilogram

PRG - Preliminary Risk-Based Remediation Goal

TABLE 3-18

HUMAN HEALTH PRGs FOR GROUNDWATER
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	USEPA RBC	Future Residents[1] HI	Future Residents[1] $1x10^{-4}$	Future Residents[1] $1x10^{-6}$	Background[2]	**PRG Value**
Organics (mg/L)						
1,1-Dichloroethene	0.044	15,010	1,000	10	NA	**10**
Chloroform	0.15	20,170	12,900	1,290	NA	**1,290**
Trichloroethene	1.6	1,310	13,100	1,310	NA	**1,310**
Explosives (mg/L)						
Amino-Dinitrotoluenes	0.22	160	--	--	NA	**160**
RDX	0.61	7,940	9,000	90	NA	**90**
2,4,6-Trinitrotoluene	2.2	1,310	34,000	340	NA	**340**
Inorganics (mg/L)						
Dissolved Arsenic	0.045	730	1,000	10	3L-5.5L	**10**
Dissolved Barium	260	171,040	--	--	5.9J-734J	**171,040**
Dissolved Thallium	0.29	140	--	--	ND	**140**

Notes:

(1) Most conservative value for either an adult or child receptor.

(2) Based on combined Station-wide and anthropogenic background concentrations

HI - Hazard Index

NA - Not Applicable

ND - Not Detected

RBC - Risk Based Concentration

mg/L - milligrams per liter

PRG - Preliminary Risk-Based Remediation Goal

TABLE 3-19

HUMAN HEALTH PRGs FOR SURFACE SOIL
SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Human Health							Background[5]	PRG Value
	RBC	Future Residents[4]			Future Commercial/Industrial Worker				
		HI	$1x10^{-4}$	$1x10^{-6}$	HI	$1x10^{-4}$	$1x10^{-6}$		
Organics (mg/kg)									
Total Carcinogenic PAHs[1]	88[2]	--	4[2]	0.04[2]	--	33[2]	0.33[2]	NA	**0.33**
Explosives (mg/kg)									
HMX	390	1.301	--	--	26,259	--	--	NA	**26,259**
Inorganics (mg/kg)									
Aluminum	7,800	71,085	--	--	3,052,569	--	--	1,960-19,900	**3,052,569**
Arsenic	0.43/2.3[3]	22	28	0.28	998	311	3.11	0.46L-63.9	**3.11**
Barium	550	4,976	--	--	213,680	--	--	4.2J-80.2	**213,680**
Chromium	39	355	--	--	15,263	--	--	2,6-18.3	**15,263**
Iron	2,300	21,325	--	--	915,771	--	--	1,440-19,900	**915,771**
Manganese	180	1,284	--	--	39,895	--	--	7.6L-491	**39,895**
Thallium	0.63	6	--	--	244	--	--	ND	**244**
Vanadium	55	498	--	--	21,368	--	--	6.1J-34.7J	**21,368**

Notes:

(1) Total carcinogenic PAHs include benzo(a)anthracene, benso(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and carbazole.

(2) Carcinogenic risk for benzo(a)pyrene only

(3) carcinogenic/noncarcinogenic

(4) Most conservative value for either an adult or child receptor.

(5) Based on combined Station-wide and anthropogenic background concentrations

HI - Hazard Index

ND - Not Detected

PAH - Polynuclear Aromatic Hydrocarbon

RBC - Risk Based Concentration

mg/kg - milligrams per kilogram

PRG - Preliminary Risk-Based Remediation Goal

TABLE 3-20

ECOLOGICAL PRGs FOR SURFACE SOIL
SITE 2
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level[1]	ER-M [2]	ORNL Benchmarks[3]			Receptor Model	Concentration Derived from Model for No Risk	PRG Value
				Phytotoxicity	Earthworm Toxicity	Microorganism Toxicity			
Organics (mg/kg)									
Fluoranthene	90	0.1	5.1	NE	NE	NE	Shrew	4.2	4.2
Phenanthrene	79	0.1	1.5	NE	NE	NE	Shrew	4.2	4.2
Pyrene	84	0.1	2.6	NE	NE	NE	Shrew	4.2	4.2
Aroclor-1254	6.2	0.1	NA	40[4]	NE	NE	Shrew	0.21	0.21
Inorganics (mg/kg)									
Cadmium	15.7	2.5	NA	4	20	20	Shrew	0.37	0.37
Cobalt	168	100	NA	20	NE	1,000	Robin	6.3	6.3
Copper	14,700	15	NA	100	50	100	Robin	1.48	1.48
Mercury	16.6	0.058	NA	0.3	0.1	30	Robin	0.06	0.06
Thallium	26.8	1	NA	1	NE	NE	Shrew	3.7	3.7

Notes:

BTAG Biological Technical Assistance Group
ER-M Effects Range - Medium
mg/kg milligrams per kilogram
ORNL Oak Ridge National Laboratory
PRG Preliminary Risk-Based Remediation Goal
L Estimated value, biased low
NA Not Applicable
NE Not Evaluated
(1) USEPA, 1995
(2) These values were discussed in WPNSTA Partnering Meetings as possible remediation goals for noncarcinogenic polynuclear aromatic hydrocarbons.
(3) Will and Suter, 1997
(4) Efroymson et al., 1996

TABLE 3-21

ECOLOGICAL PRGs FOR TIDAL FRESHWATER SURFACE WATER
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level [1]	Surface Water Benchmarks [2][3]		Receptor Model	Concentration Derived from Model for No Risk	PRG Value
			Acute	Chronic			
Nitramines (µg/L)							
2,4,6-Trinitrotoluene	0.14J	NE	570	130	NE	NE	130

Notes:

BTAG Biological Technical Assistance Group
PRG Preliminary Risk-Based Remediation Goal
NE Not Evaluated (due to lack of NOAEL and LOAEL values for aquatic receptors and TNT)

µg/l micrograms per liter
J Analyte was positively identified, value is estimated

(1) USEPA, 1995
(2) Talmage and Opresko, 1996
(3) Benchmark value for freshwater surface water

TABLE 3-22

ECOLOGICAL PRGs FOR SEDIMENT
SITE 2
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level[1]	ER-M[2]	Receptor Model	Concentration Derived from Model for No Risk	PRG Value
Inorganics (mg/kg)						
Silver	13.9	1	3.7	NE	NE	3.7

Notes:

BTAG Biological Technical Assistance Group
PRG Preliminary Risk-Based Remediation Goal
ER-M Effects Range-Median
NE Not Evaluated (due to lack of NOAEL and LOAEL values for aquatic receptors and silver)
mg/kg milligrams per kilogram

(1) USEPA, 1995
(2) Long et al., 1995

TABLE 3-23

ECOLOGICAL PRGs FOR SURFACE SOIL
SITE 8
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level[1]	ORNL Benchmarks[2]			Receptor Model	Concentration Derived from Model for No Risk	PRG Value
			Phytotoxicity	Earthworm Toxicity	Microorganism Toxicity			
Organics (mg/kg)								
Aroclor-1260	10	0.1	40[3]	NE	NE	Shrew	0.21	0.21
Inorganics (mg/kg)								
Chromium	61.5	0.0075	1	0.4	1	Shrew	0.4	0.4
Copper	68.4	15	100	50	100	Robin	1.49	1.49
Lead	129	0.01	50	500	900	Robin	1.91	1.91
Mercury	0.91	0.058	0.3	0.1	30	Robin	0.06	0.06
Zinc	249	10	50	200	100	Robin	88	88

Notes:

BTAG Biological Technical Assistance Group
ORNL Oak Ridge National Laboratory
PRG Preliminary Risk-Based Remediation Goal
mg/kg milligrams per kilogram
NE Not Evaluated
(1) USEPA, 1995
(2) Will and Suter, 1997
(3) Maxwell and Opresko, 1996

TABLE 3-24

ECOLOGICAL PRGs FOR FRESHWATER SURFACE WATER
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level[1]		ORNL Surface Water Benchmarks[3]	Receptor Model	Concentration Derived from Model for No Risk	PRG Value
		Acute	Chronic				
Inorganics (µg/L)							
Copper	58.9	35.8[2]	22.4[2]	3.8[4]	NR	NR	22.4

Notes:

BTAG Biological Technical Assistance Group
ORNL Oak Ridge National Laboratory
PRG Preliminary Risk-Based Remediation Goal
NE Not Evaluated (due to lack of NOAEL and LOAEL values for aquatic receptors)
NR No risk to aquatic recptor model from surface water concentrations
µg/l micrograms per liter

(1) USEPA, 1995
(2) Screening level is based on an average site-specific hardness of 210.79 mg/L
(3) Suter II and Tsao, 1996
(4) Value for the protection of fish

TABLE 3-25

ECOLOGICAL PRGs FOR SEDIMENT
SITE 18
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level[1]	ER-M	Receptor Model	Concentration Derived from Model for No Risk	PRG Value
Inorganics (mg/kg)						
Copper	64	34	270[2]	Heron	11.9	270
Iron	49,000	NE	27,000[3]	Heron	5,100	27,000

Notes:

BTAG Biological Technical Assistance Group
PRG Preliminary Risk-Based Remediation Goal
NE Not Evaluated
mg/kg milligrams per kilogram
ER-M Effects Range-Median

(1) USEPA, 1995
(2) Long et al., 1995
(3) This value is an Apparent Effects Threshold (Tetra Tech, 1989)

TABLE 3-26

ECOLOGICAL PRGs FOR SURFACE SOIL
SSA 14
NAVAL WEAPONS STATION, YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Maximum Detected Concentration	BTAG Screening Level[1]	ORNL Benchmarks[2]			Receptor Model	Concentration Derived from Model for No Risk	PRG Value
			Phytotoxicity	Earthworm Toxicity	Microorganism Toxicity			
Organics (mg/kg)								
HMX	17,000	NE	NE	500[3]	NE	Fox	8.6	8.6
Inorganics (mg/kg)								
Barium	2,460	440	500	NE	3,000	Shrew	4	4
Copper	113	15	100	50	100	Robin	1.48	1.48
Lead	124	0.01	50	500	900	Robin	1.91	1.91
Mercury	0.29	0.058	0.3	0.1	30	Robin	0.06	0.06
Zinc	318J	10	50	200	100	Robin	88	88

Notes:

BTAG Biological Technical Assistance Group
ORNL Oak Ridge National Laboratory
PRG Preliminary Risk-Based Remediation Goal
mg/kg milligrams per kilogram
NE Not Evaluated
(1) USEPA, 1995
(2) Will and Suter, 1997
(3) Maxwell and Opresko, 1996

TABL 7

SELECTION OF REMEDIATION GOALS
FOR CONTAMINANTS OF POTENTIAL CONCERN
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Surface Soil				Surface Water				Sediment			
	Human Health PRG (mg/kg)	Ecological PRG (mg/kg)	Final Remediation Goal (mg/kg)	Basis	Human Health PRG (mg/L)	Ecological PRG (mg/L)	Final Remediation Goal (mg/L)	Basis	Human Health PRG (mg/kg)	Ecological PRG (mg/kg)	Final Remediation Goal (mg/kg)	Basis
Organics												
Total Carcinogenic PAHs(1)	3.33	--	**3.33**	Human Health 1×10^{-5}	--	--	--		--	--	--	
Total PAHs	--	44(2)	**44**	ER-M	--	--	--		--	--	--	
PCBs					--	--	--		--	--	--	
Aroclor-1254	1.31	0.21	**1.31**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Explosives					--	--	--		--	--	--	
4-Amino-2,6-Dinitrotoluene	37	--	**37**	Human Health HI	--	--	--		--	--	--	
2,4,6-Trinitrotoluene	--	--	--		--	130	**130**	Chronic Surface Water Benchmark	--	--	--	
Inorganics					--	--	--		--	--	--	
Aluminum	3,052,569	--	**3,052,569**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Antimony	1,221	--	**1,221**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Arsenic	31.06	--	**31.06**	Human Health 1×10^{-5}	--	--	--		--	--	--	
Cadmium	11,008	0.37	**11,008**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Cobalt	--	6.3	**6.3**	Ecological Robin Model	--	--	--		--	--	--	
Copper	146,909	1.48	**146,909**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Iron	915,771	--	**915,771**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Manganese	39,895	--	**39,895**	Human Health 1×10^{-6}	--	--	--		--	--	--	
Mercury	--	0.06	**0.06**	Ecological Robin Model	--	--	--		--	--	--	
Silver	--	--	--		--	--	--		--	3.7	**3.7**	Ecological Shrew Model
Thallium	244	3.7	**244**	Human Health HI	--	--	--		--	--	--	

Notes:
(1) Total carcinogenic PAHs include benzo(a)anthracene, benso(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and carbazole.
(2) This value was discussed at WPNSTA Yorktown partnering meetings as a possible remediation goal for total PAHs.

ER-M - effects range - median
mg/kg - milligrams per kilogram
PAHs - Polynuclear Aromatic Hydrocarbons
mg/L - milligrams per liter
PRG - Preliminary Risk-Based Remediation Goal
HI - Hazard Index

TAB 8

SELECTION OF REMEDIATION GOALS
FOR CONTAMINANTS OF POTENTIAL CONCERN
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Surface Soil				Groundwater			
	Human Health PRG (mg/kg)	Ecological PRG (mg/kg)	Final Remediation Goal (mg/kg)	Basis	Human Health PRG (mg/L)	Ecological PRG (mg/L)	Final Remediation Goal (mg/L)	Basis
Organics								
Total Carcinogenic PAHs[1]	2.22	--	**2.22**	Human Health 1×10^{-5}	--	--	--	
1,1-Dichloroethene	--	--	--		10	--	**10**	Human Health 1×10^{-6}
Chloroform	--	--	--		1,290	--	**1,290**	Human Health 1×10^{-6}
Trichloroethene	--	--	--		1,310	--	**1,310**	Human Health 1×10^{-6}
PCBs								
Aroclor-1260	0.99	0.21	**0.99**	Human Health 1×10^{-6}	--	--	--	
Explosives								
4-Amino-2,6-Dinitrotoluene	37	--	**37**	Human Health HI	160	--	**160**	Human Health HI
RDX	5.46	--	**5.46**	Human Health 1×10^{-6}	90	--	**90**	Human Health 1×10^{-6}
2,4,6-Trinitrotoluene	--	--	--		340	--	**340**	Human Health 1×10^{-6}
Inorganics								
Aluminum	3,052,569	--	**3,052,569**	Human Health HI	--	--	--	
Arsenic	1.55	--	**1.55**	Human Health 1×10^{-6}	--	--	--	
Dissolved Arsenic	--	--	--		10	--	**10**	Human Health 1×10^{-6}
Dissolved Barium	--	--	--		171,040	--	**171040**	Human Health HI
Chromium	15263	0.40	**15263**	Human Health HI	--	--	--	
Copper	145,909	1.49	**146,909**	Human Health HI	--	--	--	
Iron	915,771	--	**915,771**	Human Health HI	--	--	--	
Lead	--	1.91	**1.91**	Ecological Robin Model	--	--	--	
Manganese	39,895	--	**39,895**	Human Health HI	--	--	--	
Mercury	--	0.06	**0.06**	Ecological Robin Model	--	--	--	
Thallium	244	--	**244**	Human Health HI	--	--	--	
Dissolved Thallium	--	--	--		140	--	**140**	Human Health HI
Zinc	--	88	**88**	Ecological Robin Model	--	--	--	

Notes:

PRG - Preliminary Risk-based Remediation Goal
PAH - Polynuclear Aromatic Hydrocarbons
HI - Hazard Index
mg/kg - milligrams per kilogram
mg/L - milligrams per liter

TABLE 3-29

SELECTION OF REMEDIATION GOALS
FOR CONTAMINANTS OF POTENTIAL CONCERN
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Surface Water				Sediment			
	Human Health PRG (mg/L)	Ecological PRG (mg/L)	Final Remediation Goal (mg/L)	Basis	Human Health PRG (mg/kg)	Ecological PRG (mg/kg)	Final Remediation Goal (mg/kg)	Basis
Inorganics								
Copper	--	22.4	**22.4**	Chronic BTAG Screening Level	--	270	**270**	ER-M
Iron	--	--	--		--	27,000	**27,000**	ER-M

Notes:

PRG - Preliminary Risk-based Remediation Goal
mg/L - milligrams per liter
mg/kg - milligrams per kilogram
BTAG - Biological Technical Assistance Group
ER-M - Effects Range-Median

TABLE 3-30

SELECTION OF REMEDIATION GOALS
FOR CONTAMINANTS OF POTENTIAL CONCERN
SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant	Surface Soil			
	Human Health PRG (mg/kg)	Ecological PRG (mg/kg)	Final Remediation Goal (mg/kg)	Basis
Organics				
Total Carcinogenic PAHs[1]	6.65	--	**6.65**	Human Health 1×10^{-5}
Explosives				
HMX	26,259	8.6	**8.6**	Ecological Fox Model
Inorganics				
Aluminum	3,052,569	--	**3,052,569**	Human Health HI
Arsenic	3.11	--	**3.11**	Human Health 1×10^{-6}
Barium	213,680	4	**213680**	Human Health HI
Chromium	15263	--	**15263**	Human Health HI
Copper	--	1.48	**1.48**	Ecological Robin Model
Iron	915,771	--	**915,771**	Human Health HI
Lead	--	1.91	**1.91**	Ecological Robin Model
Manganese	39,895	--	**39,895**	Human Health HI
Mercury	--	0.06	**0.06**	Ecological Robin Model
Thallium	244	--	**244**	Human Health HI
Vanadium	21,368	--	**21,368**	Human Health HI
Zinc	--	88	**88**	Ecological Robin Model

Notes:

PRG - Preliminary Risk-based Remediation Goal
mg/kg - milligrams per kilogram
PAHs - Polynuclear Aromatic Hydrocarbons
HI - Hazard Index

TABLE 3-31

SUMMARY OF FINAL REMEDIATION GOALS AND CONTAMINANTS OF CONCERN
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant of Concerns	Surface Soil		Surface Water		Sediment	
	FRG (mg/kg)	Basis	FRG (mg/L)	Basis	FRG (mg/kg)	Basis
Organics						
Total Carcinogenic PAHs	3.33	Human Health 1×10^{-5}	--	--	--	--
Total PAHs	44	Ecological ER-M	--	--	--	--
PCBs			--		--	
Aroclor-1254	1	TCSA Residential Action Level	--	--	--	--
Inorganics						
Cobalt	6.3	Ecological Robin Model	--	--	--	--
Mercury	0.1U - 5.9B	Ecological Robin Model	--	--	--	--
Silver	--	--	--	--	3.7	Ecological Shrew Model

Notes:

FRG - Final Remediation Goal
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
PAHs - Polynuclear Aromatic Hydrocarbons
TSCA - Toxic Substances Control Act
ER-M - Effects Range-Median

TABLE 3-32

SUMMARY OF FINAL REMEDIATION GOALS
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant of Concern	Surface Soil		Groundwater	
	FRG (mg/kg)	Basis	FRG (mg/L)	Basis
Organics				
Total Carcinogenic PAHs	2.2	Human Health 1×10^{-5}	--	--
1,1-Dichloroethene	--	--	10	Human Health 1×10^{-6}
PCBs			--	
Aroclor-1260	1	TCSA Residential Action Level	--	--
Explosives			--	
4-Amino-2,6-Dinitrotoluene	--	--	160	Human Health HI
RDX	5.5	Human Health 1×10^{-6}	90	Human Health 1×10^{-6}
Inorganics				
Lead	16.7	Anthropogenic Background	--	--
Mercury	0.05UL - 0.07	Detection Limit	--	--
Zinc	88	Ecological Robin Model	--	--

Notes:

FRG - Final Remediation Goal
PAHs - Polynuclear Aromatic Hydrocarbons
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
TSCA - Toxic Substances Control Act

TABLE 3-33

SUMMARY OF FINAL REMEDIATION GOALS AND CONTAMINANTS OF CONCERN
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant of Concern	Surface Water		Sediment	
	FRG (mg/L)	Basis	FRG (mg/kg)	Basis
Inorganics				
Copper	--	--	--	--
Iron	--	--	--	--

Notes:

FRG - Final Remediation Goal
mg/L - milligrams per liter
mg/kg - milligrams per kilogram
BTAG - Biological Technical Assistance Groups

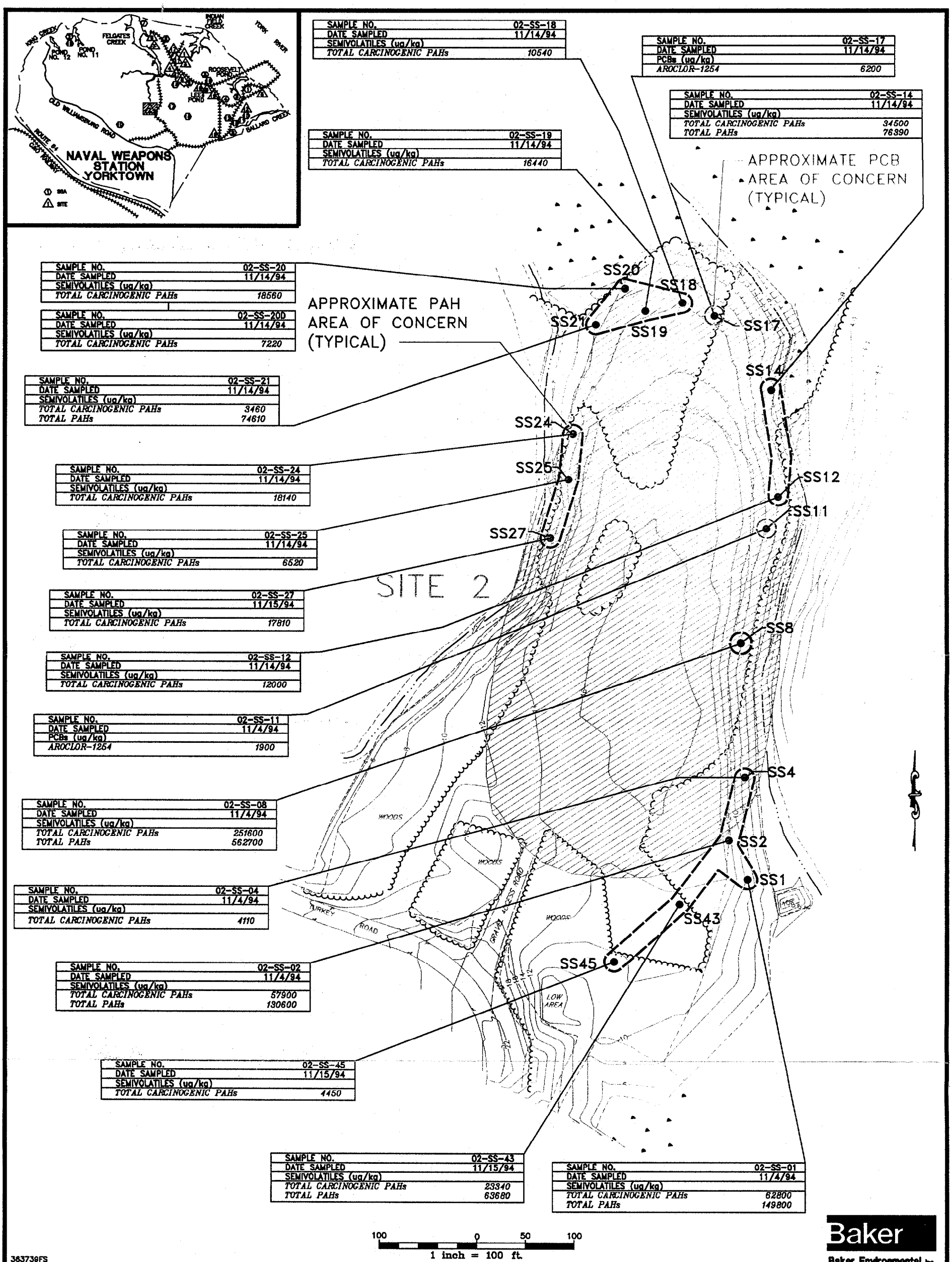
TABLE 3-34
SUMMARY OF FINAL REMEDIATION GOALS
AND CONTAMINANTS OF CONCERN
SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant of Concern	Surface Soil	
	FRG (mg/kg)	Basis
Explosives		
HMX	8.6	Ecological Fox Model
Inorganics		
Copper	7.3	Anthropogenic Background
Lead	16.7	Anthropogenic Background
Mercury	0.06U - 0.09UL	Detection Limit
Zinc	88	Ecological Robin Model

Notes:

FRG - Final Remediation Goal
mg/kg - milligrams per kilogram

SECTION 3.0 FIGURES



LEGEND

- SS1 ● – SURFACE SOIL SAMPLE LOCATION
- – APPROXIMATE PAH AOC BOUNDARY
- – APPROXIMATE PCB AOC BOUNDARY
- – APPROXIMATE SITE BOUNDARY
- – TREES
- – DRAINAGE
- – MARSH
- – GROUND SURFACE CONTOUR (FT., MSL)

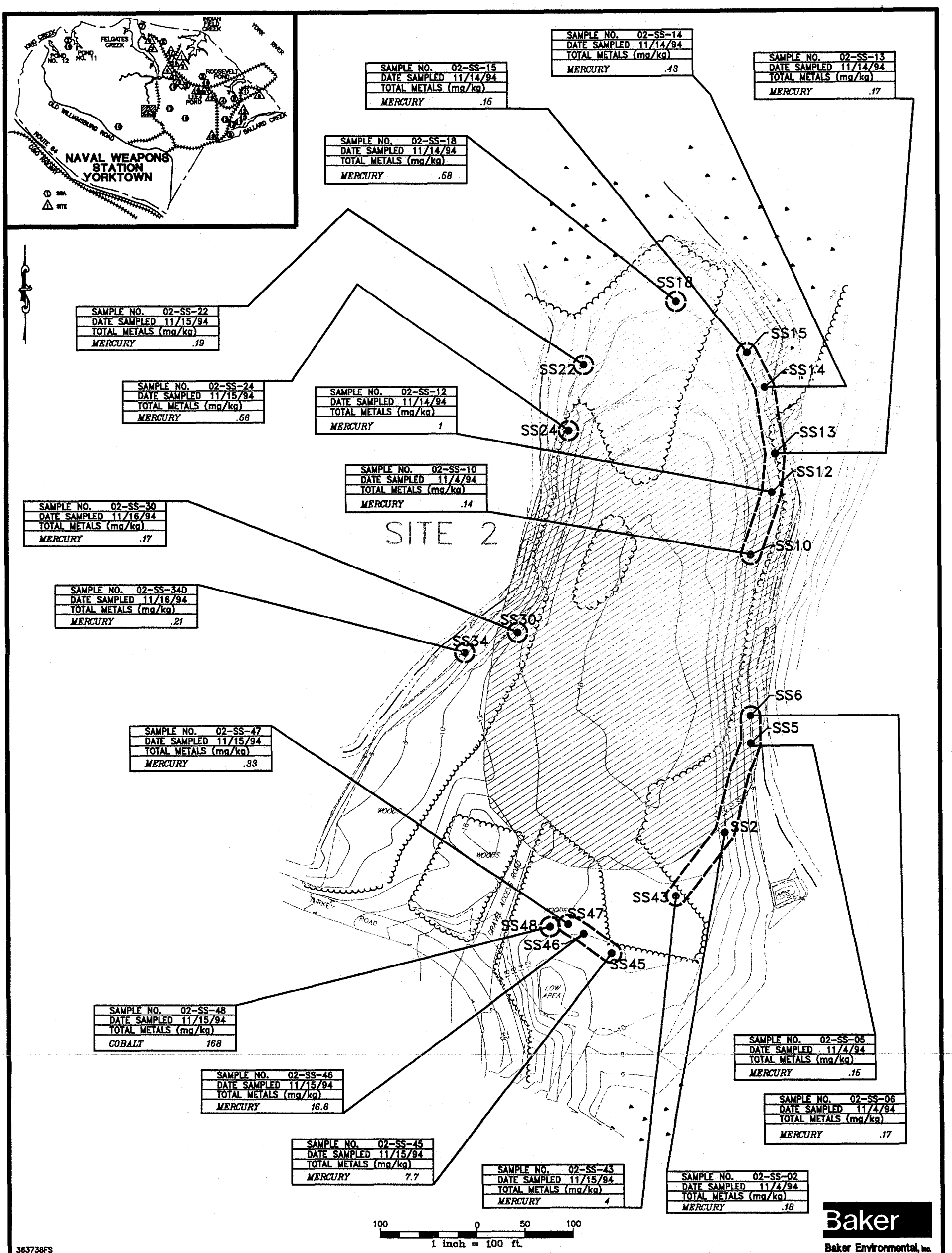
NOTE: 1) CONTAMINANT OF CONCERN CONCENTRATIONS SHOWN IN TEXT BOXES EXCEED THE FINAL REMEDIATION LEVELS.

SOURCE: LANTDIV, 1991

FIGURE 3-1
PAH AND PCB AREA OF CONCERN IN SURFACE SOIL SITE 2

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA

01764FB82



LEGEND

- SS1 – SURFACE SOIL SAMPLE LOCATION
- TREES
- APPROXIMATE SITE BOUNDARY
- APPROXIMATE MERCURY AOC BOUNDARY
- APPROXIMATE COBALT AOC BOUNDARY
- DRAINAGE
- MARSH
- GROUND SURFACE CONTOUR (FT., MSL)

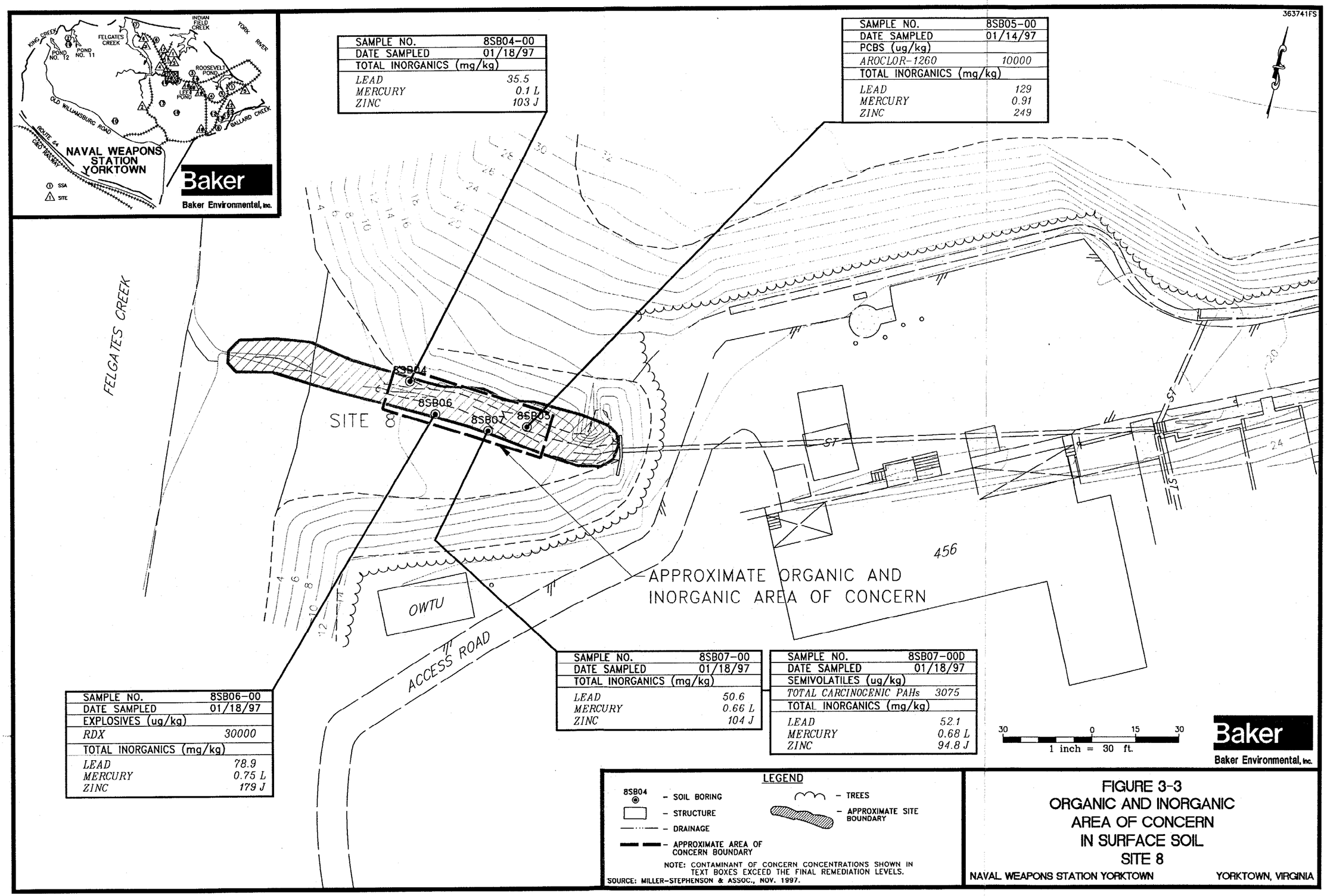
NOTE: CONTAMINANT OF CONCERN CONCENTRATIONS SHOWN IN TEXT BOXES EXCEED THE FINAL REMEDIATION LEVELS.

SOURCE: LANTDIV, 1991

FIGURE 3-2
MERCURY AND COBALT AREA OF CONCERN IN SURFACE SOIL SITE 2

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA

363741FS



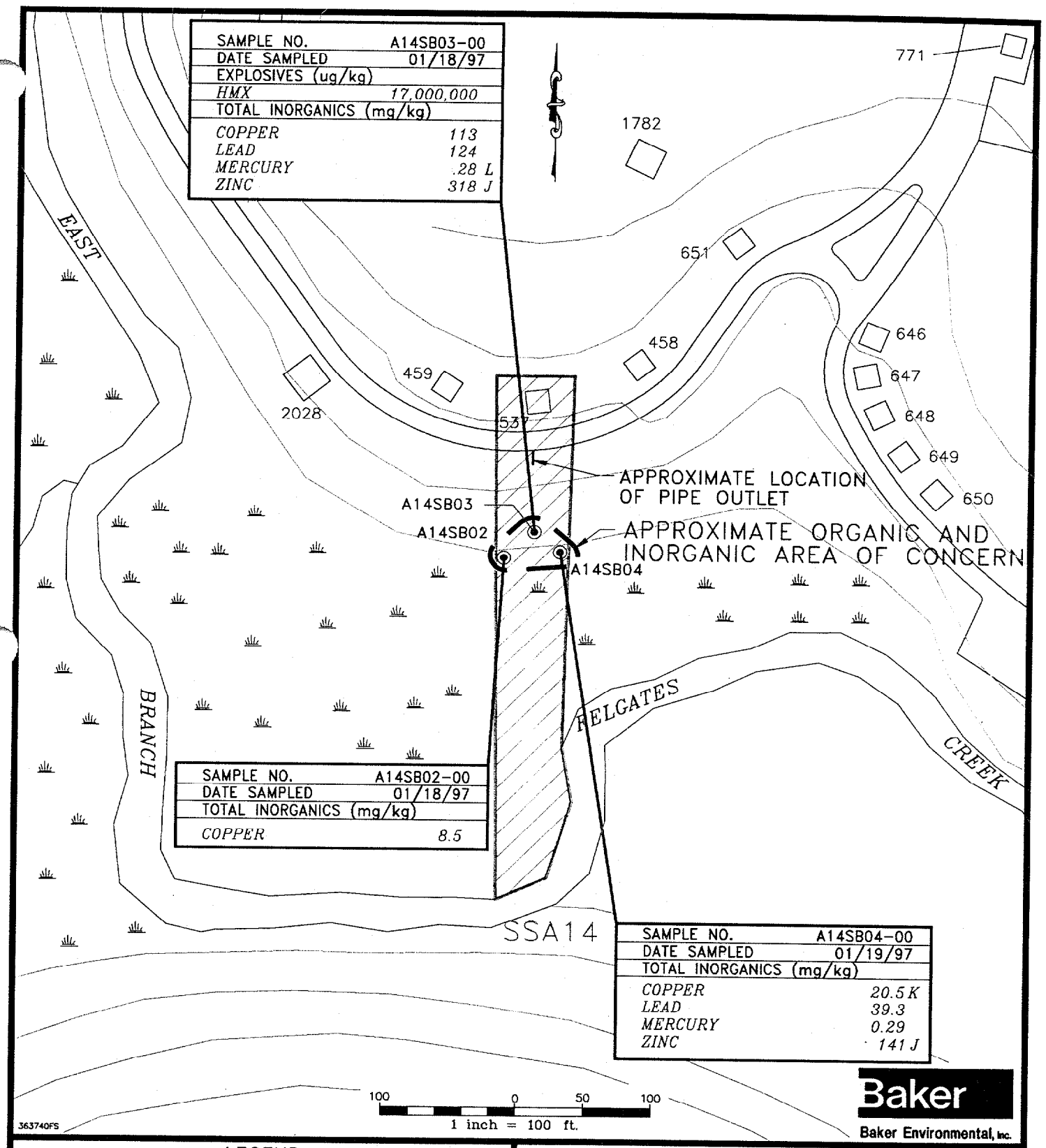
SAMPLE NO.	8SB04-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
LEAD	*35.5*
MERCURY	*0.1 L*
ZINC	*103 J*

SAMPLE NO.	8SB05-00
DATE SAMPLED	01/14/97
PCBS (ug/kg)	
AROCLOR-1260	*10000*
TOTAL INORGANICS (mg/kg)	
LEAD	*129*
MERCURY	*0.91*
ZINC	*249*

SAMPLE NO.	8SB06-00
DATE SAMPLED	01/18/97
EXPLOSIVES (ug/kg)	
RDX	*30000*
TOTAL INORGANICS (mg/kg)	
LEAD	*78.9*
MERCURY	*0.75 L*
ZINC	*179 J*

SAMPLE NO.	8SB07-00
DATE SAMPLED	01/18/97
TOTAL INORGANICS (mg/kg)	
LEAD	*50.6*
MERCURY	*0.66 L*
ZINC	*104 J*

SAMPLE NO.	8SB07-00D
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*3075*
TOTAL INORGANICS (mg/kg)	
LEAD	*52.1*
MERCURY	*0.68 L*
ZINC	*94.8 J*



LEGEND

A14SB02 – SOIL BORING

– MARSH

– DRAINAGE

– APPROXIMATE SITE BOUNDARY

– APPROXIMATE AREA OF CONCERN BOUNDARY

NOTE: CONTAMINANTS OF CONCERN CONCENTRATIONS SHOWN IN TEXT BOXES EXCEED THE FINAL REMEDIATION LEVELS.

SOURCE: LANTDIV, 1991.

FIGURE 3-4
ORGANIC AND INORGANIC AREA OF CONCERN IN SURFACE SOIL SSA14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

4.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

This section includes the identification and preliminary screening of remedial action technologies and process options that may be applicable to the remediation of the soil AOCs at Sites 2 and 8 and SSA 14. Specifically, Section 4.1 identifies a set of general response actions; Section 4.2 identifies remedial action technologies and process options for each general response action; and Section 4.3 presents the preliminary screening of remedial action technologies and process options. The process option evaluation is presented in Section 4.4.

4.1 General Response Actions

General response actions are broad-based, medium-specific categories of actions that can be identified to satisfy the remedial action objectives of an FS. Table 4-1 lists the general response actions applicable to the remedial action objective established for Sites 2, 8, and 18, and SSA 14. As shown on Table 4-1, four general response actions have been identified: no action, institutional controls, containment, and removal/ treatment/ disposal. A brief description of these response actions follows.

4.1.1 No Action

The NCP requires the evaluation of the no action response action as part of the FS process. A no action response provides a baseline assessment for comparisons involving other RAAs that have a greater level of response. A no action alternative may be considered appropriate when there are no adverse or unacceptable risks to human health or the environment, or when a response action may cause a greater environmental or health danger than the no action alternative itself.

4.1.2 Institutional Controls

Institutional controls are various "institutional" actions that can be implemented at a site as part of a complete RAA to minimize exposure to potential hazards at the site. These controls are typically considered to be "passive" actions such as limiting exposure to contaminated groundwater by placing restrictions on the use of a groundwater aquifer system.

4.1.3 Containment

Containment actions include technologies that contain and/or isolate contaminants by covering, sealing, chemically stabilizing, or providing an effective barrier against specific areas of concern. These actions also provide isolation and prevent direct exposure with or migration of the contaminated media without disturbing or removing the waste from the site.

4.1.4 Removal/Treatment/Disposal

A typical general response action applicable to soil/sediment remediation involves a combination of removal, treatment, and/or disposal actions. Treatment actions (in situ and ex situ) for soil can include biological, physical/chemical, and thermal treatment methods. In situ treatments may result in production of process water or products from off-gas treatment systems. Ex situ treatments may result in process water, products from off-gas treatment systems or contaminated soil/sediment. These remediation end products may need to be disposed. Disposal may include on-site or off-site landfill options in addition to recycling options.

4.2 Identification of Remedial Action Technologies and Process Options

In this step, a set of potentially applicable technologies and process options will be identified for each of the general response actions listed in the previous section. The term, "technology type" will refer to general categories of technologies such as physical/chemical, thermal, and biological. The term "process option" will refer to specific processes, or technologies, within each generalized technology type. For example, soil washing and solvent extraction are process options under the technology type known as physical/chemical treatment. Several technology types may be identified for each general response action, and numerous process options may exist within each generalized technology type.

Remedial action technology types and process options that are potentially applicable at Sites 2, 8, and 18 or SSA 14 are listed on Table 4-1 with respect to their corresponding general response action. (The technology types are listed in the column titled "Remedial Action Technology".) The technologies and process options listed on Table 4-1 do not represent a global list of all available soil or groundwater technologies/options. Instead the list includes a set of technologies/options that

may be applicable to soils contaminated with PAHs, PCBs, explosives, and/or inorganics. This focused list was developed based on information obtained from four sources: 1) a search of the USEPA's Vendor Information System for Innovative Technologies (VISITT) data base; 2) the document, "Remediation Technologies Screening Matrix and Reference Guide" (DOD, 1994); 4) the document "Guidance on Remedial Actions for Superfund Sites with PCB Contamination" (USEPA, 1990a); and a search of the Internet. Descriptions of each of these technologies/process options listed on Table 4-1 are presented below.

4.2.1 No Action

The no action alternative will be considered at each of the sites (Sites 2, 8, and 18, and SSA 14). The no action response provides a baseline for comparison with other response actions. Under the no action response, the contaminated media at each site will be left in place. Passive remediation (i.e., natural attenuation) may occur, but will be unmonitored and unproven. No active remediation efforts will be taken at any of the sites. No other alternatives will be considered for Site 18 because no AOCs were identified for the site.

4.2.2 Institutional Controls

4.2.2.1 Fencing

The fencing process option would include the installation and/or maintenance of security fencing and signs around the contaminated soil on the sites. Warning signs would be posted along the fence. The fencing option would eliminate direct exposure to the contaminated soil at the site by reducing the potential for dermal contact with or ingestion of the soil.

4.2.2.2 Land Use Restrictions

Land use restrictions at Sites 2 and 8 and SSA 14 would require that the contaminated AOCs have permanent land use restrictions implemented that would limit future development of the site areas.

4.2.2.3 Monitoring

Monitoring programs for soil, groundwater, surface water and/or sediment would be implemented at Sites 2 and 8 and SSA 14. The results of the sampling would be evaluated to determine if the contaminant concentrations within the sampled media are decreasing or if contaminants are migrating.

4.2.3 Containment

4.2.3.1 Capping

A capping process option (i.e., soil cover) is being considered for Sites 2 and 8 and SSA 14. The soil cover would consist of placed and compacted soil fill, with topsoil and vegetation on top of the compacted fill. The cover would reduce the potential for direct exposure to the contaminated soil in this area.

4.2.3.2 Solidification/Stabilization

Solidification/stabilization reduces the mobility of hazardous substances in soil using physical and chemical methods. A hardening agent (e.g., cement) is mixed or injected into the contaminated soil. The agent fixes the contaminants in the soil. Leachability testing is typically performed to ensure that the contaminants are no longer mobile. This process is applicable to inorganic contamination but has limited effectiveness on SVOCs.

4.2.4 Removal - Excavation

Excavation is a method for removing contaminated soil using conventional heavy construction equipment such as backhoes, cranes, bulldozers, and loaders. A typical practice is to excavate and remove contaminated "hot spots" and to employ other remedial technologies for less contaminated soils. With respect to Sites 2 and 8 and SSA 14, the soil within the contaminated AOCs could be excavated and then treated (on site or off site) or sent off site for disposal.

4.2.5 Treatment - Biological

4.2.5.1 Landfarming

Landfarming is a full-scale bioremediation technology in which contaminated media are applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste. Although landfarming is usually performed in place, landfarming systems are increasingly incorporating liners and other methods to control the leaching of contaminants. Additional controls usually require excavation and placement of contaminated soil. (DOD, 1994). Figure 4-1 shows a typical landfarming treatment system. Landfarming has been used for the treatment of explosives, PAHs, and PCBs. This process is not anticipated to be very effective for inorganics.

4.2.5.2 Composting

Composting is a controlled biological process by which biodegradable hazardous materials are converted by microorganisms to innocuous, stabilized by-products, typically at elevated temperatures in the range of 120° F to 130° F. The increased temperatures result from heat produced by microorganisms during the degradation of the organic material in the waste. In most cases, this is achieved using indigenous microorganisms. Soils are excavated and mixed with bulking agents and organic amendments such as wood chips, paper, leaves, and animal and vegetative wastes. The bulking agent serves as a source of carbon, nutrients, or microbes, in addition to increasing the porosity of the soil to be treated. Maximum degradation efficiency is achieved by maintaining moisture content, pH, oxygenation, temperature, and the carbon-to-nitrogen ratio (DOD, 1994). After composting, the material is typically cured for additional time. During the period, additional decomposition as well as stabilization, pathogen destruction, and degassing take place (Weston, 1988). The decomposed waste is reduced in weight and volume, and the process produces a stabilized material that can be used as backfill. Composting has been used for the treatment of explosives, PAHs, and PCBs. Certain microorganisms can be added to the compost which are known to biodegrade or transform certain inorganics including arsenic, selenium, lead, and mercury.

Composting is similar to landfarming in that it relies on the destruction of organic compounds through microbial metabolism. Composting methods fall into three categories: aerated static-pile; mechanically agitated in-vessel; and windrow. In static-pile composting, contaminated material is

excavated, placed in a pile(s) under protective shelter, and mixed with readily degradable carbon sources. The pile undergoes forced aeration (blowers or vacuum pumps) to maintain aerobic and thermophilic conditions, which foster the growth of microorganisms. Bulking agents, such as cow manure and vegetable waste and/or wood chips, can be added to enhance biodegradation. Figure 4-2 shows a typical aerated static pile schematic.

In mechanically agitated in-vessel composting, contaminated material is aerated and blended with carbon-source materials in a mechanical composter. These devices have been used at municipal sewage treatment ~~facilities~~ and ~~applied to~~ explosives waste.

Windrow composting is similar to static-pile composting except that compost is placed in long piles and periodically aerated (mixed) with mobile equipment, rather than a forced air system (USEPA, 1993 and DOD, 1994).

4.2.5.3 Aqueous-Phase Bioreactor (Bioslurry)

Two types of aqueous-phase bioreactors are discussed below: lagoon slurry reactor and aboveground slurry reactor. Aqueous-phase bioreactors have been used for the treatment of explosives, PAHs, and PCBs. This process would not be applicable to inorganics.

Lagoon Slurry Reactor

The lagoon slurry reactor is an aqueous-phase system which allows contaminants to remain in a lagoon, be mixed with nutrients and water and degrade under anaerobic conditions. The lagoon slurry reactor is still in the developmental stage. A typical lagoon slurry reactor is shown on Figure 4-3. These reactors can provide good process control, can be configured in several treatment trains to treat a variety of wastes, and potentially can achieve very low contaminant concentrations. A drawback to the bioreactors is that they accumulate the products of biotransformation, unlike composting which bind the contaminants to humic material (DOD, 1994).

Aboveground Slurry Reactor

Slurry phase biological treatment involves the controlled treatment of excavated soil in a bioreactor. The excavated soil is first processed to physically separate stones and rubble. The soil is then mixed with water to a predetermined concentration dependent upon the concentration of the contaminants, the rate of biodegradation, and the physical nature of the soils. Some processes pre-wash the soil to concentrate the contaminants. Clean sand may then be discharged, leaving only contaminated fines and wash water to biotreat. Typically, the slurry contains from 10 to 40 percent solids by weight. The soil is maintained in suspension in a reactor vessel and mixed with nutrients and oxygen. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. If necessary, an acid or alkali may be added to control pH. Microorganisms also may be added if a suitable population is not present. Upon completion of the process, the slurry is dewatered and the treated soil is disposed. Dewatering devices that may be used included clarifiers, pressure filters, vacuum filters, sand drying beds, or centrifuges (DOD, 1994).

The aboveground slurry reactor (or bioslurry reactor) is either constructed on site or mobilized on site as a package system. A schematic of a typical aboveground slurry reactor is shown on Figure 4-4. Like the lagoon slurry reactors, the bioslurry reactors can provide good process control; can be configured in several treatment trains to treat a variety of wastes; and potentially can achieve very low contaminant concentrations. A drawback to the bioreactors is that they accumulate the products of biotransformation, unlike composting which bind the contaminants to humic material (DOD, 1994).

4.2.5.4 Solid -Phase Biocell Reactor

Solid-phase biocell reactors can be used to treat contaminated soil. This process is a controlled solid-phase biological treatment in which excavated soils are mixed with soil amendments and placed in above ground enclosures. The technology/process option involves excavation of contaminated soil, screening to remove larger debris, and then loading of the soils into the biocells. This process can be described as "bioventing in a can". Once the soil is loaded into the biocell, little or no mixing is provided. Mixing operations may be performed by periodic use of a vertical auger mounted from above the cell (WES, 1995).

Biocells are operated in a true batch mode much like composting. The soil is added into the biocell without slurrying. Instead the soil is simply dumped into the cell and aeration is initiated to stimulate the aerobes. In some cases, if the soil has a very low hydraulic conductivity, sand or other bulking agents may be added. Low hydraulic conductivity hinders transport of air and water (WES, 1995). Figure 4-5 shows a typical solid-phase biocell reactor schematic. Solid-phase bioreactors have been used for the treatment of explosives, PAHs, and PCBs. This process would not be applicable to inorganics.

4.2.5.5 In Situ Bioremediation

Bioremediation is a developing technology that uses microorganisms to degrade organic contaminants into less hazardous compounds. In situ bioremediation uses existing indigenous or cultivated strains of bacteria to biodegrade compounds in the soil. Precise control of the biological processes is not feasible because the processes occur under the ground surface. The biological processes can be accelerated by the addition of air, nutrients or additional bacteria strains. The nutrients can be injected with vertical or horizontal wells that stimulate the growth of the microbes. The system can be combined with soil vapor extraction to strip the more easily removed and more highly concentrated contaminants out of the soil. Figure 4-6 shows a typical in situ bioremediation schematic.

4.2.5.6 White Rot Fungus

White rot fungus has been reported to degrade a wide variety of organopollutants by using their lignin-degrading or wood-rotting enzyme system. A white rot fungus system may be conducted in a bioreactor with moisturized air and wood chips added. Temperature within the biocell is controlled. The optimum temperature for biodegradation with lignin-degrading fungus ranges from 86° F to 100° F. The heat of the biodegradation reaction helps to maintain the temperature of the process near the optimum (DOD, 1994). A typical schematic for the white rot fungus is shown on Figure 4-7. White rot fungus has been used to treat soils contaminated with explosives, PAHs and PCBs. This process is not applicable to inorganics.

4.2.5.7 Monitored Natural Attenuation

The term natural attenuation refers to naturally occurring processes that occur in groundwater without the assistance of engineered systems to reduce contaminant mass, toxicity, mobility, volume, or concentration of contamination. The natural attenuation of contaminated groundwater occurs as the result of destructive and nondestructive subsurface mechanisms. Biodegradation, reduction of contamination to innocuous byproducts by microbes, is the most important destruction mechanism, although abiotic destruction, chemical reduction (or oxidation) of contamination to innocuous byproducts does occur. Extensive monitoring and analysis would be required to show that natural attenuation is occurring. Monitoring for natural attenuation encompasses a range of analytic parameters that include the contaminants of concern. This process has been used for explosives, PAHs and PCBs. This process would not be applicable to inorganics.

4.2.6 Treatment - Physical/Chemical

4.2.6.1 Solvent Extraction

Solvent extraction is a physical/chemical treatment in which waste and solvent are mixed in an extractor, dissolving the organic contaminant into the solvent. The extracted organics and solvent are then placed in a separator, where the contaminants and solvent are separated for treatment and further use. Solvent extraction does not destroy wastes, but is a means of separating hazardous contaminants from soils, thereby reducing the volume of the hazardous waste that must be treated. The technology uses an organic chemical as a solvent and differs from soil washing, which generally uses water or water with wash-improving additives. Commercial-scale units are in operation; they vary in regard to the solvent employed, type of equipment used, and mode of operation (DOD, 1994). A typical solvent extraction process schematic is shown on Figure 4-8. Solvent extraction is applicable to soil contaminated with explosives and PCBs.

Solvent extraction is commonly used in combination with other technologies - solidification/stabilization, incineration, soil washing - depending upon site-specific conditions. It can also be used as a stand-alone technology in some instances. The treated media are usually returned to the site after having met Best Demonstrated Available Technology (BDAT) and other standards (DOD, 1994).

4.2.6.2 Chemical Oxidation/Reduction

Chemical oxidation increases the oxidation state of an atom by removing electrons or adding oxygen to the atom. Oxidation may cause a substance to be transformed, degraded, or immobilized in soil. Oxidation reactions within the soil matrix may occur through management of the natural processes in a soil or through addition of an oxidizing agent to the soil complex (USEPA, 1990b).

Chemical reduction is a process in which the oxidation state of an atom is decreased. Reducing agents are electron donors, and reduction is accomplished by the addition of electrons to the atom. Reduction of chemicals may occur naturally within the soil system. Certain compounds are more susceptible to reduction than others because they will accept electrons. The addition of reducing agents to soil to degrade reducible compounds can be used as a physical/chemical treatment technology (USEPA, 1990b). A typical chemical oxidation/reduction process is shown on Figure 4-9. Chemical reduction and oxidation processes are applicable to soil contaminated with inorganics and possibly PAHs.

4.2.6.3 Solvated Electron Technology

A solvated electron process which is under development by Teledyne-Commodore, LLC, has achieved 99.999 percent destruction efficiency of TNT and tetryl. The process is also being tested on PCBs. Contaminated media are fed into a stainless steel reactor and mixed with the solvated electron solution. For explosives, the actual conversion to inert compounds takes place within several minutes of contact with the contaminated media. The solvated electron solution is made by dissolving an alkaline metal, such as sodium, potassium, lithium or calcium, in anhydrous ammonia. The resulting solution has a high density of unbounded electrons (solvated electrons) which has high conductivity and is a strong reducing agent. The solution breaks the bonds between unlike non-metals and halogenated species producing salts of the solute metal and all halogen bonds. Many sulfur, nitrogen, phosphorus and arsenic bonds are also broken. The products are separated from the solution by evaporating the ammonia, which is recovered and recycled. The other products are disposed. Small volumes of hydrogen and C_1-C_3 hydrocarbon gases may be formed. Traces of ionic cyanide may be produced but can be treated through oxidation. The process takes place at room temperature and pressures required to keep the ammonia in liquid form (140 pounds per square inch)

(Kumar, Woosley and Johnson, 1997). Figure 4-10 shows a schematic for the solvated electron technology process.

4.2.6.4 Soil Washing

Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. Contaminants sorbed onto fine soil particles are separated from bulk soil by particle size in an aqueous-based system. The wash water may be augmented with a basic leaching agent, surfactant, pH adjuster, or chelating agent to help remove organics and heavy metals. The process removes contaminants in one of two ways: 1) by dissolving or suspending them in the wash solution, which is later treated by conventional wastewater treatment methods. 2) by concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing techniques, similar to those used in sand and gravel operations. (DOD, 1994). A typical soil washing schematic is shown on Figure 4-11. Soil washing is applicable to soil contaminated with explosives, PAHs and inorganics.

A soil washing procedure, called the Lurgi Process, is being developed in Germany. In the Lurgi Process, contaminated soil is excavated and processed in an attrition reactor, which detaches the explosive material from the soil particles. The remaining material undergoes a second process, which separates clean from contaminated particles. Clean particles are dewatered, separated into heavy and light materials, and returned to the site. Contaminated particles undergo a final series of washing, separation, and chemical extraction processes to remove any remaining clean particles. Finally, the contaminated material is clarified and concentrated before being disposed or treated (DOD, 1994).

4.2.6.5 Leaching/Recovery

A leaching/recovery process is being developed for remediation of soils, dust, sludge or sediment contaminated with lead. The process can also be modified to remediate soils contaminated with cadmium, copper, mercury, and zinc. Physical separation (dry screening) can be used to separate the fines from the oversized material. Lead often adheres to the fine portion of soils. The fines (and sands if they are contaminated) are then treated with a leachate to dissolve the adsorbed lead or other heavy metals. The metal ions are then recovered from the leachate by a process that is appropriate

for the metal being recovered. The leachant can be reused after the metals are recovered. The final products of the process are treated soil, recovered metal, and leachant. No waste products are generated and the treated soil can be returned to the site. A process flow diagram is presented in Figure 4-12. Other leaching processes have been developed for other inorganics as well.

4.2.7 Treatment - Thermal

4.2.7.1 Incineration

Incineration processes can be used to treat organic and inorganic-contaminated soil. Incineration processes involve high temperatures used to combust (in the presence of oxygen) organic constituents in hazardous wastes. The destruction and removal efficiency for properly operated incinerators exceeds the 99.99 percent requirement for hazardous waste (DOD, 1994). Contaminated soil can be sent to an off-site incinerator or treated with a mobile, on-site unit.

The rotary kiln incinerator can be used to treat organic-contaminated soil. Soil is fed into a primary combustion chamber, or rotary kiln, where organic constituents are destroyed. The temperature of gases in the primary chamber ranges from 800° to 1,200° F, and the temperature of soil ranges from 600° to 800° F. Retention time in the primary chamber, which is varied by changing the rotation speed of the kiln, is approximately 30 minutes. Off gases from the primary chamber pass into a secondary combustion chamber, which destroys any residual organics. Gases from the secondary combustion chamber pass into a quench tank where they are cooled from approximately 3,600° to 4000° F. From the quench tank, gases pass through a Venturi scrubber and a series of baghouse filters, which remove particulates prior to release from the stack. The treated product of rotary kiln incineration is ash (or treated soil), which drops from the primary combustion chamber after organic contaminants have been destroyed. This product is routed into a wet quench or a water spray to re-moisturize it, then transported to an interim storage area pending receipt of chemical analytical results (DOD, 1994). Figure 4-13 shows a typical mobile incineration process.

4.2.7.2 Low Temperature Thermal Desorption

Low temperature thermal desorption (LTTD) systems are physical separation processes and are not designed to destroy contaminants, but instead volatize them. Wastes are heated to 200° to 600° F

to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them. LTTD is a full-scale technology that has been proven successful for remediation of petroleum hydrocarbon contamination in all types of soil. Contaminant destruction efficiencies in the afterburners of these units are greater than 95 percent. Decontaminated soil retains its physical properties and ability to support biological activity (DOD, 1994).

Two common thermal desorption designs are the rotary dryer and thermal screw. Rotary dryers are horizontal cylinders that can be indirect or direct fired. The dryer is normally inclined and rotated. For the thermal screw units, screw conveyors or hollow augers are used to transport the medium through an enclosed trough. Hot oil or steam circulates through the auger to indirectly heat the medium. Particulates are removed by conventional particulate removal equipment, such as wet scrubbers or fabric filters. Contaminants are removed through condensation followed by carbon adsorption, or they are destroyed in a secondary combustion chamber or a catalytic oxidizer. Most of these units are transportable (DOD, 1994). A process schematic for LTTD is shown on Figure 4-14.

4.2.7.3 Two-Phase Medium Temperature Thermal Desorption

A two-stage medium temperature thermal desorption process has been designated by the USEPA as BDAT for the treatment of mercury-contaminated materials (including soils). Because the process also results in the recovery of mercury (99 percent pure metallic form suitable for directly refining and recycling), it is actually classified as "recycling" rather than "waste treatment". Therefore, the process is exempt from air and solid waste permitting requirements. The process steps include: 1) attaining consistent particle size (through crushing or shredding if necessary); 2) blending with an additive to break down oxides, sulfides and chlorides, and prevent gaseous sulfur and chlorine compounds from mixing with exhaust gas; 3) removal of moisture by low temperature heating; 4) vaporization of mercury by high temperature heating; 5) condensation of mercury (returned to metallic state); and 6) cleaning off-gas with carbon columns. A process flow diagram for this technology is shown in Figure 4-15.

The process equipment has been demonstrated at a pilot scale and has operated commercially from a truck-mounted mobile unit with a capacity of 12 tons/day. Mercury contaminated soils have been treated from a starting concentration of 15,000 mg/kg to a final concentration of 0.07 mg/kg in sandy soil. No waste products are produced by this process, and treated soil can be placed back at the site. Organic contaminants in low concentrations do not affect the process. Permitting for higher organic concentrations may be an issue; however, because the treatment process is only permitted for mercury removal. Further, if heavy metals are in the soil and fail Toxic Characteristic Leaching Procedure (TCLP) analyses, the soil will have to go through further treatment for those contaminants.

4.2.7.4 High Temperature Thermal Desorption

Ex situ High Temperature Thermal Desorption

High temperature thermal desorption (HTTD) is a process which heats wastes from 600°F to 1,000°F to volatize water and organic contaminants. Because bed temperatures and residence times volatize but do not oxidize the organics, the organics are not destroyed, but are separated from the contaminated soil A carrier gas or vacuum system brings the volatized contaminants to the gas treatment system. PAHs are a target contaminant of HTTD process. The process also removes volatile metals.

In situ High Temperature Thermal Desorption

High temperature thermal desorption can also be achieved in situ. A remediation company, TerraTherm, has a Thermal Blanket system which was specifically designed to remediate surficial and shallow contamination up to three feet deep. The Thermal Blanket is made up of an 8-foot by 20-foot steel box suspended by stainless steel webbing which is threaded by heating element rods. Soil temperatures can reach 1,000°F. The blankets can be operated side-by-side simultaneously. The vapors are sucked into a vapor treatment system where they are oxidized or adsorbed by activated carbon adsorber. A typical in situ high temperature thermal desorption schematic is shown on Figure 4-16.

4.2.7.5 Pyrolysis

Ideally, pyrolysis is a process which chemically decomposes organic materials by heat in the absence of oxygen. The actual process occurs under less than stoichiometric conditions. Thermal desorption also occurs if SVOCs are present. Target contaminants for pyrolysis are SVOCs and pesticides. This technology has been shown to remediate PAH-contaminated material. Pyrolysis will not destroy or separate heavy metals but may remove volatile metals. Pyrolysis occurs under pressure and temperatures above 800°F. Off gases need to be treated. A typical pyrolysis process is shown on Figure 4-17.

4.2.7.6 Thermally Enhanced Vapor Extraction

Soil vapor extraction can more effectively remove heavier compounds if the soil is heated. Heating increases the mobility of the volatiles to facilitate extraction. Energy for heating can be supplied in situ with power line frequency (PLF) heating, or with radio frequency (RF) generators, that are inserted into the ground. PLF can raise soil temperatures to about 100°C and requires residual soil water as a conductive path. RF heating does not require residual soil water as a conductive path. RF heating works by applying an electromagnetic field that distorts the molecular structure of the soil. The distortion is transformed into mechanical and then thermal energy. RF heating is faster than convective or conductive methods of heating the soil and can raise the soil temperature to about 250°C. PLF and RF heating techniques can be combined in one system.

Several other methods of heating contaminated soil are being developed. Dynamic underground stripping is a combination of steam injection and electric heating. Six-phase soil heating heats the soil with six electric phases through electrodes placed in a circle. Finally, steam and hot air can be injected as a means of heating the soil. Figure 4-18 shows a schematic of a typical soil vapor extraction system enhanced by steam/hot air injection.

The effectiveness of each method of soil heating varies with the characteristics of the soil, characteristics of the contaminants, and water content of the soil.

4.2.7.7 Vitrification

In situ Vitrification

In situ vitrification involves an electric current that melts contaminated soil at extremely high temperatures (1,600 to 2,000°C). Melting the soil destroys most organics by pyrolysis. Inorganics are immobilized within the vitrified residual product. Water vapor and organic combustion products are captured in a hood over the site that conveys the contaminants into an off-gas treatment system. The off-gas treatment system may involve scrubbing, filtering, and activated carbon adsorption. The vitrification process reduces contaminant volume by 20 to 45 percent. The end product is a chemically stable, leach resistant, glass/crystalline material. Figure 4-19 shows a typical in situ vitrification system. The in situ mass of vitrified material could limit future use of the area that is treated.

Ex situ Vitrification

Ex situ vitrification encapsulates contaminants in a glass-like matrix in the same way that in situ vitrification does. However, the contaminated soil is excavated and vitrified in batches in electrically heated arc furnaces or in coal-fired cyclone combustors. Coal ash can act to enhance the strength of the final vitrified product. Because the vitrified mass is not in situ, the future use of the land is not limited. Organic contaminants are destroyed because of the high temperatures that are reached. The target contaminants are metals and radionuclides. Fluxing agents can be added to the excavated soil to improve the strength of the final vitrified mass. The vitrified material may be quench-cooled or air-cooled. Quench-cooled masses may be more easily fractured. Off-gas treatment is required if volatile contaminants are present. The resulting vitrified product, or slag, must be used or disposed. Figure 4-20 shows a schematic of a typical ex situ vitrification process.

4.2.8 Disposal

4.2.8.1 Permitted Landfill

Disposing of contaminated or treated material at a permitted off-site disposal facility is a common technology. Some pretreatment of contaminated material usually is required in order to meet land

disposal restrictions. The generator of the disposed soil/waste is still responsible for the material since disposal is not a treatment option. The availability and limitations of a landfill must be evaluated prior to the selection of this technology.

4.2.8.2 Reuse/Recycle

Soil can sometimes be reused or recycled. Depending on the contaminants, the soil may be burned for fuel. Another option is that treated soil can be reused for backfill.

4.3 Preliminary Screening of Remedial Action Technologies and Process Options

In this step, the set of remedial action technologies and process options identified in the previous section will be screened (or reduced) by evaluating the technologies with respect to technical implementability and site-specific factors. This screening step is accomplished by using readily available information from the RI (with respect to contaminant types, contaminant concentrations, and on-site characteristics) to screen out technologies and process options that cannot be effectively implemented at the sites (USEPA, 1988). In general, all technologies and process options that appear to be applicable to the site contaminants and to the site conditions will be retained for further evaluation.

The preliminary screening results are presented on Table 4-2. Several technologies and/or process options were eliminated from further evaluation following the preliminary screening. The specific reasons for elimination are provided in the column titled "Contaminant/Site-Specific Applicability" on Table 4-2. As shown on the table, the following technologies/process options were eliminated from further evaluation:

- stabilization/solidification
- in situ bioremediation
- thermally enhanced vapor extraction
- in situ vitrification

4.4 Process Option Evaluation

The objective of the process option evaluation is to select only one process option for each applicable remedial technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. More than one process option may be selected for a technology type if the processes are sufficiently different in their performance such that one option would not adequately represent the other. The representative process option provides a basis for developing performance specifications during preliminary design. However, the specific process option used to implement the remedial action may not be selected until the remedial design phase.

The process options that passed the preliminary screening (Table 4-2) were evaluated based on three criteria: effectiveness, implementability, and relative cost. The effectiveness evaluation focused on the potential effectiveness of process options in meeting the remedial action objective, the potential impacts to human health and the environment during the construction and implementation phase, and how reliable the process is with respect to the COCs. The implementability evaluation focused on administrative feasibility of implementing a technology (e.g., obtaining permits), since the technical implementability was previously considered in the preliminary screening. Order-of-magnitude capital and operating and maintenance (O&M) costs were used instead of detailed estimates. The costs were qualified as high, medium, or low. As per the USEPA guidance, the relative cost analysis was made on the basis of engineering judgement.

Table 4-3 presents a summary of the process option evaluation. The technologies/process options that were eliminated from further evaluation based on the process option evaluation include:

- capping (Site 2 only)
- composting
- solid-phase biocell reactor
- white rot fungus
- monitored natural attenuation
- solvent extraction
- solvated electron technology
- incineration

- low temperature thermal desorption
- medium temperature thermal desorption
- high temperature thermal desorption
- pyrolysis
- ex situ vitrification

Table 4-4 lists the remedial technologies/process options that have been retained and will be used to develop the RAAs applicable for each site individually.

SECTION 4.0 TABLES

TABLE 4-1
PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES
SITES 2, 8, AND 18, AND SSA14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

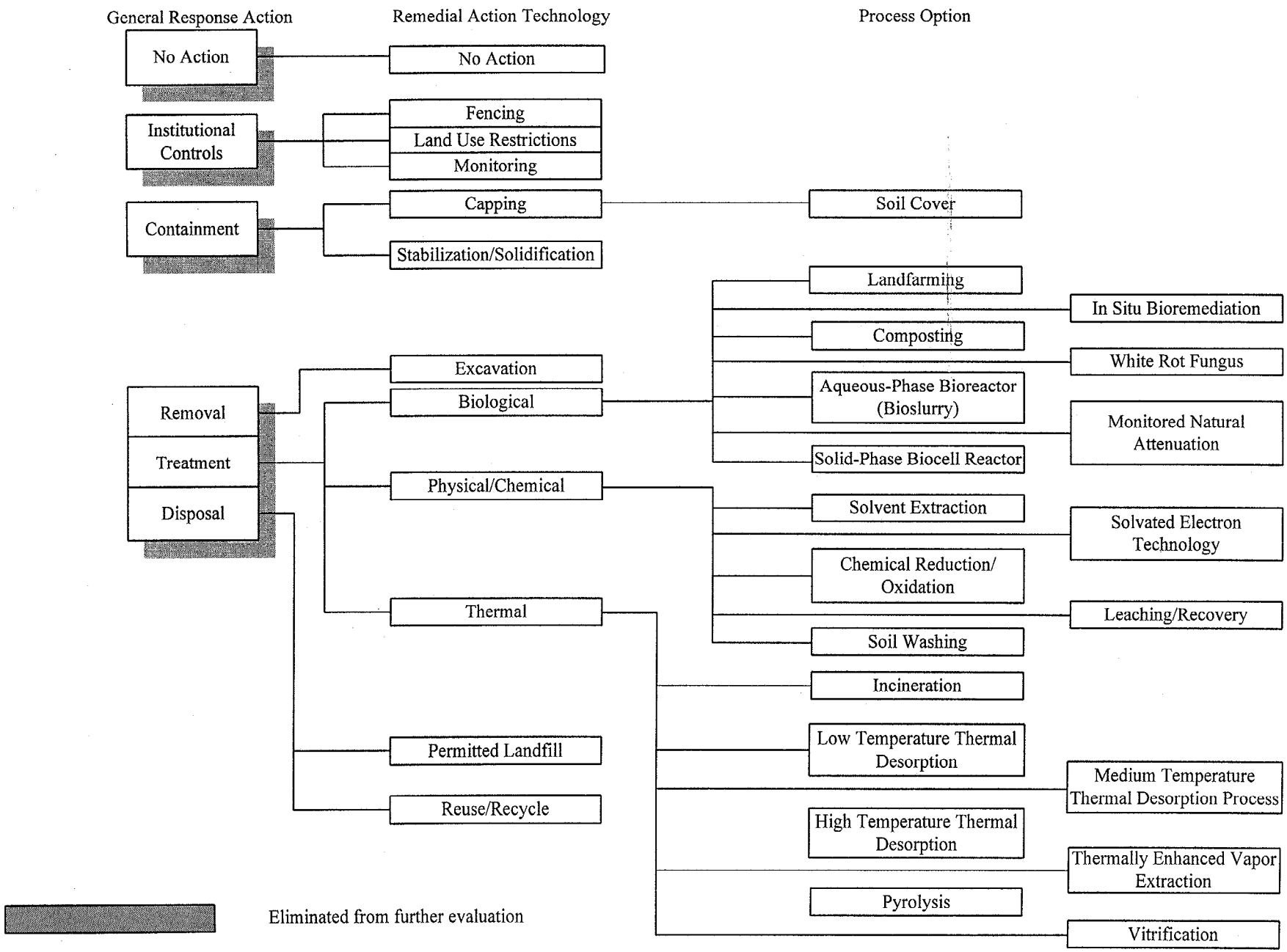


TABLE 4-2

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES
SITES 2, 8, AND 18, AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

General Response Action	Remedial Action Technology	Process Option	Site-Specific Applicability
No Action	No Action		Potentially applicable to any site; required by the NCP.
Institutional Controls	Fencing		Potentially applicable for all COCs
	Land Use Restrictions		Potentially applicable for all COCs
	Monitoring		Potentially applicable for all COCs
Containment	Capping	Soil Cover	Potentially applicable for all COCs
	Stabilization/Solidification		Eliminated; may hinder future use of site.

Eliminated from further evaluation

TABLE 4-2 (Continued)

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES
SITES 2, 8 AND 18, AND SSA 14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

General Response Action	Remedial Action Technology	Process Option	Site-Specific Applicability
Removal, Treatment, Disposal	Excavation		Potentially applicable for all COCs
	Biological	Landfarming	Potentially applicable for explosives, PAHs, and PCBs
		Composting	Potentially applicable for explosives, PAHs, PCBs, and some inorganics
		Aqueous-Phase Bioreactor (Bioslurry)	Potentially applicable for explosives, PAHs, and PCBs
		Solid-Phase Biocell Reactor	Potentially applicable for explosives, PAHs, and PCBs
		In Situ Bioremediation	Eliminated; contamination is too shallow to warrant use of wells
		Monitored Natural Attenuation	Potentially applicable for explosives, PAHs, and PCBs
		White Rot Fungus	Potentially applicable for explosives, PAHs, and PCBs
	Physical/Chemical	Solvent Extraction	Potentially applicable for explosives and PCBs
		Chemical Reduction/ Oxidation	Potentially applicable for inorganics and possibly PAHs
		Solvated Electron Technology	Potentially applicable for explosives and PCBs
		Leaching/Recovery	Potentially applicable for inorganics
		Soil Washing	Potentially applicable for explosives, PAHs, and inorganics
	Thermal	Incineration	Potentially applicable for explosives, PAHs, and PCBs
		Low Temperature Thermal Desorption	Potentially applicable for PAHs, mercury, and PCBs
		Medium Temperature Thermal Desorption	Potentially applicable for mercury
		High Temperature Thermal Desorption	Potentially applicable PAHs and PCBs
		Pyrolysis	Potentially applicable for PAHs
		Thermally Enhanced Vapor Extraction	Eliminated; contamination is too shallow to warrant use of in situ heating elements
		Vitrification - in situ	Eliminated; contamination is too shallow to warrant use of in situ heating elements and future use of site may be hindered
		Vitrification - ex situ	Potentially applicable for inorganics and PCBs
	Permitted Landfill		Potentially applicable for all COCs
	Reuse/Recycle		Potentially applicable for all remediated soils

Eliminated from further evaluation

TABLE 4-3

PROCESS OPTION EVALUATION
SITES 2, 8, AND 18, AND SSA 14
WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

			Effectiveness	Evaluation Implementability	Order-of-Magnitude Costs	Evaluation Result
No Action	No Action	Not Applicable	• Not effective	• Easily implemented	• No Costs	Retained
Institutional Controls	Fencing	Not Applicable	• Effective for limiting human access • Not effective for limiting all types of ecological access	• Easily implemented	• Low Capital Cost • Low O&M Cost	Retained
	Land Use Restrictions	Not Applicable	• Effective for limiting future development at the site	• Land development restrictions already in place at Sites 2, 8 and SSA14	• Negligible Cost	Retained
	Monitoring	Not Applicable	• Shows progress of any natural attenuation • Shows progress of any remedial action • Tracks migration of contaminants	• Easily implemented	• Low Capital Cost • Moderate O&M Cost	Retained
Containment	Capping	Soil Cover	• Prevents direct contact with contaminated soils • Contaminants still present in soil	• Standard construction equipment required • Drainage would have to be diverted to prevent erosion	• Low to Moderate Capital Cost • Low O&M Cost	Retained for Site 8 and SSA 14. Eliminated for Site 2, due to the location of the contaminants at the site.

Eliminated from further evaluation.

TABLE 4-3 (Continued)

PROCESS OPTION EVALUATION
SITES 2, 8, AND 18, AND SSA 14
WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

General Response Action	Remedial Action Technology	Process Option	Effectiveness	Evaluation Implementability	Order-of-Magnitude Costs	Evaluation Result
Removal	Excavation		• Will remove contaminated soil from the site • Method for consolidating contaminated soil for treatment • Must be used in conjunction with a treatment process option or disposal option	• Conventional equipment required • Easily implemented • High contamination contact potential during implementation • Generation of fugitive emissions may be a problem during operations	• Low Capital Cost • No O&M Cost	Retained
Treatment	Biological	Landfarming	• Typically used to treat petroleum and PAH contamination • Slow degradation rates - may take years to reach target clean-up levels	• Treatability study required • Large amount of space required • Land farming area available at Site 6	• Moderate Capital Cost • Moderate O&M Cost	Retained (ex situ)
		Composting	• Treats similar contaminants as landfarming • Provides aerobic and anaerobic treatment • Duration of treatment period varies with level of indigenous organisms and waste stream components • Waste is reduced in volume and weight - stabilized material can be used as backfill • Effective for treating explosives, PAHs, PCBs, lead, and mercury	• Treatability study required • Aeration requires utility hook-up • Large space required for treatment • Excavation required	• Low to Moderate Capital Cost • Moderate O&M Cost	Eliminated; other biological treatment areas are already available at WPNSTA
		Aqueous-Phase Bioreactor (Bioslurry)	• Previous bench-scale tests have demonstrated 99.5%-100% remediation of RDX • Good process control • May accumulate products of bio-transformation, which may present new contamination problems • Effectiveness for treating explosives was evaluated with a treatability study at WPNSTA Yorktown. Found to be effective • Effective for treating explosives, PAHs, PCBs	• Mobile treatment units available • Screening/sizing soils can be expensive • Must dispose of non-recycled waste water • Bioreactor structure available at Site 22 • Treatability study required • Dewatering soil fines after treatment can be expensive • Excavation required	• Moderate to High Capital Cost • Moderate O&M Cost	Retained
		Solid-Phase Biocell Reactor	• Have mostly been used for petroleum hydro-carbon treatment • Recent bench-scale studies indicate that this method may be applicable to explosives • Effectiveness for treating explosives was evaluated with a treatability study at WPNSTA Yorktown. Found to be effective. • Effective for treating explosives, PAHs and PCBs	• Typically contains air distribution system • Treatability study required • Requires longer treatment time than slurry-phase reactors • Excavation required	• Moderate Capital Cost • Moderate O&M Cost	Eliminated; other biological treatment areas are already available at WPNSTA
		White Rot Fungus	• Degradation of RDX, HMX, PAHs and PCBs reported. • High explosive concentrations in soil can inhibit the growth of white rot fungus • Works best in nitrogen-limited environments • Effective for treating explosives was evaluated with a treatability study at WPNSTA Yorktown. Found to be somewhat effective.	• Treatability study required • No full-scale operations to date • Excavation required	• Moderate Capital Cost • Low to Moderate O&M Cost	Eliminated; other biological treatment areas are already available at WPNSTA
		Monitored Natural Attenuation	• Often used at sites where PCBs are sorbed to soil and are not migrating • May be effective for nonhalogenated VOCs, SVOCs, and fuel hydrocarbons but less effective for hologenated VOCs, SVOCs, and pesticides • Not effective for inorganics	• Treatability study required • Long time period required for remediation	• Low Capital Cost • Low O&M Cost	Eliminated; Sites 2, 8, and SSA 14 contaminated soils are in run-off areas, possibly allowing contaminants to migrate off site over time

Eliminated from further evaluation.

TABLE 4-3 (Continued)

PROCESS OPTION EVALUATION
SITES 2, 8, AND 18, AND SSA 14
WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

General Response Action	Remedial Action Technology	Process Option	Effectiveness	Evaluation Implementability	Order-of-Magnitude Costs	Evaluation Result
Treatment	Physical/Chemical	Solvent Extraction	• Target contaminant groups include PCBs, VOCs, solvents, and petroleum wastes; less effective for other groups • Does not destroy wastes but is a means of separation • Less effective on very high molecular weight organics and very hydrophilic substances	• Mobile units available	• Moderate Capital Cost • Moderate O&M Cost	Eliminated; soil washing is similar and typically less expensive.
		Chemical Reduction/ Oxidation	• Target contaminant group is inorganics and possibly PAHs; less effective for other groups • Incomplete oxidation of the formation of intermediate contaminants may occur depending upon the contaminants and oxidizing agents	• Full-scale, well-established systems now being used more frequently for hazardous wastes in soil	• Moderate Capital Cost • Low to Moderate O&M Cost	Eliminated
		Solvated Electronic Technology	• Target contaminants include halogenated organic wastes, PCBs, explosives, and propellants • Process takes place with low temperatures and pressures • Achieved 99.999% destruction efficiency TNT and tetryl	• Off-the-shelf equipment and process chemicals are used • Products require disposal and/or treatment • Very short residence time per batch (15 minutes)	• Moderate Capital Costs • Moderate to High O&M Cost	Eliminated; technology is a pilot-scale development stage (100 to 200 pound batch units)
		Soil Washing	• Target contaminant groups include SVOCs, fuels, and inorganics; also for selected VOCs and pesticides • Fine soil particles may require the addition of a polymer to remove them from the washing fluid • Most effective for solids with small percentage of fines	• Concentrated fine fraction and aqueous waste stream requires further treatment • Can be used as pretreatment for other remediation technologies	• Moderate Capital Costs • Low to Moderate O&M Cost	Retained
		Leaching/Recovery	• Demonstrations show up to 75% lead removal • Can be modified to remove other inorganics • Not applicable for organics • Effects of presence of organics on the process is unknown	• No waste products produced • Screening/sizing soils can be expensive • Excavation required • Mobile unit available • No fixed treatment facilities currently available	• High Capital Cost • Low O&M Cost	Retained

Eliminated from further evaluation.

TABLE 4-3 (Continued)

PROCESS OPTION EVALUATION
SITES 2, 8, AND 18, AND SSA 14
WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

General Response Action	Remedial Action Technology	Process Option	Effectiveness	Evaluation Implementability	Order-of-Magnitude Costs	Evaluation Result
Treatment	Thermal	Incineration	• Effective for organic contaminants including PAHs, PCBs, and explosives • Heavy metals can produce a bottom ash that requires stabilization	• Specific feed size and materials handling requirements that can impact applicability or cost• Approx. 20 commercial RCRA-permitted hazardous waste incinerators and approx. 10 transportable high temperature units are available • Off-gas treatment is required • Excavation and long-distance transport required	• High Capital Cost ($1,000/ton) • Moderate O&M Cost	Retained
		Low Temperature Thermal Desorption	• Specific feed size and materials handling requirements that can impact applicability • Works best at moisture content of 20% • PAHs have been effectively treated at temperatures up to 450°F • Applicable for treating mercury and PCB contaminated soils	• Mobile units available • Hardware readily available • Liquid condensate and fabric filter dust require off-site treatment • Treatability study recommended • Excavation required	• Moderate Capital ($300-$400/ton) • Moderate O&M Cost	Eliminated; PAHs that require treatment have boiling points higher than 450°F
		Medium Temperature Thermal Desorption	• Two-phase process can separate and recover mercury from soil • Designated as BDAT for treatment of mercury contaminated materials • 99% pure metal recovered	• Mobile and fixed units available • Excavation required • No waste products produced by process • Exempt from air and solid waste permitting requirements because process is considered "recycling" by USEPA	• High Capital Cost ($1,000/ton) • Moderate O&M Cost	Eliminated; quantity of soil is too small to warrant on site treatment; less expensive thermal treatment is available; fixed treatment facility may not be permitted for high organic concentrations in soil.
		High Temperature Thermal Desorption	• Target contaminants are SVOCs, PAHs, PCBs • Volatile metals may be removed • Operates at temperatures that will volatilize heavy PAHs	• Most hardware components for system are readily available off the shelf • Can be implemented as an in situ or ex situ system • Excavation required for ex situ process option	• Low to Moderate Capital ($100-$300/ton) • Moderate O&M	Eliminated; not effective for explosives
		Pyrolysis	• Can achieve over 99% removal of PAHs • Volatile metals may be removed • Operates at temperatures that will volatilize heavy PAHs	• Treatability study recommended • Soil must be dried to <1% before treatment • Off-gas treatment is required • Excavation required	• Moderate Capital ($300/ton) • Moderate O&M Cost	Eliminated; excavated soil will require significant dewatering/ drying
		Vitrification *Ex situ*	• Vitrification is applicable to a full range of contaminant groups • Organics are volatilized • Vitrified mass has high strength and resists leaching • Inorganics are encapsulated	• Off-gases need to be treated • Disposal or use of the slag is required • Excavation required	• High Capital • Moderate O&M Cost	Eliminated; other thermal options can treat PAHs at a less expensive rate
Disposal	Permitted Landfill		• Contaminants are removed from the site • Cradle to grave scenario • Distance to nearest disposal facility will affect cost	• Availability of local permitted landfills must be evaluated • Land disposal restrictions may apply - requiring pretreatment of the soil	• Moderate to High Capital Cost • No O&M Cost	Retained
	Reuse/Recycle		• Effective on-site disposal alternative for treated soil	• Reuse of treated material must be approved	• May be Negligible Capital Costs • No O&M Cost	Retained

Eliminated from further evaluation.

TABLE 4-4

REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS
RETAINED FOR FURTHER EVALUATION
SITES 2, 8, AND 18, AND SSA 14

NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

General Response Action	Remedial Action Technology	Process Option
No Action	No Action	
Institutional Controls	Fencing	
	Land Use Restrictions	
	Monitoring	
Containment	Capping (Site 8 and SSA 14 only)	Soil Cover
Removal	Excavation	
Treatment	Biological	landfarming aqueous - phase bioslurry
	Physical/Chemical	soil washing leaching/recovery
	Thermal	incineration
Disposal	Permitted Landfill	
	Reuse/Recycle	

SECTION 4.0 FIGURES

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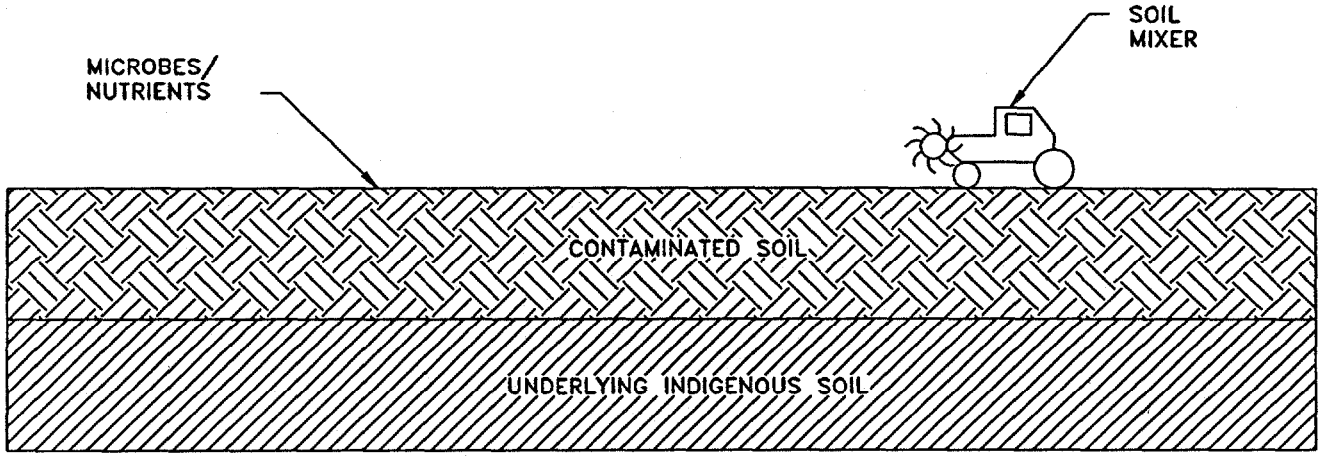

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FIGURE 4-1
TYPICAL LANDFARMING
TREATMENT
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

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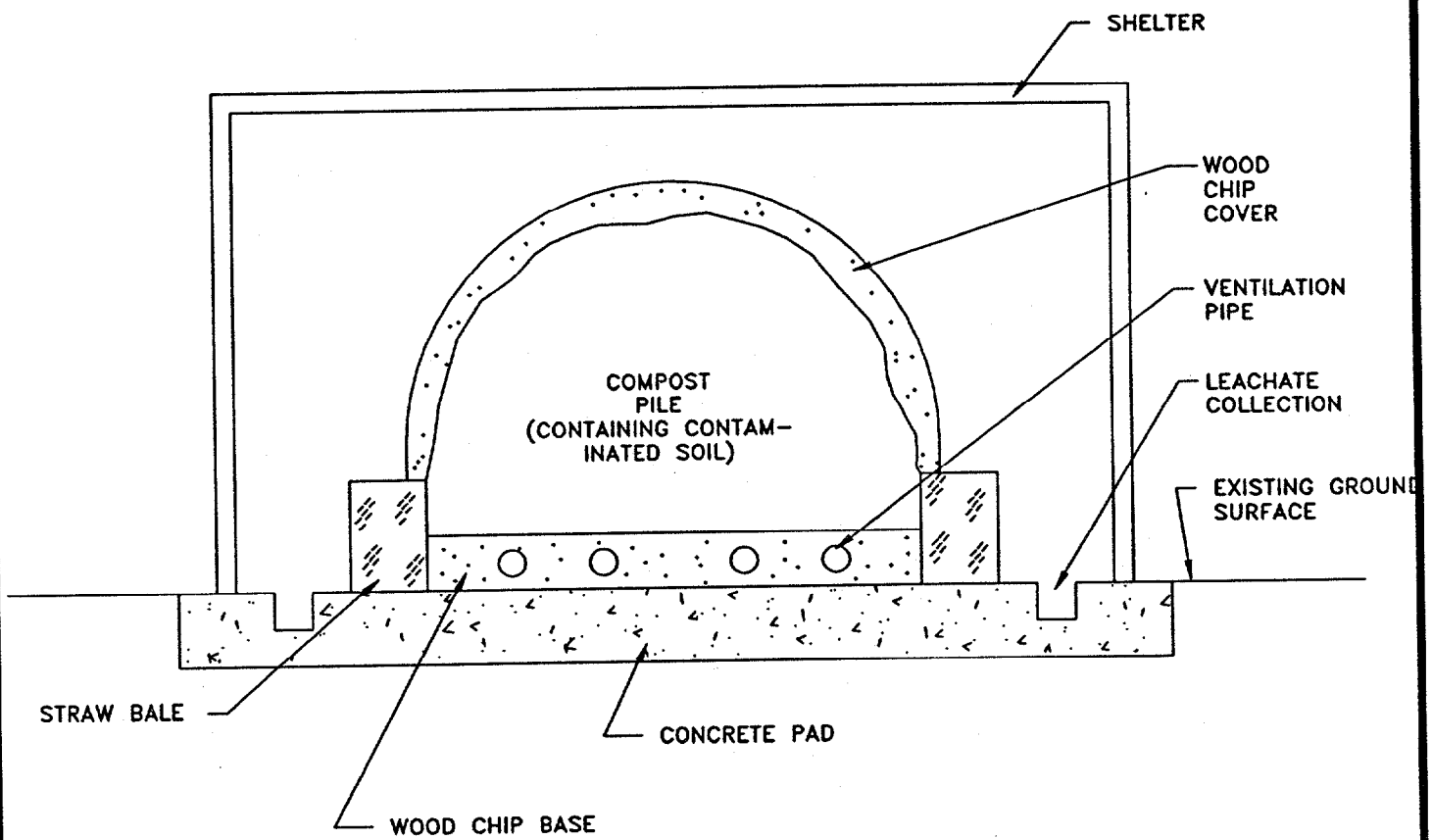

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FIGURE 4-2
TYPICAL AERATED STATIC PILE
COMPOSTING SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

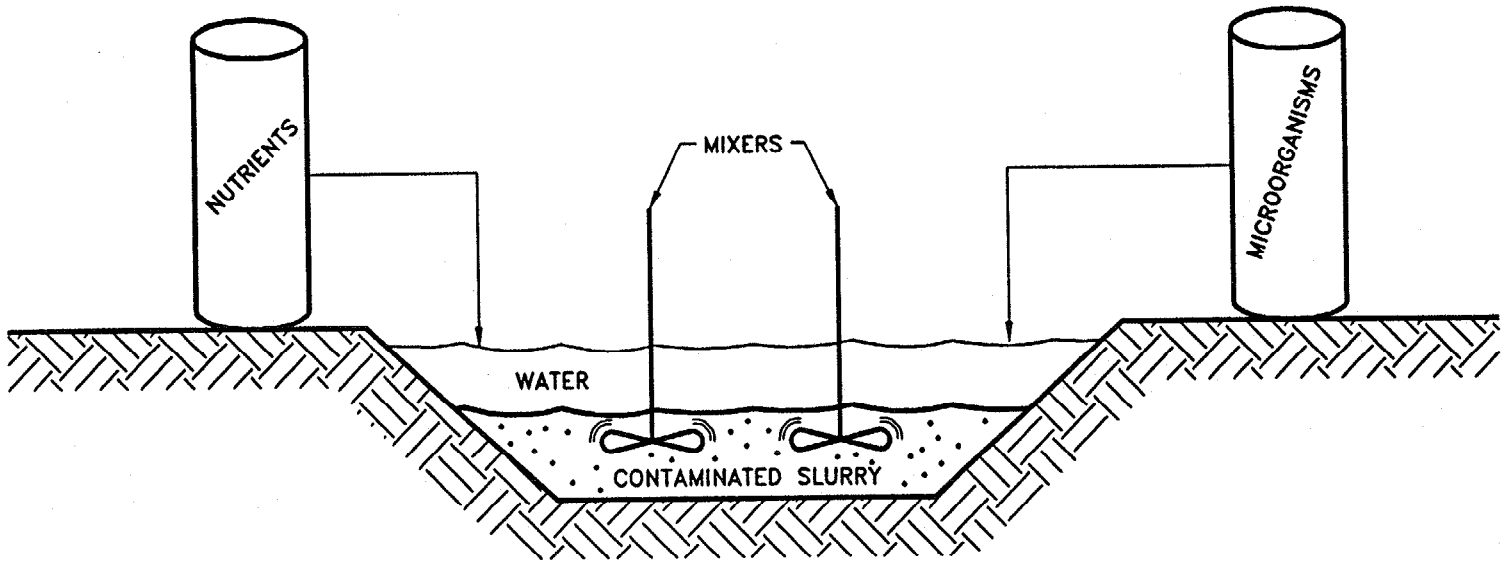

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FIGURE 4-3
TYPICAL LAGOON SLURRY
REACTOR SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363744FS

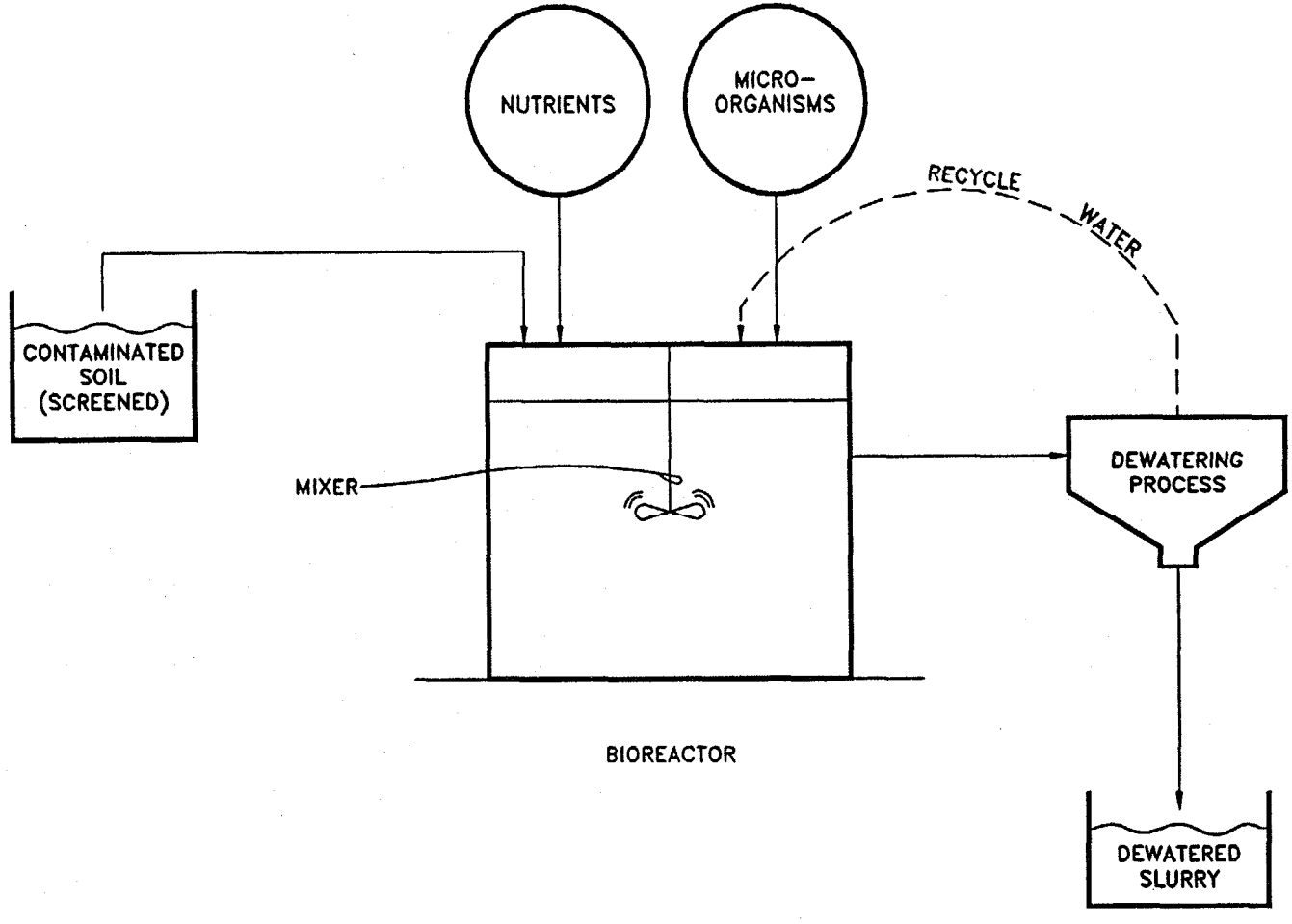

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FIGURE 4-4
TYPICAL ABOVEGROUND AQUEOUS-PHASE
(SLURRY) BIOREACTOR SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

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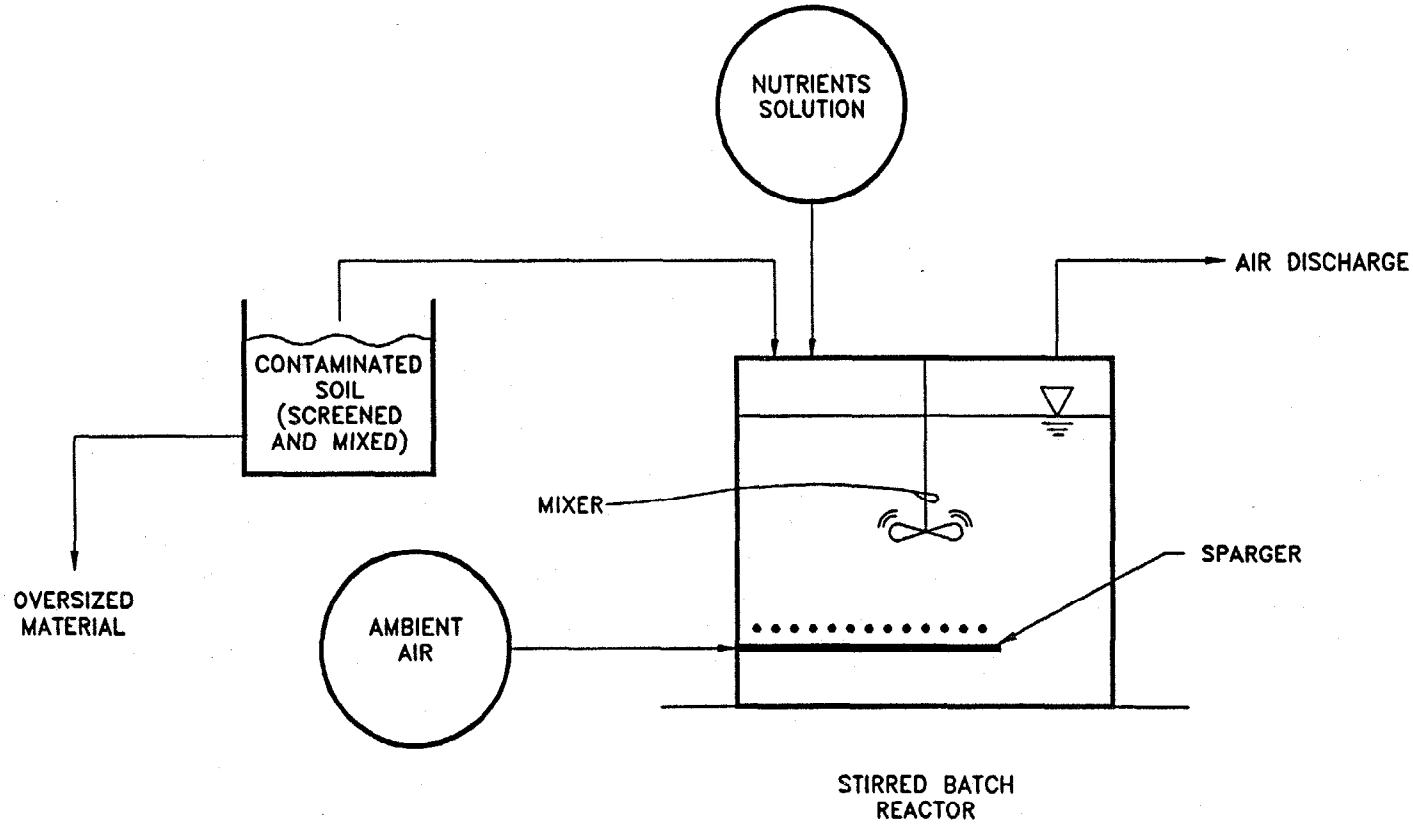

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FIGURE 4-5
TYPICAL SOLID-PHASE BIOCELL
REACTOR SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363746FS

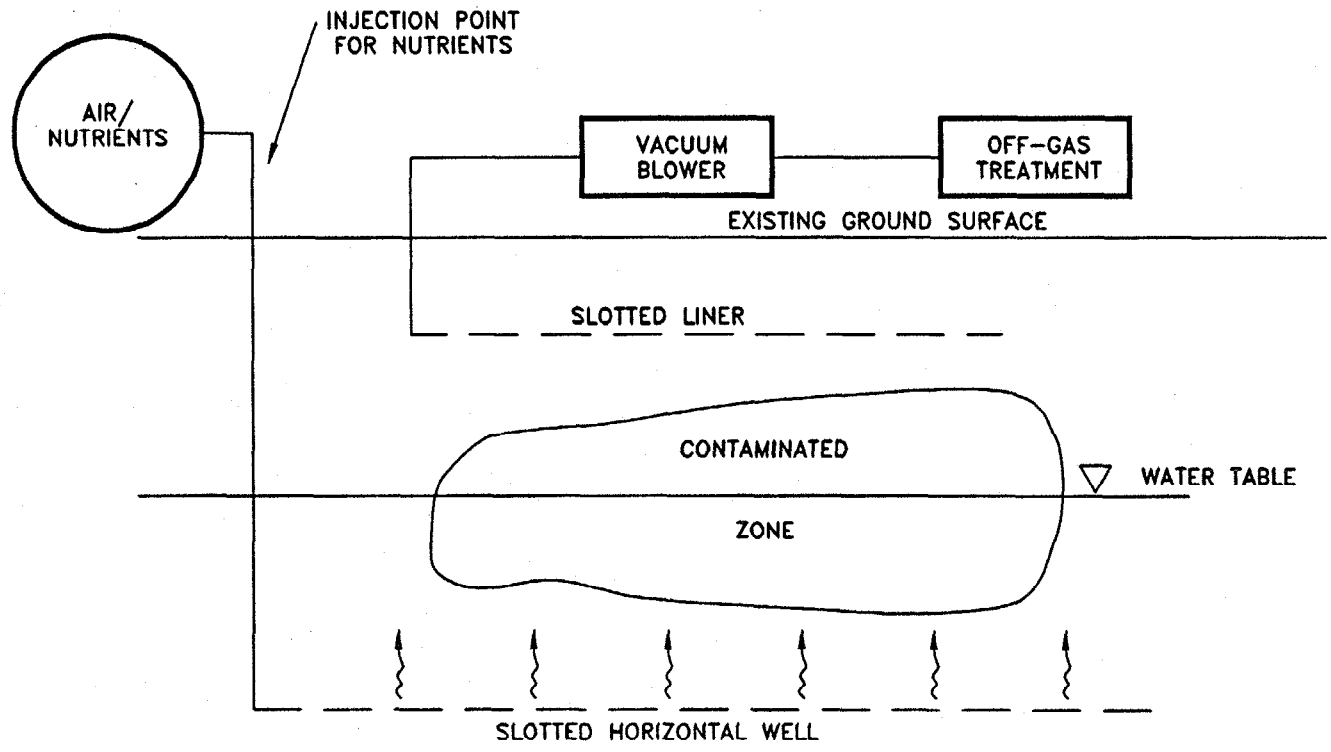

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FIGURE 4-6
TYPICAL IN-SITU
BIOREMEDIATION SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363747FS

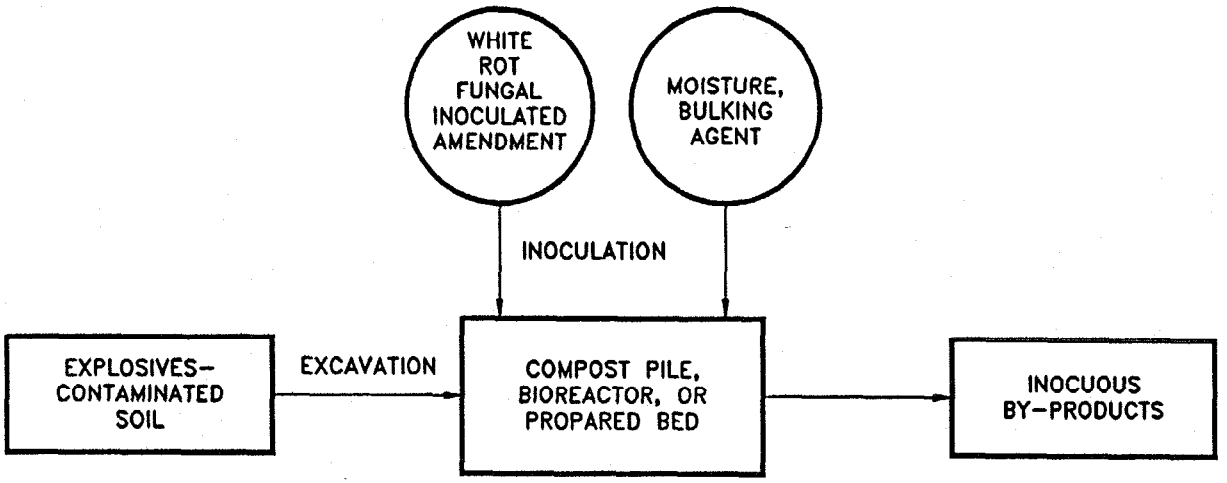

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FIGURE 4-7
TYPICAL WHITE ROT
FUNGUS SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363748FS

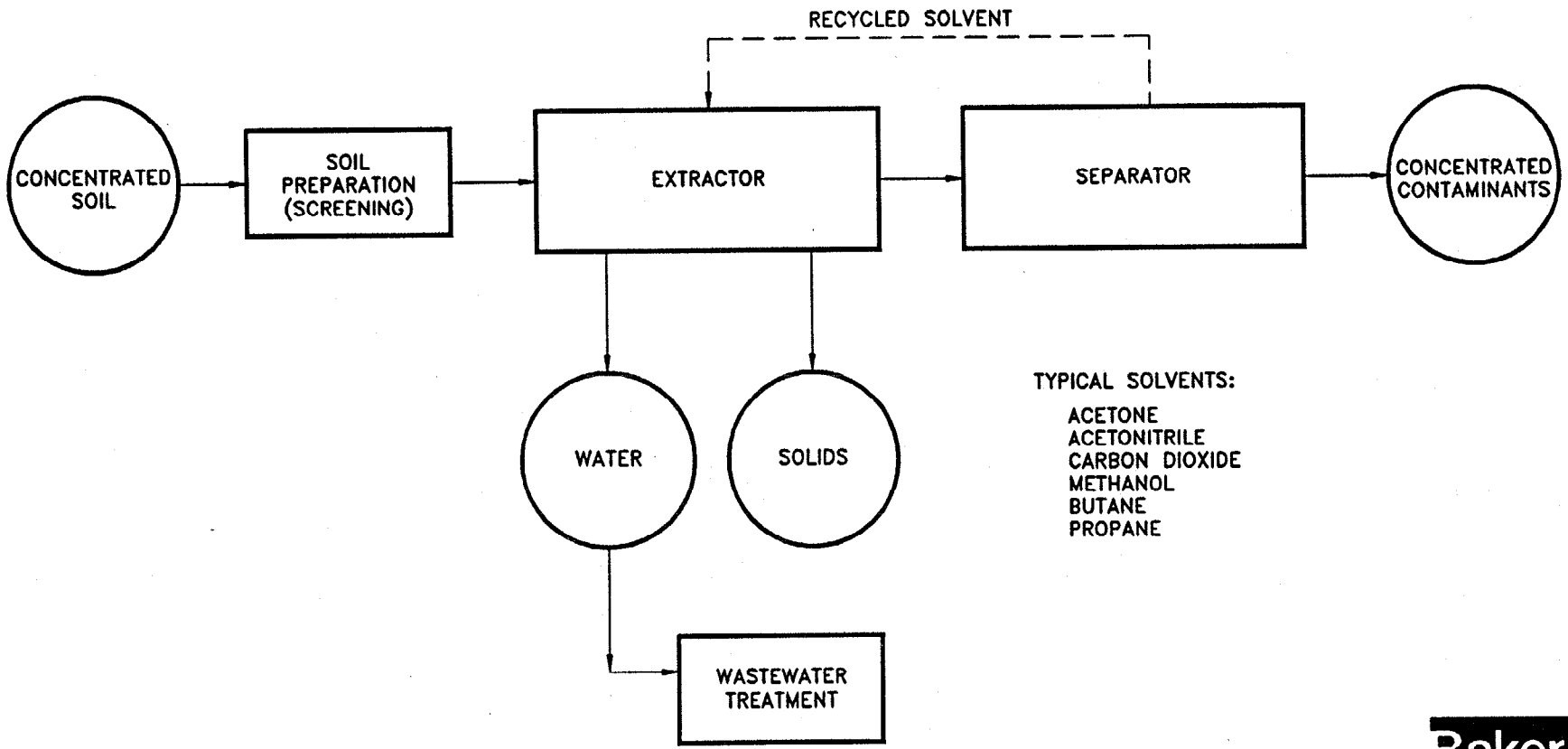

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FIGURE 4-8
TYPICAL SOLVENT EXTRACTION
PROCESS SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363749FS

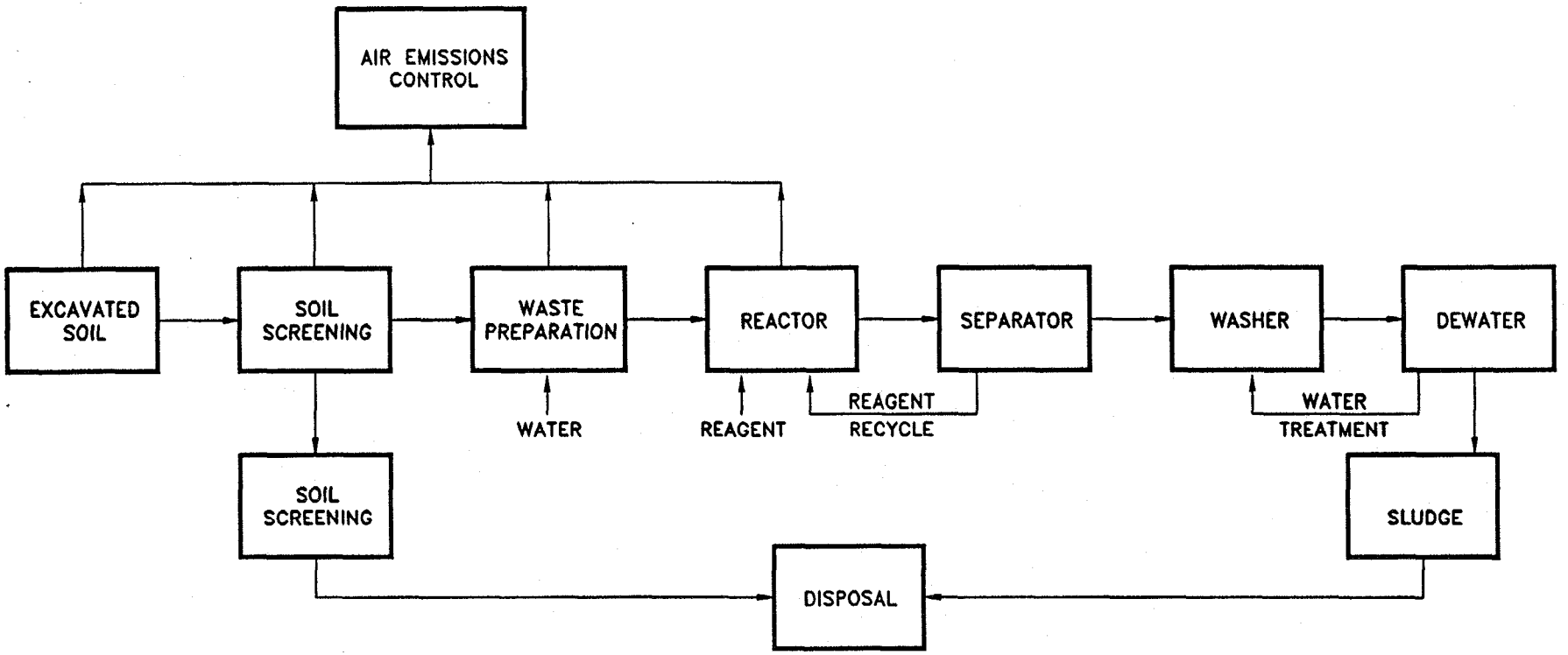

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FIGURE 4-9
TYPICAL CHEMICAL REDUCTION/
OXIDATION PROCESS
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363750ES

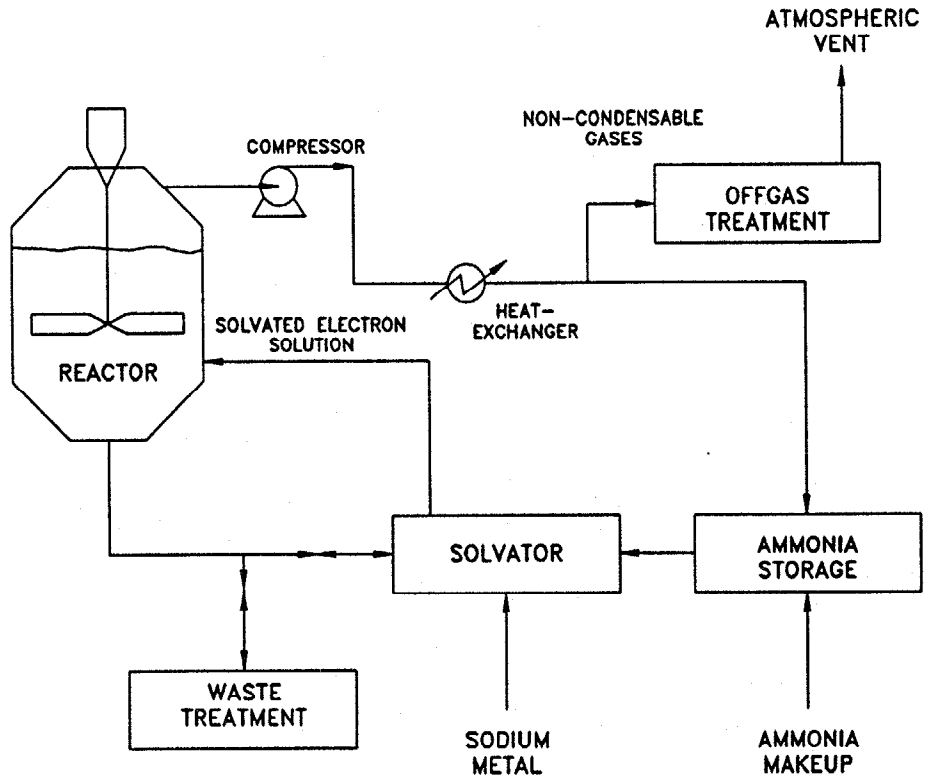

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FIGURE 4-10
TYPICAL SOLVATED ELECTRON TECHNOLOGY PROCESS FLOW DIAGRAM
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363759FS

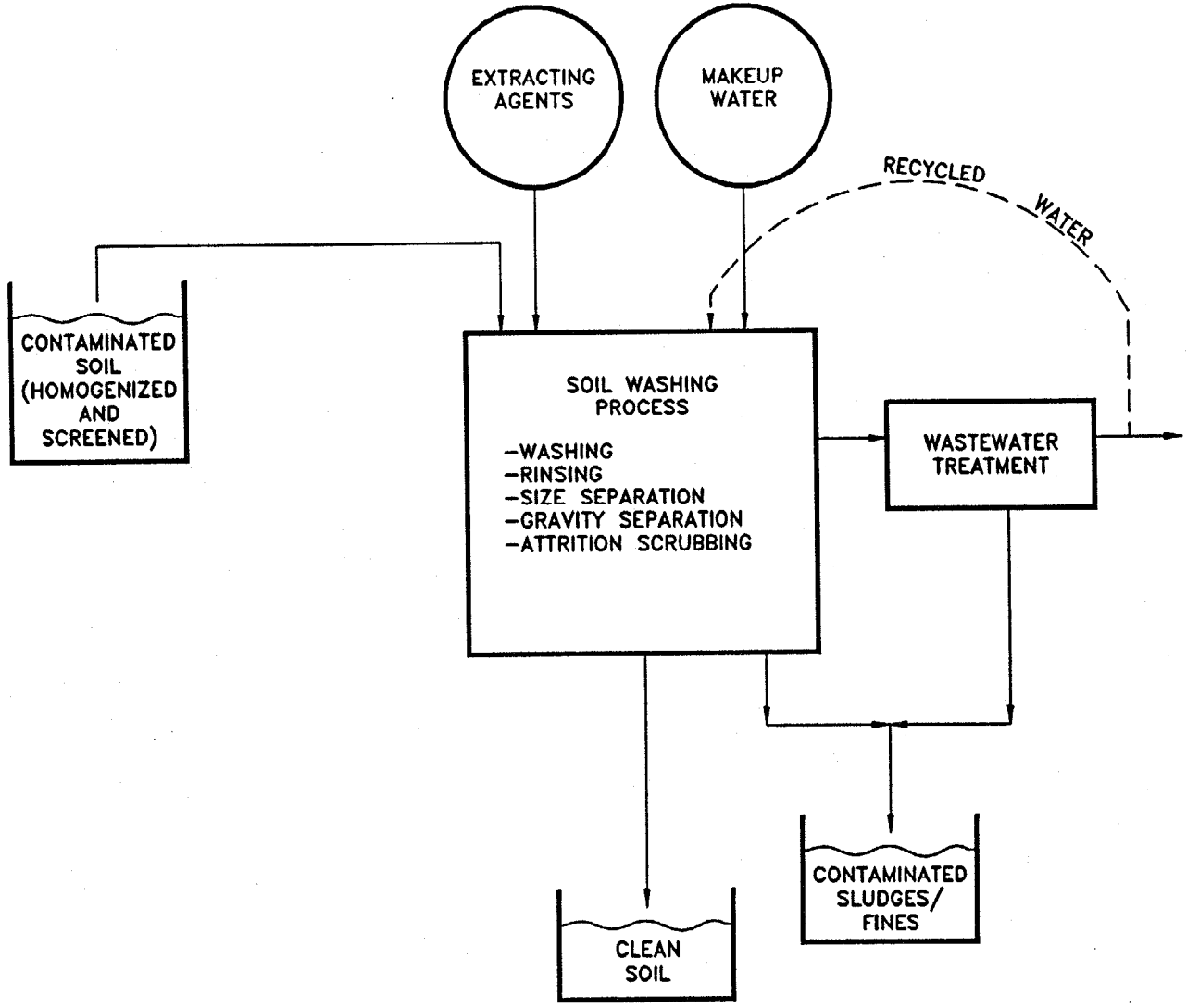

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FIGURE 4-11
TYPICAL SOIL WASHING
PROCESS SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

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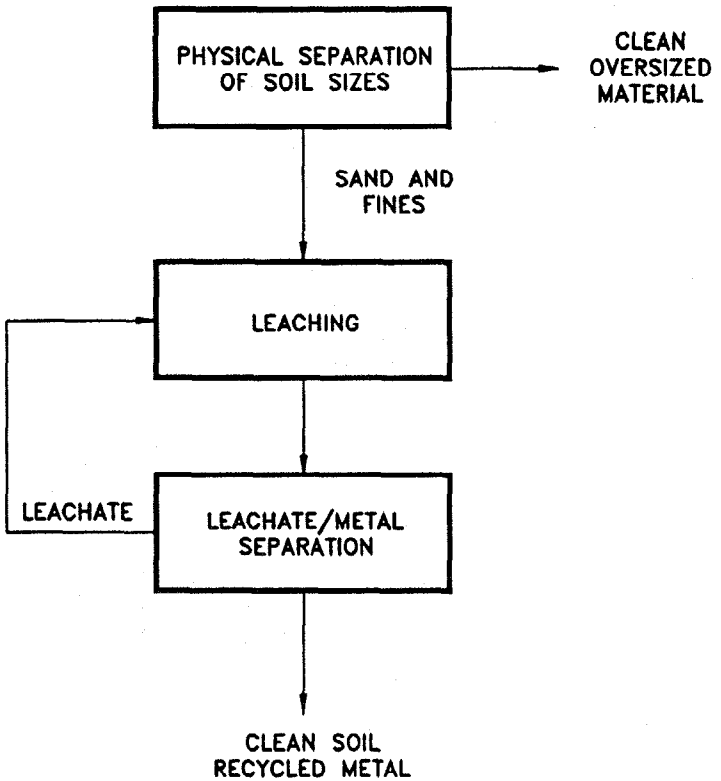

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FIGURE 4-12
LEACHING/RECOVERY
PROCESS FLOW DIAGRAM
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

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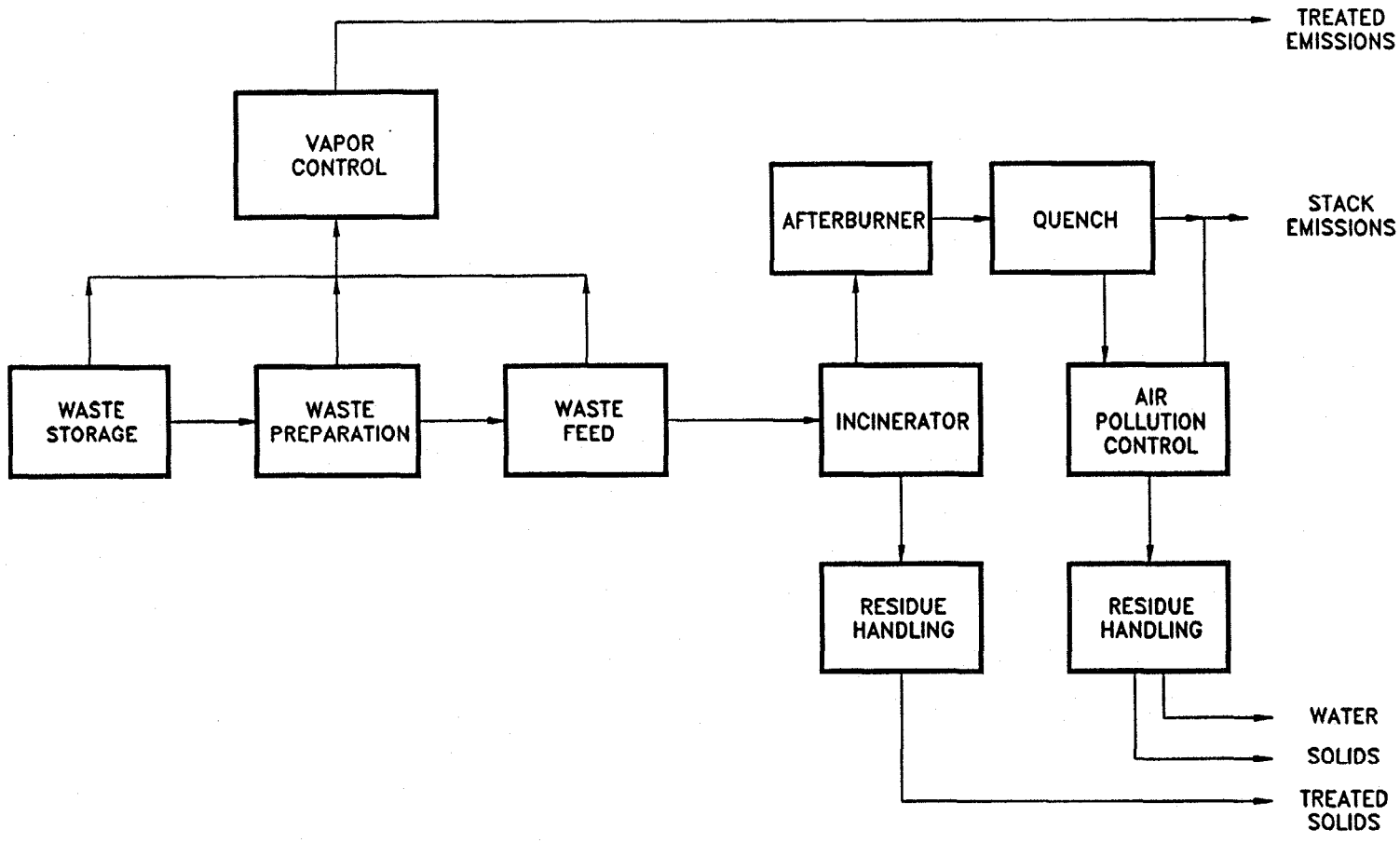

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FIGURE 4-13
TYPICAL MOBILE/TRANSPORTABLE
INCINERATION PROCESS
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363752FS

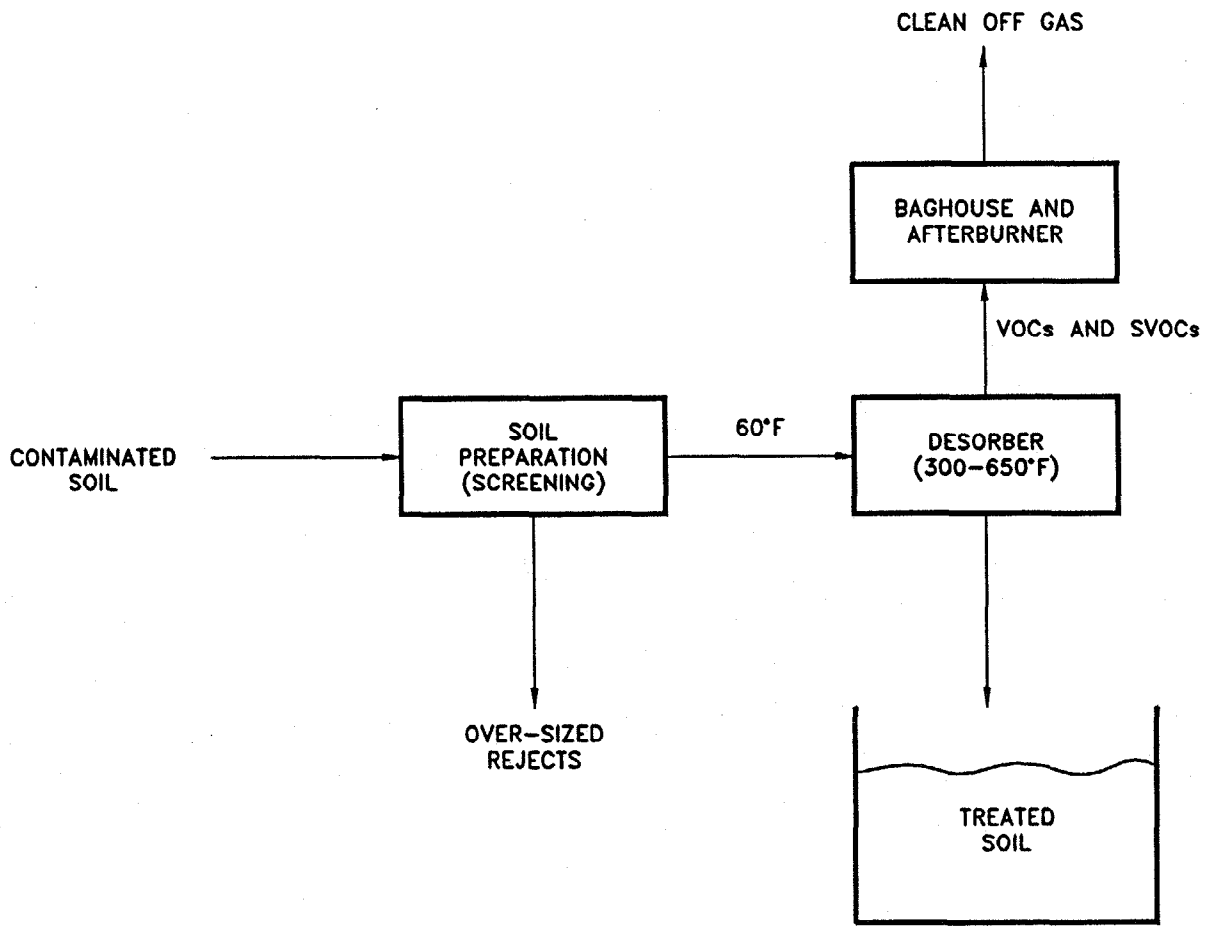

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FIGURE 4-14
TYPICAL LOW TEMPERATURE
THERMAL DESORPTION SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363753FS

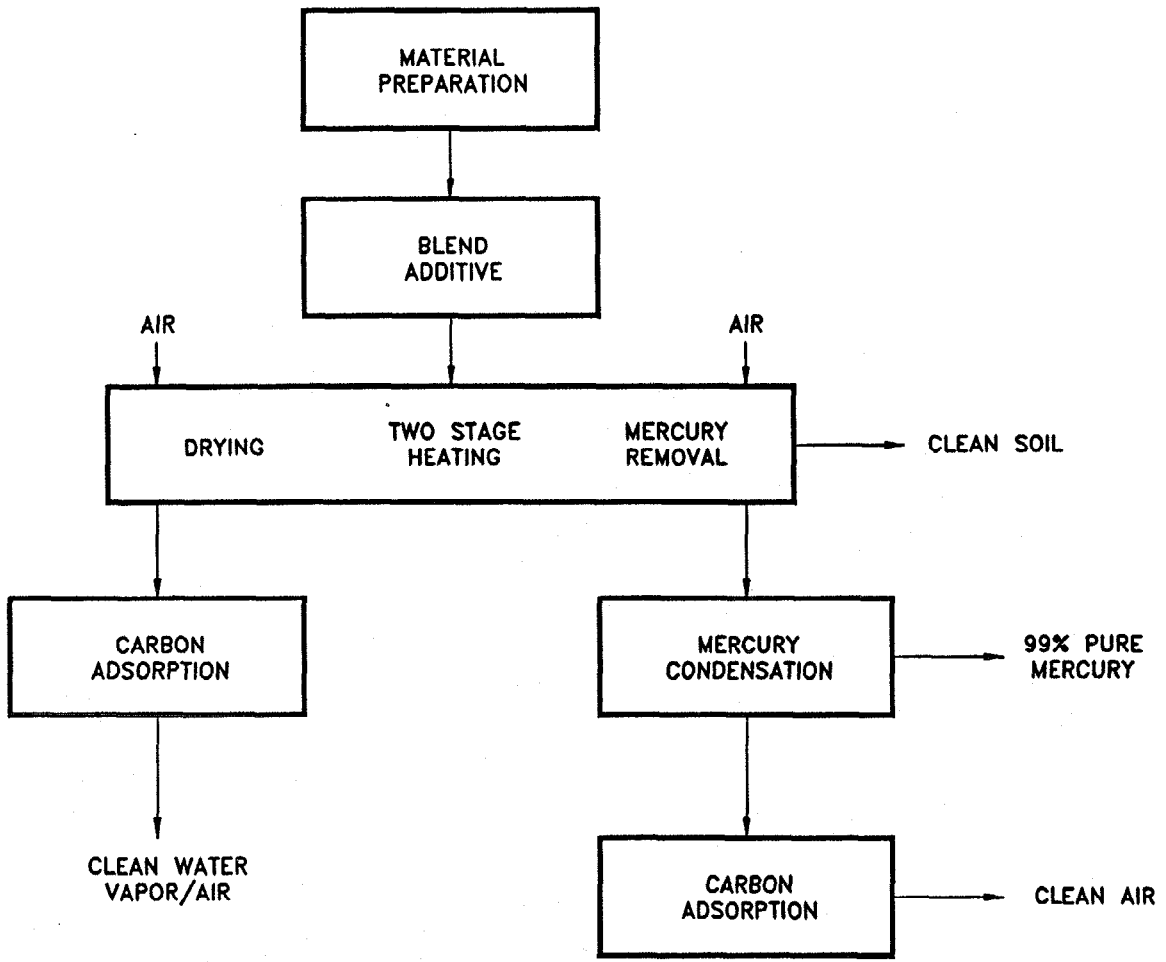

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FIGURE 4-15
TWO PHASE MEDIUM
TEMPERATURE THERMAL DESORPTION
PROCESS FLOW DIAGRAM
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363761FS

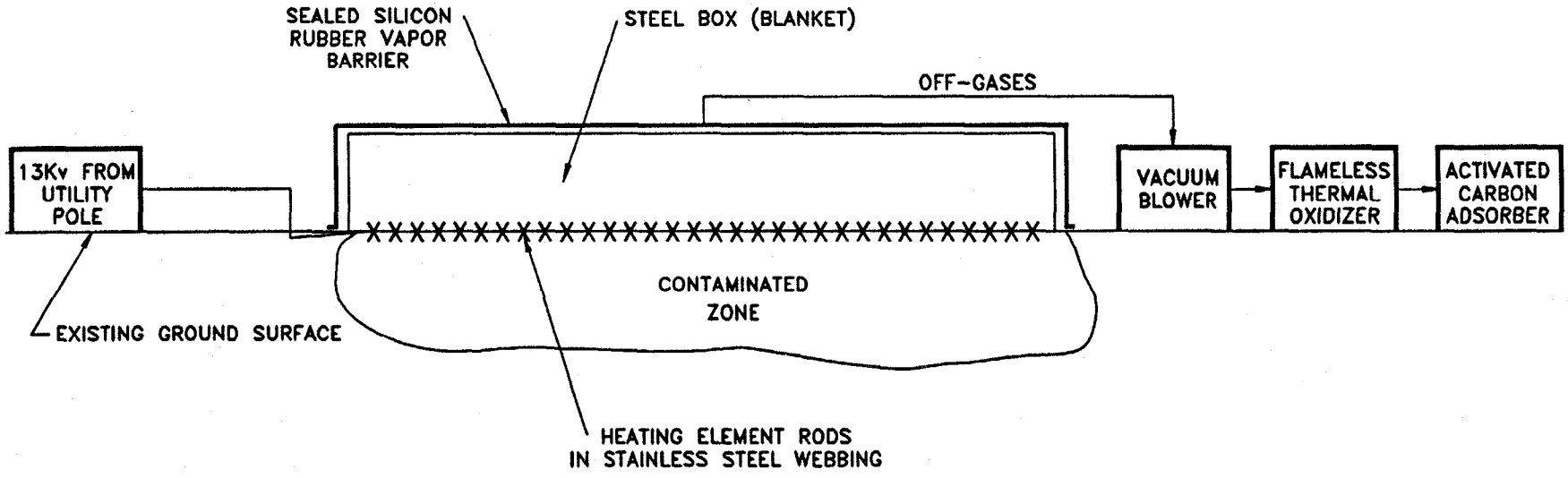

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FIGURE 4-16
TYPICAL IN-SITU HIGH TEMPERATURE THERMAL DESORPTION SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363754FS

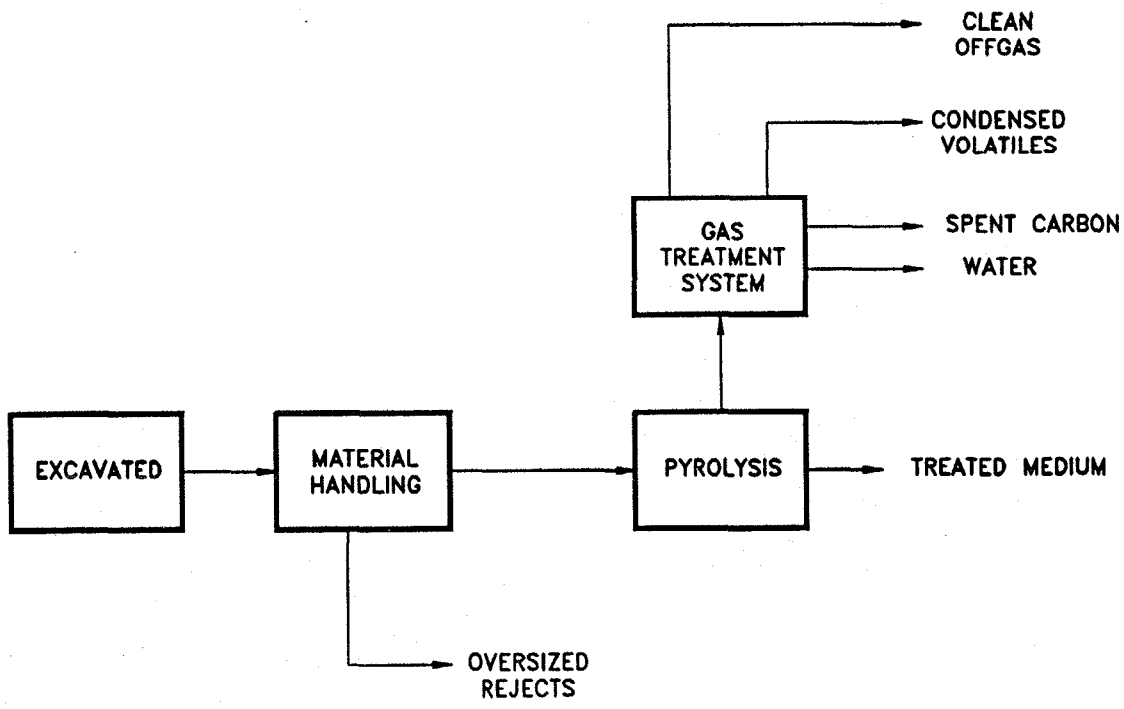

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FIGURE 4-17
TYPICAL PYROLYSIS PROCESS
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363755FS

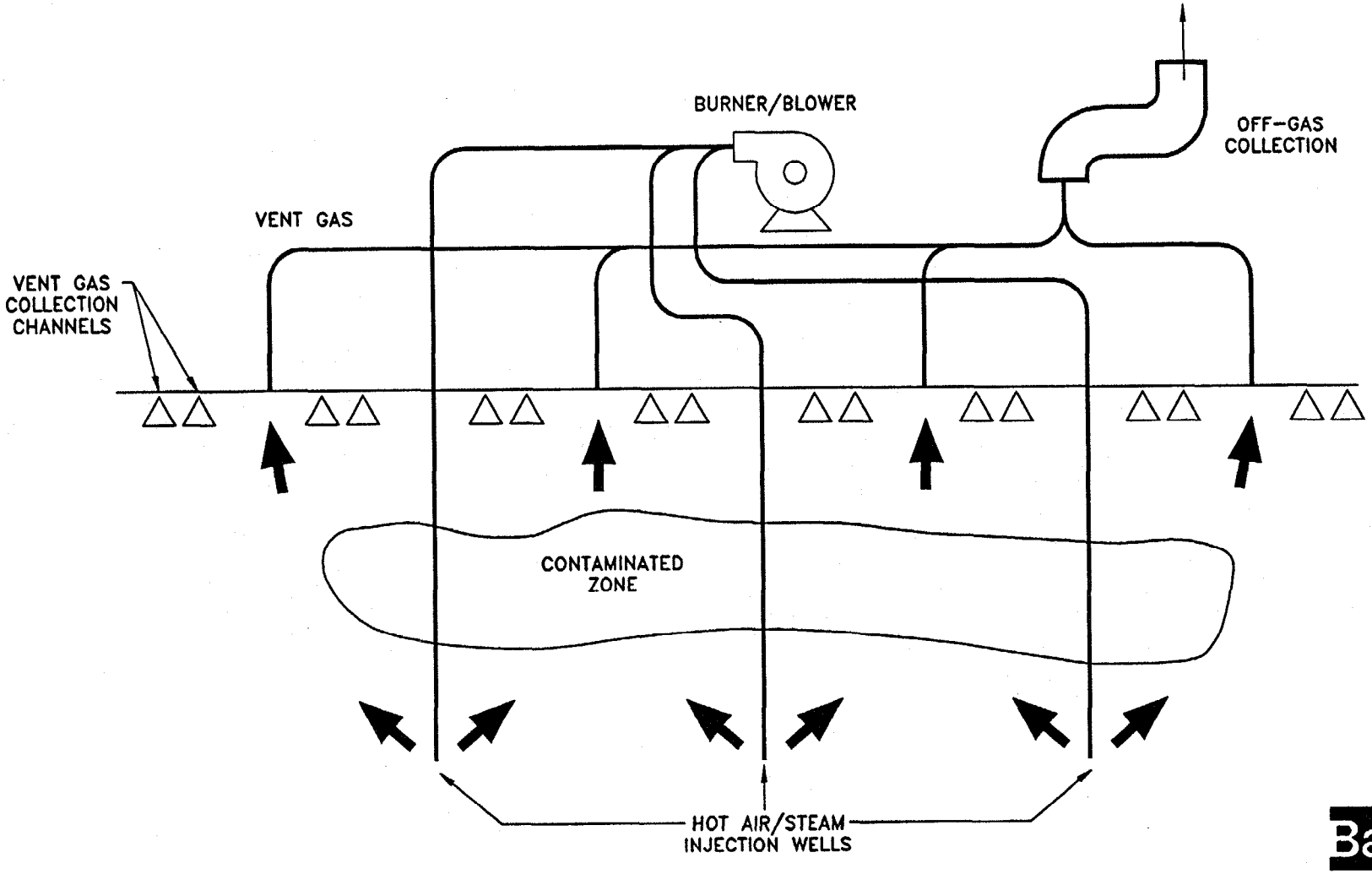

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FIGURE 4-18
TYPICAL THERMALLY ENHANCED SVE SYSTEM
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

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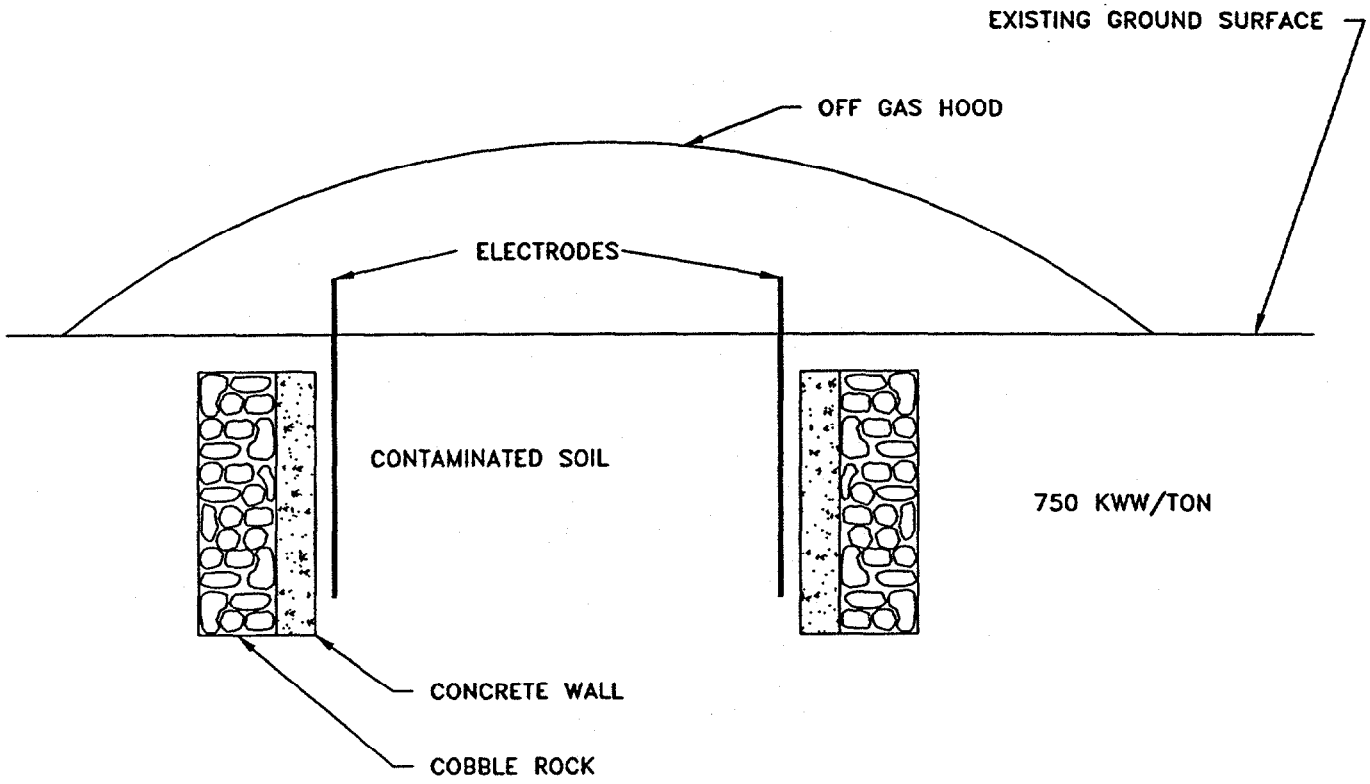
363757FS



Baker
Baker Environmental, Inc.

FIGURE 4-19
IN-SITU VITRIFICATION
SCHEMATIC
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

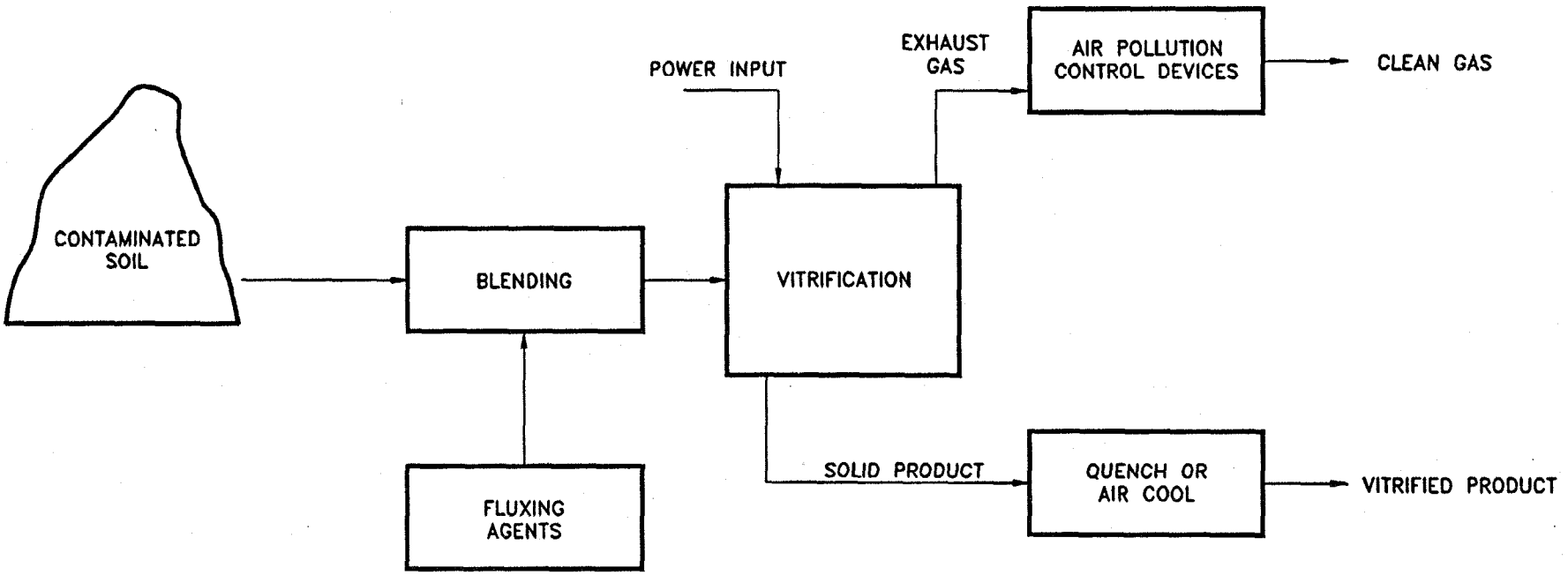


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FIGURE 4-20
TYPICAL EX SITU
VITRIFICATION PROCESS
SITES 2, 8 AND SSA 14

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

363758FS

5.0 DEVELOPMENT AND PRELIMINARY SCREENING OF REMEDIAL ACTION ALTERNATIVES

In this phase of the FS, process options and remedial action technologies will be combined to form potential RAAs for Sites 2, 8, and 18, and SSA 14. The RAAs will be described with respect to quantities of media treated/remediated, major components of each RAA, and other descriptive details. A preliminary screening of the RAAs will be conducted, if necessary. Due to the similarity of contaminants at each of the three sites, similar RAAs will be developed for each site. The alternatives will be presented for each site separately; however, costs may be saved if the same treatment technology was implemented for two or more of the sites.

5.1 Development of Alternatives

The remedial action technologies and process options identified on Table 4-4 have been combined to form RAAs that are potentially applicable to the contaminated soils at Sites 2, 8, and 18, and SSA 14. RAAs developed for Sites 2 and 8 and SSA 14 are identified on Tables 5-1, 5-2, and 5-3. The RAAs developed for the sites are described in the following subsections.

5.1.1 Site 2 RAAs

5.1.1.1 Site 2 RAA 1: No Action

Under the No Action RAA, the contaminated soil at Site 2 will remain in place. No remedial efforts will be conducted to reduce the contamination below the COC RLs. No actions will be taken to reduce human or environmental contact with the soil. The No Action RAA provides a baseline for comparison with other response actions under consideration in this FS.

5.1.1.2 Site 2 RAA 2: Land Use Restrictions With Monitoring

RAA 2 include the implementation of a long-term monitoring program and the maintenance of existing land use restrictions. Under the long-term monitoring program for RAA 2, surface soil, surface water, and sediment sampling and analysis will be conducted to monitor COC migration, natural degradation, or possible releases to the environment. Figure 5-1 shows the AOCs for

mercury, cobalt, PCBs, and PAHs. Approximately 28 surface soil samples and six sets of surface water and sediment samples will be collected at the locations indicated on Figure 5-1. The samples will be collected semiannually and analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics. In the event that monitoring indicates a possible threat to human health or the environment, further remedial action will be evaluated.

Land use restrictions are currently in place at Site 2. The site has been included as part of the Chesapeake Bay Program through which the riparian buffer zone for Felgates Creek and the York is being re-established. Through this program, the Virginia Institute of Marine Science (VIMS) and the NOAA have planted native tree species over the former landfill area at Site 2. Designation as part of the riparian buffer zone restricts the development of the Site 2 area for residential, commercial, and industrial purposes. Recreational use of the area may be permitted.

5.1.1.3 Site 2 RAA 3: Soil Washing

Under RAA 3, contaminated soil at Site 2 will be excavated and treated on site in a soil washing unit located at Site 2. Soil washing can be effective for inorganics, PAHs, PCBs, and explosives, although it may be difficult to treat soil with a mixture of organic and inorganic contaminants. A treatability study will be necessary to determine the appropriate washing agent for the mixed contaminants at the site. Confirmatory soil sampling will be performed to ensure that site-specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected from the excavated area and analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.

Assuming an excavation depth of one foot, approximately 785 cubic yards of contaminated soil will be excavated and processed through the soil washing process. Soil washing can work in several ways: 1) by dissolving or suspending contaminants in the wash solution, or 2) by concentrating the contaminants into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing. The process by which soil washing works depends on the contaminant. Organic or inorganic contaminants adhere to clay or silt, which adheres to sand. Separation of the fines concentrates the contaminants and can reduce the original excavated soil volume significantly. Gravity separation separates the particles contaminated with heavy metal compounds. Attrition scrubbing removes adherent contaminant films from the coarse particles. The concentrated contaminant waste stream will be transported off site for further treatment or disposal. Samples will

be periodically collected from the soil exiting the soil washing unit to determine if the contaminant RLs have been met. These soil samples will be analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.

Because the soil washing process will take several months to complete, the excavated areas will be restored with clean backfill from an on-site borrow pit and with topsoil. The area will then be vegetated with native species. Approximately 395 cubic yards of imported backfill and 395 cubic yards of topsoil will be required for restoration of Site 2. Figure 5-2 shows the area to be excavated and restored at Site 2 under RAA 3.

As described under RAA 2, land use will be restricted from residential, commercial, or industrial development because Site 2 has been included as part of the re-establishment of the riparian buffer for Felgates Creek and the York River.

5.1.1.4 Site 2 RAA 4: On-Site Biological Treatment

Under RAA 4, the contaminated soil at Site 2 will be excavated and treated by a combination of two different biological treatment technologies: landfarming and bioslurry. Assuming an excavation depth of one foot, approximately 785 cubic yards of contaminated soil will be excavated and processed through the treatment process. As a cost-savings measure, the existing landfarming and biocell structures at WPNSTA Yorktown will be implemented. The landfarming unit is located at Site 24, and the biocell structure is located at Site 22. A treatability study will be necessary to determine the effectiveness of the treatment system. Confirmatory soil sampling will be performed to ensure that site-specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected from the excavated area and analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.

One potential treatment system that could be implemented is the Institute of Gas Technology's (IGT's) process called the Chemical Biological Treatment (CBT) process. This is a soil slurry treatment approach that will allow for destruction of organic contaminants through the use of CBT, and removal of inorganic contaminants by leaching them from the soil and subsequently precipitating them from the leaching solution. The CBT process employs hydrogen peroxide as an oxidizing agent to initiate the oxidative destruction of organic contaminants. The chemical oxidation step of

the CBT process works best at a pH of 4 and has successfully been employed to treat soil slurries. For Site 2, a chelating agent, EDTA, will be added to the slurry to facilitate the extraction of the inorganic COCs from the soil. This portion of the treatment will be conducted in the existing biocell constructed at Site 22. The soil will then be treated in a landfarming mode (at Site 24) to complete the chemical oxidation and biodegradation process resulting in the destruction of the organic COCs. The liquid will contain chelated inorganics as well as any organic contaminants that may have leached from the soil. The liquid will first be subjected to chemical oxidation to destroy residual organic COCs and then it will be treated under anaerobic conditions using sulfate reducing bacteria to remove the inorganics from solution. Additional vendor information on the CBT process is presented in Appendix D. Other landfarming processes could potentially treat the organic and inorganic COCs at Site 2. Vendor information pertaining to these processes is presented in Appendix D.

Regardless of the individual type of landfarming/bioslurry treatment process selected for the site, the soil will be routinely collected and analyzed until it meets the site-specific final RLs. The soil samples will be analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.

The landfarming/bioslurry process will take several months or longer to completely treat the contaminated soil. Therefore, clean backfill from an on-site borrow area will be used to restore the excavated area. Topsoil will be placed and planted with native species. Approximately 395 cubic yards of backfill and 395 cubic yards of topsoil will be required for restoration of Site 2. Figure 5-2 shows the area to be excavated and restored at Site 2 (the same area as RAA 3).

As described under RAA 2, land use will be restricted from residential, commercial, or industrial development because Site 2 has been included as part of the re-establishment of the riparian buffer for Felgates Creek and the York River.

5.1.1.5 Site 2 RAA 5: Off-Site Incineration

Under this alternative, contaminated soil at Site 2 will be excavated and transported to an off-site incineration facility. Assuming an excavation depth of approximately one foot, 785 cubic yards of soil will be excavated and transported off site to a permitted incineration facility. Confirmatory sampling will be performed to ensure that site-specific COCs above final RLs have been removed.

Confirmatory samples will be collected and analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics. Because the soil will not be returned to the site, the excavated areas will be restored with clean backfill from an on-site borrow pit and topsoil. These areas will be vegetated with native species. Approximately 395 cubic yards of backfill and 395 cubic yards of topsoil will be required for restoration of Site 2. Figure 5-2 shows the area to be excavated and restored at Site 2 (the same area for RAA 3).

As described under RAA 2, land use will be restricted from residential, commercial, or industrial development because Site 2 has been included as part of the re-establishment of the riparian buffer for Felgates Creek and the York River.

5.1.1.6 Site 2 RAA 6: Off-Site Landfill Disposal

Under RAA 6, contaminated soil at Site 2 will be excavated and transported to an approved off-site landfill for permanent disposal. Assuming an excavation depth of approximately one foot, 785 cubic yards of soil will be excavated and transported off site to a permitted landfill facility. The excavated soil will be loaded into trucks and transported to the nearest permitted facility. The soil will have TCLP testing to determine if it is hazardous. The TCLP results will determine the type of landfill that can accept the soil. Confirmatory sampling will be conducted to ensure that site specific COCs above the final RLs have been removed. Confirmatory samples will be collected and analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics. Because the soil will not be returned to the site, clean backfill from an on-site borrow pit will be used to restore the excavated areas. Topsoil will be placed and the area vegetated with native species. Approximately 395 cubic yards of backfill and 395 cubic yards of topsoil will be required for restoration of Site 2. Figure 5-2 shows the area to be excavated and restored at Site 2 (the same area for RAA 3).

As described under RAA 2, land use will be restricted from residential, commercial, or industrial development because Site 2 has been included as part of the re-establishment of the riparian buffer for Felgates Creek and the York River.

5.1.2 Site 8 RAAs

5.1.2.1 Site 8 RAA 1: No Action

Under the No Action RAA, the contaminated soil at Site 8 will remain in place. No remedial efforts will be conducted to reduce the contamination below the COC RLs. No actions will be taken to reduce human or environmental contact with the soil. The No Action RAA provides a baseline for comparison with other response actions under consideration in this FS.

5.1.2.2 Site 8 RAA 2: No Action With Monitoring

RAA 2 includes the implementation of a long-term monitoring program. No active remediation is included with this alternative. Under RAA 2, surface soil, surface water, and sediment sampling and analysis will be conducted to monitor COC migration, natural degradation, or possible releases to the environment. Approximately four surface soil samples and three sets of surface water and sediment samples will be collected semiannually and analyzed for TCL SVOCs, TCL PCBs, nitramines (explosives), and TAL inorganics. Proposed sample locations are shown on Figure 5-3. If monitoring indicates a possible threat to human health or the environment, further remedial action will be evaluated.

5.1.2.3 Site 8 RAA 3: Soil Washing

Under RAA 3, contaminated soil at Site 8 will be excavated and treated on site in a soil washing unit located at Site 8. Soil washing can be effective for inorganics, PAHs, PCBs, and explosives, although it may be difficult to treat soil with a mixture of organic and inorganic contaminants. A treatability study will be necessary to determine the appropriate washing agent for the mixed contaminants at the site. Confirmatory soil sampling will be performed to ensure that site-specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected from the excavated area and analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.

Assuming an excavation depth of one foot, approximately 30 cubic yards of contaminated soil will be excavated and processed through the soil washing process. Soil washing can work in several ways: 1) by dissolving or suspending contaminants in the wash solution, or 2) by concentrating the

contaminants into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing. The process by which soil washing works depends on the contaminant. Organic or inorganic contaminants adhere to clay or silt, which adheres to sand. Separation of the fines concentrates the contaminants and can reduce the original excavated soil volume significantly. Gravity separation separates the particles contaminated with heavy metal compounds. Attrition scrubbing removes adherent contaminant films from the coarse particles. The concentrated contaminant waste stream will be transported off site for further treatment or disposal. Samples will be periodically collected from the soil exiting the soil washing unit to determine if the contaminant RLs ~~have been met. These~~ soil samples will be analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.

Because the soil washing process will take several months to complete, the excavated areas will be restored with clean backfill from an on-site borrow pit and with topsoil. The area will then be vegetated with native species. Approximately 15 cubic yards of imported backfill and 15 cubic yards of topsoil will be required for restoration of Site 8. Figure 5-4 shows the area to be excavated and restored at Site 8.

5.1.2.4 Site 8 RAA 4: On-Site Biological Treatment

Under RAA 4, the contaminated soil at Site 8 will be excavated and treated by a combination of two different biological treatment technologies: landfarming and bioslurry. Assuming an excavation depth of one foot, approximately 30 cubic yards of contaminated soil will be excavated and processed through the treatment process. As a cost-savings measure, the existing landfarming and biocell structures at WPNSTA Yorktown will be used. The landfarming unit is located at Site 24, and the biocell structure is located at Site 22. A treatability study will be necessary to determine the effectiveness of the treatment system. Confirmatory soil sampling will be performed to ensure that site-specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected from the excavated area and analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.

As previously mentioned for Site 2, one potential treatment system that could be implemented is IGT's CBT process. This is a soil slurry treatment approach that will allow for destruction of organic contaminants through the use of CBT, and removal of inorganic contaminants by leaching

them from the soil and subsequently precipitating them from the leaching solution. The CBT process employs hydrogen peroxide as an oxidizing agent to initiate the oxidative destruction of organic contaminants. The chemical oxidation step of the CBT process works best at a pH of 4 and has successfully been employed to treat soil slurries. For Site 8, a chelating agent, EDTA, will be added to the slurry to facilitate the extraction of the inorganic COCs from the soil. This portion of the treatment will be conducted in the existing biocell constructed at Site 22. The soil will then be treated in a landfarming mode (at Site 24) to complete the chemical oxidation and biodegradation process resulting in the destruction of the organic COCs. The liquid will contain chelated inorganics as well as any organic contaminants that may have ~~leached from the soil. The liquid~~ will first be subjected to chemical oxidation to destroy residual organic COCs and then it will be treated under anaerobic conditions using sulfate reducing bacteria to remove the inorganics from solution. Additional vendor information on the CBT process is presented in Appendix D. Other landfarming processes could potentially treat the organic and inorganic COCs at Site 8. Vendor information pertaining to these processes is presented in Appendix D.

Regardless of the individual type of landfarming/bioslurry treatment process selected for the site, the soil will be routinely collected and analyzed until it meets the site-specific final RLs. The soil samples will be analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.

The landfarming/bioslurry process will take several months or longer to completely treatment to contaminated soil. Therefore, clean backfill from an on-site borrow area will be used to restore the excavated area. Topsoil will be placed and planted with native species. Approximately 15 cubic yards of backfill and 15 cubic yards of topsoil will be required for restoration of Site 8. Figure 5-4 shows the area to be excavated and restored at Site 8.

5.1.2.5 Site 8 RAA 5: Off-Site Incineration

Under this alternative, contaminated soil will be excavated and transported to an off-site incineration facility. Assuming an excavation depth of approximately one foot, approximately 30 cubic yards of soil will be excavated and transported to a permitted incineration facility. Confirmatory soil sampling will be performed to ensure that site-specific COCs above final RLs have been removed. Confirmatory soil samples will be collected and analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics. Because the soil will not be returned to the site, the excavated areas will be

restored with clean backfill from an on-site borrow pit and topsoil. These areas will be vegetated with native species. Approximately 15 cubic yards of backfill and 15 cubic yards of topsoil (6 inches deep) will be required to restore the site. Figure 5-4 shows the area to be excavated and restored at Site 8 (the same area for RAA 3).

5.1.1.6 Site 8 RAA 6: Off-Site Landfill Disposal

Under RAA 5, contaminated soil will be excavated and transported to an approved off-site landfill for permanent disposal. Assuming ~~an excavation depth of~~ approximately one foot, approximately 30 cubic yards of soil will be excavated and transported to a permitted landfill facility. Confirmatory soil sampling will be conducted to ensure that site specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected and analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics. The excavated soil will be loaded into trucks and transported to the nearest permitted facility. The soil will have TCLP testing to determine if it is hazardous. The TCLP results will determine the type of landfill that can accept the soil. Because the soil will not be returned to the site, clean backfill from an on-site borrow pit will be used to restore the excavated areas. Topsoil will be placed and the area vegetated with native species. Approximately 15 cubic yards of backfill and 15 cubic yards of topsoil (6 inches deep) will be required to restore the site. Figure 5-4 shows the area to be excavated and restored at Site 8 (the same area for RAA 3).

5.1.2.7 Site 8 RAA 7: Capping and Drainage Diversion

Under this alternative, a soil cover will be installed in the drainage area at Site 8, and the existing drainage way will be diverted. The AOC and surrounding area will be filled in with backfill, topsoil will be added, and the site graded so that the area is no longer a natural drainage way. The area will be revegetated with native species. Runoff will be diverted away from the covered area by contouring a new drainage way. This will prevent erosion and re-exposure of the contaminated surface soil.

The AOC (approximately 825 square feet) at Site 8 will be covered to prevent exposure to contaminated surface soil. The soil cover will be designed to divert runoff away from the existing drainage way. In order to divert the drainage, the surrounding area (which incorporates the AOC) will be covered and contoured. Assuming a trapezoidal drainage ditch with a cross sectional area

of 3.75 square feet (2 feet wide at the top, 1 foot wide at the bottom, 2.5 feet deep), and with 80 linear feet of the ditch filled in, approximately 300 cubic feet (approximately 11 cubic yards) of backfill will be required to fill in the drainage ditch. Then the entire drainage area (80 feet by 15 feet) will be covered with 18 inches of backfill (approximately 65 cubic yards) and 6 inches of topsoil (approximately 25 cubic yards). The area will then be revegetated. A cross section of the ditch at Site 8 is shown in relation to the sample locations on Figure 5-5. Figure 5-6 shows the area to be capped for Site 8.

The existing drainage way may potentially be recharged with groundwater in addition to receiving storm water runoff. The existing storm water structures (pipe and concrete headwall) will be removed as indicated in Figure 5-6. New piping and manholes will be installed at the site, and a new headwall built so that erosion of the soil cover will be minimized. Samples should be collected and analyzed for the site-specific COCs to determine if the remainder of the pipe is acting as a secondary source of contamination. If this is the case, the entire pipe may need to be replaced. However, this is not included as part of the alternative. While the soil cover will prevent the surface runoff from coming into contact with the contaminated surface soil at Site 8, it will not prevent recharging groundwater from coming into contact with the contaminated soil. Groundwater at Site 8 was identified as a medium of concern (but will be addressed in a separate FS). The contaminated soil in the drainage way is a potential source of contamination for groundwater.

Routine maintenance of the soil cover will be conducted under this alternative. This maintenance may include but not be limited to inspections, repairs, and mowing, if appropriate.

This alternative would be effective for preventing direct contact with surface soil contaminants at Site 8 (the concern for this FS). However, it may not be effective for protecting the groundwater (a concern for a separate FS).

5.1.3 Site 18 RAA

5.1.3.1 Site 18 RAA 1: No Action

The No Action RAA is the only alternative being considered for Site 18 because no AOCs were identified for this site. Under the No Action alternative, no actions will be taken because no media were determined to pose an unacceptable risk to human health or the environment.

5.1.4 SSA 14 RAAs

5.1.4.1 SSA 14 RAA 1: No Action

Under the No Action RAA, the contaminated soil at SSA 14 will remain in place. No remedial efforts will be conducted to reduce the contamination below the COC RLs. No actions will be taken to reduce human or environmental contact with the soil. The No Action RAA provides a baseline for comparison with other response actions under consideration in this FS.

5.1.4.2 SSA 14 RAA 2: No Action With Monitoring

RAA 2 includes a long-term monitoring program. No active remediation activities are included with this alternative. Under RAA 2, surface soil, surface water, and sediment sampling and analysis will be conducted to monitor COC migration, natural degradation, or possible releases to the environment. Approximately three surface soil samples and four sets of surface water and sediment samples will be collected semiannually and analyzed for nitramines and TAL inorganics. Proposed sample locations are shown on Figure 5-7. In the event that monitoring indicates a possible threat to human health or the environment, further remedial action will be evaluated.

5.1.4.3 SSA 14 RAA 3: Soil Washing

Under RAA 3, contaminated soil will be excavated and treated in a soil washing unit located at SSA 14. Soil washing can be effective for inorganics and explosives, although it may be difficult to treat soil with a mixture of organic and inorganic contaminants. A treatability study will be required to determine the appropriate washing agent for the mixed contaminants at the site.

Assuming an excavation depth of one foot, approximately 70 cubic yards of contaminated soil will be excavated and processed through the soil washing process. Soil washing can work in several ways: 1) by dissolving or suspending contaminants in the wash solution, or 2) by concentrating the contaminants into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing. The process by which soil washing works depends on the contaminant. Organic or inorganic contaminants adhere to clay or silt, which adheres to sand. Separation of the fines concentrates the contaminants and can reduce the original excavated soil volume significantly. Gravity separation separates the particles contaminated with heavy metal compounds. Attrition scrubbing removes adherent contaminant films from the coarse particles. The concentrated contaminant waste stream will be transported off site for further treatment or disposal. Samples will be periodically collected from the soil exiting the soil washing unit to determine if the contaminant RLs have been met. These soil samples will be analyzed for nitramines and TAL inorganics.

Because the soil washing process will take several months to complete, the excavated areas will be restored with clean backfill from an on-site borrow pit and with topsoil. The area will then be vegetated with native species. Approximately 35 cubic yards of imported backfill and 35 cubic yards of topsoil will be required for restoration of SSA 14. Figure 5-8 shows the area to be excavated and restored at SSA 14.

5.1.4.4 SSA 14 RAA 4: On-Site Biological Treatment

Under RAA 4, the contaminated soil at SSA 14 will be excavated and treated by a combination of two different biological treatment technologies: landfarming and bioslurry. Assuming an excavation depth of one foot, approximately 70 cubic yards of contaminated soil will be excavated and processed through the treatment process. As a cost-savings measure, the existing landfarming and biocell structures at WPNSTA Yorktown will be used. The landfarming unit is located at Site 24, and the biocell structure is located at Site 22. A treatability study will be necessary to determine the effectiveness of the treatment system. Confirmatory soil sampling will be performed to ensure that site-specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected from the excavated area and analyzed for TAL inorganics.

As previously mentioned for Sites 2 and 8, one potential treatment system that could be implemented is IGT's CBT process. This is a soil slurry treatment approach that will allow for destruction of

organic contaminants through the use of CBT, and removal of inorganic contaminants by leaching them from the soil and subsequently precipitating them from the leaching solution. The CBT process employs hydrogen peroxide as an oxidizing agent to initiate the oxidative destruction of organic contaminants. The chemical oxidation step of the CBT process works best at a pH of 4 and has successfully been employed to treat soil slurries. For SSA 14, a chelating agent, EDTA, will be added to the slurry to facilitate the extraction of the inorganic COCs from the soil. This portion of the treatment will be conducted in the existing biocell constructed at Site 22. The soil will then be treated in a landfarming mode (at Site 24) to complete the chemical oxidation and biodegradation process resulting in the destruction of the organic COCs. The liquid will contain chelated inorganics as well as any organic contaminants that may have leached from the soil. The liquid will first be subjected to chemical oxidation to destroy residual organic COCs and then it will be treated under anaerobic conditions using sulfate reducing bacteria to remove the inorganics from solution. Additional vendor information on the CBT process is presented in Appendix D. Other landfarming processes could potentially treat the organic and inorganic COCs at SSA 14. Vendor information pertaining to these processes is presented in Appendix D.

Regardless of the individual type of landfarming/bioslurry treatment process selected for the site, the soil will be routinely collected and analyzed until it meets the site-specific final RLs. The soil samples will be analyzed for TAL inorganics.

The landfarming/bioslurry process will take several months or longer to completely treatment to contaminated soil. Therefore, clean backfill from an on-site borrow area will be used to restore the excavated area. Topsoil will be placed and planted with native species. Approximately 35 cubic yards of backfill and 35 cubic yards of topsoil will be required for restoration of SSA 14. Figure 5-8 shows the area to be excavated and restored at SSA 14.

5.1.4.5 SSA 14 RAA 5: Off-Site Incineration

Under this alternative, contaminated soil from SSA 14 will be excavated and transported to an off-site incineration facility. Assuming an excavation depth of one foot, approximately 70 cubic yards of soil will be removed and transported to a permitted incineration facility. Confirmatory soil sampling will be performed to ensure that site-specific COCs above final RLs have been removed. Confirmatory soil samples will be collected and analyzed for nitramines and TAL inorganics.

Because the soil will not be returned to the site, the excavated areas will be restored with clean backfill from an on-site borrow pit and topsoil. These areas will be vegetated with native species. Approximately 35 cubic yards of backfill and 35 cubic yards of topsoil (6 inches deep) will be required to restore the site. Figure 5-8 shows the area to be excavated and restored at SSA 14 (the same area for RAA 3).

5.1.4.6 SSA 14 RAA 6: Off-Site Landfill Disposal

Under RAA 5, contaminated soil from SSA 14 will be excavated and transported to an approved off-site landfill for permanent disposal. Assuming an excavation depth of approximately one foot, 70 cubic yards of soil will be excavated and transported to a permitted landfill facility. Confirmatory soil sampling will be conducted to ensure that site specific COCs above the final RLs have been removed. Confirmatory soil samples will be collected and analyzed for nitramines and TAL inorganics. The excavated soil will be loaded into trucks and transported to the nearest permitted facility. The soil will have TCLP testing to determine if it is hazardous. The TCLP results will determine the type of landfill that can accept the soil. Because the soil will not be returned to the site, clean backfill from an on-site borrow pit will be used to restore the excavated areas. Topsoil will be placed and the area vegetated with native species. Approximately 35 cubic yards of backfill and 35 cubic yards of topsoil (6 inches deep) will be required to restore the site. Figure 5-8 shows the area to be excavated and restored at SSA 14 (the same area for RAA 3).

5.1.4.7 SSA 14 RAA 7: Capping and Drainage Diversion

Under this alternative, a soil cover will be installed in the drainage area at SSA 14, and the existing drainage way will be diverted. The AOC and surrounding area will be filled in with backfill, topsoil will be added, and the site graded so that the area is no longer a natural drainage way. The area will be revegetated with native species. Runoff will be diverted away from the covered area by contouring a new drainage way. This will prevent erosion and re-exposure of the contaminated surface soil.

The AOC (approximately 1,800 square feet) will be covered at SSA 14 to prevent direct contact with surface soil. The soil cover will be designed to divert runoff away from the existing drainage way. In order to divert the drainage, a larger area than the AOC will be covered and contoured. The inlet

location of the drainage pipe discharging to the SSA drainage way is unknown. If the pipe is still in use, the drainage will be rerouted. Otherwise, the pipe will be removed. It is assumed that an area of approximately 50 feet by 80 feet will be capped with a soil cover consisting of 18 inches of backfill (approximately 220 cubic yards) and 6 inches of topsoil (approximately 75 cubic yards). The area will be revegetated. Figure 5-9 shows the area to be capped for SSA 14.

Routine maintenance of the soil cover will be conducted under this alternative. This maintenance may include but not be limited to inspections, repairs, and mowing, if appropriate.

No hydrogeologic cross sections are available for SSA 14 because there is only one existing monitoring well at the SSA; however, it is likely that the existing drainage way is recharged with groundwater. While the soil cover will prevent the surface runoff from coming into contact with the contaminated surface soil and potentially moving it downstream, it will not prevent contact with groundwater. Groundwater at SSA 14 does not pose an unacceptable human health or ecological risk. Therefore, groundwater contact with the contaminated soil should not pose a potential threat to human health and the environment

5.2 Screening of Alternatives

This section of the FS usually presents a preliminary screening of the RAAs. The objective of this screening is to make comparisons between similar alternatives, so that only the most promising alternatives are carried forward for further evaluation (USEPA, 1988). This screening is an optional step in the FS process and is usually conducted if there are too many RAAs on which to conduct the detailed evaluation. Since only six RAAs were developed for Site 2 and seven each for Site 8 and SSA 14, and they are all different from one another, this screening step will not be necessary.

SECTION 5.0 TABLES

TABLE 5-1
SUMMARY OF REMEDIAL ACTION ALTERNATIVES
SITE 2
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Remedial Action/Process Option	Component	RAA 1: No Action	RAA 2: Land Use Restrictions with Monitoring	RAA 3: Soil Washing	RAA 4: On-Site Biological Treatment	RAA 5: Off-Site Incineration	RAA 6: Off-Site Landfill
Soil Monitoring	Collect approximately 28 soil samples and analyze the samples for TCL SVOCs, TCL PCBs, and TAL inorganics on a semiannual basis.		X				
Surface Water and Sediment Monitoring	Collect approximately six sets of surface water and sediment samples and analyze the samples for TCL SVOCs, TCL PCBs, and TAL inorganics on a semiannual basis.		X				
Land Use Restrictions	Maintain the existing land use restrictions that have been implemented as part of the Chesapeake Bay Program.		X	X	X	X	X
Excavation	Excavate approximately 785 cubic yards of soil. Conduct confirmatory soil sampling to confirm the extent of excavation. Soil samples will be analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.			X	X	X	X
Treatment - Soil Washing	Treat the excavated soil in a mobile soil washing unit. Samples of the treated "washed" soil will be collected and analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.			X			

TABLE 5-1 (Continued)
SUMMARY OF REMEDIAL ACTION ALTERNATIVES
SITE 2
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Remedial Action/Process Option	Component	RAA 1: No Action	RAA 2: Land Use Restrictions with Monitoring	RAA 3: Soil Washing	RAA 4: On-Site Biological Treatment	RAA 5: Off-Site Incineration	RAA 6: Off-Site Landfill
Treatment - Biological	Treat the excavated soil in the existing biocell at Site 22 and at the existing landfarming unit at Site 24. Routine sampling of the soil will be conducted. The samples will be analyzed for TCL SVOCs, TCL PCBs, and TAL inorganics.				X		
Treatment - Off-site Incineration	The excavated soil will be transported off site to an approved incineration facility.					X	
Disposal - Off-site Landfill	The excavated soil will be transported off site to an approved landfill.						X

Notes:

PCBs polychlorinated biphenyls
RAA remedial action alternative
SVOCs semivolatile organic compounds
TCL Target Compound List
TAL Target Analyte List

TABLE 5-2
SUMMARY OF REMEDIAL ACTION ALTERNATIVES
SITE 8
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Remedial Action/Process Option	Component	RAA 1: No Action	RAA 2: No Action with Monitoring	RAA 3: Soil Washing	RAA 4: On-Site Biological Treatment	RAA 5: Off-Site Incineration	RAA 6: Off-Site Landfill	RAA 7: Capping and Drainage Diversion
Soil Monitoring	Collect approximately 4 soil samples and analyze the samples for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics on a semiannual basis.		X					
Surface Water and Sediment Monitoring	Collect approximately three sets of surface water and sediment samples and analyze the samples for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics on a semiannual basis.		X					
Excavation	Excavate approximately 30 cubic yards of soil. Conduct confirmatory soil sampling to confirm the extent of excavation. Soil samples will be analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.			X	X	X	X	
Treatment - Soil Washing	Treat the excavated soil in a mobile soil washing unit. Samples of the treated "washed" soil will be collected and analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.			X				
Treatment - Biological	Treat the excavated soil in the existing biocell at Site 22 and at the existing landfarming unit at Site 24. Routine sampling of the soil will be conducted. The samples will be analyzed for TCL SVOCs, TCL PCBs, nitramines, and TAL inorganics.				X			

TABLE 5-2 (Continued)
SUMMARY OF REMEDIAL ACTION ALTERNATIVES
SITE 8
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Remedial Action/Process Option	Component	RAA 1: No Action	RAA 2: No Action with Monitoring	RAA 3: Soil Washing	RAA 4: On-Site Biological Treatment	RAA 5: Off-Site Incineration	RAA 6: Off-Site Landfill	RAA 7: Capping and Drainage Diversion
Treatment - Off-site Incineration	The excavated soil will be transported off site to an approved incineration facility.					X		
Disposal - Off-site Landfill	The excavated soil will be transported off site to an approved landfill.						X	
Capping - Soil Cover	The existing drainage way will be filled in with a soil cover consisting of backfill and topsoil. The surrounding area will be contoured to allow runoff to flow to a newly constructed drainage way. A new headwall, piping, and manholes will be installed as needed.							X

Notes:

PCBs polychlorinated biphenyls
RAA remedial action alternative
SVOCs semivolatile organic compounds
TCL Target Compound List
TAL Target Analyte List

TABLE 5-3
SUMMARY OF REMEDIAL ACTION ALTERNATIVES
SSA 14
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Remedial Action/Process Option	Component	RAA 1: No Action	RAA 2: No Action with Monitoring	RAA 3: Soil Washing	RAA 4: On-Site Biological Treatment	RAA 5: Off-Site Incineration	RAA 6: Off-Site Landfill	RAA 7: Capping and Drainage Diversion
Soil Monitoring	Collect approximately 3 soil samples and analyze the samples for nitramines and TAL inorganics on a semiannual basis.		X					
Surface Water and Sediment Monitoring	Collect approximately four sets of surface water and sediment samples and analyze the samples for nitramines and TAL inorganics on a semiannual basis.		X					
Excavation	Excavate approximately 70 cubic yards of soil. Conduct confirmatory soil sampling to confirm the extent of excavation. Soil samples will be analyzed for nitramines and TAL inorganics.			X	X	X	X	
Treatment - Soil Washing	Treat the excavated soil in a mobile soil washing unit. Samples of the treated "washed" soil will be collected and analyzed for nitramines and TAL inorganics.			X				
Treatment - Biological	Treat the excavated soil in the existing biocell at Site 22 and at the existing landfarming unit at Site 24. Routine sampling of the soil will be conducted. The samples will be analyzed for nitramines and TAL inorganics.				X			

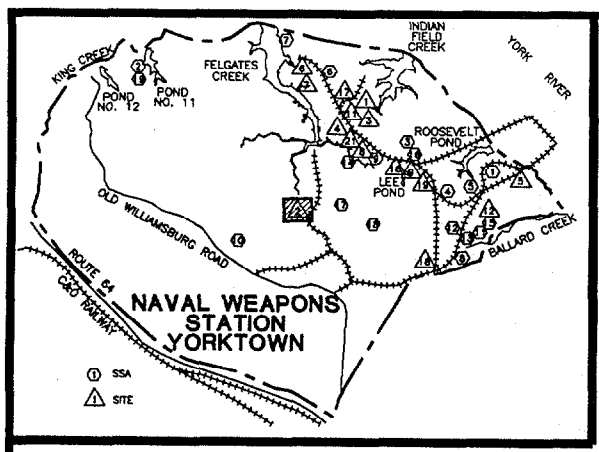
TABLE 5-3 (Continued)
SUMMARY OF REMEDIAL ACTION ALTERNATIVES
SSA 14
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Remedial Action/Process Option	Component	RAA 1: No Action	RAA 2: No Action with Monitoring	RAA 3: Soil Washing	RAA 4: On-Site Biological Treatment	RAA 5: Off-Site Incineration	RAA 6: Off-Site Landfill	RAA 7: Capping and Drainage Diversion
Treatment - Off-site Incineration	The excavated soil will be transported off site to an approved incineration facility.					X		
Disposal - Off-site Landfill	The excavated soil will be transported off site to an approved landfill.						X	
Capping - Soil Cover	The existing drainage way will be filled in with a soil cover consisting of backfill and topsoil. The surrounding area will be contoured to allow runoff to flow to a newly constructed drainage way. The pipe may be removed, or if it is still in use, its drainage will be rerouted.							X

Notes:

RAA remedial action alternative
TAL Target Analyte List

SECTION 5.0 FIGURES



APPROXIMATE PCB AREA OF CONCERN (TYPICAL)

APPROXIMATE MERCURY AREA OF CONCERN (TYPICAL)

APPROXIMATE PAH AREA OF CONCERN (TYPICAL)

SITE 2

APPROXIMATE COBALT AREA OF CONCERN

WOODS

TURKEY ROAD

LOW AREA

100 0 50 100

1 inch = 100 ft.

363763FS

Baker

Baker Environmental, Inc.

LEGEND

- PROPOSED SURFACE SOIL SAMPLE LOCATION
- APPROXIMATE PAH AOC BOUNDARY
- APPROXIMATE MERCURY AOC BOUNDARY
- APPROXIMATE PCB AOC BOUNDARY
- APPROXIMATE COBALT AOC BOUNDARY
- DRAINAGE
- MARSH
- GROUND SURFACE CONTOUR (FT., MSL)
- APPROXIMATE SITE BOUNDARY
- TREES
- PROPOSED SURFACE WATER/SEDIMENT SAMPLE LOCATION

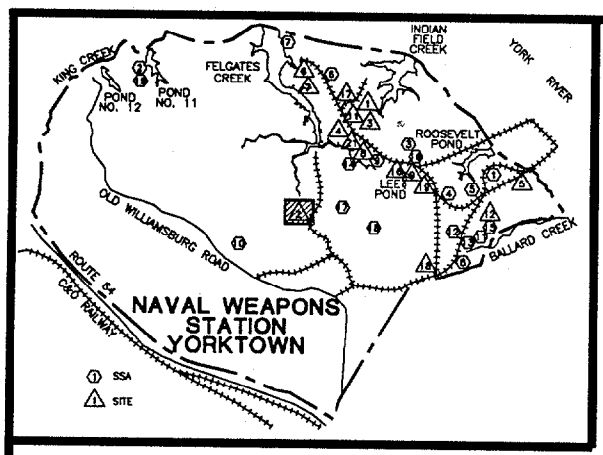
SOURCE: LANTDIV, 1991

FIGURE 5-1
RAA 2: LAND USE RESTRICTIONS AND MONITORING
SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

01764FB9Z



APPROXIMATE AREA TO BE EXCAVATED AND RESTORED (TYPICAL)

SITE 2

POSSIBLE LOCATION FOR SOIL WASHING UNIT (RAA 3 ONLY)

WOODS

GRAVEL ACCESS ROAD

TURKEY ROAD

LOW AREA

NOTE:
EXCAVATED SOIL WILL BE TRANSPORTED TO THE FOLLOWING LOCATIONS FOR EACH RAA:
RAA 3: ON-SITE SOIL WASHING UNIT
RAA 4: SITE 22 and SITE 24, EXISTING BIOSLURRY AND LANDFARMING AREAS
RAA 5: PERMITTED OFF-SITE INCINERATION FACILITY
RAA 6: PERMITTED OFF-SITE LANDFILL FACILITY

100 0 50 100
1 inch = 100 ft.

363772FS

Baker
Baker Environmental, Inc.

LEGEND

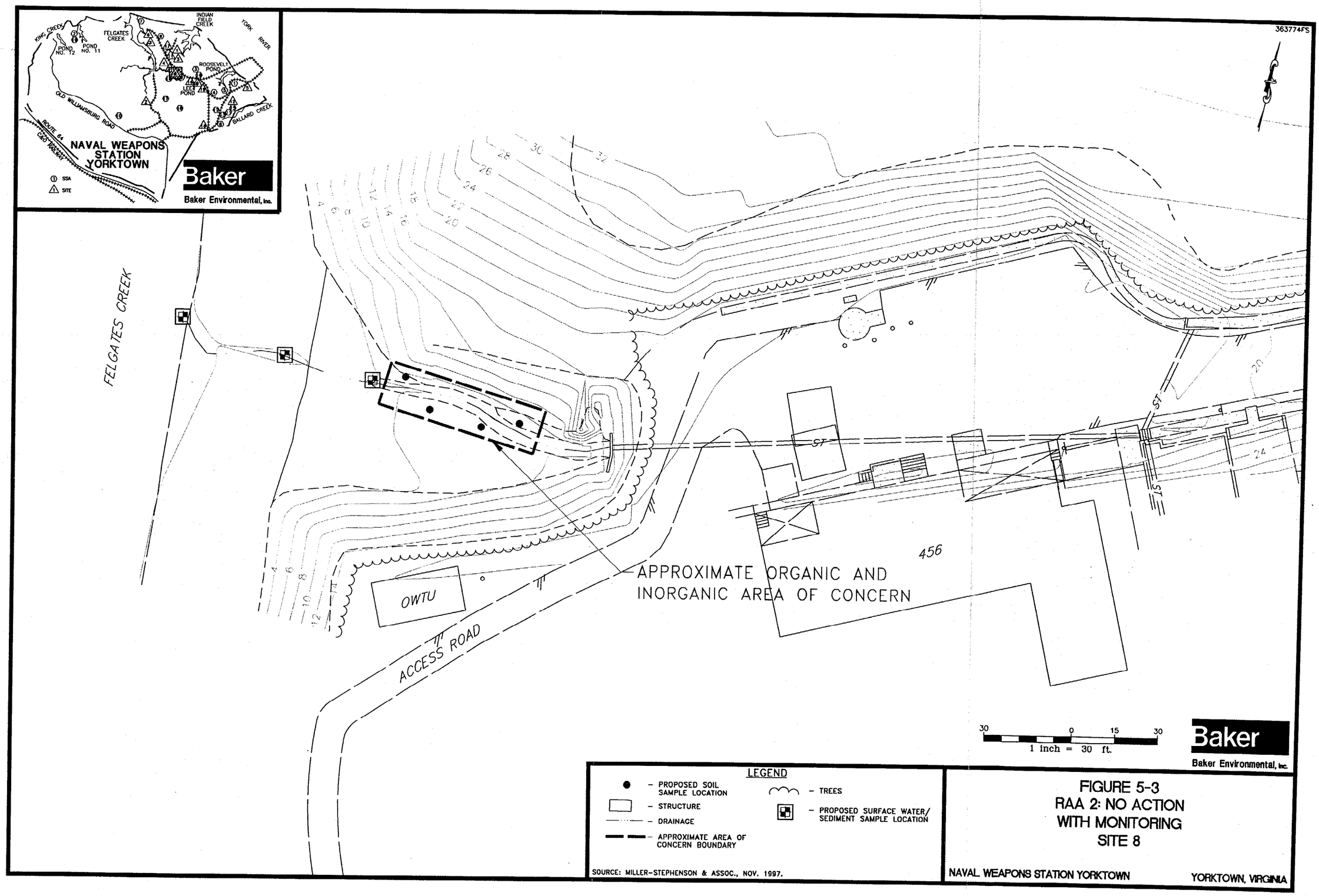
- APPROXIMATE AREA TO BE EXCAVATED AND RESTORED
- APPROXIMATE SITE BOUNDARY
- TREES
- DRAINAGE
- MARSH
- GROUND SURFACE CONTOUR (FT., MSL)
- SILT FENCE
- SAFETY FENCE

SOURCE: LANTDIV, 1991

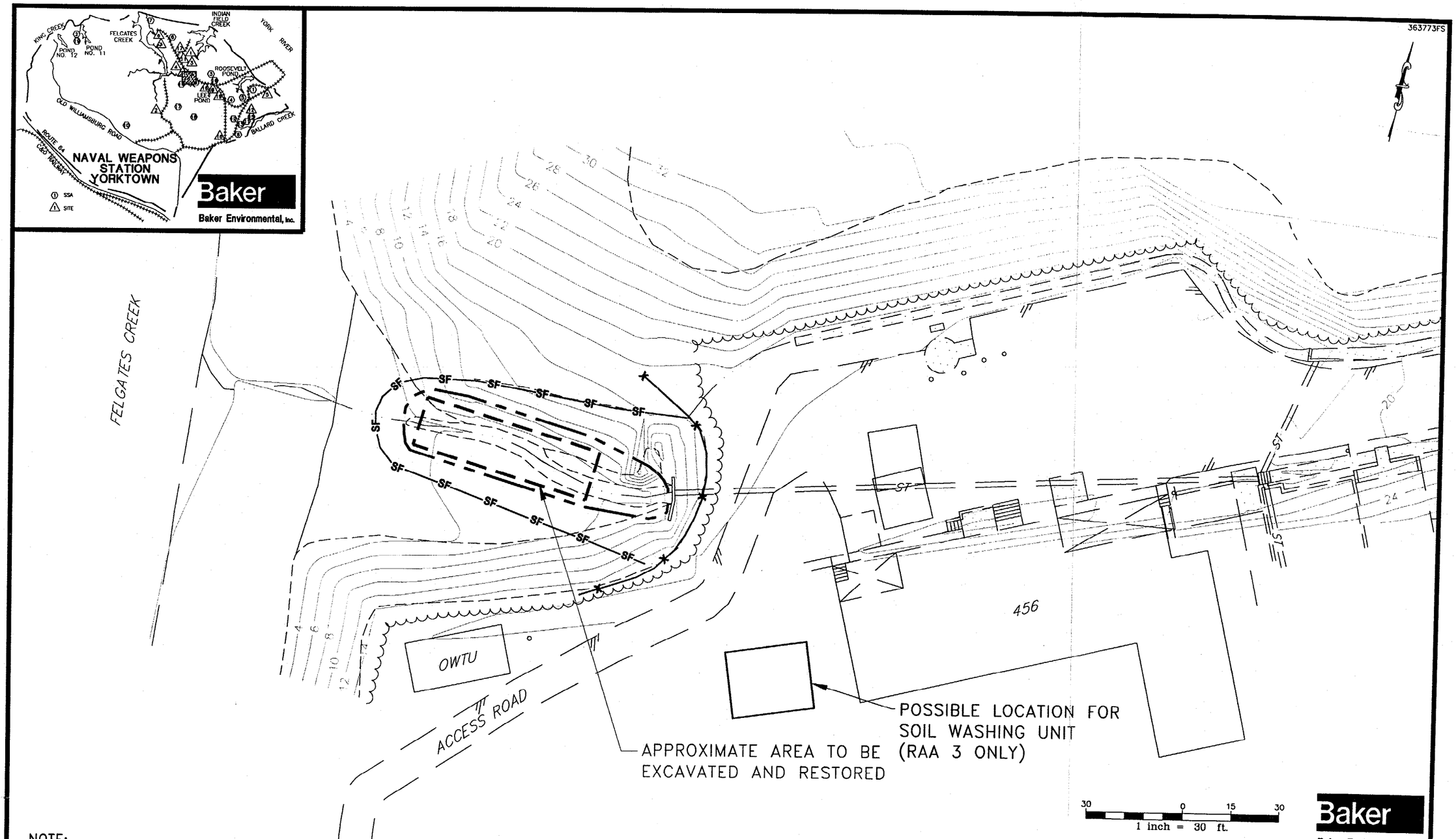
FIGURE 5-2
AREAS TO BE EXCVATED AND RESTORED
RAAs 3, 4, 5, AND 6
SITE 2

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA


363774FS
KING CREEK
POND NO. 12
POND NO. 11
FELGATES CREEK
INDIAN FIELD CREEK
YORK RIVER
ROOSEVELT POND
LEE POND
OLD WILLIAMSBURG ROAD
ROUTE 64
OLD RAILWAY
BALLARD CREEK
NAVAL WEAPONS STATION YORKTOWN
SSA
SITE
Baker
Baker Environmental, Inc.
FELGATES CREEK
OWTU
ACCESS ROAD
APPROXIMATE ORGANIC AND INORGANIC AREA OF CONCERN
456
ST
30
0
15
30
1 inch = 30 ft.
Baker
Baker Environmental, Inc.
LEGEND
PROPOSED SOIL SAMPLE LOCATION
STRUCTURE
DRAINAGE
APPROXIMATE AREA OF CONCERN BOUNDARY
TREES
PROPOSED SURFACE WATER/ SEDIMENT SAMPLE LOCATION
SOURCE: MILLER-STEPHENSON & ASSOC., NOV. 1997.
FIGURE 5-3
RAA 2: NO ACTION
WITH MONITORING
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

363773FS



NOTE:
EXCAVATED SOIL WILL BE TRANSPORTED TO THE FOLLOWING LOCATIONS FOR EACH RAA:
RAA 3: ON-SITE SOIL WASHING UNIT
RAA 4: SITE 22 and SITE 24, EXISTING BIOSLURRY AND LANDFARMING AREAS
RAA 5: PERMITTED OFF-SITE INCINERATION FACILITY
RAA 6: PERMITTED OFF-SITE LANDFILL FACILITY

LEGEND

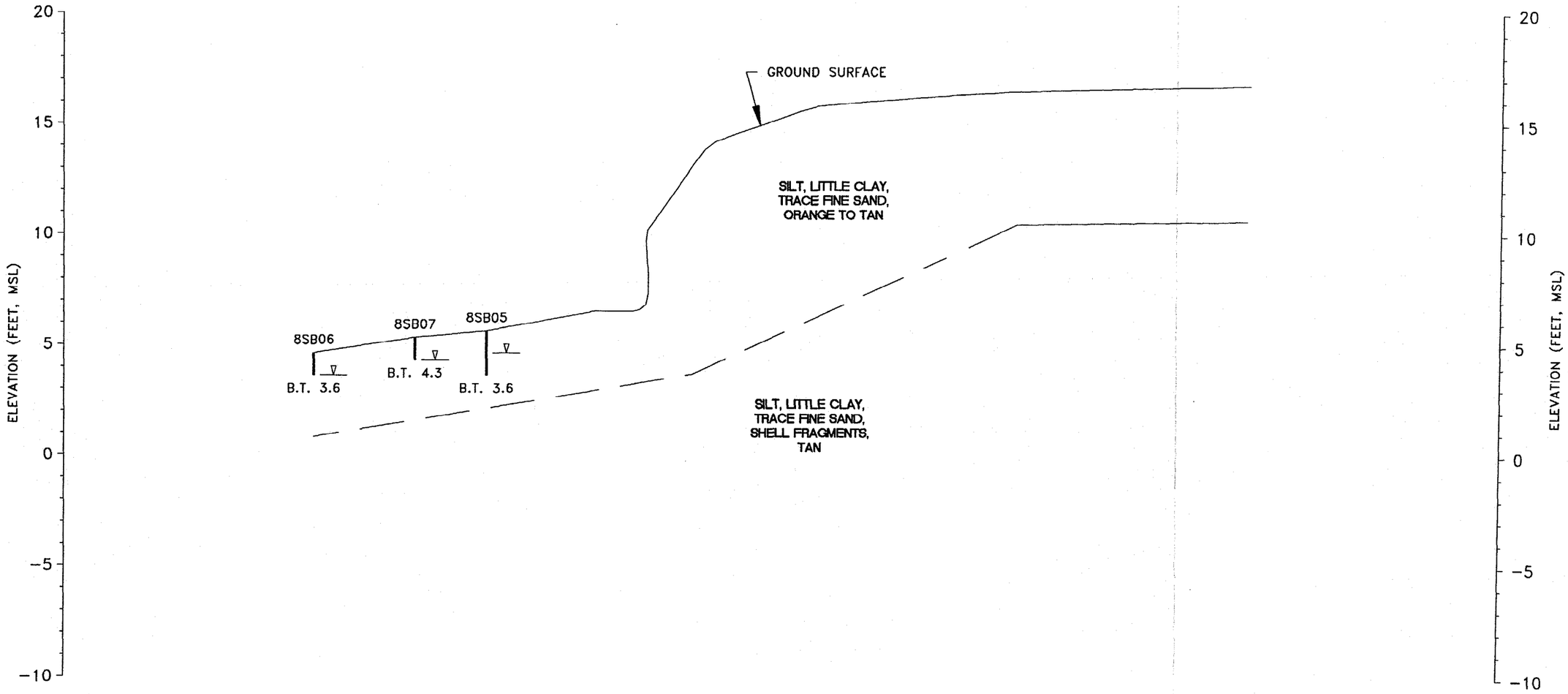
- STRUCTURE
- DRAINAGE
- TREES
- SF — SILT FENCE
- SAFETY FENCE
- APPROXIMATE AREA TO BE CLEARED AND GRUBBED
- APPROXIMATE AREA TO BE EXCAVATED AND RESTORED

SOURCE: MILLER-STEPHENSON & ASSOC., NOV. 1997.

FIGURE 5-4
AREAS TO BE EXCAVATED AND RESTORED
RAAs 3, 4, 5, and 6
SITE 8

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA

363769FS



Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION ON MARCH 20, 1997
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. 3.6 BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED — — — PROJECTED

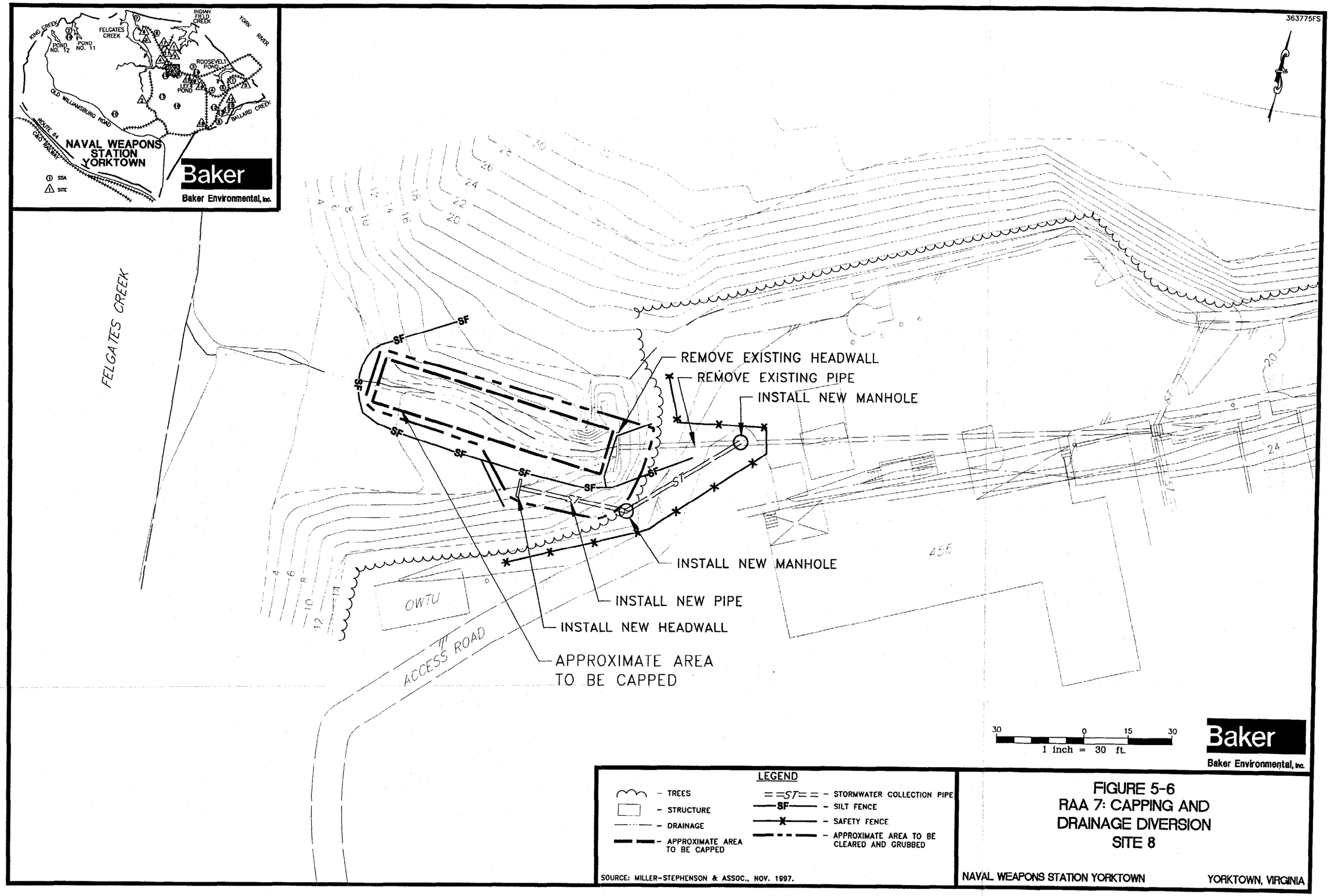
20 0 10 20 40
Horizontal Scale: 1 inch = 20 ft.

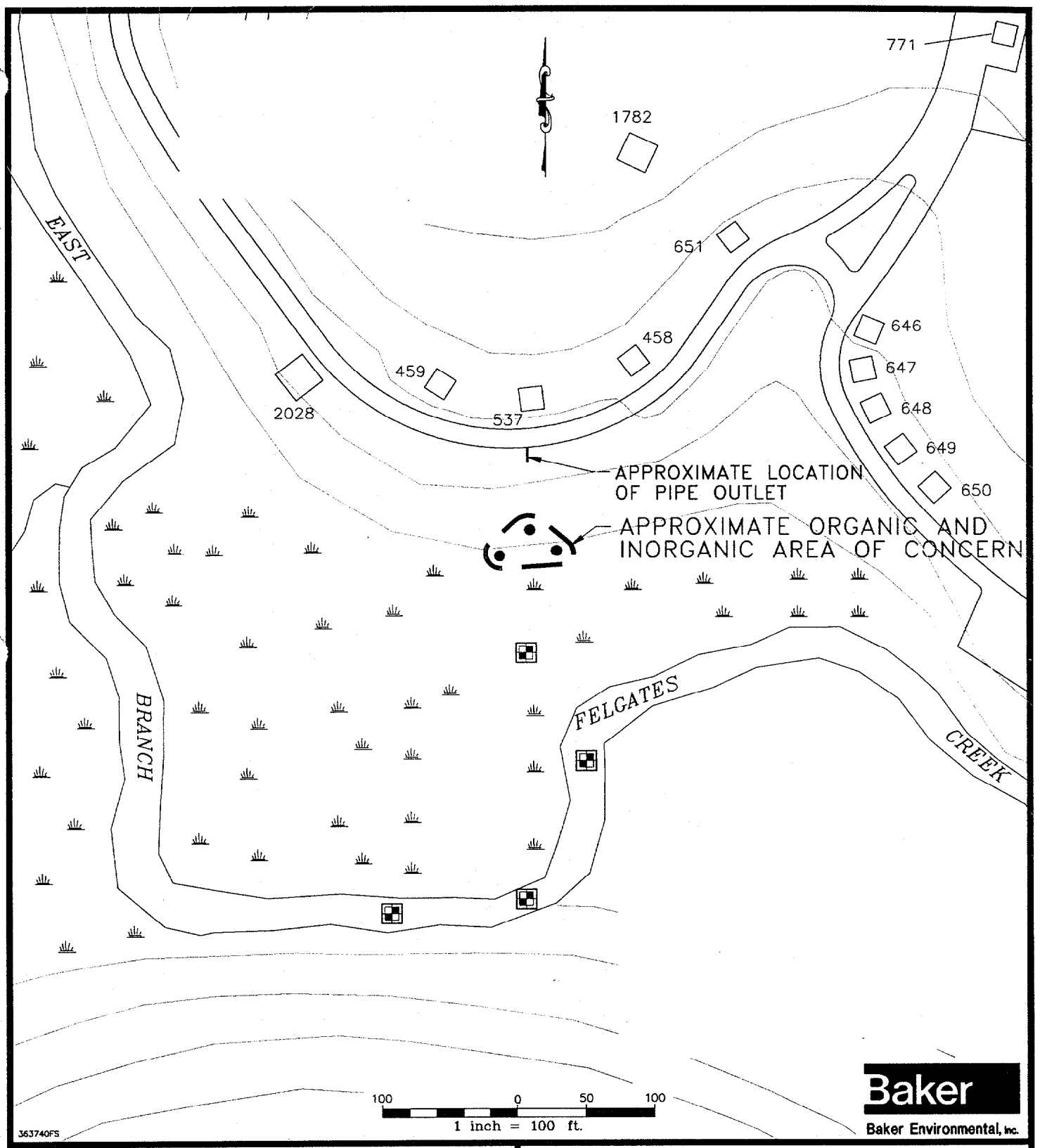
5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 5-5
HYDROGEOLOGIC CROSS-SECTION
OF THE DRAINAGE AREA
SITE 8

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA


363775FS
KING CREEK
POND NO. 12
POND NO. 11
FELGATES CREEK
INDIAN FIELD CREEK
YORK RIVER
ROOSEVELT POND
LEFF POND
OLD WILLIAMSBURG ROAD
ROUTE 64
C&O RAILWAY
BALLARD CREEK
NAVAL WEAPONS STATION YORKTOWN
SSA
SITE
Baker
Baker Environmental, Inc.
FELGATES CREEK
SF
REMOVE EXISTING HEADWALL
REMOVE EXISTING PIPE
INSTALL NEW MANHOLE
INSTALL NEW MANHOLE
INSTALL NEW PIPE
INSTALL NEW HEADWALL
APPROXIMATE AREA TO BE CAPPED
OWTU
ACCESS ROAD
456
30 0 15 30
1 inch = 30 ft.
Baker
Baker Environmental, Inc.
LEGEND
TREES
STRUCTURE
DRAINAGE
APPROXIMATE AREA TO BE CAPPED
STORMWATER COLLECTION PIPE
SILT FENCE
SAFETY FENCE
APPROXIMATE AREA TO BE CLEARED AND GRUBBED
SOURCE: MILLER-STEPHENSON & ASSOC., NOV. 1997.
FIGURE 5-6
RAA 7: CAPPING AND DRAINAGE DIVERSION
SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



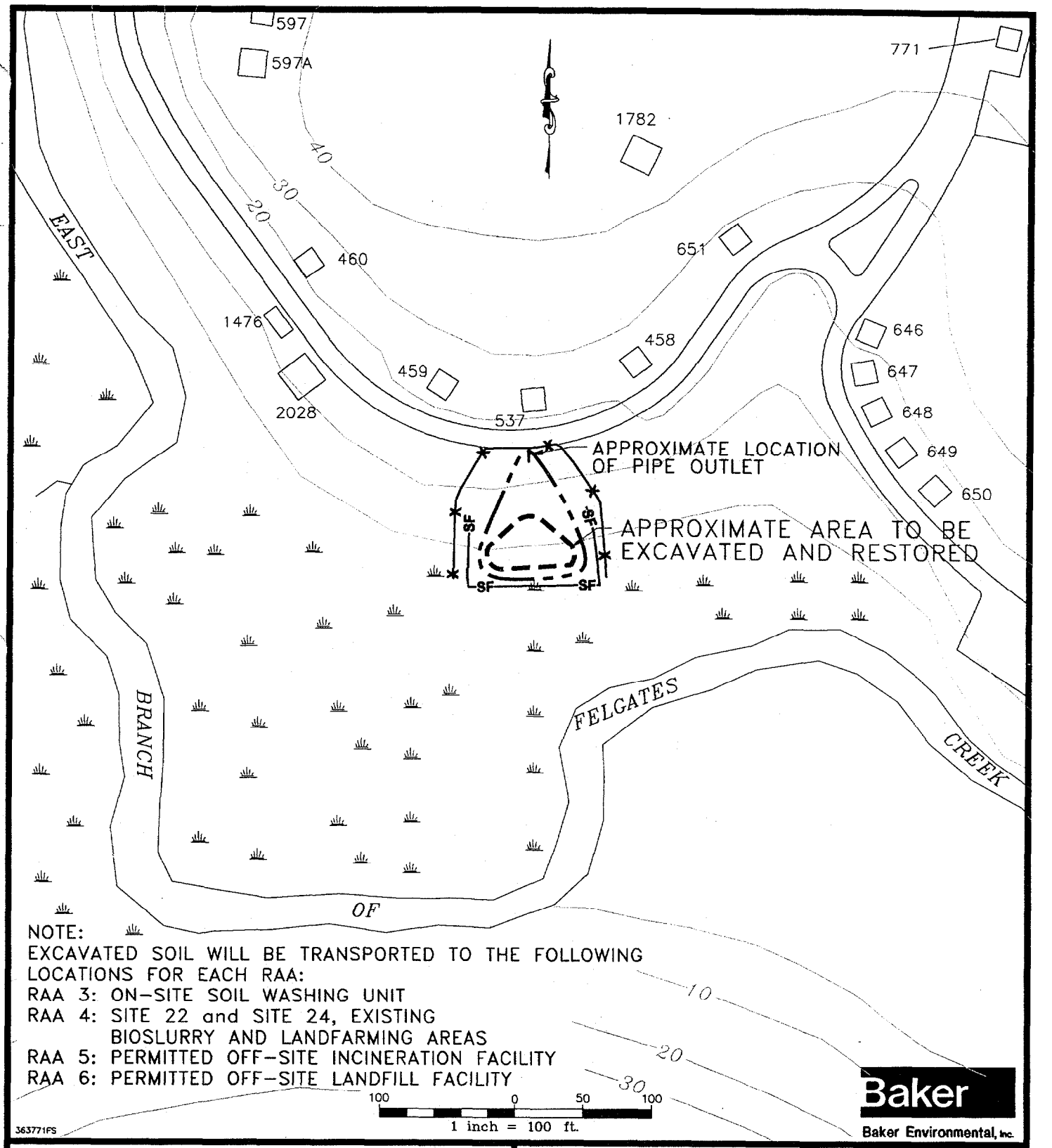
LEGEND

- PROPOSED SOIL SAMPLE LOCATION
- PROPOSED SURFACE WATER/ SEDIMENT SAMPLE LOCATION
- MARSH
- DRAINAGE
- APPROXIMATE AREA OF CONCERN BOUNDARY

SOURCE: LANTDIV, 1991.

FIGURE 5-7
RAA 2: NO ACTION
WITH MONITORING
SSA14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



NOTE:
EXCAVATED SOIL WILL BE TRANSPORTED TO THE FOLLOWING LOCATIONS FOR EACH RAA:
RAA 3: ON-SITE SOIL WASHING UNIT
RAA 4: SITE 22 and SITE 24, EXISTING BIOSLURRY AND LANDFARMING AREAS
RAA 5: PERMITTED OFF-SITE INCINERATION FACILITY
RAA 6: PERMITTED OFF-SITE LANDFILL FACILITY

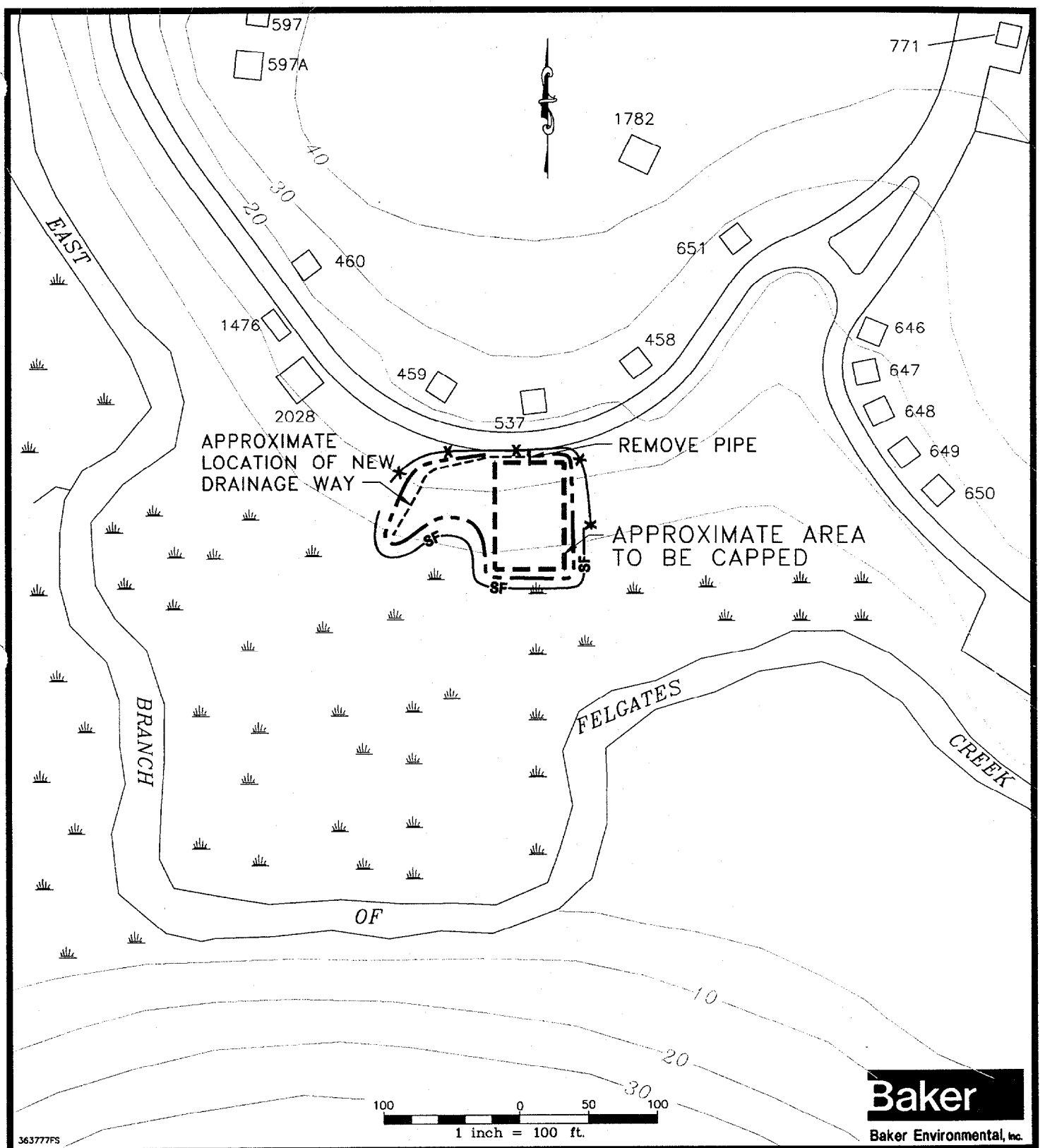
LEGEND

- MARSH
- DRAINAGE
- STRUCTURE
- SF — SILT FENCE
- SAFETY FENCE
- APPROXIMATE AREA TO BE CLEARED AND GRUBBED

SOURCE: LANTDIV, 1991.

FIGURE 5-8
AREA TO BE EXCAVATED AND RESTORED
RAAs 3, 4, 5, and 6
SSA-14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



LEGEND

- MARSH
- DRAINAGE
- STRUCTURE
- SF — SILT FENCE
- X — SAFETY FENCE
- APPROXIMATE AREA TO BE CLEARED AND GRUBBED
- APPROXIMATE LOCATION OF NEW DRAINAGE WAY

SOURCE: LANTDIV, 1991.

FIGURE 5-9
RAA 7: CAPPING AND DRAINAGE DIVERSION
SSA-14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

6.0 CRITERIA FOR THE DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

This section of the FS presents the criteria used to conduct the detailed evaluation of the RAAs for each site/SSA. Nine criteria typically are considered in the detailed evaluation of alternatives. The nine criteria are categorized into three groups with each group having a distinct function in selecting the remedy:

- Threshold Criteria
  - Overall protection of human health and the environment
  - Compliance with ARARs

- Primary Balancing Criteria
  - Short-term effectiveness
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume
  - Implementability
  - Cost

- Modifying Criteria
  - State acceptance
  - Community acceptance

Descriptions of each of these nine criteria are presented in greater detail in the following paragraphs.

6.1 Overall Protection of Human Health and the Environment

Evaluation of the overall protectiveness of the RAAs focuses on whether a specific RAA would achieve adequate protection of human health and the environment and how risks posed by each pathway would be eliminated, reduced, or controlled through treatment, engineering, or institutional controls. The overall assessment of the level of protection includes the evaluations conducted under other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Consideration of each alternative with respect to overall protection of

human health and the environment focuses on how the source of contamination is to be eliminated, reduced, or controlled.

6.2 Compliance with ARARs

This evaluation involves determining whether each alternative for each site would meet all of the pertinent Federal and state ARARs (as identified in Section 3.0 of this report).

Each RAA was evaluated for compliance with applicable or relevant and appropriate Federal and state requirements. The evaluation summarizes which requirements are applicable or relevant and appropriate to each RAA. The following items were considered for each alternative:

- Compliance with chemical-specific ARARs. This addresses whether the ARARS can be met and , if not, whether a waiver may be appropriate.

- Compliance with location-specific ARARs (e.g., preservation of historic sites, regulations relative to activities near wetlands or floodplains, etc.). As with other ARAR-related factors, these involve consideration of whether the ARARs can be met or whether a waiver is appropriate.

- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards). It must be determined whether ARARs can be met or must be waived.

6.3 Long-term Effectiveness and Permanence

This criterion evaluated alternatives with respect to their long-term effectiveness and the degree of permanence. The primary focus of this evaluation was the residual risk that will remain at the sites and the effectiveness of the controls that will be applied to manage residual risk.

Evaluation of each RAA relative to its long-term effectiveness and permanence was based on the risks remaining at the sites after the remedial action objectives are achieved. The assessment of long-term effectiveness was made considering the following four factors:

- The magnitude of the residual risk to human and environmental receptors remaining from untreated waste or treatment residues at the completion of remedial activities.

- An assessment of the type, degree, and adequacy of long-term management (including engineering controls, institutional controls, monitoring, and operation and maintenance) required for untreated waste or treatment residues remaining at the site.

- ~~An assessment~~ of the long-term reliability of engineering and/or institutional controls to provide continued protection from untreated waste or treatment residues.

- The potential need for replacement of the remedy and the continuing need for repairs to maintain the performance of the remedy.

6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This evaluation criterion addresses the degree to which the RAAs employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of hazardous substances. Alternatives that do not employ treatment technologies were not considered to reduce toxicity, mobility , or volume of the COCs. The evaluation considered the following specific factors:

- The treatment processes, the remedies to be employed, and the materials to be treated.

- The amount or volume of hazardous materials that will be destroyed or treated.

- The degree of expected reduction in toxicity, mobility, or volume, including how the principle threat is addressed through treatment.

- The degree to which the treatment will be irreversible.

- The type and quantity of treatment residuals that will remain following treatment.

6.5 Short-Term Effectiveness

The short-term effectiveness of each RAA was evaluated relative to its effect on human health and the environment during implementation of the remedial action. Potential threats to human health and the environment associated with the handling, treatment, or transportation of hazardous substances were considered. The short-term effectiveness assessment was based on four key factors:

- Short-term risks that might be posed to the community during implementation an alternative.
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures.
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.
- Time until remedial response objectives are achieved.

6.6 Implementability

Implementability considerations include the technical and administrative feasibility of each RAA and the availability of various materials and services required for implementation. The following factors were considered during the implementability analysis:

- Technical Feasibility: The relative ease of implementing or completing an action based on site-specific constraints, including the use of established technologies, such as:
  - Ability to construct the alternative (constructability).
  - Operational reliability, or the ability of a technology to meet specified process efficiencies or performance goals.

- Ability to undertake future remedial actions that may be required.
- Ability to monitor the effectiveness of the remedy.

- Administrative Feasibility: The ability and time required to obtain necessary approvals and permits from regulatory agencies.

- Availability of Services and Materials: The availability of the technologies, materials, or services required to implement an alternative, including:

  - Available capacity and location of needed treatment, storage, and disposal services.
  - Availability of equipment, specialists, and provisions for additional resources.
  - Timing of the availability of prospective technologies under consideration.
  - Availability of services and materials, plus the potential for obtaining bids that are cost competitive.

6.7 Cost

For each RAA, a detailed cost estimate was developed based on conceptual engineering and analyses. Unit prices were based on published construction cost data, quotes from vendors and contractors, and/or engineering judgment. Costs are expressed in terms of 1998 dollars. In order to allow the costs of the remedial alternatives to be compared on the basis of a single figure, the net present worth (NPW) value of all capital and annual costs was determined for each RAA for each site. The USEPA CERCLA RI/FS Guidance Document (USEPA, 1988) recommends that a five percent discount rate be used in present worth analyses.

Cost estimates were prepared to assist in the evaluation of alternatives using currently available information. In accordance with the USEPA CERCLA RI/FS Guidance Document (USEPA, 1988),

the costs were developed as order-of-magnitude estimates with an intended accuracy range of +50 percent to -30 percent. Final project costs will depend on actual local labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule, and other variable factors. As a result, the actual final project costs probably will vary from the cost estimates presented herein. This variance must be considered in evaluating project funding needs. The cost estimate of the selected remedial actions will be refined in the design phase of this project.

The cost analysis of remedial alternatives consisted of three principal elements:

- Capital Costs: Capital costs consist of direct (construction) and indirect (non-construction and overhead) costs. Direct costs include costs for equipment; labor and materials incurred to develop, construct, and implement a remedial action; and the operation and maintenance costs for the first year after the action is completed. Indirect costs are expenditures for services that are not actually a part of construction, but are required to implement a remedial alternative. In this FS, indirect costs include the following items:

  - Engineering and Design

  - Preconstruction Submittals
    - Work Plans
    - Health and Safety
    - License, Legal Fees, and Permits
    - Erosion and Sediment Control Plans
    - Quality Control Plans

  - Contract Administration

  - Post Construction Submittals

Additionally, a contingency allowance was included in the cost estimate to account for factors that cannot be anticipated or estimated. Contingencies address costs associated with constructing a given

project, such as general economic conditions at the time of bidding, adverse weather condition, strikes by material suppliers, inherent uncertainties in characterizing wastes or waste volumes, and regulatory or policy changes that may affect the FS assumptions.

- Annual Costs: Annual costs refer to post-construction costs necessary to ensure the continued effectiveness of a remedial action. They typically refer to long-term power and material costs (such as the operational costs of a treatment facility), equipment replacement costs, and long-term monitoring costs.

- Present Worth Analysis: This assessment is used to evaluate the capital and annual costs of a RAA on a present worth basis. Present worth analysis is a method of comparing expenditures for various alternatives that occur over different time periods. By discounting all costs to a common base year, the costs for different remedial action alternatives can be compared on the basis of a single cost figure for each alternative. The total NPW for a given alternative is equal to the full amount of all costs incurred until the end of the firs year of operation (capital costs), plus the series of expenditures in following years reduced by the appropriate future value/present worth discount factors. This analysis allows the comparison of remedial alternatives on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover costs associated with the remedial action over its planned life. A maximum 30-year performance period is assumed for present worth analyses. The discount rate represents the anticipated difference between the rate of inflation and investment return. A five percent discount was used in the present worth analysis.

6.8 State Acceptance

This criterion reflects the statutory requirement to provide for substantial and meaningful state involvement. State (Commonwealth) comments will be addressed in the development of this FS and in the Proposed Remedial Action Plan (PRAP) and Record of Decision (ROD) reports. State (Commonwealth) acceptance of the selected remedies for Site 2, Site 8, Site 18, and SSA 14 will be evaluated at the PRAP stage. Therefore, this criterion will not be addressed any further in this FS report.

6.9 Community Acceptance

Community acceptance is a modifying criterion addressing the issues and concerns the public may have regarding each alternative. Community involvement will have a significant impact on implementation of the selected alternative. Community acceptance will be evaluated during the PRAP stage of the remedial process. Therefore, this criterion will not be addressed any further in this FS report.

7.0 DETAILED EVALUATION AND COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

This section of the FS presents the detailed evaluation of each RAA with respect to the threshold and primary balancing criteria described in Section 6.0. A comparison analysis of the RAAs for each site/SSA is presented in Section 7.2.

7.1 Detailed Evaluation of the Remedial Action Alternatives

Due to the similarities of the RAAs developed for each site/SSA, the detailed evaluation of the RAAs for all three sites/SSAs will be discussed in the same subsections below. It should be noted that the same alternative may not be implemented at all three sites/SSAs. The costs for these alternatives are estimated separately for each site/SSA. However, if the same alternative for the sites/SSA is selected, costs may be saved due to economy of scale.

7.1.1 RAA 1: No Action

The No Action RAA applies to Sites 2, 8, and 18, and SSA 14. The detailed evaluation of this RAA would be the same for all three sites/SSA; therefore, it will only be presented once.

7.1.1.1 Overall Protection of Human Health and the Environment

Since no remedial actions will be implemented under this RAA, this alternative will not be protective of human health or the environment for Site 2, Site 8 or SSA 14. There are no unacceptable risks identified at Site 18. Therefore, this alternative is protective of human health and the environment at Site 18.

Although no action will be taken as part of this alterative, land use restrictions are already in place at Site 2. The area around Site 2 has been included as part of the Chesapeake Bay Program to re-establish the riparian buffer zone for Felgates Creek. As part of this program, trees have been planted at Site 2. Commercial/industrial or residential development will be restricted at Site 2 due to this program.

7.1.1.2 Compliance With ARARs

There are no chemical-specific ARARs for the soil COCs at Site 2 (PAHs, Aroclor-1254, cobalt, and mercury), Site 8 (carcinogenic PAHs, Aroclor-1260, RDX, lead, mercury, and zinc) and SSA 14 (HMX, copper, lead, mercury, zinc). There are no COCs for Site 18. However, with respect to Sites 2 and 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 1 will not comply with this TBC (for residential use or ecological protection) because PCBs will remain in place at the sites/SSA.

No location- or action-specific ARARs apply to RAA 1.

7.1.1.3 Long-Term Effectiveness and Permanence

The No Action RAA would not achieve long-term effectiveness at Sites 2 and 8 and SSA 14 because the soil contamination will be left in place. This alternative does not provide long-term protectiveness of human health and the environment from exposure to the COCs in soil. Natural attenuation (natural in situ degradation of organic contaminants) may occur over time but the progress will be unmonitored and, therefore, unproven at Site 2, Site 8, or SSA 14. Under this RAA, there will also be no warning of a release from a potential source of contamination or indication of migration of contaminants. Since contaminants will remain at the sites/SSA under this RAA, five year reviews will be required to evaluate the effectiveness of this RAA. This alternative provides long-term effectiveness and permanence for Site 18.

7.1.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The No Action RAA will not include any reduction of toxicity, mobility, or volume of the contaminants through treatment. Natural attenuation processes may reduce the toxicity of the organic contaminants. The No Action RAA offers no means to monitor the effectiveness of natural attenuation.

7.1.1.5 Short-Term Effectiveness

The No Action RAA will have no short-term effects on human health and the environment associated with the handling, treatment, or transportation of hazardous substances because this alternative includes no remedial actions. However, the potential risks to human health and the environment that were calculated in the RI for current uses of the site would still exist.

7.1.1.6 Implementability

Because this alternative does not include any remedial actions or institutional controls, there are no implementability concerns associated with this RAA.

7.1.1.7 Cost

There are no costs associated with the No Action RAA for Site 2, Site 8, Site 18 or SSA 14.

7.1.2 RAA 2: No Action With Monitoring/ Land Use Restrictions With Monitoring

The Land Use Restrictions With Monitoring RAA applies to Site 2; the No Action With Monitoring RAA applies to Site 8 and SSA 14. Due to the similarities between these two RAAs, they can be evaluated together.

7.1.2.1 Overall Protection of Human Health and the Environment

Contaminants will be left in place at Sites 2 and 8 and SSA 14. However, as described under RAA1, land use restrictions designed to re-establish the riparian buffer zones of Felgates Creek through the Chesapeake Bay Program will limit the land use at Site 2. While this will limit commercial, industrial, or residential development of Site 2, it will not prevent human or environmental contact with the contaminated surface soil.

The monitoring program implemented under RAA 2 for Sites 2 and 8 and SSA 14 will provide some protection to human health and the environment by being able to detect releases or contaminant migration.

7.1.2.2 Compliance With ARARs

There are no chemical-specific ARARs for the soil COCs at Site 2 (PAHs, Aroclor-1254, cobalt, and mercury), Site 8 (carcinogenic PAHs, Aroclor-1260, RDX, lead, mercury, and zinc) and SSA 14 (HMX, copper, lead, mercury, zinc) for soil remediation. However, with respect to Sites 2 and 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 2 will not comply with this TBC (for residential use or ecological protection) because PCBs will remain in place.

No location- or action-specific ARARs apply to RAA 2.

7.1.2.3 Long-Term Effectiveness and Permanence

The long-term monitoring program included under RAA 2 will be effective and permanent if the monitoring is conducted on a regular basis. A review of the sites/SSA will be required every five years under this RAA since contaminants will remain at the sites/SSA.

7.1.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA 2 will not include any reduction of toxicity, mobility, or volume of the contaminants through treatment. Natural attenuation processes may reduce the toxicity of the organic contaminants. Reduction in the COC concentrations and/or migration of the COCs will be detected via the long-term monitoring program.

7.1.2.5 Short-Term Effectiveness

Implementation of the monitoring program at each of the sites/SSA will not increase risks to the surrounding community or the environment. Minimal risks may be introduced to site workers as they conduct the sampling activities.

7.1.2.6 Implementability

RAA 2 is easily implemented at all of the sites/SSA. Collection of soil, surface water, or sediment samples is easily implementable. Sampling equipment is readily available.

7.1.2.7 Cost

The capital and O&M costs and the NPW of RAA 2 for each of the sites/SSA are presented below.

Site 2

The estimated capital cost for RAA 2 is $95,000. It is anticipated that the monitoring program will be implemented for 30 years under this RAA. The annual O&M cost associated with the monitoring program is estimated to be approximately $50,000. The NPW for RAA 2 is approximately $880,000. The cost estimate for this RAA is presented in Appendix E.1.

Site 8

The estimated capital cost for RAA 2 is $67,000. The annual O&M cost associated with the monitoring program is estimated to be approximately $27,000. The NPW for RAA 2 is approximately $490,000. The cost estimate for this RAA is presented in Appendix E.2.

SSA 14

The estimated capital cost for RAA 2 is $54,000. The annual O&M cost associated with the monitoring program is estimated to be approximately $16,000. The NPW for RAA 2 is approximately $300,000. The cost estimate for this RAA is presented in Appendix E.3.

7.1.3 RAA 3: Soil Washing

RAA 3 applies to Sites 2 and 8 and SSA 14. The detailed evaluation of this RAA would be the same for all three sites/SSA, therefore, it will only be presented once.

7.1.3.1 Overall Protection of Human Health and the Environment

RAA 3 will provide protection to human health and the environment through treatment at Site 2, Site 8, and SSA 14. Organic and inorganic contaminants will be separated from the soils by agitating the soil and adding solvents. A liquid waste that is concentrated with contaminants will be produced and disposed off site. Therefore, RAA 3 will be protective of human health and the environment since the soil COCs will be excavated and treated.

7.1.3.2 Compliance with ARARs

There are no chemical-specific ARARs associated with the soil COCs at Site 2, Site 8, and SSA 14. However, with respect to Sites 2 and 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 3 will comply with this TBC since soil with PCB concentrations exceeding the TSCA action level for residential soil will be excavated and treated on site.

Action-specific ARARs for hazardous waste disposal apply to the inorganic contaminated sludge resulting from the soil washing process. This RAA will be able to comply with the action-specific ARARs.

Location-specific ARARs regarding wetlands apply to this alternative because excavation activities may disturb existing wetlands (all three sites/SSA). The alternative will be implemented so that it complies with the action- and location-specific ARARs.

7.1.3.3 Long-Term Effectiveness and Permanence

RAA 3 will be an effective and permanent solution for all three sites/SSA. The contaminated soil will be excavated and treated via soil washing thereby removing the soil COCs.

A five year review will not be required for this RAA since the soil COCs exceeding the RLs will be removed from the sites/SSA.

7.1.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under RAA 3, the reduction of toxicity, mobility, or volume of contaminants through treatment will be accomplished. The primary component of RAA 3 is treatment via soil washing. As such, the soil COCs exceeding the RLs will be excavated from the sites/SSA and treated on site.

7.1.3.5 Short-Term Effectiveness

Because this ~~RAA includes~~ earthmoving activities and on-site remediation, the potential risk to the surrounding community and construction workers may increase due to increased potential for direct contact with contaminated soil. Further, the potential risk of affecting wetland areas may increase due to the earthmoving activities. However, the alternative can be implemented so that these risks are minimized or eliminated.

7.1.3.6 Implementability

Soil excavation activities are routine construction operations that require standard construction equipment. Soil washing is easily implementable, although vendors supplying the technology may not be readily available. Restoration of the site would require routine construction operations. Provided that soil washing vendors are available, RAA 3 is easily implementable.

7.1.3.7 Costs

The capital and O&M costs and the NPW of RAA 3 for each of the sites/SSA are presented below.

Site 2

The estimated capital cost for RAA 3 is $1.45 million. No O&M costs are anticipated for this alternative. Therefore, the NPW for Site 2 RAA3 is the same as the capital cost: $1.45 million. The cost estimate is presented in Appendix E.1.

Site 8

The estimated capital cost for RAA 3 is $295,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for Site 8 RAA 3 is $295,000. The cost estimate is presented in Appendix E.2.

SSA 14

The estimated capital costs for RAA 3 is $340,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for SSA 14 RAA 3 is $340,000. The cost estimate is presented in Appendix E.3.

7.1.4 RAA 4: On-Site Biological Treatment

RAA 4 applies to Sites 2 and 8 and SSA 14. The detailed evaluation of this RAA would be the same for all three sites/SSA, therefore, it will only be presented once.

7.1.4.1 Overall Protection of Human Health and the Environment

RAA 4 will provide protection to human health and the environment through treatment at Site 2, Site 8, and SSA 14. Organic contaminants will be sequentially treated through a bioslurry and a landfarming process. Soil will be loaded into the bioslurry reactor. Organic contaminants will be broken down by microbes, and inorganic contaminants will be separated from the soils during the bioslurry process through leaching. A liquid waste that is concentrated with inorganics will be produced and disposed off site. The remaining soil will be treated through landfarming to complete the treatment of the organic contaminants. The treated soil could be used as backfill elsewhere on the site. Due to the duration of treatment, however, clean backfill and topsoil will be placed at the excavated areas to restore the site. Therefore, RAA 4 will be protective of human health and the environment since the soil COCs will be excavated and treated.

7.1.4.2 Compliance with ARARs

There are no chemical-specific ARARs associated with the soil COCs at Site 2, Site 8, and SSA 14. However, with respect to Sites 2 and 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 4 will comply with this TBC since soil with PCB concentrations exceeding the TSCA action level for residential soil will be excavated and treated on site.

Action-specific ARARs for hazardous waste disposal apply to the inorganic contaminated sludge resulting from the soil washing process. This RAA will be able to comply with the action-specific ARARs.

Location-specific ARARs regarding wetlands apply to this alternative because excavation activities may disturb existing wetlands (all three sites/SSA). The alternative will be implemented so that the action- and location-specific ARARs will be complied with.

7.1.4.3 Long-Term Effectiveness and Permanence

RAA 4 will be an effective and permanent remedy for all three sites/SSA. The contaminated soil will be excavated and treated via biological treatment, thereby removing the soil COCs.

A five year review will not be required for this RAA since the soil COCs exceeding the RLs will be removed from the sites/SSA.

7.1.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under RAA 4, the reduction of toxicity, mobility, or volume of contaminants through treatment will be accomplished. The primary component of RAA 4 is treatment via bioslurry and landfarming. As such, the soil COCs exceeding the RLs will be excavated from the sites/SSA and treated on site.

7.1.4.5 Short-Term Effectiveness

Because this RAA includes earthmoving activities and on-site remediation, the potential risk to the surrounding community and construction workers may increase due to increased potential for direct contact with contaminated soil. Further, the potential risk of affecting wetland areas may increase due to the earthmoving activities. However, the alternative can be implemented so that these risks are minimized or eliminated.

7.1.4.6 Implementability

Soil excavation activities are routine construction operations that require standard construction equipment. Soil leaching is easily implementable although vendors supplying the technology may not be readily available. Biological treatment is a proven and easily implemented technology. However, the combination of COCs at Site 2, Site 8, and SSA 14 may make biological treatment more difficult. The structures for the landfarming and bioslurry treatments are already in place from former remediation activities at WPNSTA Yorktown. Restoration of the site would require routine construction operations. Provided that vendors of the soil leaching and biological technologies are available, RAA 4 is easily implementable.

7.1.4.7 Costs

Site 2

The estimated capital cost for RAA 4 is $520,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for Site 2 RAA 4 is $520,000. The cost estimate is presented in Appendix E.1.

Site 8

The estimated capital cost for RAA 4 is $235,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for Site 8 RAA 4 is $235,000. The cost estimate is presented in Appendix E.2.

SSA 14

The estimated capital cost for RAA 4 is $240,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for SSA 14 RAA4 is $240,000. The cost estimate is presented in Appendix E.3.

7.1.5 RAA 5: Off-Site Incineration

RAA 5 applies to Sites 2 and 8 and SSA 14. The detailed evaluation of this RAA would be the same for all three sites/SSA, therefore, it will only be presented once.

7.1.5.1 Overall Protection of Human Health and the Environment

RAA 5 will provide protection of human health and the environment for Site 2, Site 8 and SSA 14. The contaminated soil will be removed from the sites/SSA and treated off site. Therefore, RAA 5 will provide a significant reduction in risks to human health and the environment.

7.1.5.2 Compliance with ARARs

There are no chemical-specific ARARs associated with the soil COCs at Site 2, Site 8, and SSA 14. However, with respect to Sites 2 and 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 5 will comply with this TBC since soil with PCB concentrations exceeding the TSCA action level for residential soil will be excavated and treated on site.

The off-site incineration facility would have to be permitted to take the contaminated soils from the sites/SSA. Action-specific ARARs regarding transportation of hazardous waste may apply to this RAA. This RAA will be able to comply with the action-specific ARARs.

Location-specific ARARs regarding wetlands apply to this alternative because excavation activities may disturb existing wetlands (all three sites/SSA). The alternative will be implemented so that it will comply with the action- and location-specific ARARs.

7.1.5.3 Long-Term Effectiveness and Permanence

RAA 5 will be an effective and permanent solution for Site 2, Site 8, and SSA 14. The contaminated soil will be removed from the site and treated off site.

A five year review will not be required for this RAA since the soil COCs exceeding the RLs will be removed from the sites/SSA.

7.1.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under RAA 5, the reduction of toxicity, mobility, or volume of contaminants through treatment will be accomplished. The primary component of RAA 5 is treatment via incineration. As such, the soil COCs exceeding the RLs will be excavated from the sites/SSA and treated off site.

7.1.5.5 Short-Term Effectiveness

Because this RAA includes earthmoving activities, the potential risk to the surrounding community and construction workers may increase due to increased potential for direct contact with contaminated soil during the excavation and transportation activities. Further, the potential risk of affecting wetland areas may increase due to the earthmoving activities. However, the alternative can be implemented so that these risks are minimized or eliminated.

7.1.5.6 Implementability

Soil excavation activities are routine construction operations that require standard construction equipment. Incineration is a proven technology. However, it may be difficult to find a facility that is permitted for all of the COCs at Site 2, Site 8, and SSA 14 or that is available at the time of remediation. Restoration of the site requires clean backfill and topsoil which is readily available and easily placed. Provided that an incineration facility is available, this RAA is easy to implement.

7.1.5.7 Costs

Site 2

The estimated capital cost of RAA 5 is $2.12 million. No O&M costs are anticipated for this alternative. Therefore, the NPW for Site 2 RAA 5 is estimated to be $2.12 million. The cost estimate is provided in Appendix E.1.

Site 8

The estimated capital cost of RAA 5 is $210,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for Site 8 RAA 5 is estimated to be $210,000. The cost estimate is provided in Appendix E.2.

SSA 14

The estimated capital cost of RAA 5 is $315,000. No O&M costs are anticipated for this alternative. Therefore, the NPW for SSA 14 RAA 5 is estimated to be $315,000. The cost estimate is provided in Appendix E.3.

7.1.6 RAA 6: Off-Site Landfill Disposal

RAA 6 applies to Sites 2 and 8 and SSA 14. The detailed evaluation of this RAA would be the same for all three sites/SSA, therefore, it will only be presented once.

7.1.6.1 Overall Protection of Human Health and the Environment

RAA 6 will provide protection of human health and the environment for Site 2, Site 8, and SSA 14. The contaminated soil will be removed from the sites/SSA and disposed off site. Therefore, RAA 6 will provide a significant reduction in risks to human health and the environment.

7.1.6.2 Compliance with ARARs

There are no chemical-specific ARARs associated with the soil COCs at Site 2, Site 8, and SSA 14. However, with respect to Sites 2 and 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 6 will comply with this TBC since soil with PCB concentrations exceeding the TSCA action level for residential soil will be excavated and disposed off site.

The off-site landfill facility would have to be permitted to take the contaminated soils from the site (including PCB wastes from Sites 2 and 8). If soils contaminated with inorganics do not pass TCLP standards, the soil will have to be solidified/stabilized prior to landfilling. Action-specific ARARs regarding transportation of hazardous waste may apply to this RAA. This RAA will be able to comply with the action-specific ARARs.

Location-specific ARARs regarding wetlands apply to this alternative because excavation activities may disturb existing wetlands (all three sites/SSA). The alternative will be implemented so that it complies with the action- and location-specific ARARs will be complied with.

7.1.6.3 Long-Term Effectiveness and Permanence

RAA 6 will be an effective and permanent solution for Site 2, Site 8, and SSA 14. The contaminated soil will be removed from the site and disposed off site.

A five year review will not be required for this RAA since the soil COCs exceeding the RLs will be removed from the sites/SSA.

7.1.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA 6 will not provide a reduction of toxicity, mobility, or volume of contaminants through treatment. No treatment technologies are included under this alternative.

7.1.6.5 Short-Term Effectiveness

Because this RAA includes earthmoving activities, the potential risk to the surrounding community and construction workers may increase due to increased potential for direct contact with contaminated soil during the excavation and transportation activities. Further, the potential risk of affecting wetland areas at all three sites/SSA may increase due to the earthmoving activities. However, the alternative can be implemented so that these risks are minimized or eliminated.

7.1.6.6 Implementability

Soil excavation activities are routine construction operations that require standard construction equipment. It may be difficult to find a landfill facility that is permitted for all of the COCs at Site 2, Site 8, and SSA 14. Pretreatment (stabilization) of the soil may be required prior to landfilling. Restoration of the sites/SSA requires clean backfill and topsoil which is readily available and easily placed. Provided that a landfill facility is available, this RAA is easy to implement.

7.1.6.7 Costs

Site 2

The estimated capital cost of RAA 6 (assuming nonhazardous disposal) is $320,000. The estimated capital cost assuming hazardous disposal is approximately $610,000. No O&M costs are anticipated for this alternative. Therefore, the NPWs for Site 2 RAA 6 are the same as the capital costs. The cost estimate is provided in Appendix E.1.

Site 8

The estimated capital cost of RAA 6 (assuming nonhazardous disposal) is $140,000. The estimated capital cost assuming hazardous disposal is approximately $150,000. No O&M costs are anticipated for this alternative. Therefore, the NPWs for Site 8 RAA 6 are the same as the capital costs. The cost estimate is provided in Appendix E.2.

SSA 14

The estimated capital cost of RAA 6 (assuming nonhazardous disposal) is $150,000. The estimated capital cost assuming hazardous disposal is approximately $175,000. No O&M costs are anticipated for this alternative. Therefore, the NPWs for SSA 14 RAA 6 are the same as the capital costs. The cost estimate is provided in Appendix E.3.

7.1.7 RAA 7: Capping and Drainage Diversion

RAA 7 applies to Site 8 and SSA 14 only. The detailed evaluation of this RAA would be the same for both site/SSA, therefore, it will only be presented once.

7.1.7.1 Overall Protection of Human Health and the Environment

RAA 7 will provide protection to human health and the environment through prevention of direct contact with contaminated surface soil at Site 8 and SSA 14. The contaminated areas will be covered with backfill and topsoil. Vegetation will be established and drainage pathways altered such that the caps will not erode. The cap will be maintained through inspection and repairs when necessary so contaminated soil will not be re-exposed.

7.1.7.2 Compliance With ARARs

There are no chemical-specific ARARs associated with the soil COCs at Site 8 and SSA 14. However, with respect to Site 8, TSCA recommends PCB action levels (a TBC) for industrial and residential use, or ecological protection for soils contaminated with PCBs. RAA 7 will not comply with this TBC since soil with PCB concentrations exceeding the TSCA action level for residential soil will remain at the site.

No action-specific ARARs are applicable to this RAA either at Site 8 or SSA 14.

Location-specific ARARs regarding wetlands apply to this alternative at Site 8 and SSA 14 because excavation activities may disturb existing wetlands. The alternative will be implemented so that it complies with the location-specific ARARs.

7.1.7.3 Long-Term Effectiveness and Permanence

RAA 7 will be an effective and permanent solution as long as the soil cover is properly maintained. The cover will be inspected on a regular basis and repaired when necessary. Risk to workers may increase if they are periodically exposed to contaminated soil during repairs.

Five year reviews will be required for this RAA since the soil COCs exceeding the RLs will not be removed from the site/SSA.

7.1.7.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAA 7 will not provide a reduction of toxicity, mobility, or volume of contaminants through treatment. No treatment technologies are included under this alternative.

7.1.7.5 Short-Term Effectiveness

Risk to construction workers may potentially increase if they come into contact with contaminated soil during installation of the soil cover.

7.1.7.6 Implementability

This alternative is easily implemented. Conventional construction equipment and operations are required to install the soil cover and divert the drainage. Because wetlands exist at both the site and the SSA, precautions will be taken to prevent impact from construction.

7.1.7.7 Costs

Site 8

The estimated capital cost for RAA 7 at Site 8 is approximately $140,000. O&M costs have been included for the routine inspection and maintenance of the soil cover. Therefore, the annual O&M for this alternative is estimated to be approximately $1,600. The NPW for RAA 7 is estimated to be approximately $160,000. Appendix E.2 presents the cost estimates for this alternative.

SSA 14

The estimated capital cost for RAA 7 at SSA 14 is approximately $130,000. O&M costs have been included for the routine inspection and maintenance of the soil cover. Therefore, the annual O&M for this alternative is estimated to be approximately $1,600. The NPW for RAA 7 is estimated to be approximately $155,000. Appendix E.3 presents the cost estimates for this alternative.

7.2 Comparative Analysis

This section of the FS presents a comparative analysis of the RAAs for each site/SSA. The purpose of this analysis is to identify the relative advantages and disadvantages of each RAA with respect to the detailed evaluation criteria. Again, because of the similarities between the alternatives for each site/SSA, the RAAs are discussed together. If there are differences in the comparative analysis for the sites/SSA, it will be explained in the text.

7.2.1 Overall Protectiveness of Human Health and the Environment

The treatment and disposal RAAs (RAAs 3, 4, 5, and 6) provide the most overall protection to human health and the environment since the soil COCs exceeding the RLs are removed from the sites/SSA. RAAs 5 (Off-Site Incineration) and 6 (Off-Site Landfill Disposal) may provide the most overall protection since the contaminated soil will be excavated and removed from the sites/SSA. One benefit that the on-site treatment RAAs have over the off-site treatments, though, is that there is no increased risks to the outside community due to transportation of the soil to off-site facilities. For Site 8 and SSA 14, RAA 7 (Capping and Drainage Diversion) is the next most protective alternative. Direct exposure to the contaminated soil is significantly reduced (with the exception of maintenance workers). However, potential risks remain if the soil cover is not properly maintained. RAA 2 (No Action With Monitoring) provides some protection in that migration or additional releases of contaminants would be detected and further action could be taken if necessary. RAA 1 (No Action) provides no protection to human health and the environment at Sites 2 and 8 and SSA14. However, at Site 18, RAA 1 adequately protects human health and the environment because no COCs were identified at the site.

7.2.2 Compliance With ARARs

All of the RAAs will comply with the ARARs that apply. RAAs 1, 2, and 7 do not comply with the TBC for PCB action levels (Sites 2 and 8) because PCBs will remain in place.

7.2.3 Long-Term Effectiveness and Permanence

RAAs 3, 4, and 5 are all equally effective and permanent solutions. The treatments are irreversible and the contaminants will be destroyed/removed. RAA 6 does not destroy the contaminants, but the contaminants will be permanently removed from the site and disposed of in a secure landfill preventing spread of the contaminants at the sites/SSA. RAA 7 (Soil Cover for Site 8 and SSA 14) is effective and permanent for preventing dermal contact with soil as long as the soil cover is maintained. However, because the contaminated soil will not be treated or removed from the site or SSA under RAA 7, there is a possibility of contaminants impacting groundwater, or being exposed by erosion. RAA 2 also provides no remediation of the contaminated soil, and therefore, is not an effective or permanent solution for the soil contamination. RAA 2 does provide monitoring to evaluate if the contaminants migrate or degrade. The long-term effectiveness and permanence of RAA 1 is unknown for Sites 2 and 8 and SSA 14. It is possible that organic contaminant concentrations may decrease due to natural attenuation, but there are no means of monitoring this under the No Action RAA. Because there are no COCs identified at Site 18, RAA 1 provides long-term effectiveness and permanence at this site.

7.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

RAAs 3, 4, and 5 provide reduction of toxicity, mobility, or volume of contaminants through treatment. Under RAA 5, the contaminated soil will be reduced to ash. The organic and volatile inorganic compounds will be destroyed. The non-volatile inorganic compounds will remain in the ash which will be disposed of in a secure landfill. The volume of the ash will be significantly less than the volume of the excavated soil. RAAs 3 and 4 will reduce the toxicity and/or volume of contaminants. The volume of the inorganic contaminated soil will be reduced through the soil washing (RAA 3) or leaching (RAA 4) process. The toxicity of the soil contaminants that are treated biologically (RAA 4) will be reduced via microbial destruction. RAAs 1, 2, 6, and 7 do not include treatment.

7.2.5 Short-Term Effectiveness

No additional short-term risks to the community will be incurred under RAAs 1 or 2 because they include no remedial action. However, human receptors and the environment at the sites/SSA continue to be at risk in the short term with no provisions for detecting increased risks under RAA 1. RAA 2 provides monitoring to protect human health and the environment against potential increased risks. RAAs 3, 4, 5, 6, and 7 pose short-term risks to workers during earth moving activities. RAAs 5 and 6 pose slightly less short-term risk to workers because the soil will be taken directly off site rather than exposing workers during on-site treatment as in RAAs 3 and 4. However, short-term risk to the community is greater for RAAs 5 and 6 because contaminated soil will be transported off site, increasing potential exposure risks.

7.2.6 Implementability

RAA 1 is the most easily implemented alternative because no action will be taken. RAA 7 (for Site 8 and SSA 14) is the next most easily implemented because conventional construction equipment and permitting is required. RAAs 5 and 6 are the next easily implemented from a technical standpoint, but they may require more administrative efforts due to manifesting and permitting. Also, facilities that will accept the contaminated soil from the sites/SSA may not be readily available. RAAs 3 and 4 are easily implemented but involve on-site treatment which could pose soil handling problems. However, RAAs 3 and 4 may be more easily implemented than RAAs 5 and 6 from an administrative standpoint.

7.2.7 Costs

The following is a summary of the estimated comparative costs for the RAAs for Sites 2, 8 and SSA 14.

7.2.7.1 Site 2 Costs

In terms of NPW, the No Action Alternative (RAA1) will be the least expensive to implement, followed by RAA 6 (Off-Site Disposal), RAA 4 (On-Site Biological Treatment), RAA 2

(Monitoring), RAA 3 (Soil Washing), and RAA 5 (Off-Site Incineration). The estimated NPW values are listed below in increasing order.

- RAA 1 $0
- RAA 6 $320,000 (nonhazardous) $610,000 (hazardous)
- RAA 4 $520,000
- RAA 2 $880,000
- RAA 3 $1,450,000
- RAA 5 $2,120,000

7.2.7.2 Site 8 Costs

In terms of NPW, the No Action Alternative (RAA1) will be the least expensive to implement, followed by RAA 6 (Off-Site Disposal), RAA 7 (Soil Cover), RAA 5 (Off-Site Incineration), RAA 4 (On-Site Biological Treatment), RAA 3 (Soil Washing), and RAA 2 (Monitoring). The estimated NPW values are listed below in increasing order.

- RAA 1 $0
- RAA 6 $140,000 (nonhazardous) $150,000 (hazardous)
- RAA 7 $160,000
- RAA 5 $210,000
- RAA 4 $235,000
- RAA 3 $295,000
- RAA 2 $490,000

7.2.7.3 Site 18 Costs

The No Action alternative (RAA 1) is the only alternative being considered for Site 18. There is no cost associated with this alternative (NPW = $0).

7.2.7.4 SSA 14 Costs

In terms of NPW, the No Action Alternative (RAA1) will be the least expensive to implement, followed by RAA 6 (Off-Site Disposal), RAA 7 (Soil Cover), RAA 4 (On-Site Biological Treatment), and RAA 2 (Monitoring), RAA 5 (Off-Site Incineration), and RAA 3 (Soil Washing). The estimated NPW values are listed below in increasing order.

- RAA 1 $0
- RAA 6 $150,000 (nonhazardous) $175,000 (hazardous)
- RAA 7 $155,000
- RAA 4 $240,000
- RAA 2 $300,000
- RAA 5 $315,000
- RAA 3 $340,000

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APPENDIX A
HUMAN HEALTH RISK GOALS AND ECOLOGICAL MODELS

HUMAN HEALTH RISK GOALS

FUTURE COMMERCIAL/INDUSTRIAL WORKER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 2
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	5E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	9125	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	25	
EF = exposure frequency, days/year	250	
IR = ingestion rate, mg/day	50	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.032	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	5.00E-06	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	33.27	--
Benzo(a)pyrene	5.00E-06	--	0.10	7.30E+00	--	1.46E+01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	3.33	--
Benzo(b)fluoranthene	5.00E-06	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	33.27	--
Benzo(k)fluoranthene	5.00E-06	--	0.10	7.30E-02	--	1.46E-01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	333	--
Chrysene	5.00E-06	--	0.10	7.30E-03	--	1.46E-02	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	3,327	--
benzo(a,h)anthracene	5.00E-06	--	0.10	7.30E+00	--	1.46E+01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	3.33	--
eno(1,2,3-cd)pyrene	5.00E-06	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	33.27	--
rbazole	5.00E-06	--	0.10	2.00E-02	--	4.00E-02	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	1,214	--
PCBs:													
Aroclor-1254	5.00E-06	--	0.06	2.00E+00	--	2.22E+00	--	8.74E-08	3.56E-08	2.45E-07	9.96E-08	19.70	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	8.74E-08	2.96E-07	2.45E-07	8.30E-07	--	37
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	3,052,569
Antimony	--	1.0	0.010	--	4.00E-04	--	8.00E-05	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	1,221
Arsenic	5.00E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	8.74E-08	1.90E-08	2.45E-07	5.31E-08	31.06	998
Cadmium	--	1.0	0.010	--	1.00E-02	--	2.50E-04	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	11,008
Copper	--	1.0	0.010	--	4.00E-02	--	2.40E-02	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	146,909
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	915,771
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	39,895
Mercury	--	1.0	0.010	--	--	--	--	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	--
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	244

FUTURE RESIDENTIAL ADULT
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 2
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	5E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	8760	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	24	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	100	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	4.67	--
Benzo(a)pyrene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.47	--
Benzo(b)fluoranthene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	4.67	--
Benzo(k)fluoranthene	5.0E-06	--	0.10	7.30E-02	--	1.46E-01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	47	--
Chrysene	5.0E-06	--	0.10	7.30E-03	--	1.46E-02	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	467	--
Dibenzo(a,h)anthracene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.47	--
ieno(1,2,3-cd)pyrene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	4.67	--
bazole	5.0E-06	--	0.10	2.00E-02	--	4.00E-02	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	171	--
ds:													
Aroclor-1254	5.0E-06	--	0.06	2.00E+00	--	2.22E+00	--	4.70E-07	2.99E-07	1.37E-06	8.71E-07	3.12	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	4.70E-07	2.49E-06	1.37E-06	7.26E-06	--	4
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	477,124
Antimony	--	1.0	0.010	--	4.00E-04	--	8.00E-05	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	191
Arsenic	5.0E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	4.70E-07	1.59E-07	1.37E-06	4.65E-07	5.23	161
Cadmium	--	1.0	0.010	--	1.00E-02	--	2.50E-04	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	1,393
Copper	--	1.0	0.010	--	4.00E-02	--	2.40E-02	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	24,816
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	143,137
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	5,381
Mercury	--	1.0	0.010	--	--	--	--	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	--
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	38

FUTURE RESIDENTIAL CHILD
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 2
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KTOWN, VIRGINIA

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Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	5E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	2190	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	6	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	200	
BW = body weight, kg	15	
SA = skin surface area available for contact, cm2	2006	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	4.46	--
Benzo(a)pyrene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.45	--
Benzo(b)fluoranthene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	4.46	--
Benzo(k)fluoranthene	5.0E-06	--	0.10	7.30E-02	--	1.46E-01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	45	--
Chrysene	5.0E-06	--	0.10	7.30E-03	--	1.46E-02	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	446	--
Dibenzo(a,h)anthracene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.45	--
deno(1,2,3-cd)pyrene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	4.46	--
bazole	5.0E-06	--	0.10	2.00E-02	--	4.00E-02	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	163	--
ds:													
Aroclor-1254	5.0E-06	--	0.06	2.00E+00	--	2.22E+00	--	1.10E-06	1.32E-07	1.28E-05	1.54E-06	2.01	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	1.10E-06	1.10E-06	1.28E-05	1.28E-05	--	2
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	71,085
Antimony	--	1.0	0.010	--	4.00E-04	--	8.00E-05	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	28
Arsenic	5.0E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	1.10E-06	7.03E-08	1.28E-05	8.21E-07	2.85	22
Cadmium	--	1.0	0.010	--	1.00E-02	--	2.50E-04	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	434
Copper	--	1.0	0.010	--	4.00E-02	--	2.40E-02	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	3,027
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	21,325
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	1,284
Mercury	--	1.0	0.010	--	--	--	--	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	--
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	6

CURRENT ADULT TRESPASSER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 2
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	5E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	10950	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	30	
EF = exposure frequency, days/year	52	
IR = ingestion rate, mg/day	100	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	30	--
Benzo(a)pyrene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	3.0	--
Benzo(b)fluoranthene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	30	--
Benzo(k)fluoranthene	5.0E-06	--	0.10	7.30E-02	--	1.46E-01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	300	--
Chrysene	5.0E-06	--	0.10	7.30E-03	--	1.46E-02	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	2,997	--
benzo(a,h)anthracene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	3.0	--
eno(1,2,3-cd)pyrene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	30	--
arbazole	5.0E-06	--	0.10	2.00E-02	--	4.00E-02	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	1,094	--
PCBs:													
Aroclor-1254	5.0E-06	--	0.06	2.00E+00	--	2.22E+00	--	4.36E-08	5.55E-08	1.02E-07	1.29E-07	24	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	4.36E-08	4.62E-07	1.02E-07	1.08E-06	--	32
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	4,770,351
Antimony	--	1.0	0.010	--	4.00E-04	--	8.00E-05	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	1,908
Arsenic	5.0E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	4.36E-08	2.96E-08	1.02E-07	6.90E-08	45	1,720
Cadmium	--	1.0	0.010	--	1.00E-02	--	2.50E-04	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	10,366
Copper	--	1.0	0.010	--	4.00E-02	--	2.40E-02	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	290,451
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	1,431,105
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	43,133
Mercury	--	1.0	0.010	--	--	--	--	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	--
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	382

CURRENT ADOLESCENT TRESPASSER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 2
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	5E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	3285	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	9	
EF = exposure frequency, days/year	52	
IR = ingestion rate, mg/day	100	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	37	
SA = skin surface area available for contact, cm2	3925	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	67	--
Benzo(a)pyrene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	6.7	--
Benzo(b)fluoranthene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	67	--
Benzo(k)fluoranthene	5.0E-06	--	0.10	7.30E-02	--	1.46E-01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	668	--
Chrysene	5.0E-06	--	0.10	7.30E-03	--	1.46E-02	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	6,684	--
benzo(a,h)anthracene	5.0E-06	--	0.10	7.30E+00	--	1.46E+01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	6.7	--
eno(1,2,3-cd)pyrene	5.0E-06	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	67	--
rbazole	5.0E-06	--	0.10	2.00E-02	--	4.00E-02	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	2,440	--
PCBs:													
Aroclor-1254	5.0E-06	--	0.06	2.00E+00	--	2.22E+00	--	2.48E-08	2.33E-08	1.93E-07	1.81E-07	49	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	2.48E-08	1.94E-07	1.93E-07	1.51E-06	--	22
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	2,909,933
Antimony	--	1.0	0.010	--	4.00E-04	--	8.00E-05	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	1,164
Arsenic	5.0E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	2.48E-08	1.24E-08	1.93E-07	9.67E-08	88	1,019
Cadmium	--	1.0	0.010	--	1.00E-02	--	2.50E-04	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	7,135
Copper	--	1.0	0.010	--	4.00E-02	--	2.40E-02	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	164,678
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	872,980
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	28,857
Mercury	--	1.0	0.010	--	--	--	--	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	--
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	233

FUTURE COMMERCIAL/INDUSTRIAL WORKER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 8
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	3E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOn = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	9125	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	25	
EF = exposure frequency, days/year	250	
IR = ingestion rate, mg/day	50	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.032	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	3.33E-06	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	22.18	--
Benzo(a)pyrene	3.33E-06	--	0.10	7.30E+00	--	1.46E+01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	2.22	--
Benzo(b)fluoranthene	3.33E-06	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	22.18	--
Benzo(k)fluoranthene	3.33E-06	--	0.10	7.30E-02	--	1.46E-01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	222	--
Chrysene	3.33E-06	--	0.10	7.30E-03	--	1.46E-02	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	2,218	--
Benzo(a,h)anthracene	3.33E-06	--	0.10	7.30E+00	--	1.46E+01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	2.22	--
Ideno(1,2,3-cd)pyrene	3.33E-06	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	22.18	--
Carbazole	3.33E-06	--	0.10	2.00E-02	--	4.00E-02	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	809	--
PCBs:													
Aroclor-1260	3.33E-06	--	0.06	2.00E+00	--	2.22E+00	--	8.74E-08	3.56E-08	2.45E-07	9.96E-08	13.14	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	8.74E-08	2.96E-07	2.45E-07	8.30E-07	--	37
RDX	3.33E-06	1.0	0.50	1.1E-01	3.00E-03	1.22E-01	2.70E-03	8.74E-08	2.96E-07	2.45E-07	8.30E-07	72.73	2,572
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	3,052,569
Arsenic	3.33E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	8.74E-08	1.90E-08	2.45E-07	5.31E-08	20.71	998
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	15,263
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	915,771
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	39,895
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	244

FUTURE RESIDENTIAL ADULT
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 8
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	3E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	8760	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	24	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	100	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	3.12	--
Benzo(a)pyrene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.31	--
Benzo(b)fluoranthene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	3.12	--
Benzo(k)fluoranthene	3.3E-06	--	0.10	7.30E-02	--	1.46E-01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	31	--
Chrysene	3.3E-06	--	0.10	7.30E-03	--	1.46E-02	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	312	--
Dibenzo(a,h)anthracene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.31	--
teno(1,2,3-cd)pyrene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	3.12	--
bazole	3.3E-06	--	0.10	2.00E-02	--	4.00E-02	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	114	--
ds:													
Aroclor-1260	3.3E-06	--	0.06	2.00E+00	--	2.22E+00	--	4.70E-07	2.99E-07	1.37E-06	8.71E-07	2.08	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	4.70E-07	2.49E-06	1.37E-06	7.26E-06	--	4
RDX	3.3E-06	1.0	0.50	1.1E-01	3.00E-03	1.22E-01	2.70E-03	4.70E-07	2.49E-06	1.37E-06	7.26E-06	9.37	318
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	477,124
Arsenic	3.3E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	4.70E-07	1.59E-07	1.37E-06	4.65E-07	3.49	161
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	2,386
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	143,137
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	5,381
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	38

FUTURE RESIDENTIAL CHILD
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 8
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	3E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	2190	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	6	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	200	
BW = body weight, kg	15	
SA = skin surface area available for contact, cm2	2006	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	2.97	--
Benzo(a)pyrene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.30	--
Benzo(b)fluoranthene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	2.97	--
Benzo(k)fluoranthene	3.3E-06	--	0.10	7.30E-02	--	1.46E-01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	30	--
Chrysene	3.3E-06	--	0.10	7.30E-03	--	1.46E-02	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	297	--
Dibenzo(a,h)anthracene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.30	--
›eno(1,2,3-cd)pyrene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	2.97	--
›azole	3.3E-06	--	0.10	2.00E-02	--	4.00E-02	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	109	--
›s:													
Aroclor-1260	3.3E-06	--	0.06	2.00E+00	--	2.22E+00	--	1.10E-06	1.32E-07	1.28E-05	1.54E-06	1.34	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	1.10E-06	1.10E-06	1.28E-05	1.28E-05	--	2
RDX	3.3E-06	1.0	0.50	1.1E-01	3.00E-03	1.22E-01	2.70E-03	1.10E-06	1.10E-06	1.28E-05	1.28E-05	13.08	111
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	71,085
Arsenic	3.3E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	1.10E-06	7.03E-08	1.28E-05	8.21E-07	1.90	22
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	355
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	21,325
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	1,284
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	6

CURRENT ADULT TRESPASSER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 8
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	3E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	10950	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	30	
EF = exposure frequency, days/year	52	
IR = ingestion rate, mg/day	100	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	19.98	--
Benzo(a)pyrene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	2.00	--
Benzo(b)fluoranthene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	19.98	--
Benzo(k)fluoranthene	3.3E-06	--	0.10	7.30E-02	--	1.46E-01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	200	--
Chrysene	3.3E-06	--	0.10	7.30E-03	--	1.46E-02	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	1,998	--
benzo(a,h)anthracene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	2.00	--
leno(1,2,3-cd)pyrene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	19.98	--
rbazole	3.3E-06	--	0.10	2.00E-02	--	4.00E-02	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	729	--
PCBs:													
Aroclor-1260	3.3E-06	--	0.06	2.00E+00	--	2.22E+00	--	4.36E-08	5.55E-08	1.02E-07	1.29E-07	15.84	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	4.36E-08	4.62E-07	1.02E-07	1.08E-06	--	32
RDX	3.3E-06	1.0	0.50	1.1E-01	3.00E-03	1.22E-01	2.70E-03	4.36E-08	4.62E-07	1.02E-07	1.08E-06	54.38	2,307
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	4,770,351
Arsenic	3.3E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	4.36E-08	2.96E-08	1.02E-07	6.90E-08	29.73	1,720
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	23,852
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	1,431,105
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	43,133
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	382

CURRENT ADOLESCENT TRESPASSER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SITE 8
VAL WEAPONS STATION YORKTOWN
:KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	3E-06	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	3285	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	9	
EF = exposure frequency, days/year	52	
IR = ingestion rate, mg/day	100	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	37	
SA = skin surface area available for contact, cm2	3925	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	44.56	--
Benzo(a)pyrene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	4.46	--
Benzo(b)fluoranthene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	44.56	--
Benzo(k)fluoranthene	3.3E-06	--	0.10	7.30E-02	--	1.46E-01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	446	--
Chrysene	3.3E-06	--	0.10	7.30E-03	--	1.46E-02	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	4,456	--
benzo(a,h)anthracene	3.3E-06	--	0.10	7.30E+00	--	1.46E+01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	4.46	--
eno(1,2,3-cd)pyrene	3.3E-06	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	44.56	--
arbazole	3.3E-06	--	0.10	2.00E-02	--	4.00E-02	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	1,626	--
PCBs:													
Aroclor-1260	3.3E-06	--	0.06	2.00E+00	--	2.22E+00	--	2.48E-08	2.33E-08	1.93E-07	1.81E-07	32.90	--
Nitramines:													
4-Amino-2,6-Dinitrotoluene	--	1.0	0.50	--	6.00E-05	--	3.60E-05	2.48E-08	1.94E-07	1.93E-07	1.51E-06	--	22
RDX	3.3E-06	1.0	0.50	1.1E-01	3.00E-03	1.22E-01	2.70E-03	2.48E-08	1.94E-07	1.93E-07	1.51E-06	125.92	1,603
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	2,909,933
Arsenic	3.3E-06	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	2.48E-08	1.24E-08	1.93E-07	9.67E-08	58.72	1,019
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	14,550
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	872,980
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	28,857
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	233

FUTURE ON-SITE ADULT RESIDENT
FUTURE BENEFICIAL USE SCENARIO
GROUNDWATER EXPOSURE ASSESSMENT- PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINING INGESTION AND DERMAL ROUTES OF EXPOSURE
E 8
'AL WEAPONS STATION YORKTOWN
RKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/([Ing + Derm][CSF])
RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)
Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where:	INPUTS
ICR = incremental cancer risk (unitless)	5.00E-06
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	8760
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	40
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	5300
ED = exposure duration (years)	24
BW = body weight (kg)	70
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-1	Dermally Adj. Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
Volatiles:													
1,1-Dichloroethene	5.00E-06	1.00E+00	1.60E-02	6.00E-01	6.00E-01	9.00E-03	9.00E-03	2.68E-05	4.55E-05	7.83E-05	1.33E-04	0.12	42.65
Chloroform	5.00E-06	1.00E+00	8.90E-03	6.10E-03	6.10E-03	1.00E-02	1.00E-02	2.68E-05	2.53E-05	7.83E-05	7.38E-05	15.72	65.74
Trichloroethene	5.00E-06	1.00E+00	2.30E-01	1.10E-02	1.38E-02	6.00E-03	4.80E-03	2.68E-05	6.54E-04	7.83E-05	1.91E-03	0.54	2.44
Nitramines:													
Amino-Dinitrotoluenes	--	1.00E+00	8.40E-04	--	--	6.00E-05	3.60E-05	2.68E-05	2.39E-06	7.83E-05	6.97E-06	--	0.67
RDX	5.00E-06	1.00E+00	8.40E-04	1.10E-01	1.10E-01	3.00E-03	3.00E-03	2.68E-05	2.39E-06	7.83E-05	6.97E-06	1.56	35.19
-Trinitrotoluene	5.00E-06	1.00E+00	8.40E-04	3.00E-02	4.05E-02	5.00E-04	3.70E-04	2.68E-05	2.39E-06	7.83E-05	6.97E-06	5.54	5.70
ganics:													
solved Arsenic	5.00E-06	1.00E+00	3.00E-03	1.5	1.58E+00	3.00E-04	2.85E-04	2.68E-05	8.53E-06	7.83E-05	2.49E-05	0.09	2.87
Dissolved Barium	--	1.00E+00	3.00E-03	--	--	7.00E-02	7.00E-02	2.68E-05	8.53E-06	7.83E-05	2.49E-05	--	678.49
Dissolved Thallium	--	1.00E+00	3.00E-03	--	--	8.00E-05	1.60E-05	2.68E-05	8.53E-06	7.83E-05	2.49E-05	--	0.39

FUTURE ON-SITE CHILD RESIDENT
FUTURE BENEFICIAL USE SCENARIO
GROUNDWATER EXPOSURE ASSESSMENT- PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINING INGESTION AND DERMAL ROUTES OF EXPOSURE
E 8
'AL WEAPONS STATION YORKTOWN
RKTOWN, VIRGINIA

RGOs from ingestion and dermal contact with groundwater are calculated as follows:

RGOc (mg/L) = ICR/([Ing + Derm][CSF])
RGOnc (mg/L) = HQ*RfD/(Ing + Derm)

Ing = IR*EF*ED/(ATc or ATnc*BW)
Derm = SA*EF*ET*PC*ED*CF/(ATc or ATnc*BW)

Where:	INPUTS
ICR = incremental cancer risk (unitless)	5.00E-06
HQ = hazard quotient (unitless)	1
RGOc = carcinogenic contaminant concentration in water (ug/L)	calculated
RGOnc = noncarcinogenic contaminant concentration in water (ug/L)	calculated
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	2190
CF = conversion factor (0.001 L/cm3)	0.001
CSF = cancer slope factor (mg/kg-day)-1	specific
RfD = reference dose (mg/kg-day)	specific
EF = exposure frequency (days/year)	40
IR = water ingestion rate (L/hour)	0.05
SA = skin surface area available for contact (cm2)	2006
ED = exposure duration (years)	6
BW = body weight (kg)	15
ET = exposure time (hours/day)	1
PC = permeability constant (cm/hr)	specific

Note: Inputs are scenario and site specific

Contaminant	ICR	HQ	Permeability Constant (cm/hr)	Slope Factor (mg/kg-day)-1	Dermally Adj. Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/L)	RGO Noncarc (mg/L)
Volatiles:													
1,1-Dichloroethene	5.00E-06	1.00E+00	1.60E-02	6.00E-01	6.00E-01	9.00E-03	9.00E-03	3.13E-05	2.01E-05	3.65E-04	2.34E-04	0.16	15.01
Chloroform	5.00E-06	1.00E+00	8.90E-03	6.10E-03	6.10E-03	1.00E-02	1.00E-02	3.13E-05	1.12E-05	3.65E-04	1.30E-04	19.29	20.17
Trichloroethene	5.00E-06	1.00E+00	2.30E-01	1.10E-02	1.38E-02	6.00E-03	4.80E-03	3.13E-05	2.89E-04	3.65E-04	3.37E-03	1.16	1.31
Nitramines:													
Amino-Dinitrotoluenes	--	1.00E+00	8.40E-04	--	--	6.00E-05	3.60E-05	3.13E-05	1.06E-06	3.65E-04	1.23E-05	--	0.16
RDX	5.00E-06	1.00E+00	8.40E-04	1.10E-01	1.10E-01	3.00E-03	3.00E-03	3.13E-05	1.06E-06	3.65E-04	1.23E-05	1.40	7.94
-Trinitrotoluene	5.00E-06	1.00E+00	8.40E-04	3.00E-02	4.05E-02	5.00E-04	3.70E-04	3.13E-05	1.06E-06	3.65E-04	1.23E-05	5.09	1.31
ganics:													
ssolved Arsenic	5.00E-06	1.00E+00	3.00E-03	1.5	1.58E+00	3.00E-04	2.85E-04	3.13E-05	3.77E-06	3.65E-04	4.40E-05	0.09	0.73
Dissolved Barium	--	1.00E+00	3.00E-03	--	--	7.00E-02	7.00E-02	3.13E-05	3.77E-06	3.65E-04	4.40E-05	--	171.04
Dissolved Thallium	--	1.00E+00	3.00E-03	--	--	8.00E-05	1.60E-05	3.13E-05	3.77E-06	3.65E-04	4.40E-05	--	0.14

FUTURE COMMERCIAL/INDUSTRIAL WORKER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SSA 14
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-05	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/k	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	9125	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	25	
EF = exposure frequency, days/year	250	
IR = ingestion rate, mg/day	50	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.032	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	66.53	--
Benzo(a)pyrene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	6.65	--
Benzo(b)fluoranthene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	66.53	--
Benzo(k)fluoranthene	1.00E-05	--	0.10	7.30E-02	--	1.46E-01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	665	--
Chrysene	1.00E-05	--	0.10	7.30E-03	--	1.46E-02	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	6,653	--
benzo(a,h)anthracene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	6.65	--
leno(1,2,3-cd)pyrene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	66.53	--
arbazole	1.00E-05	--	0.10	2.00E-02	--	4.00E-02	--	8.74E-08	5.93E-08	2.45E-07	1.66E-07	2,428	--
Nitramines:													
HMX	--	1.0	0.50	--	5.00E-02	--	2.50E-02	8.74E-08	2.96E-07	2.45E-07	8.30E-07	--	26,259
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	3,052,569
Arsenic	1.00E-05	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	8.74E-08	1.90E-08	2.45E-07	5.31E-08	62.12	998
Barium	--	1.0	0.010	--	7.00E-02	--	1.40E-02	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	213,680
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	15,263
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	915,771
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	39,895
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	244
Vanadium	--	1.0	0.010	--	7.00E-03	--	1.40E-03	8.74E-08	5.93E-09	2.45E-07	1.66E-08	--	21,368

FUTURE RESIDENTIAL ADULT
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SSA 14
VAL WEAPONS STATION YORKTOWN
RKTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-05	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/k	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	8760	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	24	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	100	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	9.35	--
Benzo(a)pyrene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.93	--
Benzo(b)fluoranthene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	9.35	--
Benzo(k)fluoranthene	1.00E-05	--	0.10	7.30E-02	--	1.46E-01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	93	--
Chrysene	1.00E-05	--	0.10	7.30E-03	--	1.46E-02	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	935	--
Dibenzo(a,h)anthracene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	0.93	--
deno(1,2,3-cd)pyrene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	9.35	--
rbazole	1.00E-05	--	0.10	2.00E-02	--	4.00E-02	--	4.70E-07	4.98E-07	1.37E-06	1.45E-06	341	--
amines:													
HMX	--	1.0	0.50	--	5.00E-02	--	2.50E-02	4.70E-07	2.49E-06	1.37E-06	7.26E-06	--	3,147
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	477,124
Arsenic	1.00E-05	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	4.70E-07	1.59E-07	1.37E-06	4.65E-07	10.46	161
Barium	--	1.0	0.010	--	7.00E-02	--	1.40E-02	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	33,399
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	2,386
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	143,137
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	5,381
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	38
Vanadium	--	1.0	0.010	--	7.00E-03	--	1.40E-03	4.70E-07	4.98E-08	1.37E-06	1.45E-07	--	3,340

FUTURE RESIDENTIAL CHILD
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SSA 14
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-05	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	2190	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	6	
EF = exposure frequency, days/year	350	
IR = ingestion rate, mg/day	200	
BW = body weight, kg	15	
SA = skin surface area available for contact, cm2	2006	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	8.92	--
Benzo(a)pyrene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.89	--
Benzo(b)fluoranthene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	8.92	--
Benzo(k)fluoranthene	1.00E-05	--	0.10	7.30E-02	--	1.46E-01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	89	--
Chrysene	1.00E-05	--	0.10	7.30E-03	--	1.46E-02	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	892	--
Dibenzo(a,h)anthracene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	0.89	--
eno(1,2,3-cd)pyrene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	8.92	--
bazole	1.00E-05	--	0.10	2.00E-02	--	4.00E-02	--	1.10E-06	2.20E-07	1.28E-05	2.56E-06	326	--
amines:													
HMX	--	1.0	0.50	--	5.00E-02	--	2.50E-02	1.10E-06	1.10E-06	1.28E-05	1.28E-05	--	1,301
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	71,085
Arsenic	1.00E-05	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	1.10E-06	7.03E-08	1.28E-05	8.21E-07	5.70	22
Barium	--	1.0	0.010	--	7.00E-02	--	1.40E-02	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	4,976
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	355
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	21,325
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	1,284
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	6
Vanadium	--	1.0	0.010	--	7.00E-03	--	1.40E-03	1.10E-06	2.20E-08	1.28E-05	2.56E-07	--	498

CURRENT ADULT TRESPASSER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SSA 14
VAL WEAPONS STATION YORKTOWN
RKTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-05	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	10950	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	CS	(chemical specific value)
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	30	
EF = exposure frequency, days/year	52	
IR = ingestion rate, mg/day	100	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	70	
SA = skin surface area available for contact, cm2	5300	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	Absorption Factor (unitless)	Slope Factor (mg/kg-day)-1	Reference Dose (mg/kg-day)	Dermally Adj. Slope Factor (mg/kg-day)-1	Derm. Adj. Ref. Dose (mg/kg-day)	Ingestion Dose Carc	Dermal Dose Carc	Ingestion Dose Noncarc	Dermal Dose Noncarc	RGO Carc (mg/kg)	RGO Noncarc (mg/kg)
Carcinogenic PAHs:													
Benzo(a)anthracene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	59.94	--
Benzo(a)pyrene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	5.99	--
Benzo(b)fluoranthene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	59.94	--
Benzo(k)fluoranthene	1.00E-05	--	0.10	7.30E-02	--	1.46E-01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	599	--
Chrysene	1.00E-05	--	0.10	7.30E-03	--	1.46E-02	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	5,994	--
ibenzo(a,h)anthracene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	5.99	--
leno(1,2,3-cd)pyrene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	59.94	--
arbazole	1.00E-05	--	0.10	2.00E-02	--	4.00E-02	--	4.36E-08	9.25E-08	1.02E-07	2.16E-07	2,188	--
Nitramines:													
HMX	--	1.0	0.50	--	5.00E-02	--	2.50E-02	4.36E-08	4.62E-07	1.02E-07	1.08E-06	--	22,133
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	4,770,351
Arsenic	1.00E-05	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	4.36E-08	2.96E-08	1.02E-07	6.90E-08	89.18	1,720
Barium	--	1.0	0.010	--	7.00E-02	--	1.40E-02	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	333,925
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	23,852
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	1,431,105
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	43,133
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	382
Vanadium	--	1.0	0.010	--	7.00E-03	--	1.40E-03	4.36E-08	9.25E-09	1.02E-07	2.16E-08	--	33,392

CURRENT ADOLESCENT TRESPASSER
SOIL EXPOSURE ASSESSMENT-PRELIMINARY REMEDIATION GOALS (PRGs)
COMBINED INGESTION AND DERMAL ROUTES OF EXPOSURE
SSA 14
VAL WEAPONS STATION YORKTOWN
KTOWN, VIRGINIA

RGOs from accidental ingestion and dermal contact with soil are calculated as follows:

*RGOc (mg/kg) = ICR/[(Ing *CSFo)+ (Derm*CSFd)]*
RGOnc (mg/kg) = HQ/[(Ing/RfDo) + (Derm/RfDd)]

Ing = IR*ED*EF*CF/ATc or ATnc*BW
Derm = SA*ED*EF*AF*ABS*CF/ATc or ATnc*BW

Where:

	INPUTS	
ICR = apportioned target incremental cancer risk, unitless	1E-05	
HQ = target hazard quotient, unitless	1.0	
RGOc = carcinogenic contaminant concentration in surface soil, mg/kg	calculated	
RGOnc = noncarcinogenic contaminant concentration in surface soil, mg/kg	calculated	
ATc = averaging time for carcinogen, days	25550	
ATnc = averaging time for noncarcinogen, days	3285	
CF = conversion factor, kg/mg	1E-06	
CSFo = oral cancer slope factor, (mg/kg-day)-1	*CS*	*(chemical specific value)*
CSFd = dermally adjusted cancer slope factor, (mg/kg-day)-1	CS	
RfDo = oral reference dose, mg/kg-day	CS	
RfDd = dermally adjusted reference dose, mg/kg-day	CS	
ED = exposure duration, years	9	
EF = exposure frequency, days/year	52	
IR = ingestion rate, mg/day	100	
FI = Fraction Ingested, unitless	0.5	
BW = body weight, kg	37	
SA = skin surface area available for contact, cm2	3925	
AF = soil to skin adherence factor, mg/cm2	0.2	
ABS = Absorption Factor, unitless	CS	

Note: Inputs are scenario and site specific

Contaminant	Target ICR	Target HQ	*Absorption Factor (unitless)*	*Slope Factor (mg/kg-day)-1*	*Reference Dose (mg/kg-day)*	*Dermally Adj. Slope Factor (mg/kg-day)-1*	*Derm. Adj. Ref. Dose (mg/kg-day)*	*Ingestion Dose Carc*	*Dermal Dose Carc*	*Ingestion Dose Noncarc*	*Dermal Dose Noncarc*	*RGO Carc (mg/kg)*	*RGO Noncarc (mg/kg)*
Carcinogenic PAHs:													
Benzo(a)anthracene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	133.68	--
Benzo(a)pyrene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	13.37	--
Benzo(b)fluoranthene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	133.68	--
Benzo(k)fluoranthene	1.00E-05	--	0.10	7.30E-02	--	1.46E-01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	1,337	--
Chrysene	1.00E-05	--	0.10	7.30E-03	--	1.46E-02	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	13,368	--
benzo(a,h)anthracene	1.00E-05	--	0.10	7.30E+00	--	1.46E+01	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	13.37	--
eno(1,2,3-cd)pyrene	1.00E-05	--	0.10	7.30E-01	--	1.46E+00	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	133.68	--
rbazole	1.00E-05	--	0.10	2.00E-02	--	4.00E-02	--	2.48E-08	3.89E-08	1.93E-07	3.02E-07	4,879	--
Nitramines:													
HMX	--	1.0	0.50	--	5.00E-02	--	2.50E-02	2.48E-08	1.94E-07	1.93E-07	1.51E-06	--	15,552
Inorganics:													
Aluminum	--	1.0	0.010	--	1.00E+00	--	2.00E-01	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	2,909,933
Arsenic	1.00E-05	1.0	0.032	1.50E+00	3.00E-04	1.58E+00	2.85E-04	2.48E-08	1.24E-08	1.93E-07	9.67E-08	176.17	1,019
Barium	--	1.0	0.010	--	7.00E-02	--	1.40E-02	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	203,695
Chromium	--	1.0	0.010	--	5.00E-03	--	1.00E-03	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	14,550
Iron	--	1.0	0.010	--	3.00E-01	--	6.00E-02	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	872,980
Manganese	--	1.0	0.010	--	2.30E-02	--	1.15E-03	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	28,857
Thallium	--	1.0	0.010	--	8.00E-05	--	1.60E-05	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	233
Vanadium	--	1.0	0.010	--	7.00E-03	--	1.40E-03	2.48E-08	3.89E-09	1.93E-07	3.02E-08	--	20,370

ECOLOGICAL MODELS

Back-Calculated Concentrations for Site 2 .
Naval Weapons Station Yorktown
Yorktown, Virginia

Short-Tailed Shrew
(Less Conservative Inputs)

Body Weight	0.0167980	kg
Food Ingestion Rate	0.0093229	kg/day
Water Ingestion Rate	0.0037459	L/day
Soil Ingestion Rate	0.0009672	kg/day

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Fluoranthene	4.2	0	4.2	2.572828789	1.3	2.6	1.98E+00	9.90E-01
Phenanthrene	4.2	0	4.2	2.572828789	1.3	2.6	1.98E+00	9.90E-01
Pyrene	4.2	0	4.2	2.572828789	1.3	2.6	1.98E+00	9.90E-01
Aroclor-1254	0.21	0	0.21	0.128641439	0.1	0.13	1.29E+00	9.90E-01
Cadmium	0.37	0	0.37	0.226653965	0.023	0.23	9.85E+00	9.85E-01
Thallium	3.7	0	3.7	2.266539648	0.23	2.3	9.85E+00	9.85E-01

HQ_n . Hazard Quotient based on the NOAEL
HQ_l . Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for Site 2
Naval Weapons Station Yorktown
Yorktown, Virginia

American Robin
(Less Conservataive Inputs)

Body Weight	0.0810200 kg
Food Ingestion Rate	0.0976300 kg/day
Water Ingestion Rate	0.0113400 L/day
Soil Ingestion Rate	0.0292890 kg/day

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Cobalt	6.3	0	6.3	9.869040978	1	10	9.87E+00	9.87E-01
Copper	1.48	0	1.48	2.318441373	0.235	2.35	9.87E+00	9.87E-01
Mercury	0.06	0	0.06	0.093990866	0.01	0.1	9.40E+00	9.40E-01

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

American Robin
(Less Conservataive Inputs)

Body Weight	0.0810200	kg
Food Ingestion Rate	0.0976300	kg/day
Water Ingestion Rate	0.0113400	L/day
Soil Ingestion Rate	0.0292890	kg/day

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	1.48	0	1.48	2.318441373	0.235	2.35	9.87E+00	9.87E-01
Lead	1.91	0	1.91	2.992042582	0.3	3	9.97E+00	9.97E-01
Mercury	0.06	0	0.06	0.093990866	0.01	0.1	9.40E+00	9.40E-01
Zinc	88	0	88	137.8532708	13.9	139	9.92E+00	9.92E-01

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

Short-Tailed Shrew
(Less Conservative Inputs)

Body Weight	0.0167980 kg
Food Ingestion Rate	0.0093229 kg/day
Water Ingestion Rate	0.0037459 L/day
Soil Ingestion Rate	0.0009672 kg/day

Mean Concentrations

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Barium	4	0	4	2.450313133	0.25	2.5	9.80E+00	9.80E-01
Thallium	3.7	0	3.7	2.266539648	0.23	2.3	9.85E+00	9.85E-01

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for SSA 14
Naval Weapons Station Yorktown
Yorktown, Virginia

Red Fox
(Less Conservative Inputs)

Body Weight	5.0000000 kg
Food Ingestion Rate	0.3200000 kg/day
Water Ingestion Rate	0.2752000 L/day
Soil Ingestion Rate	0.0090000 kg/day

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Small Mammal Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
HMX	8.6	0	8.6	0.56588	0.057	0.57	9.93E+00	9.93E-01

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for Site 8
Naval Weapons Station Yorktown
Yorktown, Virginia

Short-Tailed Shrew
(Less Conservative Inputs)

Body Weight	0.0167980 kg
Food Ingestion Rate	0.0093229 kg/day
Water Ingestion Rate	0.0037459 L/day
Soil Ingestion Rate	0.0009672 kg/day

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Aroclor-1260	0.21	0	0.21	0.128641439	0.1	0.13	1.29E+00	9.90E-01
Chromium	0.4	0	0.4	0.245031313	0.025	0.25	9.80E+00	9.80E-01

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for Site 8
Naval Weapons Station Yorktown
Yorktown, Virginia

American Robin
(Less Conservataive Inputs)

Body Weight	0.0810200 kg
Food Ingestion Rate	0.0976300 kg/day
Water Ingestion Rate	0.0113400 L/day
Soil Ingestion Rate	0.0292890 kg/day

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	1.49	0	1.49	2.334106517	0.235	2.35	9.93E+00	9.93E-01
Lead	1.91	0	1.91	2.992042582	0.3	3	9.97E+00	9.97E-01
Mercury	0.06	0	0.06	0.093990866	0.01	0.1	9.40E+00	9.40E-01
Zinc	88	0	88	137.8532708	13.9	139	9.92E+00	9.92E-01

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

Back-Calculated Concentrations for Site 18
Naval Weapons Station Yorktown
Yorktown, Virginia

Great Blue Heron
(Less Conservative Inputs)

Body Weight	2.2680000 kg
Food Ingestion Rate	0.4082500 kg/day
Water Ingestion Rate	0.1020600 L/day
Sediment Ingestion Rate	0.0360000 kg/day

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	11.9	0	11.9	2.330941358	0.235	2.35	9.92E+00	9.92E-01
Iron	5100	0	5100	998.9748677	100	1000	9.99E+00	9.99E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

APPENDIX B
CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOALS

SAMPLE NO.	02-SS-14
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*34500*
TOTAL PAHs	*76390*
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	.25

SAMPLE NO.	02-SS-12
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*12000*
TOTAL PAHs	24545
PCBs (ug/kg)	
AROCLOR-1254	510
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-11
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	468
TOTAL PAHs	824
PCBs (ug/kg)	
AROCLOR-1254	*1900*
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-17
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	NA
TOTAL PAHs	NA
PCBs (ug/kg)	
AROCLOR-1254	*6200*
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-08
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*251600*
TOTAL PAHs	*562700*
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-18
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*10540*
TOTAL PAHs	28780
PCBs (ug/kg)	
AROCLOR-1254	140
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-20
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*18660*
TOTAL PAHs	30180
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-20D
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*7220*
TOTAL PAHs	19590
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-04
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*4110*
TOTAL PAHs	8768
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	.76

SAMPLE NO.	02-SS-19
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*16440*
TOTAL PAHs	32120
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-03
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	2190
TOTAL PAHs	4620
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-01
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*62800*
TOTAL PAHs	*149800*
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-21
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*3460*
TOTAL PAHs	*74610*
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-45
DATE SAMPLED	11/15/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*4450*
TOTAL PAHs	10255
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

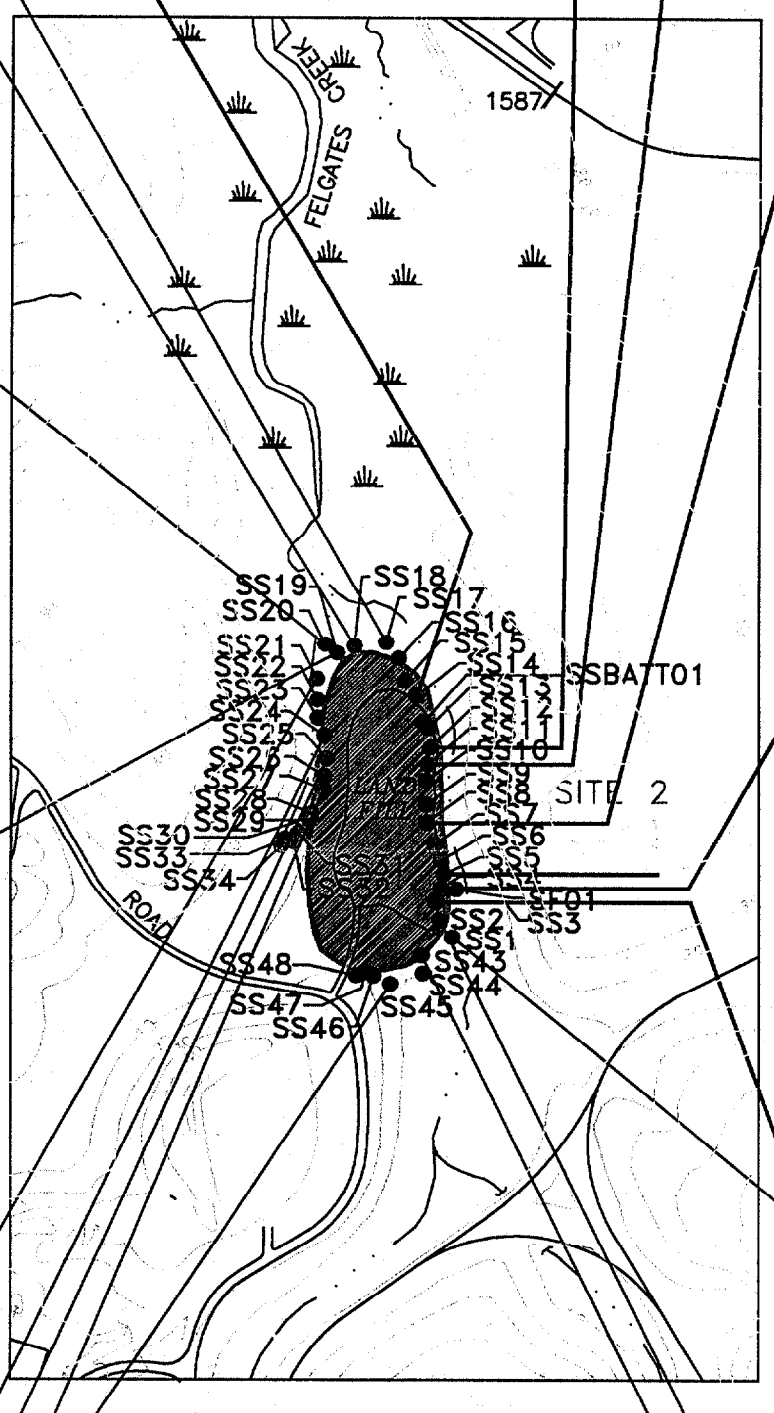
SAMPLE NO.	02-SS-02
DATE SAMPLED	11/4/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*57900*
TOTAL PAHs	*130600*
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-24
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*18140*
TOTAL PAHs	38030
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-27
DATE SAMPLED	11/15/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*17810*
TOTAL PAHs	48780
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-43
DATE SAMPLED	11/15/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*23340*
TOTAL PAHs	*63680*
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND

SAMPLE NO.	02-SS-25
DATE SAMPLED	11/14/94
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	*6520*
TOTAL PAHs	14496
PCBs (ug/kg)	
AROCLOR-1254	ND
EXPLOSIVES (ug/kg)	
4-AMINO-2,6-DINITROTOLUENE	ND



400 0 200 400

1 inch = 400 ft.

363729FS

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LEGEND

DRAINAGE

MARSH

APPROXIMATE SITE BOUNDARY

SS1 SOIL SAMPLE LOCATION

NA NOT ANALYZED

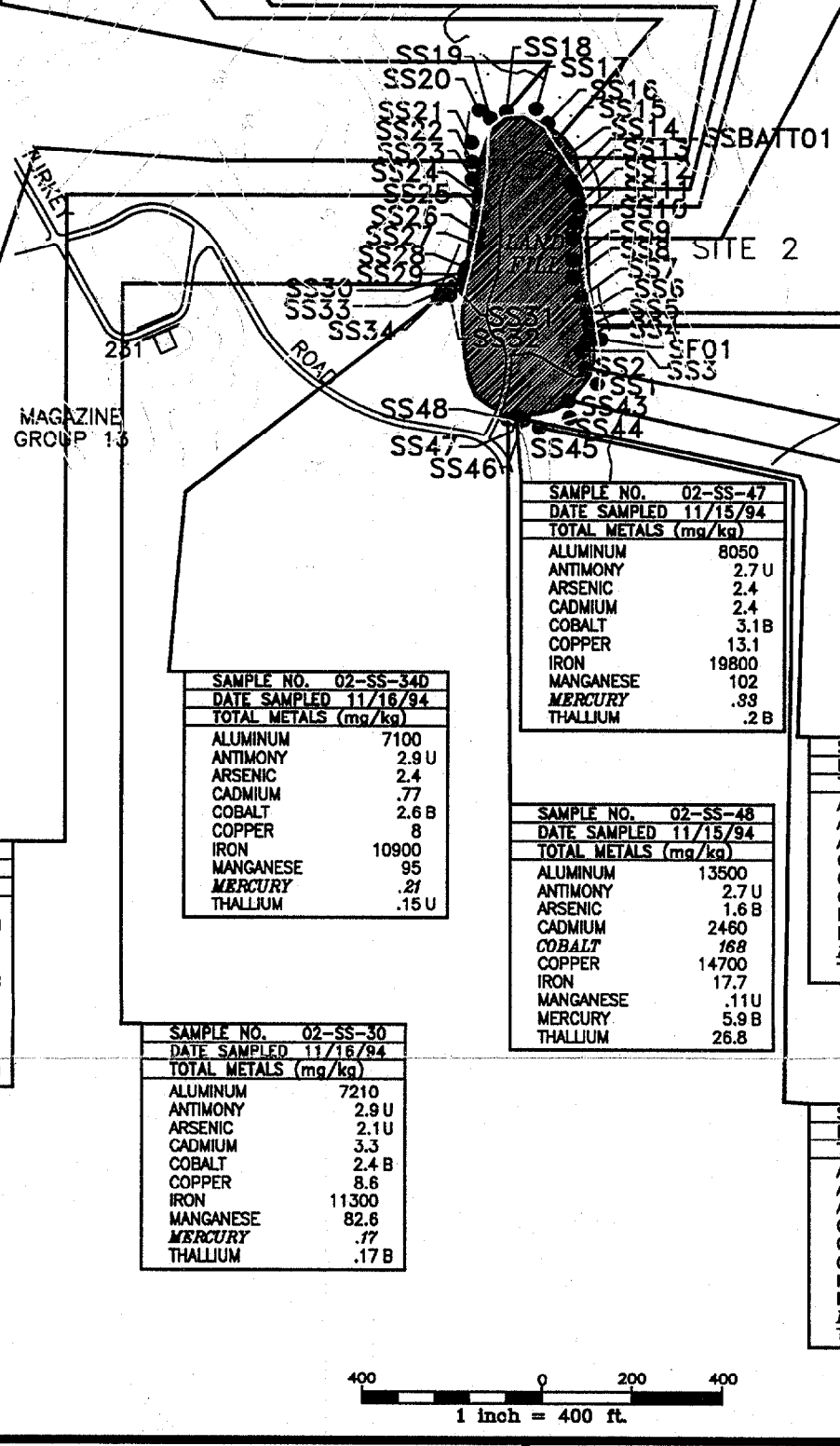
NOTES: 1) SAMPLE LOCATIONS WITH NO TEXT BOXES INDICATE THAT NO COC CONCENTRATIONS WERE ABOVE THE FRGs.

2) CONCENTRATIONS IN RED ITALICS INDICATE INDICATE AN EXCEEDANCE OF THE FRG.

SOURCE: LANTDIV, OCT. 1991

FIGURE B-1
ORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOALS IN SURFACE SOIL
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

01764FB10Z



SAMPLE NO.	02-SS-15
DATE SAMPLED	11/14/94
TOTAL METALS (mg/kg)	
ALUMINUM	5810
ANTIMONY	2.9 U
ARSENIC	2.1 B
CADMIUM	6
COBALT	2.7 B
COPPER	30.6
IRON	8440
MANGANESE	145
MERCURY	*.15*
THALLIUM	.21 U

SAMPLE NO.	02-SS-14
DATE SAMPLED	11/14/94
TOTAL METALS (mg/kg)	
ALUMINUM	5730
ANTIMONY	3.3 U
ARSENIC	1.4 B
CADMIUM	1.3 B
COBALT	1.4 B
COPPER	5.4 B
IRON	7180
MANGANESE	159
MERCURY	*.43*
THALLIUM	.24 U

SAMPLE NO.	02-SS-13
DATE SAMPLED	11/14/94
TOTAL METALS (mg/kg)	
ALUMINUM	9300
ANTIMONY	2.9 U
ARSENIC	2.5
CADMIUM	1.3
COBALT	3.8 B
COPPER	6.3
IRON	16100
MANGANESE	122
MERCURY	*.17*
THALLIUM	.21 U

SAMPLE NO.	02-SS-12
DATE SAMPLED	11/14/94
TOTAL METALS (mg/kg)	
ALUMINUM	6470
ANTIMONY	2.4 U
ARSENIC	2.5
CADMIUM	2.5
COBALT	2.2 B
COPPER	6.4
IRON	6690
MANGANESE	141
MERCURY	*1*
THALLIUM	.18 U

SAMPLE NO.	02-SS-10
DATE SAMPLED	11/4/94
TOTAL METALS (mg/kg)	
ALUMINUM	7310
ANTIMONY	2.9 U
ARSENIC	4.5
CADMIUM	4.2
COBALT	2.6 B
COPPER	6.9
IRON	8620
MANGANESE	178
MERCURY	*.14*
THALLIUM	.21 U

SAMPLE NO.	02-SS-18
DATE SAMPLED	11/14/94
TOTAL METALS (mg/kg)	
ALUMINUM	5810
ANTIMONY	2.9 U
ARSENIC	3.5
CADMIUM	.98 B
COBALT	2.7 B
COPPER	8.9
IRON	7920
MANGANESE	143
MERCURY	*.58*
THALLIUM	.21

SAMPLE NO.	02-SS-06
DATE SAMPLED	11/4/94
TOTAL METALS (mg/kg)	
ALUMINUM	9280
ANTIMONY	3.3 B
ARSENIC	2.3 B
CADMIUM	1.7
COBALT	2.3 B
COPPER	8
IRON	11200
MANGANESE	94.2
MERCURY	*.17*
THALLIUM	.21 U

SAMPLE NO.	02-SS-22
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	6820
ANTIMONY	2.9 U
ARSENIC	4.1
CADMIUM	.36 U
COBALT	3.3 B
COPPER	3.6 B
IRON	10100
MANGANESE	183
MERCURY	*.19*
THALLIUM	.14 B

SAMPLE NO.	02-SS-05
DATE SAMPLED	11/4/94
TOTAL METALS (mg/kg)	
ALUMINUM	6880
ANTIMONY	2.9 U
ARSENIC	1.8 B
CADMIUM	.83 B
COBALT	2.3 B
COPPER	2.3
IRON	10400
MANGANESE	91.1
MERCURY	*.15*
THALLIUM	.2 U

SAMPLE NO.	02-SS-47
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	8050
ANTIMONY	2.7 U
ARSENIC	2.4
CADMIUM	2.4
COBALT	3.1 B
COPPER	13.1
IRON	19800
MANGANESE	102
MERCURY	*.33*
THALLIUM	.2 B

SAMPLE NO.	02-SS-34D
DATE SAMPLED	11/16/94
TOTAL METALS (mg/kg)	
ALUMINUM	7100
ANTIMONY	2.9 U
ARSENIC	2.4
CADMIUM	.77
COBALT	2.6 B
COPPER	8
IRON	10900
MANGANESE	95
MERCURY	*.21*
THALLIUM	.15 U

SAMPLE NO.	02-SS-02
DATE SAMPLED	11/4/94
TOTAL METALS (mg/kg)	
ALUMINUM	8340
ANTIMONY	3.1 U
ARSENIC	2.5 B
CADMIUM	2.3
COBALT	2.9 B
COPPER	14.7
IRON	12500
MANGANESE	126
MERCURY	*.18*
THALLIUM	.21 U

SAMPLE NO.	02-SS-46
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	7780
ANTIMONY	2.8 U
ARSENIC	1.6 B
CADMIUM	2.4 B
COBALT	2.4 B
COPPER	25.2
IRON	12400
MANGANESE	70.7
MERCURY	*16.6*
THALLIUM	.14 U

SAMPLE NO.	02-SS-48
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	13500
ANTIMONY	2.7 U
ARSENIC	1.6 B
CADMIUM	2460
COBALT	*168*
COPPER	14700
IRON	17.7
MANGANESE	.11 U
MERCURY	5.9 B
THALLIUM	26.8

SAMPLE NO.	02-SS-24
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	8740
ANTIMONY	3.1 U
ARSENIC	2.6
CADMIUM	2.9
COBALT	6 B
COPPER	12.1
IRON	34500
MANGANESE	265
MERCURY	*.56*
THALLIUM	.15 U

SAMPLE NO.	02-SS-30
DATE SAMPLED	11/16/94
TOTAL METALS (mg/kg)	
ALUMINUM	7210
ANTIMONY	2.9 U
ARSENIC	2.1 U
CADMIUM	3.3
COBALT	2.4 B
COPPER	8.6
IRON	11300
MANGANESE	82.6
MERCURY	*.17*
THALLIUM	.17 B

SAMPLE NO.	02-SS-43
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	5280
ANTIMONY	2.9 U
ARSENIC	1.4 B
CADMIUM	1.7
COBALT	1.7 B
COPPER	5.5 B
IRON	7460
MANGANESE	106
MERCURY	*4*
THALLIUM	.14 U

SAMPLE NO.	02-SS-45
DATE SAMPLED	11/15/94
TOTAL METALS (mg/kg)	
ALUMINUM	7410
ANTIMONY	3 U
ARSENIC	1.6 B
CADMIUM	.63 B
COBALT	1.7 B
COPPER	3.8 B
IRON	9500
MANGANESE	89.9
MERCURY	*7.7*
THALLIUM	.14 U

400 0 200 400

1 inch = 400 ft.

363726FS

Baker

Baker Environmental, Inc.

LEGEND

DRAINAGE

STRUCTURE

APPROXIMATE SITE BOUNDARY

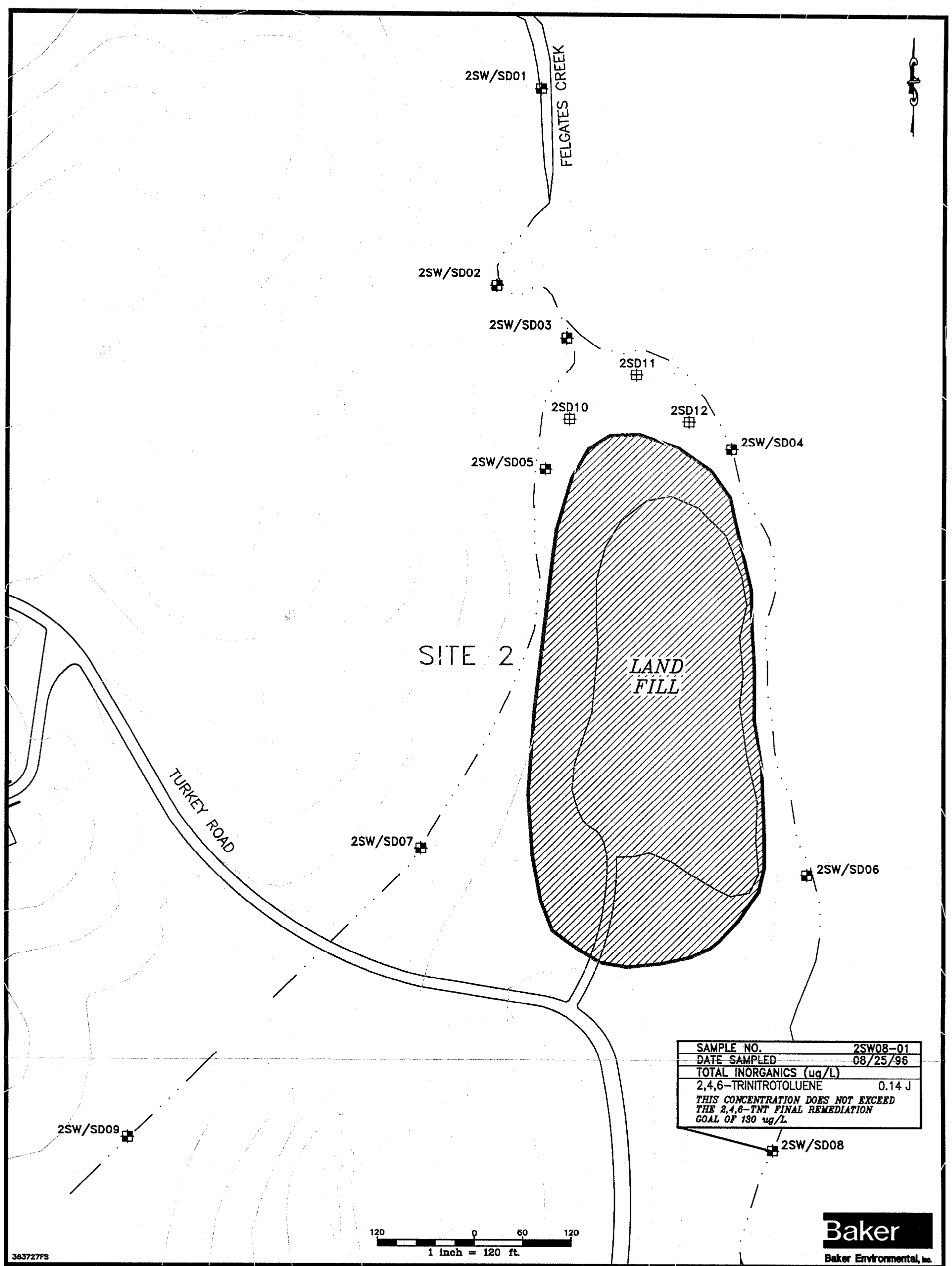
SS1 SOIL SAMPLE LOCATION

NOTES: 1) NO TEXT BOX AT A SAMPLE LOCATION INDICATES THAT THERE WERE NO COC CONCENTRATIONS EXCEEDING THE FRGs.
2) CONCENTRATIONS IN RED ITALICS INDICATE AND EXCEEDANCE OF THE FRG.

SOURCE: LANTDIV, OCT. 1991

FIGURE B-2
INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOALS IN SURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



LEGEND

2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997

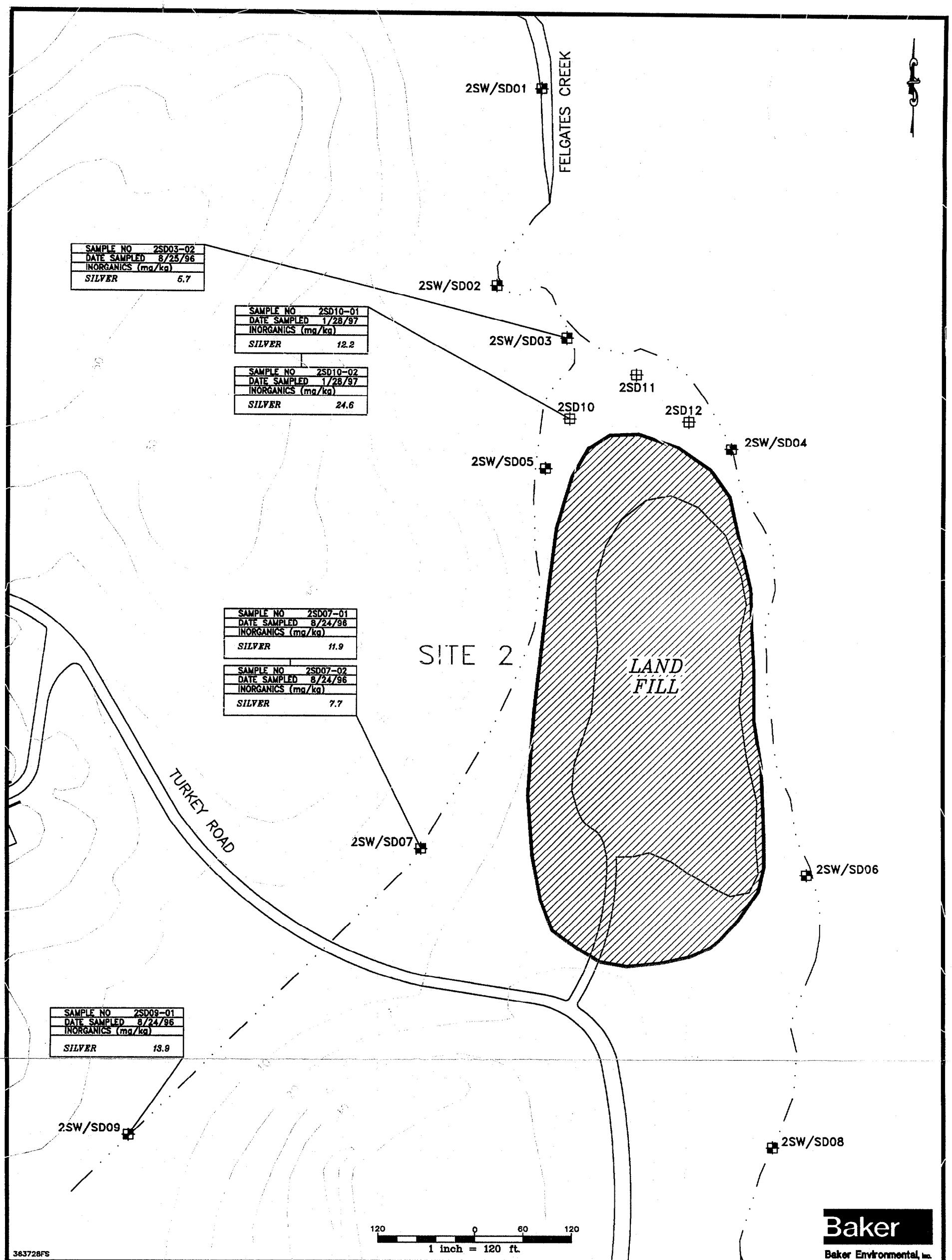
– DRAINAGE

– APPROXIMATE SITE BOUNDARY

NOTE: NO TEXT BOX AT SAMPLE LOCATION INDICATES THAT THERE WAS NO COC (2,4,6-TNT) DETECTED.

SOURCE: LANTDIV, 1991

FIGURE B-3
ORGANIC CONTAMINANT OF CONCERN EXCEEDING FINAL REMEDIATION GOAL IN SURFACE WATER
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



LEGEND

2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997

– APPROXIMATE SITE BOUNDARY

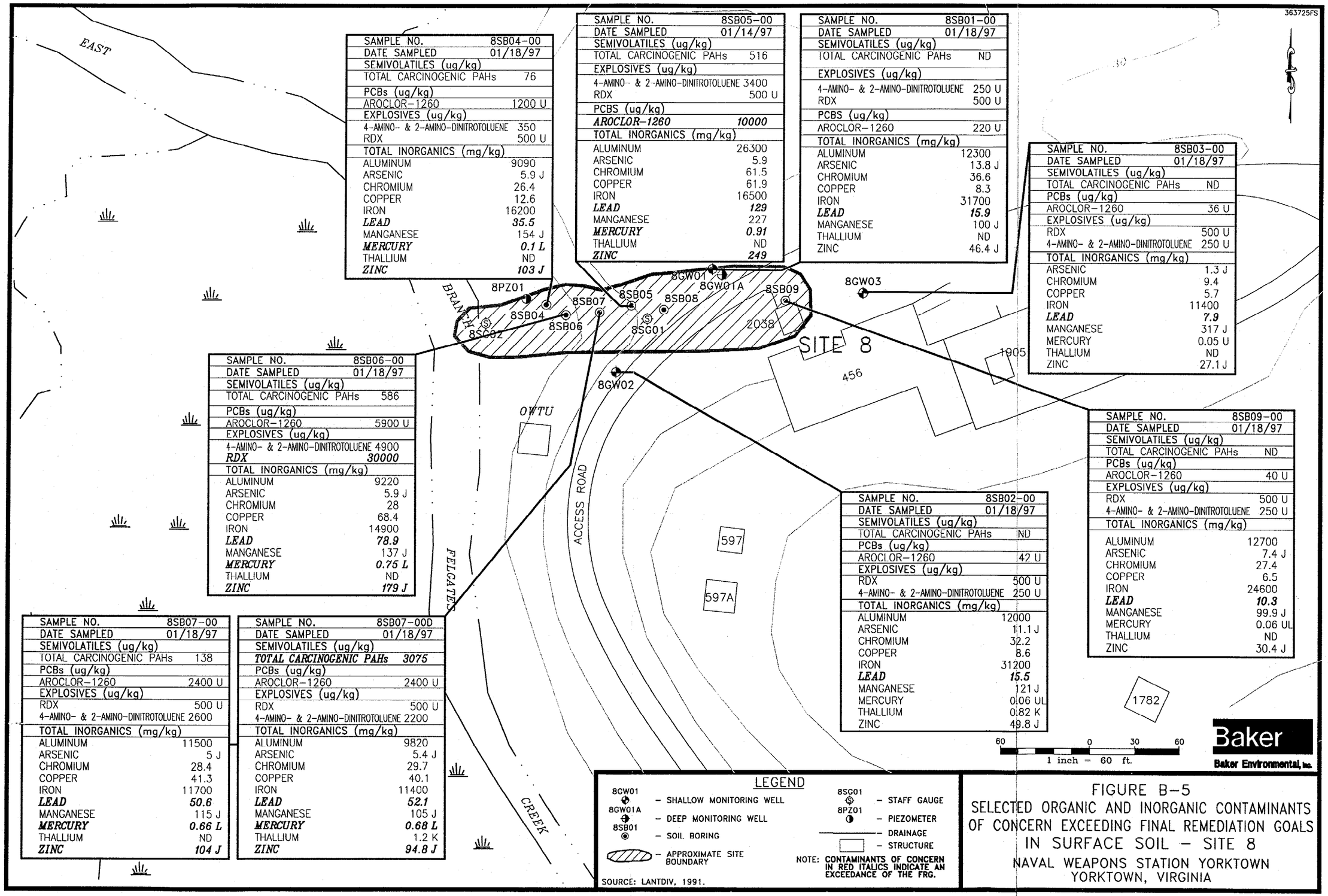
– DRAINAGE

NOTES: 1) NO TEXT BOX AT SAMPLE LOCATION INDICATES THAT THERE WERE NO COC CONCENTRATIONS EXCEEDING THE FRG.
2) CONCENTRATIONS IN RED ITALICS INDICATES AN EXCEEDANCE OF THE FRG.

SOURCE: LANTDIV, 1991

FIGURE B-4
INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOAL IN SEDIMENT
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

363725FS



SAMPLE NO.	8SB04-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	76
PCBs (ug/kg)	
AROCLOR-1260	1200 U
EXPLOSIVES (ug/kg)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	350
RDX	500 U
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9090
ARSENIC	5.9 J
CHROMIUM	26.4
COPPER	12.6
IRON	16200
LEAD	***35.5***
MANGANESE	154 J
MERCURY	***0.1 L***
THALLIUM	ND
ZINC	***103 J***

SAMPLE NO.	8SB05-00
DATE SAMPLED	01/14/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	516
EXPLOSIVES (ug/kg)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	3400
RDX	500 U
PCBS (ug/kg)	
AROCLOR-1260	***10000***
TOTAL INORGANICS (mg/kg)	
ALUMINUM	26300
ARSENIC	5.9
CHROMIUM	61.5
COPPER	61.9
IRON	16500
LEAD	***129***
MANGANESE	227
MERCURY	***0.91***
THALLIUM	ND
ZINC	***249***

SAMPLE NO.	8SB01-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
EXPLOSIVES (ug/kg)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	250 U
RDX	500 U
PCBS (ug/kg)	
AROCLOR-1260	220 U
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12300
ARSENIC	13.8 J
CHROMIUM	36.6
COPPER	8.3
IRON	31700
LEAD	***15.9***
MANGANESE	100 J
THALLIUM	ND
ZINC	46.4 J

SAMPLE NO.	8SB03-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
PCBs (ug/kg)	
AROCLOR-1260	36 U
EXPLOSIVES (ug/kg)	
RDX	500 U
4-AMINO- & 2-AMINO-DINITROTOLUENE	250 U
TOTAL INORGANICS (mg/kg)	
ARSENIC	1.3 J
CHROMIUM	9.4
COPPER	5.7
IRON	11400
LEAD	***7.9***
MANGANESE	317 J
MERCURY	0.05 U
THALLIUM	ND
ZINC	27.1 J

SAMPLE NO.	8SB06-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	586
PCBs (ug/kg)	
AROCLOR-1260	5900 U
EXPLOSIVES (ug/kg)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	4900
RDX	***30000***
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9220
ARSENIC	5.9 J
CHROMIUM	28
COPPER	68.4
IRON	14900
LEAD	***78.9***
MANGANESE	137 J
MERCURY	***0.75 L***
THALLIUM	ND
ZINC	***179 J***

SAMPLE NO.	8SB09-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
PCBs (ug/kg)	
AROCLOR-1260	40 U
EXPLOSIVES (ug/kg)	
RDX	500 U
4-AMINO- & 2-AMINO-DINITROTOLUENE	250 U
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12700
ARSENIC	7.4 J
CHROMIUM	27.4
COPPER	6.5
IRON	24600
LEAD	***10.3***
MANGANESE	99.9 J
MERCURY	0.06 UL
THALLIUM	ND
ZINC	30.4 J

SAMPLE NO.	8SB02-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
PCBs (ug/kg)	
AROCLOR-1260	42 U
EXPLOSIVES (ug/kg)	
RDX	500 U
4-AMINO- & 2-AMINO-DINITROTOLUENE	250 U
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12000
ARSENIC	11.1 J
CHROMIUM	32.2
COPPER	8.6
IRON	31200
LEAD	***15.5***
MANGANESE	121 J
MERCURY	0.06 UL
THALLIUM	0.82 K
ZINC	49.8 J

SAMPLE NO.	8SB07-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	138
PCBs (ug/kg)	
AROCLOR-1260	2400 U
EXPLOSIVES (ug/kg)	
RDX	500 U
4-AMINO- & 2-AMINO-DINITROTOLUENE	2600
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11500
ARSENIC	5 J
CHROMIUM	28.4
COPPER	41.3
IRON	11700
LEAD	***50.6***
MANGANESE	115 J
MERCURY	***0.66 L***
THALLIUM	ND
ZINC	***104 J***

SAMPLE NO.	8SB07-00D
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	***3075***
PCBs (ug/kg)	
AROCLOR-1260	2400 U
EXPLOSIVES (ug/kg)	
RDX	500 U
4-AMINO- & 2-AMINO-DINITROTOLUENE	2200
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9820
ARSENIC	5.4 J
CHROMIUM	29.7
COPPER	40.1
IRON	11400
LEAD	***52.1***
MANGANESE	105 J
MERCURY	***0.68 L***
THALLIUM	1.2 K
ZINC	***94.8 J***

LEGEND

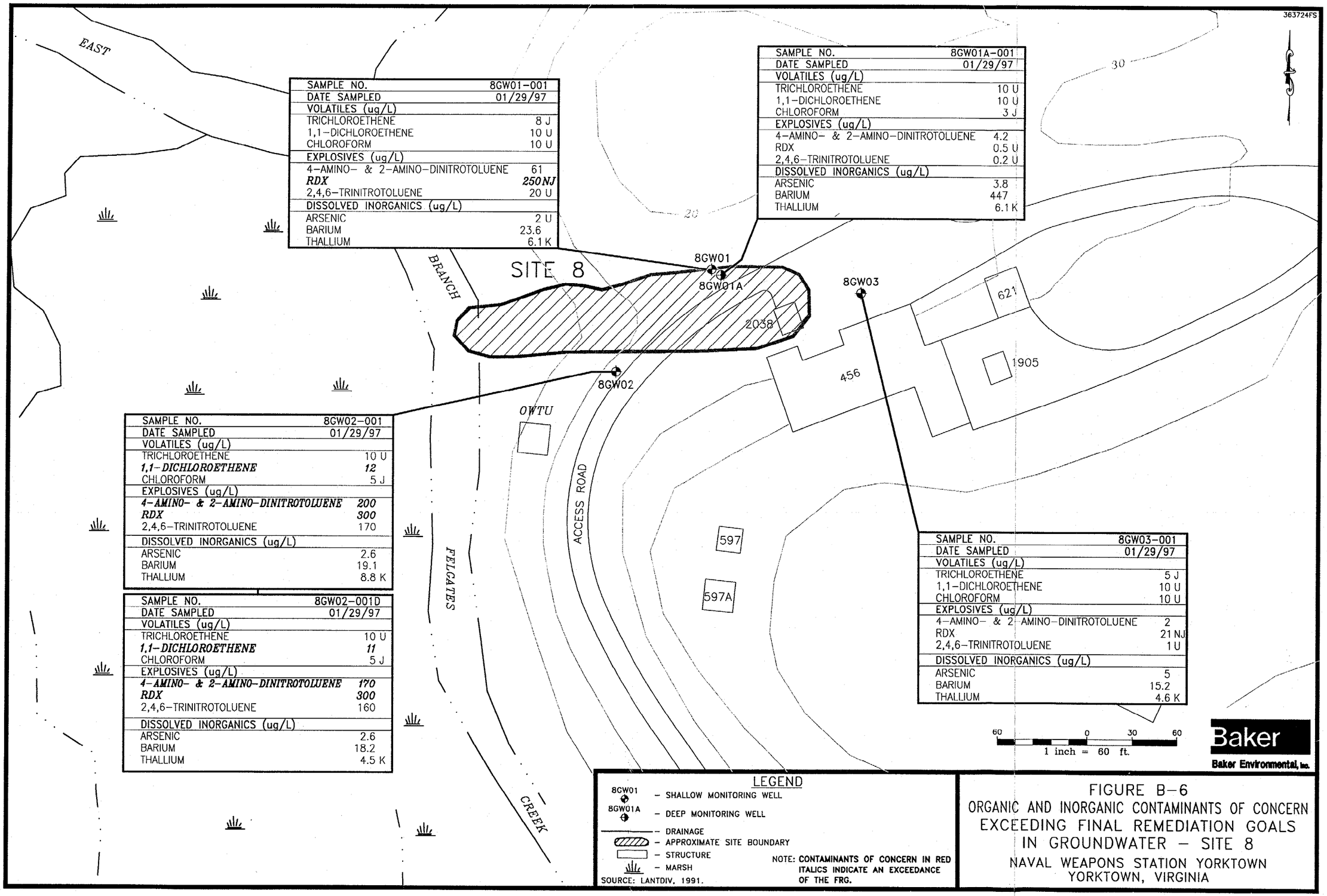
- 8GW01 – SHALLOW MONITORING WELL
- 8GW01A – DEEP MONITORING WELL
- 8SB01 – SOIL BORING
- APPROXIMATE SITE BOUNDARY
- 8SG01 – STAFF GAUGE
- 8PZ01 – PIEZOMETER
- DRAINAGE
- STRUCTURE

NOTE: CONTAMINANTS OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF THE FRG.

SOURCE: LANTDIV, 1991.

FIGURE B-5
SELECTED ORGANIC AND INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOALS IN SURFACE SOIL – SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

363724FS



SAMPLE NO.	8GW01-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	8 J
1,1-DICHLOROETHENE	10 U
CHLOROFORM	10 U
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	61
RDX	***250NJ***
2,4,6-TRINITROTOLUENE	20 U
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2 U
BARIUM	23.6
THALLIUM	6.1 K

SAMPLE NO.	8GW01A-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	10 U
1,1-DICHLOROETHENE	10 U
CHLOROFORM	3 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	4.2
RDX	0.5 U
2,4,6-TRINITROTOLUENE	0.2 U
DISSOLVED INORGANICS (ug/L)	
ARSENIC	3.8
BARIUM	447
THALLIUM	6.1 K

SAMPLE NO.	8GW02-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	10 U
1,1-DICHLOROETHENE	***12***
CHLOROFORM	5 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	***200***
RDX	***300***
2,4,6-TRINITROTOLUENE	170
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2.6
BARIUM	19.1
THALLIUM	8.8 K

SAMPLE NO.	8GW02-001D
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	10 U
1,1-DICHLOROETHENE	***11***
CHLOROFORM	5 J
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	***170***
RDX	***300***
2,4,6-TRINITROTOLUENE	160
DISSOLVED INORGANICS (ug/L)	
ARSENIC	2.6
BARIUM	18.2
THALLIUM	4.5 K

SAMPLE NO.	8GW03-001
DATE SAMPLED	01/29/97
VOLATILES (ug/L)	
TRICHLOROETHENE	5 J
1,1-DICHLOROETHENE	10 U
CHLOROFORM	10 U
EXPLOSIVES (ug/L)	
4-AMINO- & 2-AMINO-DINITROTOLUENE	2
RDX	21 NJ
2,4,6-TRINITROTOLUENE	1 U
DISSOLVED INORGANICS (ug/L)	
ARSENIC	5
BARIUM	15.2
THALLIUM	4.6 K

LEGEND

8GW01 – SHALLOW MONITORING WELL

8GW01A – DEEP MONITORING WELL

– DRAINAGE

– APPROXIMATE SITE BOUNDARY

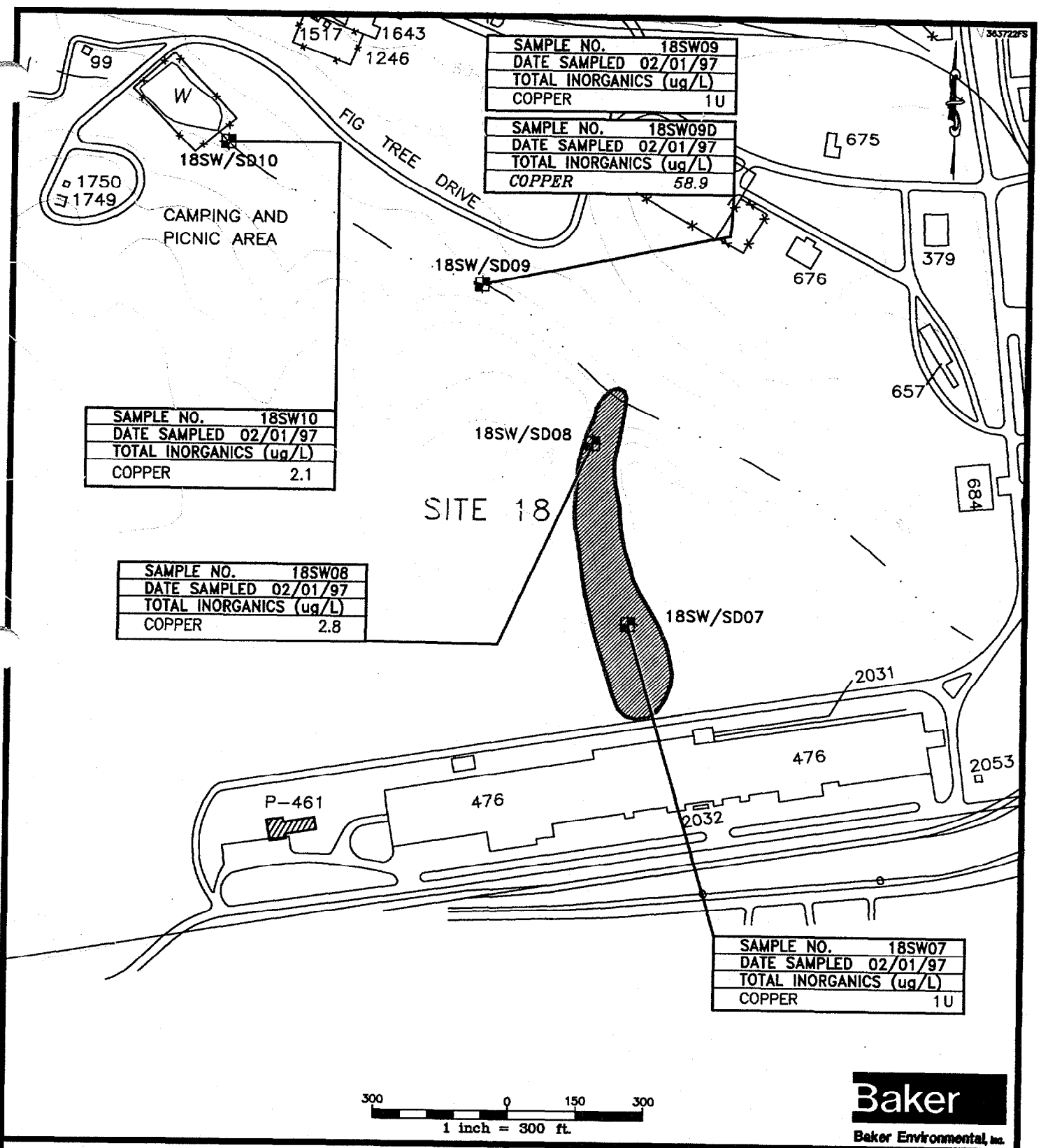
– STRUCTURE

– MARSH

SOURCE: LANTDIV, 1991.

NOTE: CONTAMINANTS OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF THE FRG.

FIGURE B-6
ORGANIC AND INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOALS IN GROUNDWATER – SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



LEGEND

18SW/SD09 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

– DRAINAGE

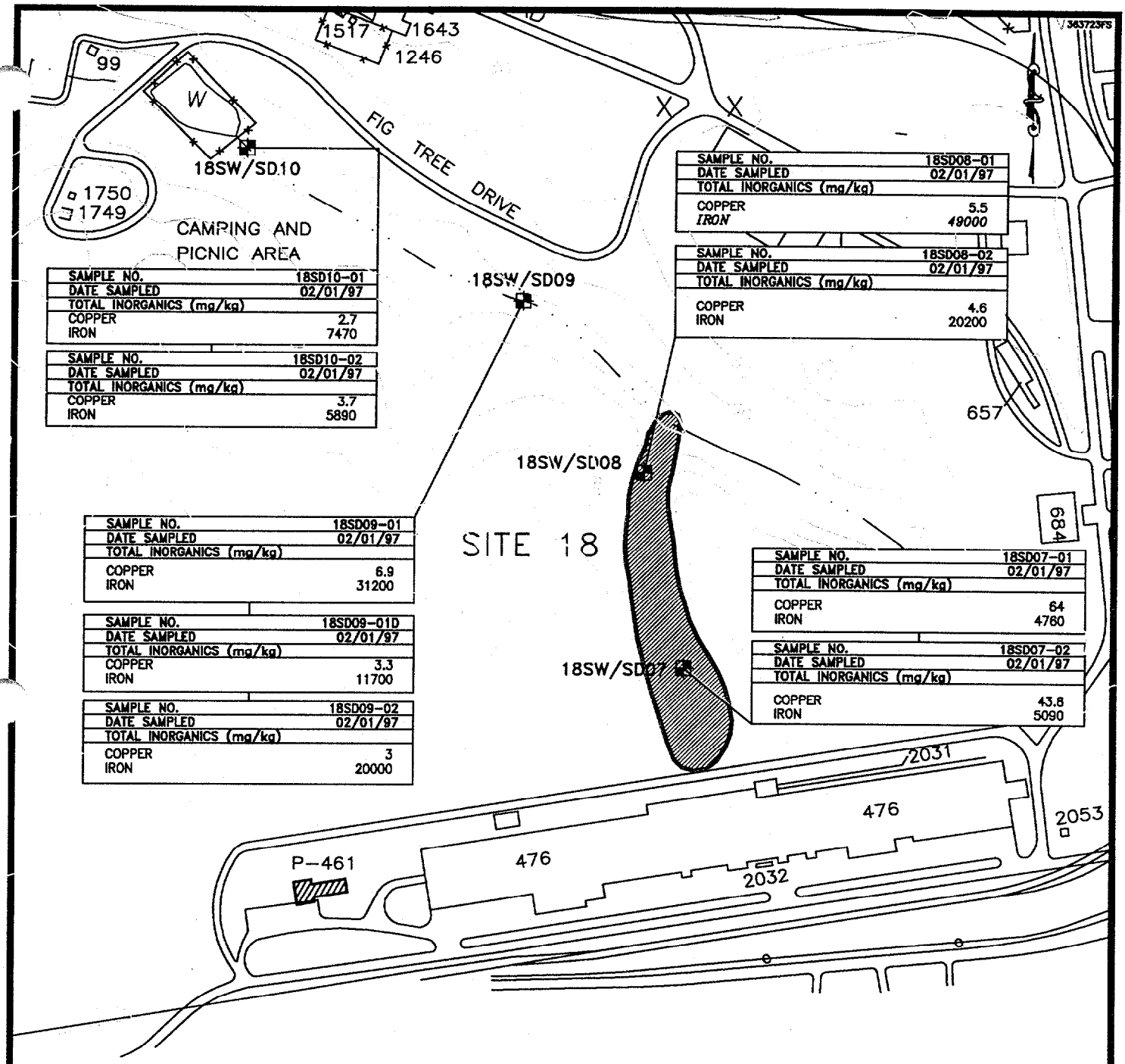
– STRUCTURE

– APPROXIMATE SITE BOUNDARY

NOTE: CONTAMINANT OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF THE FRG.

SOURCE: LANTDIV, 1991.

FIGURE B-7
INORGANIC CONTAMINANT OF CONCERN IN EXCEEDING OF FINAL REMEDIATION GOAL IN SURFACE WATER
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	18SD10-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	2.7
IRON	7470

SAMPLE NO.	18SD10-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	3.7
IRON	5890

SAMPLE NO.	18SD08-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	5.5
IRON	*49000*

SAMPLE NO.	18SD08-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	4.6
IRON	20200

SAMPLE NO.	18SD09-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	6.9
IRON	31200

SAMPLE NO.	18SD09-01D
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	3.3
IRON	11700

SAMPLE NO.	18SD09-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	3
IRON	20000

SAMPLE NO.	18SD07-01
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	64
IRON	4760

SAMPLE NO.	18SD07-02
DATE SAMPLED	02/01/97
TOTAL INORGANICS (mg/kg)	
COPPER	43.8
IRON	5090

300 0 150 300

1 inch = 300 ft.

Baker

Baker Environmental, Inc.

LEGEND

18SW/SD09 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

– DRAINAGE

– FENCE

– STRUCTURE

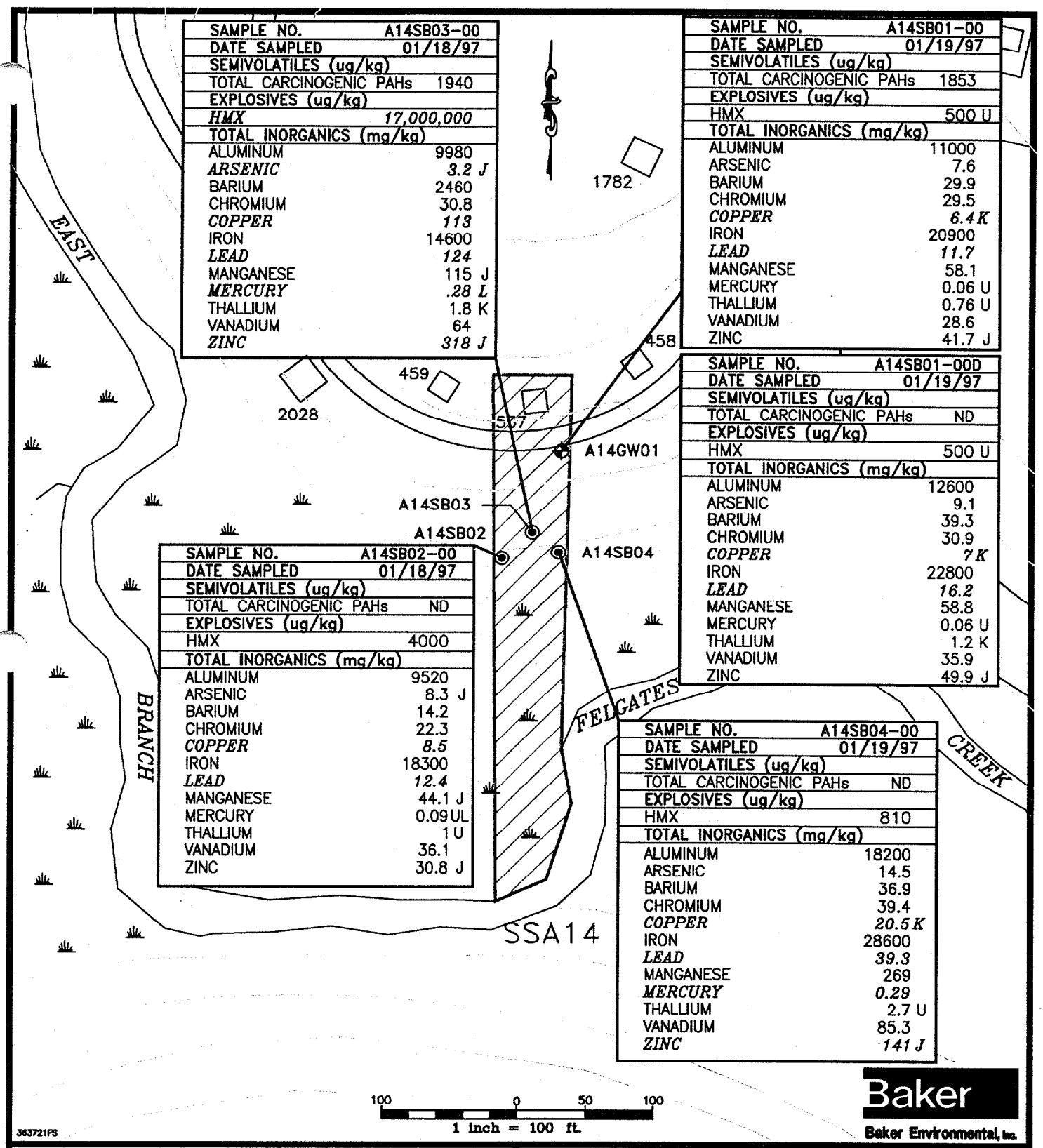
– APPROXIMATE SITE BOUNDARY

NOTE: CONTAMINANTS OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF AN FRG.

SOURCE: LANTDIV, 1991.

FIGURE B-8
INORGANIC CONTAMINANTS OF CONCERN IN EXCEEDANCE OF FINAL REMEDIATION GOAL IN SEDIMENT
SITE 18

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



SAMPLE NO.	A14SB03-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	1940
EXPLOSIVES (ug/kg)	
HMX	*17,000,000*
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9980
ARSENIC	*3.2 J*
BARIUM	2460
CHROMIUM	30.8
COPPER	*113*
IRON	14600
LEAD	*124*
MANGANESE	115 J
MERCURY	*.28 L*
THALLIUM	1.8 K
VANADIUM	64
ZINC	*318 J*

SAMPLE NO.	A14SB01-00
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	1853
EXPLOSIVES (ug/kg)	
HMX	500 U
TOTAL INORGANICS (mg/kg)	
ALUMINUM	11000
ARSENIC	7.6
BARIUM	29.9
CHROMIUM	29.5
COPPER	*6.4K*
IRON	20900
LEAD	*11.7*
MANGANESE	58.1
MERCURY	0.06 U
THALLIUM	0.76 U
VANADIUM	28.6
ZINC	41.7 J

SAMPLE NO.	A14SB01-00D
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
EXPLOSIVES (ug/kg)	
HMX	500 U
TOTAL INORGANICS (mg/kg)	
ALUMINUM	12600
ARSENIC	9.1
BARIUM	39.3
CHROMIUM	30.9
COPPER	*7K*
IRON	22800
LEAD	*16.2*
MANGANESE	58.8
MERCURY	0.06 U
THALLIUM	1.2 K
VANADIUM	35.9
ZINC	49.9 J

SAMPLE NO.	A14SB02-00
DATE SAMPLED	01/18/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
EXPLOSIVES (ug/kg)	
HMX	4000
TOTAL INORGANICS (mg/kg)	
ALUMINUM	9520
ARSENIC	8.3 J
BARIUM	14.2
CHROMIUM	22.3
COPPER	*8.5*
IRON	18300
LEAD	*12.4*
MANGANESE	44.1 J
MERCURY	0.09 UL
THALLIUM	1 U
VANADIUM	36.1
ZINC	30.8 J

SAMPLE NO.	A14SB04-00
DATE SAMPLED	01/19/97
SEMIVOLATILES (ug/kg)	
TOTAL CARCINOGENIC PAHs	ND
EXPLOSIVES (ug/kg)	
HMX	810
TOTAL INORGANICS (mg/kg)	
ALUMINUM	18200
ARSENIC	14.5
BARIUM	36.9
CHROMIUM	39.4
COPPER	*20.5K*
IRON	28600
LEAD	*39.3*
MANGANESE	269
MERCURY	*0.29*
THALLIUM	2.7 U
VANADIUM	85.3
ZINC	*141 J*

LEGEND

- A14GW01 – MONITORING WELL (BAKER 1997)
- A14SB02 – SOIL BORING
- DRAINAGE
- MARSH
- STRUCTURE
- APPROXIMATE SITE BOUNDARY

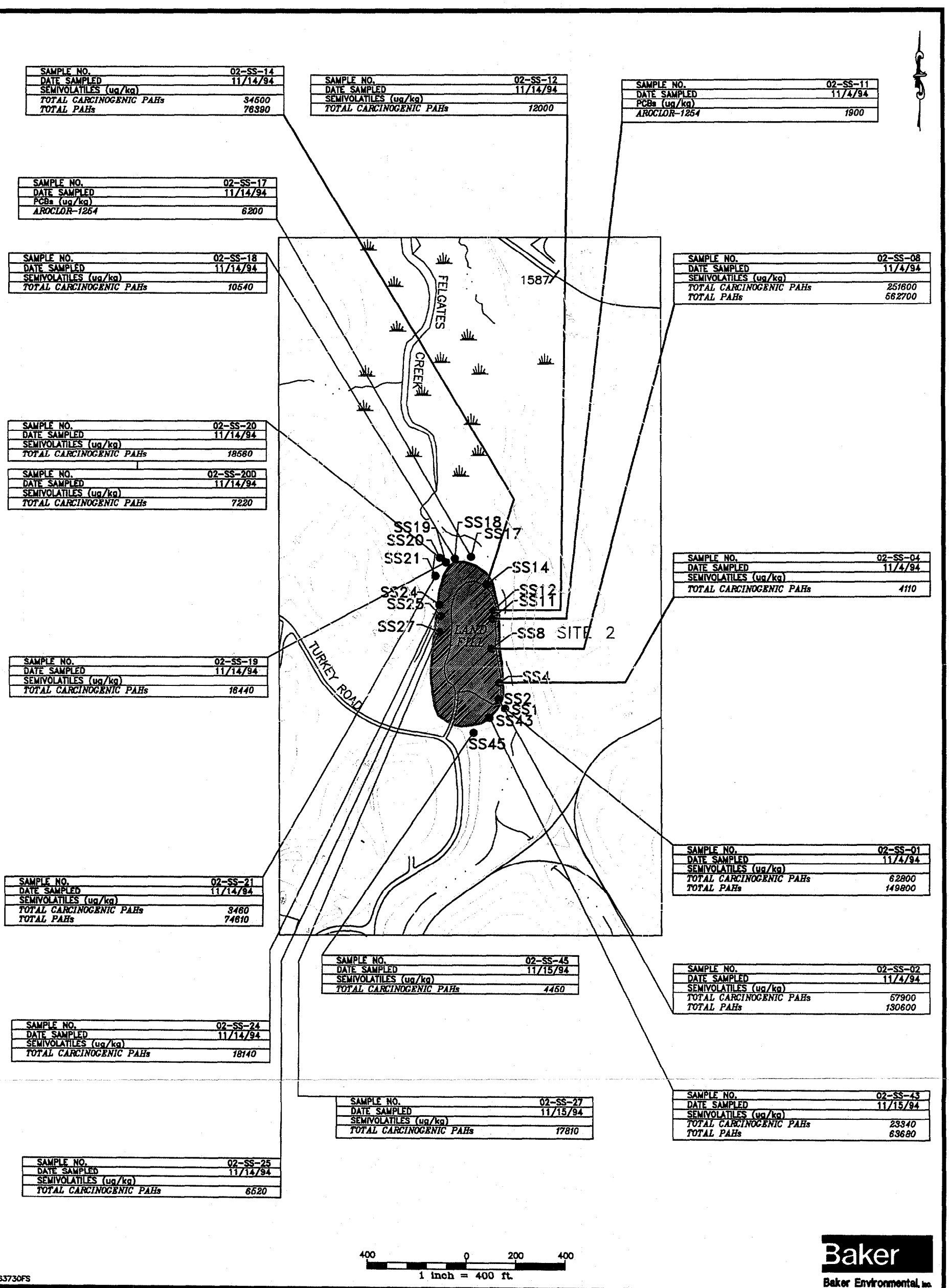
NOTE: CONTAMINANTS OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF THE FRG.

SOURCE: LANTDIV, 1991.

FIGURE B-9
ORGANIC AND INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION GOALS IN SURFACE SOIL SSA-14

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

APPENDIX C
CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS



LEGEND

SS1 ● SOIL SAMPLE LOCATION

DRAINAGE

MARSH

APPROXIMATE SITE BOUNDARY

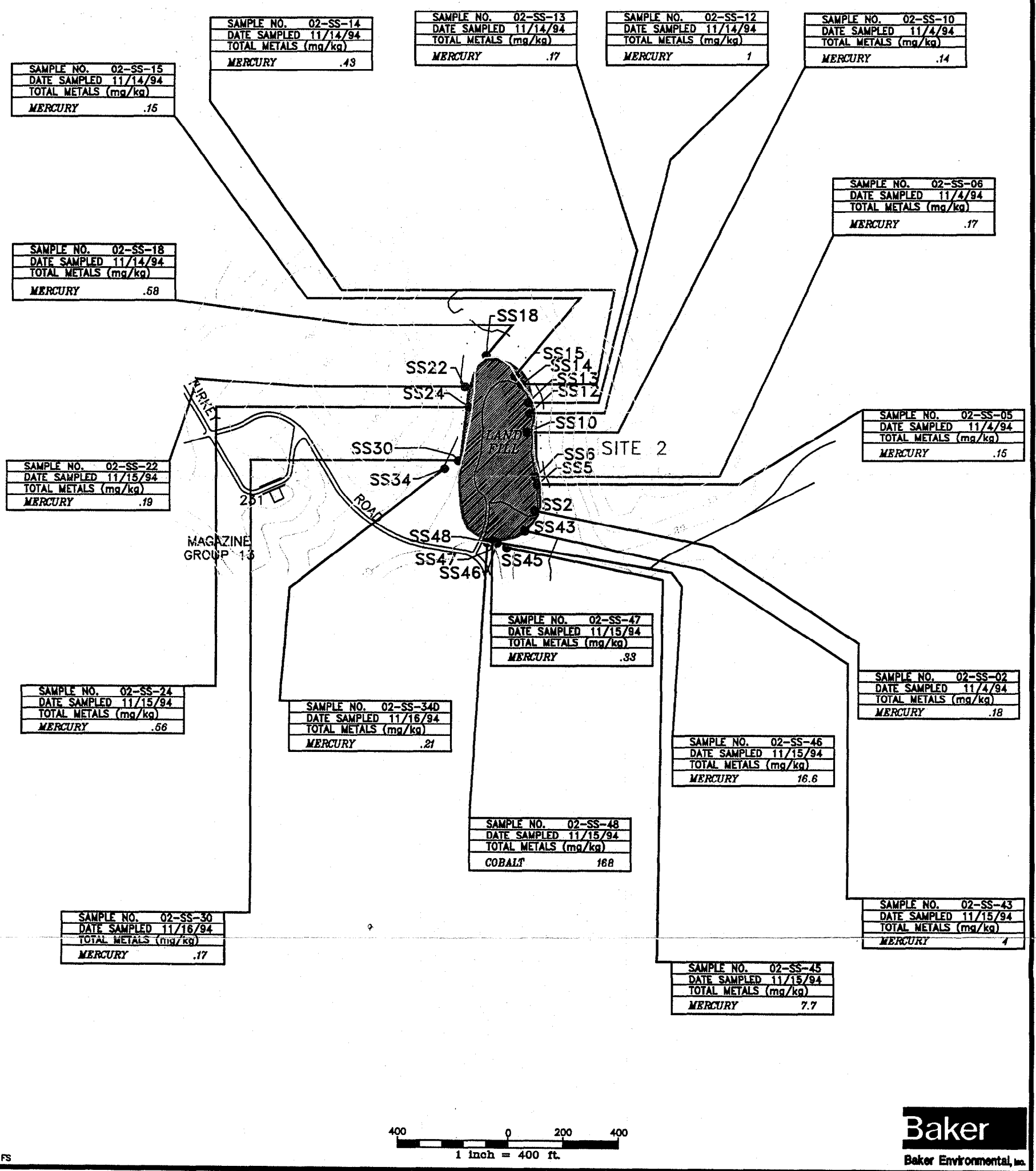
NOTES: 1) CONCENTRATIONS IN RED ITALICS INDICATE INDICATE AN EXCEEDANCE OF THE FINAL RL.

SOURCE: LANTDIV, OCT. 1991

FIGURE C-1
ORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS IN SURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

01764FB11Z



LEGEND

DRAINAGE

APPROXIMATE SITE BOUNDARY

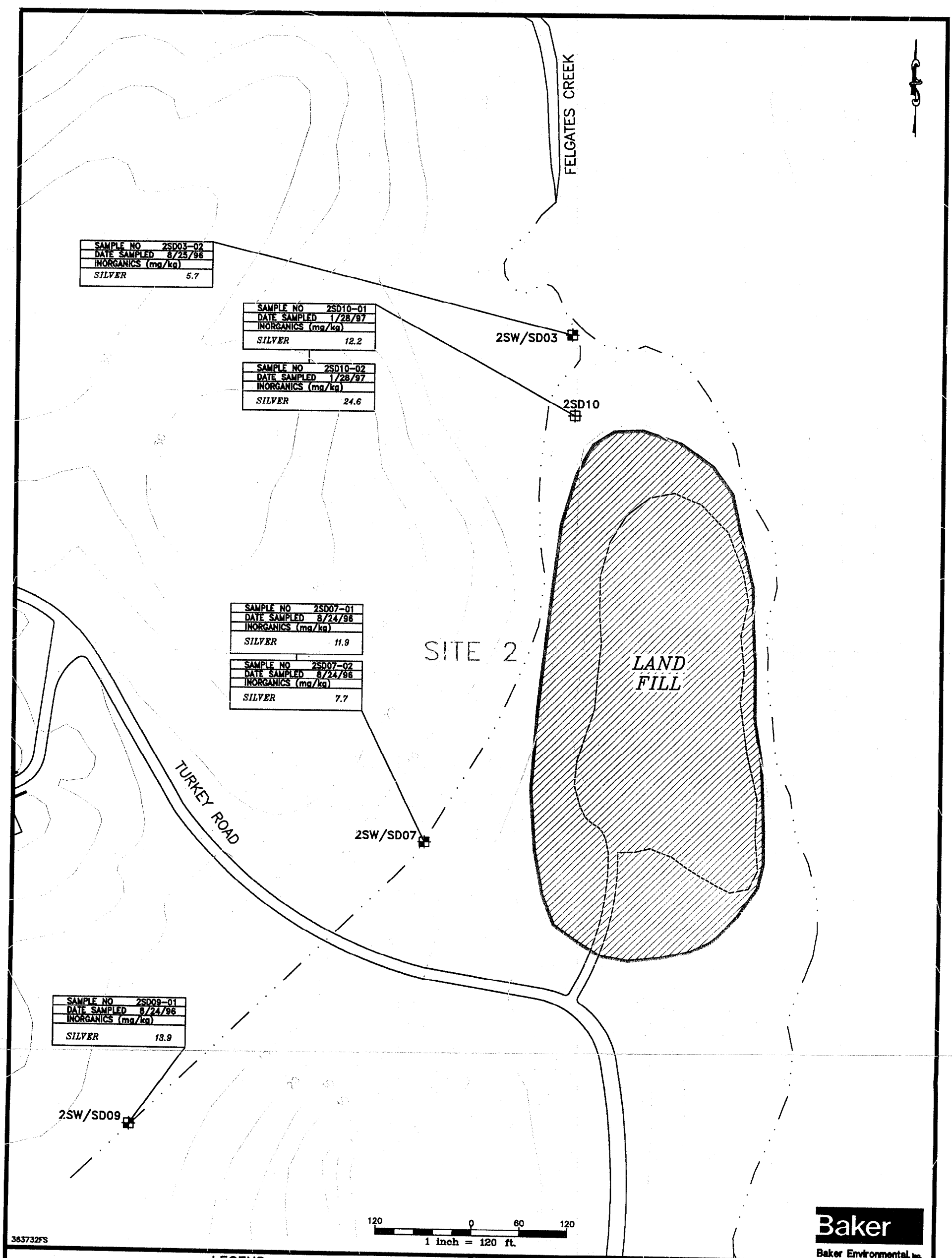
SS1 SOIL SAMPLE LOCATION

NOTES: 1) CONCENTRATIONS IN RED ITALICS INDICATE AND EXCEEDANCE OF THE FINAL RL.

SOURCE: LANTDIV, OCT. 1991

FIGURE C-2
INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS IN SURFACE SOIL
SITE 2

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



LEGEND

2SW/SD01 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

2SD10 – SEDIMENT SAMPLE LOCATION, JANUARY 1997

— · · · — – DRAINAGE

– APPROXIMATE SITE BOUNDARY

NOTES: 1) CONCENTRATIONS IN RED ITALICS INDICATES AN EXCEEDANCE OF THE FINAL RL.

SOURCE: LANTDIV, 1991

FIGURE C-3
INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS IN SEDIMENT
SITE 2
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

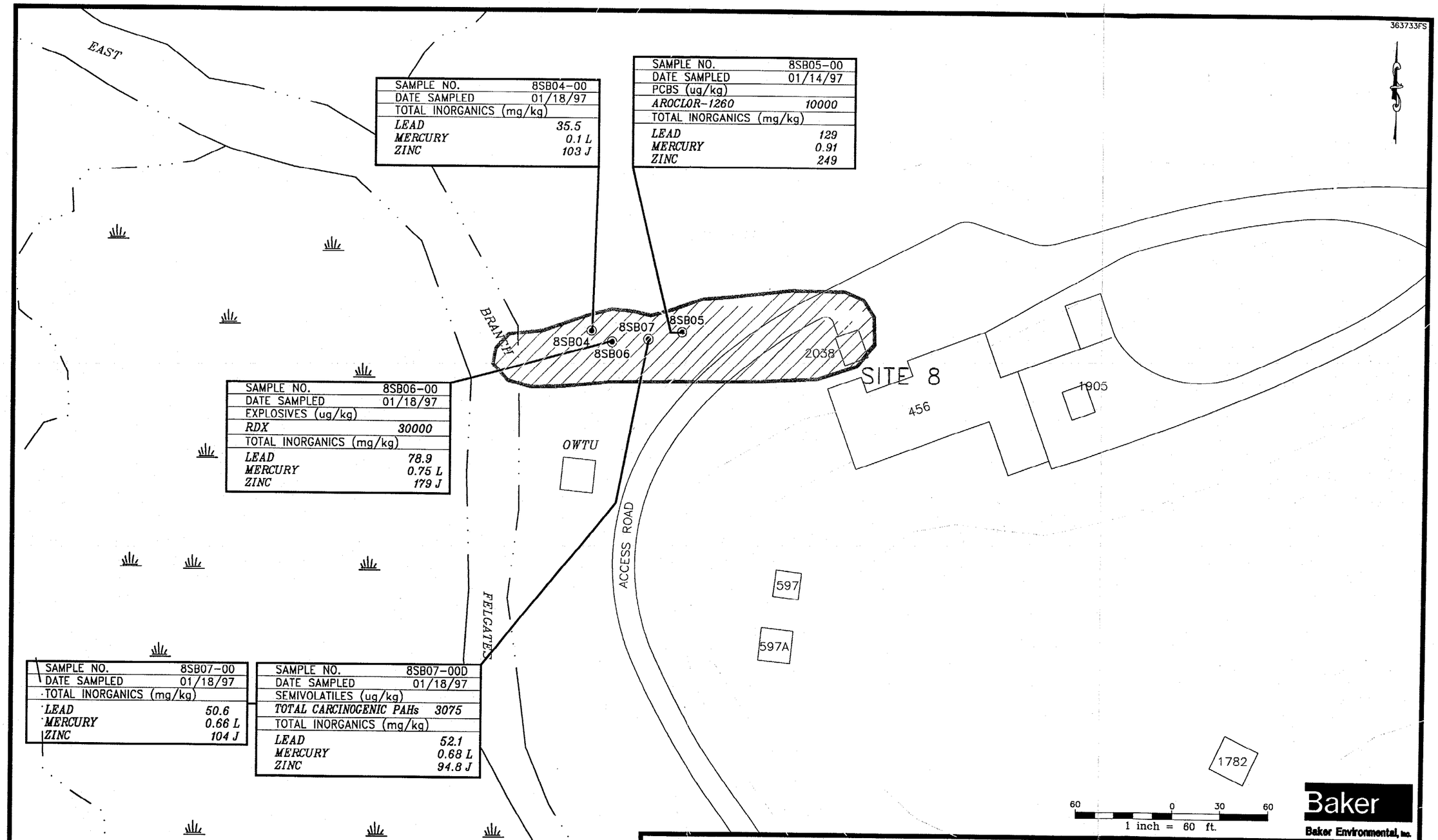


FIGURE C-4
SELECTED ORGANIC AND INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS IN SURFACE SOIL – SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

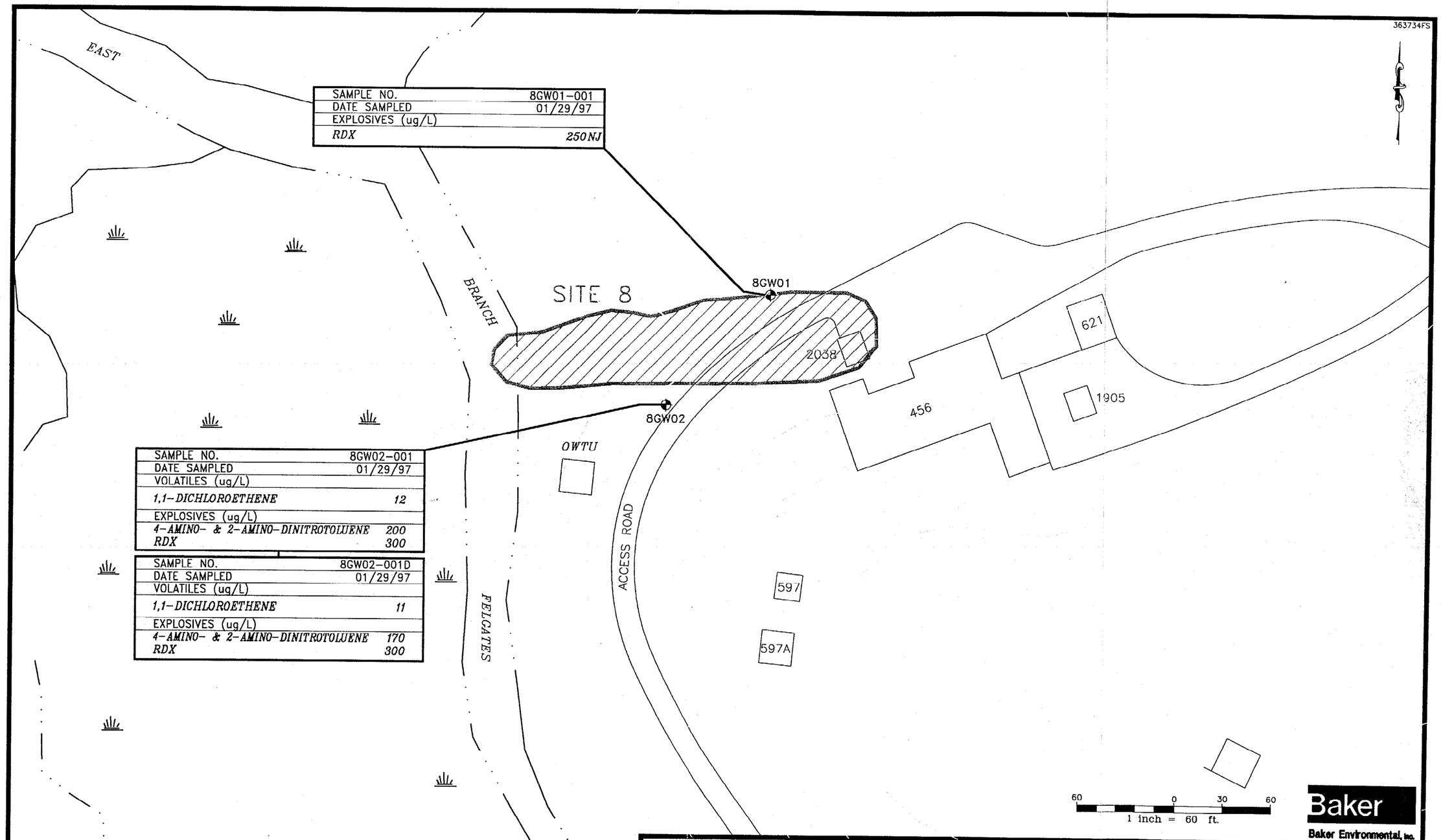
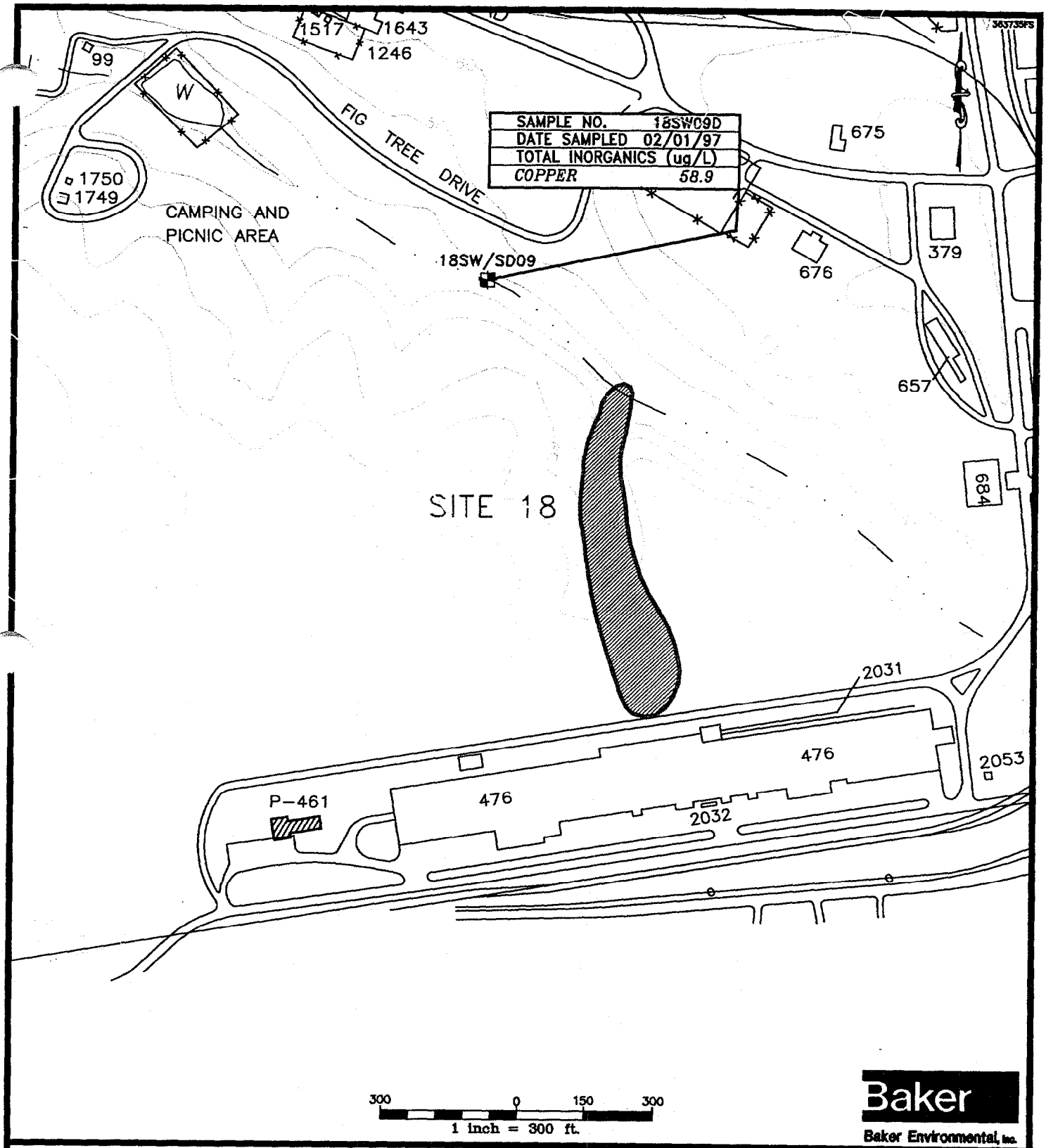


FIGURE C-5
ORGANIC AND INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS IN GROUNDWATER – SITE 8
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



Baker

Baker Environmental, Inc.

LEGEND

18SW/SD09 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

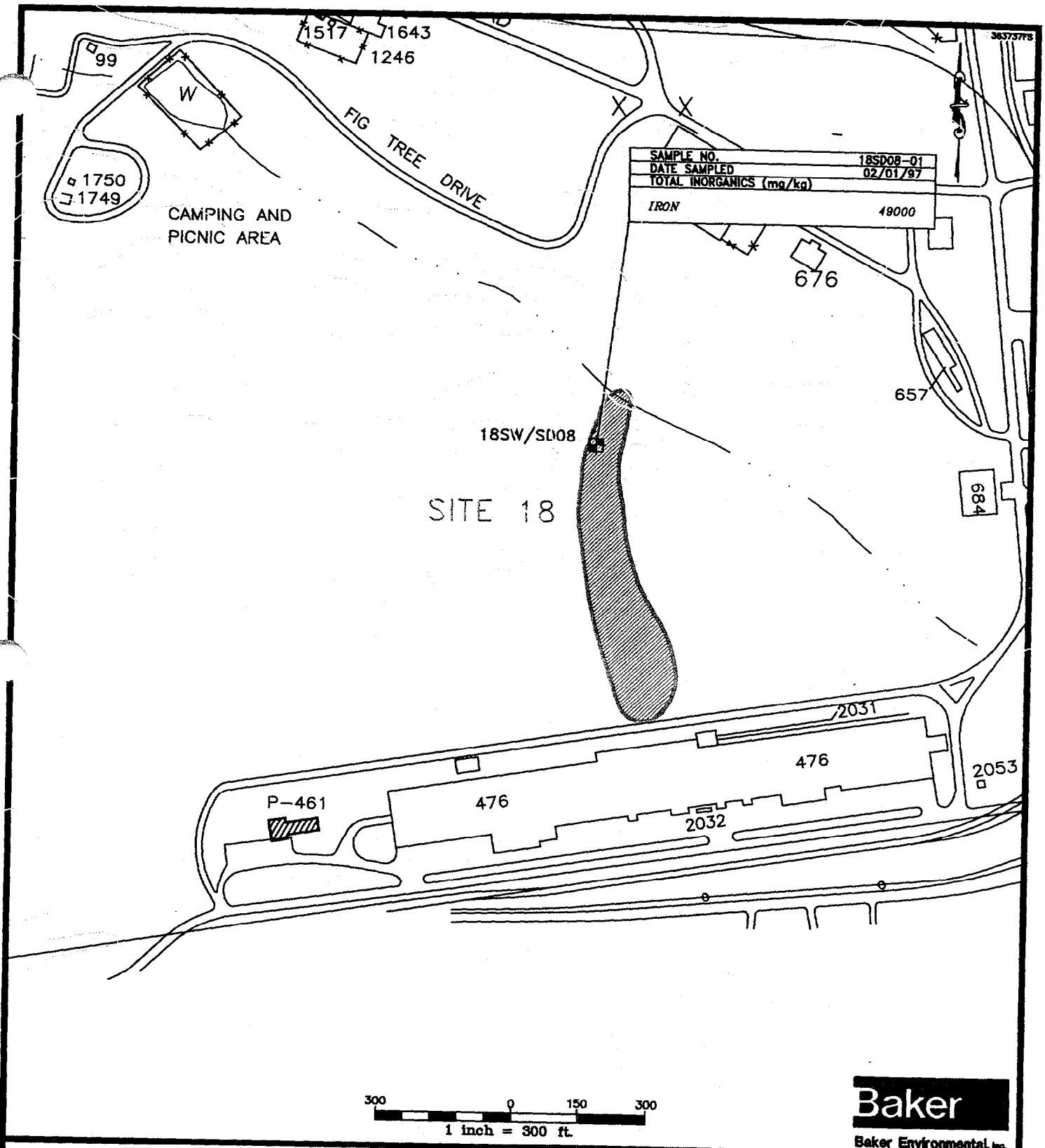
– DRAINAGE

– APPROXIMATE SITE BOUNDARY

NOTE: CONTAMINANT OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF THE FINAL RL.

SOURCE: LANTDIV, 1991.

FIGURE C-6
INORGANIC CONTAMINANT OF CONCERN IN EXCEEDING OF FINAL REMEDIATION LEVELS IN SURFACE WATER
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



Baker

Baker Environmental, Inc.

LEGEND

18SW/SD08 – SURFACE WATER AND SEDIMENT SAMPLE LOCATION

– DRAINAGE

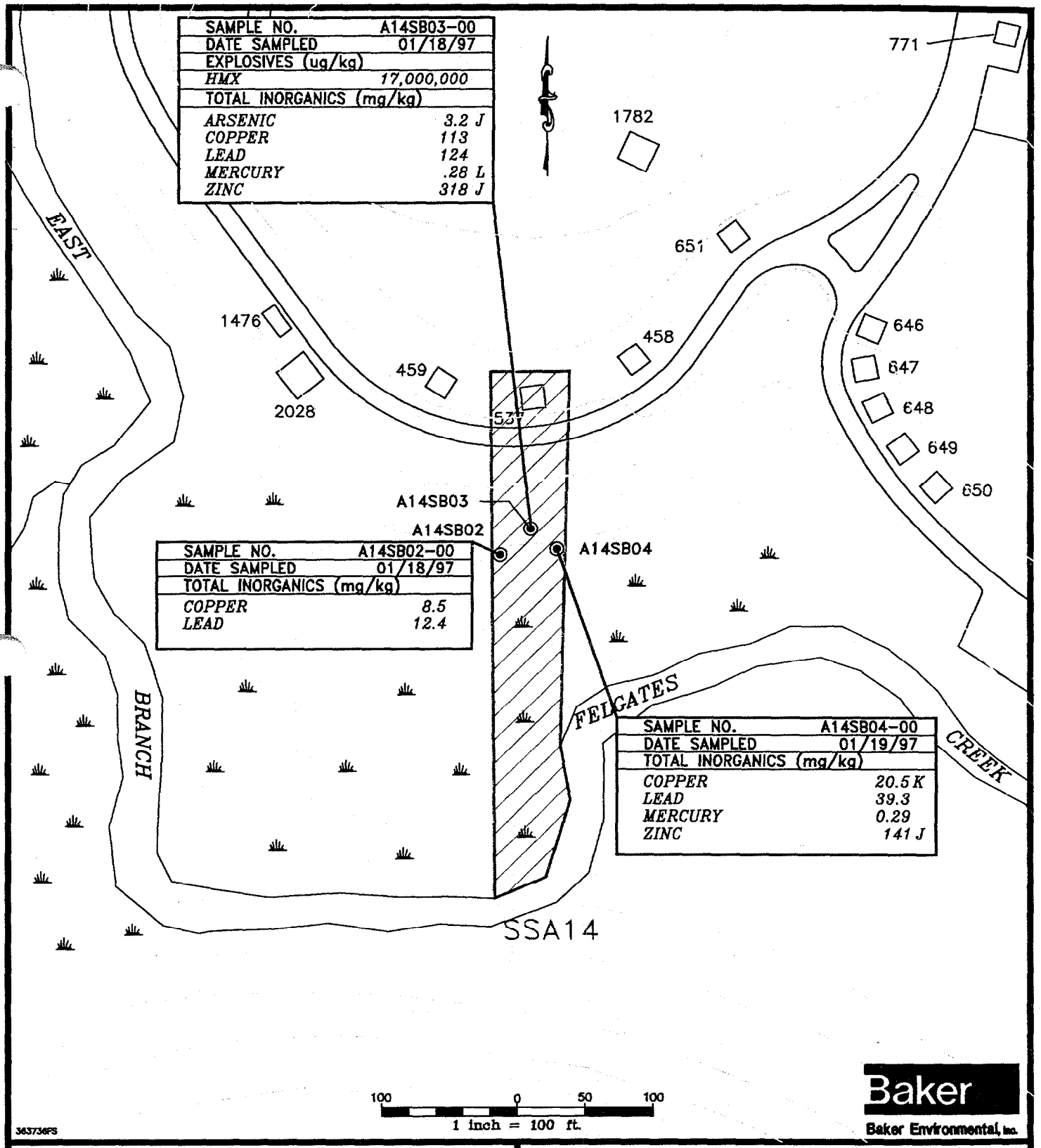
– APRROXIMATE SITE BOUNDARY

– STRUCTURE

NOTE: CONTAMINANTS OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF AN FINAL RL.

SOURCE: LANTDIV, 1991.

FIGURE C-7
INORGANIC CONTAMINANTS OF CONCERN IN EXCEEDING OF FINAL REMEDIATION LEVELS IN SEDIMENT
SITE 18
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



Baker
Baker Environmental, Inc.

LEGEND

A14SB02 – SOIL BORING
– DRAINAGE
– APPROXIMATE SITE BOUNDARY
– STRUCTURE
– MARSH

NOTE: CONTAMINANTS OF CONCERN IN RED ITALICS INDICATE AN EXCEEDANCE OF THE FINAL RL.
SOURCE: LANTDIV, 1991.

FIGURE C-8
ORGANIC AND INORGANIC CONTAMINANTS OF CONCERN EXCEEDING FINAL REMEDIATION LEVELS IN SURFACE SOIL
SSA-14
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

APPENDIX D
VENDOR INFORMATION

Baker

Phone Call Report

Project/Location:	Sites 2, 8 and SSA 14 WPNSTA, Yorktown	S.O. No.:	62470
		Date:	9/22/98
		Contract No.:	0356

To:	Mr. William Mahaffey	From:	Ellen Bjerklie
Repres.:	Pelorus Environmental Technology Corporation	Repres.:	Baker Environmental, Inc.
Phone No.:	(303) 670-2875	Phone No.:	(412) 269-6117

Subject: bioslurry treatment of PAH contaminated soils

Pelorus Environmental is a vendor for bioslurry technology for treatment for PAH-contaminated soils. Full scale systems have been operated. Treatment time may be lengthy. Mr. Mahaffey suggested that composting may be a faster treatment option. 135 cubic yards of soil may be the vary lowest volume that can be treated and still be cost effective. He suggested that the process should be run sequentially under aerobic and anaerobic conditions.

Prepared by: Ellen Bjerklie Title: Engineer Page: 1 of 1

bcc:

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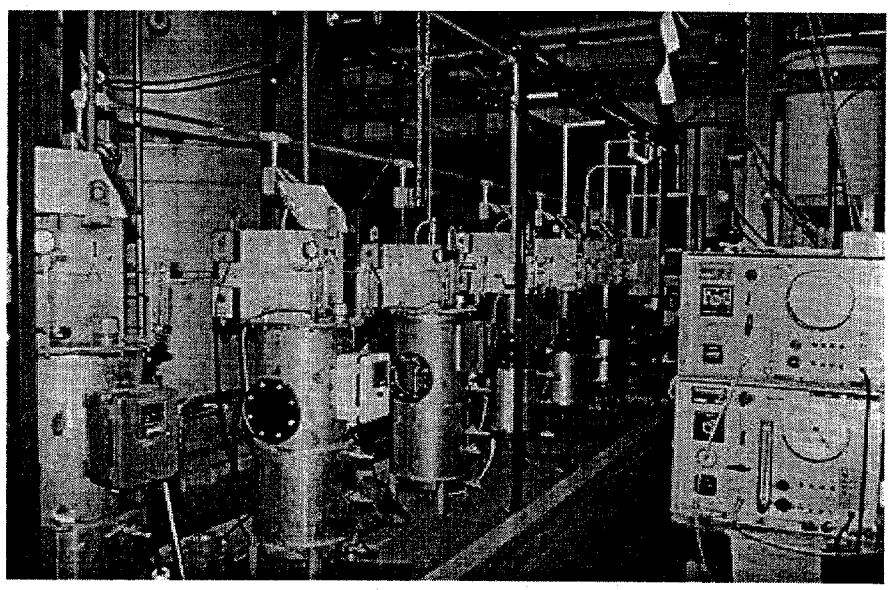
ECOVA CORPORATION

(Bioslurry Reactor)

TECHNOLOGY DESCRIPTION:

The ECOVA Corporation (ECOVA) slurry-phase bioremediation (bioslurry) technology aerobically biodegrades creosote-contaminated materials. The technology uses batch and continuous flow bioreactors to process polynuclear aromatic hydrocarbon (PAH)-contaminated soils, sediments, and sludges. The bioreactors are supplemented with oxygen, nutrients, and a specific inoculum of enriched indigenous microorganisms to enhance the degradation process.

Because site-specific environments influence biological treatment, all chemical, physical, and microbial factors are designed into the treatment process. The ultimate goal is to convert organic wastes into relatively harmless by-products of microbial metabolism, such as carbon dioxide, water, and inorganic salts. Biological reaction rates are accelerated in a slurry system because of the increased contact efficiency between contaminants and microorganisms. The photograph below shows the bioslurry reactor.



Bioslurry Reactor

WASTE APPLICABILITY:

The bioslurry reactor is designed to treat highly contaminated creosote wastes. It can also treat other concentrated contaminants that can be aerobically biodegraded, such as petroleum wastes. The bioslurry reactor system must be engineered to maintain parameters such as pH, temperature, and dissolved oxygen within ranges conducive to the desired microbial activity.

STATUS:

This technology was accepted into the SITE Demonstration Program in spring 1991. From May through September 1991, EPA conducted a SITE demonstration using six bioslurry reactors at EPA's Test and Evaluation Facility in Cincinnati, Ohio.

ECOVA conducted bench- and pilot-scale studies to evaluate bioremediation of PAHs in creosote-contaminated soil from the Burlington Northern Superfund site in Brainerd, Minnesota.

Bench-scale studies were conducted before pilot-scale evaluations to determine optimal treatment protocols. EIMCO Biolift slurry reactors were used for the pilot-scale processing. Data from the optimized pilot-scale program were used to establish treatment standards for K001 wastes as part of EPA's Best Demonstrated Available Technology program.

This technology is no longer available through ECOVA. However, the technology is being implemented by Walsh Environmental Scientists & Engineers. For further information on the technology, contact either the EPA Project Manager or the technology developer contact.

DEMONSTRATION RESULTS:

Results from the SITE demonstration indicated that slurry-phase biological treatment significantly improved biodegradation rates of carcinogenic 4- to 6-ring PAHs. The pilot-scale bioslurry reactor reduced 82 ± 15 percent of the total soil-bound PAHs in the first week. After 14 days, total PAHs had been biodegraded by 96 ± 2 percent. An overall reduction of 97 ± 2 percent was observed over a 12-week treatment period, indicating that almost all biodegradation occurred within the first 2 weeks of treatment. Carcinogenic PAHs were biodegraded by 90 ± 3.2 percent to 501 ± 103 milligrams per kilogram (mg/kg) from levels of 5,081 ± 1,530 mg/kg.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:
Ronald Lewis
U.S. EPA
National Risk Management Research Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7856
Fax: 513-569-7105

TECHNOLOGY DEVELOPER CONTACT:
William Mahaffey
~~Walsh Environmental Scientists & Engineers~~ Pelorus Environmental Technology Group
~~4888 Pearl E. Circle, Suite 108~~
~~Boulder, CO 80301-2475~~ 3528 Evergreen Pkway
303-670-2875 Evergreen, CO 80439
~~303-443-3282~~
Fax: 303-~~443-0367~~ 674-6103

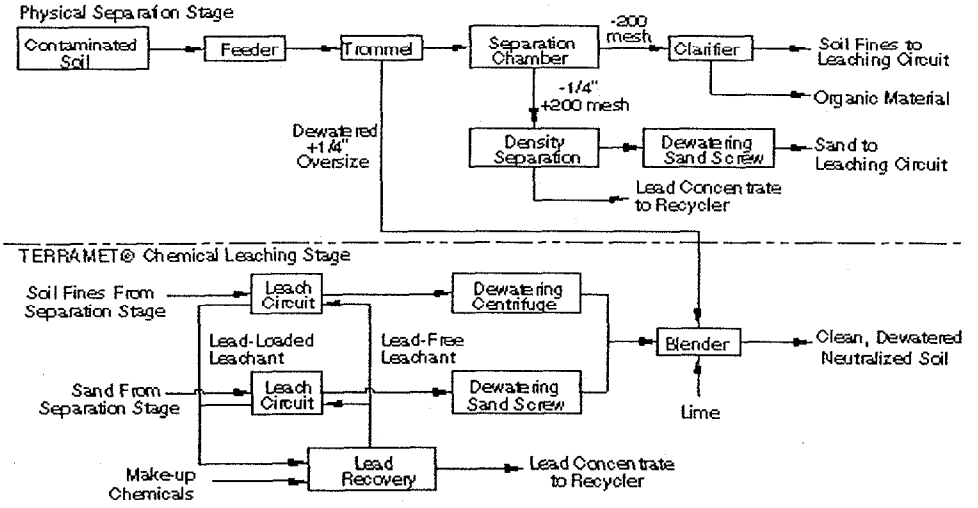
COGNIS, INC.

(TERRAMET® Soil Remediation System)

TECHNOLOGY DESCRIPTION:

The COGNIS, Inc. (COGNIS), TERRAMET® soil remediation system leaches and recovers lead and other metals from contaminated soil, dust, sludge, or sediment. The system uses a patented aqueous leachant that is optimized through treatability tests for the soil and the target contaminant. The TERRAMET® system can treat most types of lead contamination, including metallic lead and lead salts and oxides. The lead compounds are often tightly bound by fine soil constituents such as clay, manganese and iron oxides, and humus.

The figure below illustrates the process. A pretreatment, physical separation stage may involve dry screening to remove gross oversized material. The soil can be separated into oversized (gravel), sand, and fine (silt, clay, and humus) fractions. Soil, including the oversized fraction, is first washed. Most lead contamination is typically associated with fines fraction, and this fraction is subjected to countercurrent leaching to dissolve the adsorbed lead and other heavy metal species. The sand fraction may also contain significant lead, especially if the contamination is due to particulate lead, such as that found in battery recycling, ammunition burning, and scrap yard activities. In this case, the sand fraction is pretreated to remove dense metallic or magnetic materials before subjecting the sand fraction to countercurrent leaching. Sand and fines can be treated in separate parallel streams.



TERRAMET® Soil Remediation System

After dissolution of the lead and other heavy metal contaminants, the metal ions are recovered from the aqueous leachate by a metal recovery process such as reduction, liquid ion exchange, resin ion exchange, or precipitation. The metal recovery technique depends on the metals to be recovered and the leachant employed. In most cases, a patented reduction process is used so that the metals are recovered in a compact form suitable for recycling. After the metals are recovered, the leachant can be reused within the TERRAMET® system for continued leaching.

Important characteristics of the TERRAMET® leaching/recovery combination are as follows: (1) the leachant is tailored to the substrate and the contaminant; (2) the leachant is fully recycled within the

treatment plant; (3) treated soil can be returned on site; (4) all soil fractions can be treated; (5) end products include treated soil and recycled metal; and (6) no waste is generated during processing.

WASTE APPLICABILITY:

The COGNIS TERRAMET® soil remediation system can treat soil, sediment, and sludge contaminated by lead and other heavy metals or metal mixtures. Appropriate sites include contaminated ammunition testing areas, firing ranges, battery recycling centers, scrap yards, metal plating shops, and chemical manufacturers. Certain lead compounds, such as lead sulfide, are not amenable to treatment because of their exceedingly low solubilities. The system can be modified to leach and recover other metals, such as cadmium, zinc, copper, and mercury, from soils.

STATUS:

This technology was accepted into the SITE Emerging Technology Program in August 1992. Based on results from the Emerging Technology Program, the technology was accepted into the Demonstration Program in 1994. The demonstration took place at the Twin Cities Army Ammunition Plant (TCAAP) Site F during August 1994. The TERRAMET® system was evaluated during a full-scale remediation conducted by COGNIS at TCAAP. The full-scale system was linked with a soil washing process developed by Brice Environmental Services Corporation (BESCORP). The system treated soil at a rate of 12 to 15 tons per hour.

An Innovative Technology Evaluation Report and a Technology Capsule describing the demonstration and its results will be available in 1997.

The TERRAMET® system is no longer available through COGNIS, Inc. For further information about the system, contact the EPA Project Manager. For further information on the BESCORP soil washing process, refer to the profile in the Demonstration Program section (completed projects).

DEMONSTRATION RESULTS:

Lead levels in the feed soil ranged from 380 to 1,800 milligrams per kilogram (mg/kg). Lead levels in untreated and treated fines ranged from 210 to 780 mg/kg and from 50 to 190 mg/kg, respectively. Average removal efficiencies for lead were about 75 percent. The TERRAMET® and BESCORP processes operated smoothly at a feed rate of 12 to 15 tons per hour. Size separation using the BESCORP process proved to be effective and reduced the lead load to the TERRAMET® leaching process by 39 to 63 percent. Leaching solution was recycled, and lead concentrates were delivered to a lead smelting facility. The cost of treating contaminated soil at the TCAAP site using the COGNIS and BESCORP processes is about $200 per ton of treated soil, based on treatment of 10,000 tons of soil. This cost includes the cost of removing ordnance from the soil.

FOR FURTHER INFORMATION:

EPA PROJECT MANAGER:
Michael Royer
U.S. EPA
National Risk Management Research Laboratory
2890 Woodbridge Avenue, MS-104
Edison, NJ 08837-3679
732-~~908~~-321-6633
Fax: 908-321-6640

EPA Site report not printed yet

Baker

Phone Call Report

Project/Location:	Sites 2, 8 and SSA 14	S.O. No.:	62470
	WPNSTA, Yorktown	Date:	9/17/98
		Contract No.:	0356

To:	Ms. Maggie Thomas	From:	Ellen Bjerklie
Repres.:	Doe Run Company	Repres.:	Baker Environmental, Inc.
Phone No.:	(573) 626-3445	Phone No.:	(412) 269-6117

Subject: soil washing/leaching recovery of metal contaminants in soils

The leaching of metals from soil has been found to be effective on most heavy metals (including lead, copper, zinc) but has not been tried on cobalt. The process has not been successful on mercury. The process has no impact on organic contaminants. It is uncertain whether the process would be impacted by the presence of organics. A mobile unit is available but the cost for processing depends on the quantity and type of contaminants. Doe Run is in the process of permitting their fixed facility in Missouri so small quantities can be processed. However, this facility is a secondary lead smelter and the permit will not allow organic materials to be processed. The waste stream is a metals concentrate which may or may not be suitable for metals recycling. If metals concentrations are high enough, the wastestream will go through a recycling process.

Prepared by: Ellen Bjerklie Title: Engineer Page: 1 of 1

bcc:

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THE DOE RUN COMPANY
RESOURCE RECYCLING DIVISION
BUICK FACILITY

HC 1 BOX 1395
HWY. KK
BOSS, MO 65440
573-626-4813 • FAX 573-626-3304

September 28, 1998

Ms. Ellen Bjerklie
Baker Environmental
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, PA 15108

Dear Ms. Bjerklie:

Enclosed is an information packet which includes an overview of The Doe Run Resource Recycling Division as well as some history of the TERRAMET® technology. Thanks for your interest!

I spoke with our technical personnel regarding the application of the TERRAMET process to soil contaminated with lead and other heavy metals, including mercury, as well as organics. Could you provide us with more detailed information about the contaminants? Specifically, we are interested in the levels of each contaminant involved, both organics and metals.

If you could fax something to the number above, I would appreciate it. I will follow up with you as soon as possible with more information about how Doe Run may be able to assist with your project. Thank you!

Sincerely yours,

Maggie Thomas

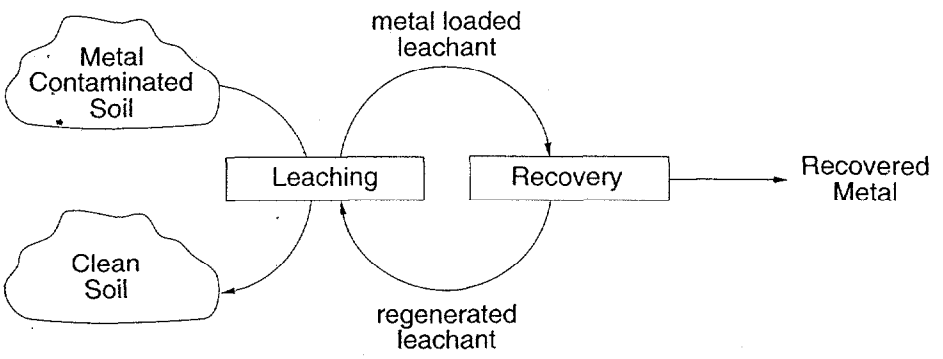
Maggie Thomas
Assistant Raw Materials Coordinator

Enclosure (1)

COGNIS
Metal Remediation

COGNIS' TERRAMET® metal remediation process leaches heavy metals from contaminated soil, dust, sludge or sediment with proprietary aqueous leaching solutions. The process is effective for Pb, Cu, Ni, Zn, Cd and other metals. A specific variation of the TERRAMET leaching process has been developed for mercury remediation. When coupled with the physical separation techniques of soil washing, both discrete metallic fragments and ionic species (which are often tightly bound by fine soil constituents such as clay, manganese and iron oxides, and humus) can be treated. Metals are removed in a continuous countercurrent leaching operation to maximize effectiveness. The leached metal is then recovered via direct reduction or an extraction/stripping process. COGNIS provides its clients with a cost-effective alternative to either stabilization or excavation, transport and disposal of metal-contaminated soils, sludges or sediments which are currently restricted to Class I landfills. COGNIS' proprietary process can also be used to remove and recover these same metals from industrial waste streams.

COGNIS TERRAMET® Metal Remediation Process



The important characteristics of the TERRAMET leaching process are the following:

- Metals are concentrated and recovered
- Process has been commercially proven
- COGNIS has 30 years of experience in the extraction and mining business
- Soil handling is performed with mobile, proven equipment
- Contamination levels can be monitored during the reclamation
- Treated soil is reusable on site
- COGNIS process does not preclude organic removal
- No aqueous waste stream is generated
- Leachants and extractants are reusable

TERRAMET is a registered trademark of COGNIS.

TERRAMET® Heavy Metal Recovery Process

COGNIS

TERRAMET Heavy Metal Recovery Process
Twin Cities RCRA Cleanup Project

The COGNIS TERRAMET Heavy Metal Recovery Process is successfully cleaning up lead-contaminated soil at the Twin Cities Army Ammunition Plant (TCAAP) in New Brighton, MN. TCAAP is Minnesota's #1 priority Superfund site; the TERRAMET Process is being used as part of a $370 million Installation Restoration Program being overseen by the Minnesota Pollution Control Agency (MPCA). Normally, metals-contaminated soils are hauled away for disposal. This project is the first ever RCRA cleanup in which soil is actually treated, contaminant metals are removed and recycled, and cleaned soil is returned to the site.

Project Results

An acceptance period was required by MPCA to prove the TERRAMET technology. The first six days of operation constituted the acceptance test; all of the cleanup goals were met from day one (see table).

Acceptance Period Results

Metal	RCRA Cleanup Goal	Acceptance Period Run Number (ppm)					
		1	2	3	4	5	6
Antimony	4	<1	<1	<1	<1	<1	<1
Cadmium	4	0.8	1.8	<0.02	3.0	0.2	1.5
Chromium	100	3.5	0.6	2.6	6.0	5.0	5.0
Copper	80	23.7	12.6	9.8	12.7	16.1	11.3
Lead	300	19	60	30	<60	<60	38
Mercury	0.3	<0.02	0.04	0.03	<0.02	<0.02	0.3
Nickel	45	8.9	6.2	4.6	5.4	6	7.8
Silver	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

During operation, lead results have ranged from 19 ppm to 175 ppm. 1,600 tons of soil were successfully processed in 1993; the remainder of the site (approximately 10,000 tons) will be processed in the Spring and Summer of 1994.

TERRAMET is a registered trademark of COGNIS, Inc.

Twin Cities Army Ammunition Plant
Site F—burning area

Quantity: 11,600 tons

Contaminants: antimony, cadmium, chromium, copper, lead, mercury, nickel, silver, live and spent ammunition

Initial lead: avg. 6,000 ppm, up to 86,000 ppm

Cleanup Goals: <175 ppm lead, background levels for other seven metals, removal of all ammunition

Site Description

Army contractors used Site F from the 1940's to the 1960's to burn scrap munitions and powder and to bury scrap casings and burning residues. Ash and residue were spread around the site's surface, as well as buried in trenches. Heavy metals have been found in the upper 1-2 feet of soil over three acres, and 10 feet down in the trench areas. Lead is the primary concern, with concentrations found up to 86,000 ppm and averaging 6,000 ppm over the entire contamination area. Seven additional heavy metals (antimony, cadmium, chromium, copper, mercury, nickel, and silver) have been detected in elevated levels at the site.

The site must be cleaned up to satisfy both the Federal Facility Agreement for TCAAP and the installation's RCRA permit. Lead must be decreased to a target of <175 ppm with a 300 ppm enforceable standard; the other seven metals must be reduced to background levels.

The TERRAMET® Process

The Army and MPCA favored finding a permanent remediation approach—removing the ammunition, recovering the contaminant metals, and allowing the cleaned soil to be returned to the site. COGNIS was selected in the Fall of 1992 to perform a treatability study on Site F soil. Bench-scale tests showed the site's sandy, silty soils were amendable to soil washing and leaching, producing a clean soil stream and a recoverable metal product which could be recycled at a smelter. A contract was negotiated and full-scale operations commenced in the Fall of 1993. The entire process from start of the treatability study to arrival of equipment on site was only 12 months.

The Treatment Plant

- **Completely Mobile**
- **Capacity: 10-20 tons/hour**
- **Treatment Includes:**
  - **Soil Washing**
  - **Ammunition Removal**
  - **Soil Leaching**
  - **Metals Reclamation**

COGNIS is the prime remedial contractor on site, and together with Bescorp Inc. (soil washing contractor, Fairbanks, Alaska), provides all services directly related to the remediation: health and safety planning and implementation, excavation, ammunition removal, complete soil treatment, and return of the soil to the site.

Further information on this or other COGNIS services can be obtained by calling (707) 575-7155 or writing to the address below.

COGNIS
A Company for Biological and Environmental Technology
2331 Circadian Way
Santa Rosa, CA 95407
(707) 575-7155
Fax (707) 575-7833

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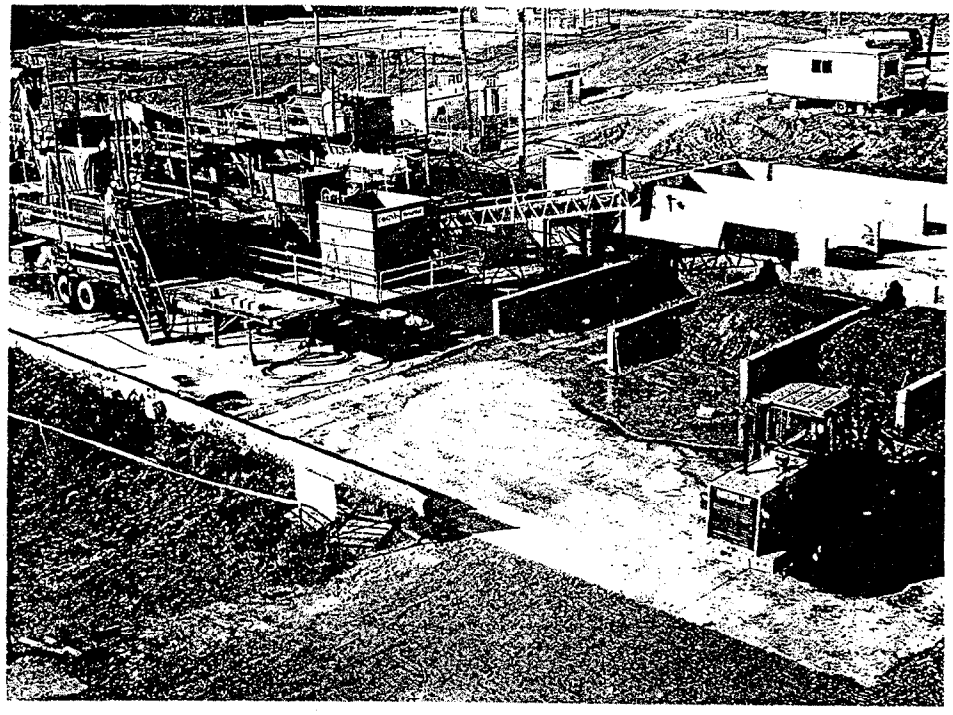
Printed on recycled paper.

Treating Metals in Soil

By Keith W. Benker

UNTIL now, the remediation of metals-contaminated soil has traditionally meant immobilizing it on site or landfilling it off site. But, rather than rely on the traditional, the Twin Cities Army Ammunition Plant selected a pioneering soil treatment technology to clean up this facility in the heart of Minnesota's #1-ranked Superfund site.



The Twin Cities Army Ammunition Plant (TCAAP), built during World War II, no longer produces ammunition. But, over the years, it generated plenty of contaminants. A former open burning area, called Site F, had eight heavy metals in it, the worst being lead (averaging 1,600 ppm but reaching 86,000 ppm). The state's pollution control agency initially pursued a lead cleanup level of less than 40 ppm. Later negotiations resulted in a target of 175 ppm, with an enforceable standard of 300 ppm for lead. Other metals being reduced to negotiated background levels are antimony, 4 ppm; cadmium, 4; chromium, 100; copper, 80; mercury, 0.3; nickel, 45; and silver, 5 ppm. These are challenging standards; the EPA's health-based cleanup levels for lead are usually 500 to 1,000 ppm.

Because regulators and the Army wanted a solution better than those offered by the three metal-removal techniques typically used, and the Army especially wanted to achieve "clean closure," TCAAP chose an untried, but promising, technology called soil washing and leaching.

Soil Washing

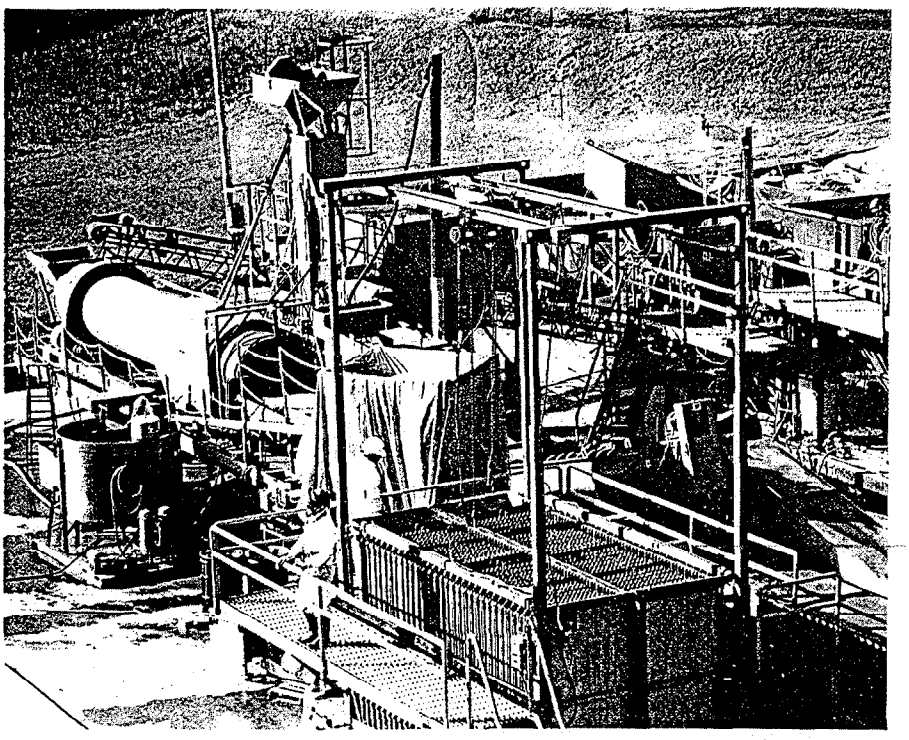
Soil washing, essentially a sorting technique, comes from the mining industry. It has been used on some cleanup projects to reduce the amount of soil that must be landfilled because the larger, clean soil particles can be segregated from the more heavily contaminated fines. But soil washing can also remove larger, loose metallic fragments, especially sand-size or greater.

Top, empty casings after high-pressure rinsing were collected for storage and disposal. Below, after treatment, most of the soil was clean enough to be returned to the site.

Soil washing has been used as a remediation technique in The Netherlands and Germany for nearly 10 years. In the U.S., the Bescorp firm recently used soil washing in the EPA-sponsored Superfund Innovative Technologies Evaluation (SITE) Demonstration Program at an Alaska battery site. Bescorp is the contractor at Site F.

At Site F, the soil is excavated, stockpiled, and fed into a hopper; 6 to 15 tons are processed in an hour. The soil first goes through a trommel, which breaks soil clumps and screens out material greater than ¼-inch di-

Reprinted from the Nov.-Dec. 1994 issue of The Military Engineer



The leaching process, shown here, dissolves the finer metallic residuals in sand and silt/clay by an acid wash. The blue equipment is the mixer for treating silt/clay and the metals recovery equipment is in the front.

ameter, and is then subjected to a high-pressure water rinse. The oversized material is conveyed to inspectors who pick out empty cartridge casings for storage and disposal. The rinsed stones and gravel are then tested and returned to the site.

Smaller materials travel to a chamber where sand is separated from fine silts and clays. From here, the sand goes through a spiral classifier and a mining industry "jig," where heavy metallic fragments are removed by density separation. The sand is sent to a soil leaching process and the recovered metals are dewatered and stored in drums for recycling.

The fines fraction contains most of the contamination that remains after soil washing; it consists of metallic-form metals smaller than sand-size and ionic metals bound to the fines. Therefore, the fines go from the separation chamber to clarifiers for soil leaching as well.

Soil Leaching

In soil leaching, chemicals are used to remove metals that remain in sand and fine silts and clays. Due to the physical and chemical properties of sand and fines, they require different equipment to mix and convey each stream. Thus, sand and fines are leached in separate, parallel circuits.

In each of the two treatment circuits, the soil undergoes an acid wash that dissolves fine metal fragments and ionic metals and produces a solution. This occurs in a series of mixers and clarifiers. The leachant flows against the incoming soil current and becomes progressively cleaner as the soil goes through the series.

The clean sand and fines are dewatered, neutralized, tested, and added to the clean oversize material and returned to the site. The spent leachant is sent to a recovery unit. There, it flows through an electrochemical reduction system which precipitates metals into a "cake." The leachant is then recycled internally. The soil leaching technique used here is a proprietary process called Terramet, developed by COGNIS.

Metals Reclamation

Metals are reclaimed by collecting particles from the soil washing process and the precipitated material from the soil leaching process. The metals are drummed and shipped to a smelter. Reclamation removes the metals from the hazardous material cycle, thereby eliminating long-term liability.

Lessons Learned

From the start in mid-1993, this project has been generally successful. The COGNIS/Bescorp process works best for lead removal. By project completion next year, some 95 percent of the soil is expected to pass the enforceable lead standard of 300 ppm. The remaining soil, which cannot be treated by this process, will be landfilled.

However, this treatment process is less effective on other metals (especially copper and mercury) because they are more difficult to leach or are more difficult to recover from the leachant; the treatment does not achieve the stringent background-based cleanup goals for these metals. Still, the treatment would achieve the cleanup levels based on health risk.

Of the treated soil that failed the copper and/or mercury background-based goals, 95 percent of it would pass typical health risk-based cleanup goals some 10 to 100 times higher. TCAAP is currently attempting to renegotiate the metals cleanup goals; disposing of soil that poses little or no risk to human health and the environment is of questionable value, particularly in view of limited landfill space and funds.

We also face continuing challenges related to the disposal trenches at the site; they have higher contaminant concentrations and greater clay content. Moreover, the processing rate has not reached the design rate of 20 tons an hour. The moisture content of treated soil, especially the fines, posed an early problem, but a dewatering centrifuge overcame this.

As with most new technologies, difficulties arise and, just as certain, improvements come. It is gratifying to treat metals-contaminated soil in this way. This project amply demonstrates the value of an emerging treatment technology.

Keith W. Benker, P.E., of Wenck Associates, Inc., an environmental engineering consulting firm, managed the Site F project. He has a B.S. degree in geological engineering. In writing this article, he was assisted by Martin R. McCleery, P.E., TCAAP; Peter J. Rissell, Army Environmental Center; and Darryl L. Terho, P.E., and Bridgette Manderfeld, Federal Cartridge Co., TCAAP's operating contractor.

THE DOE RUN COMPANY
RESOURCE RECYCLING DIVISION
BUICK FACILITY

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HWY. KK
BOSS, MO 65440
573-626-4813 • FAX 573-626-3304

TERRAMET® TECHNOLOGY UPDATE

The TERRAMET process equipment and license to the technology was sold to The Doe Run Company when Henkel Chemical Company, the parent of COGNIS, INC., exited the remediation market. Upon completion of the Twin Cities Army Ammunition Plant project, the equipment was demobed from Minnesota to Doe Run's Buick Resource Recycling Facility in Boss, MO.

The Doe Run Company has been producing lead in Missouri for over a century. In 1990, Doe Run completed the construction of its new RCRA part B permitted facility designed to "mine" lead from scrap. Doe Run is committed to the recycling of metals, particularly lead, at the Buick Resource Recycling Facility. The facility, located in Boss, Missouri, has recovered and recycled lead from more than 25 National Guard firing ranges around the country. Soil and other waste streams from the Defense Nuclear Agency, Naval Facilities Engineering Command and Government Owned/Contractor Operated (GOCO) facilities have also been recycled at Doe Run.

The Doe Run Company is in the process of integrating the TERRAMET equipment into its existing RCRA Part B permitted facility. The TERRAMET process complements Doe Run's existing capability to recycle lead contaminated sands and soils through its pyrometallurgical circuit. The two have come together as TERRAMET Services to provide low cost, permanent solutions for metals contaminated soil and other solid waste streams. Contaminated soil can be shipped to the facility, the metals removed and reused as feed in the smelting of lead and lead alloys, and the soil put to beneficial reuse as part of the mining operation. Shipping contaminants offsite to a permitted facility benefits those who require immediate reuse and transfer of clean parcels of land. If required, TERRAMET equipment can still be mobilized to projects. Special projects, such as the separation of lead from depleted uranium at Lake City Army Ammunition Plant in Independence, Missouri, will require the plant to set up at the remediation site.

TERRAMET Services offers the flexibility of treating waste streams either on or offsite, together with options that can be tailored to minimize costs.

- **Waste Classification** The first step is to determine if the soil or waste stream should go straight to the lead smelter. RCRA recycling exemptions may allow a generator to classify lead contaminated sand and soil as a nonhazardous material under certain circumstances. This classification greatly reduces transportation costs, storage requirements, and turnaround time if it is available.

- **Soil Washing** If the metals can be removed physically, the soil will only undergo soil washing. The lead concentrate will go directly to the smelter. The soil with lead below the state's required lead concentration will be declared clean and used as cover in the mining operation.

- **Soil Washing/Soil Leaching** If the lead or other metals have weathered or have been smeared into the soil, they cannot be removed by soil washing alone. In that case, the soil will be washed to remove particulate metal and then leached to remove ionic lead. Again, the lead concentrate would be reclaimed at the smelter and the soil reused after lab tests confirm that it has been treated to below state limits for hazardous contaminants.

- **Pyrometallurgical** Some metals and minerals are required in the smelting process. The soil may be used as direct feed for the smelter, depending on the material makeup and the current metallurgical requirements of the plant.

- **Selective Processing** Doe Run personnel can work with generators to custom fit a treatment process for a particular waste. There are instances, driven by regulation or waste characterization, that require a certain process step, end use, or remediation goal. Doe Run will combine unit operations, segregate and process "hot spots," or modify its system (in compliance with the Part B permit) to accommodate special needs.

The overall costs are lower than previously experienced in the field because there are no mobilization costs, no per diems, and the labor force is already in place manufacturing lead. Material handling, health and safety activities and maintenance are all performed less expensively at a fixed facility than in the field.

revised 5/5/98

Baker

Phone Call Report

Project/Location:	Sites 2, 8 and SSA 14 WPNSTA, Yorktown	S.O. No.:	62470
		Date:	10/9/98
		Contract No.:	0356

To:	Mr. Eric Klein	From:	Ellen Bjerklie
Repres.:	Doe Run Company	Repres.:	Baker Environmental, Inc.
Phone No.:	(925) 943-2460	Phone No.:	(412) 269-6117

Subject: soil washing treatment of contaminated soils

Doe Run has a mobile unit for soil washing. Mobilization/demobilization costs will total $100,000. The process would have to go through two stages: one stage for all contaminants except for PCBs, and one stage for PCBs (a different solvent is required). The cost for the first stage would be $125/ton to process. For the PCB treatment, the cost to process would be another $200/ton on top of the $125/ton. Off-site disposal would be required for the concentrated waste stream. This cost is not inlcuded in the processing cost. This technology has been used successfully for soils from firing ranges contaminated with lead.

Prepared by: Ellen Bjerklie Title: Engineer Page: 1 of 1

bcc:

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Applied EnviroDevelopment, Inc.

Cover Sheet

Date : 10/8/98

Time : 3:17:20 PM

To:	Mr. John Mentz	From:	Eric Klein
Company:	Baker Environmental	Fax:	925-930-2832
Fax Number:	+1 (412) 2692002	Phone:	925-943-2460

Subject:

Pages including cover page: 1

Message:

TO ELLEN BJERKLIE:

I forgot to mention the option of direct smelting of the soils at Yorktown.

If the PCB's and the low level explosives pose no problem to the Missouri DNR, the soil can all be directly fed into the smelter. The smelter needs silica from the sand to help float off the impurities in the ore. Therefore, the soil becomes a commercial substititute for purchasing silica, and it all escapes the hazardous waste regulations.

The costs would be:

Mob/Demob	$ 0
Direct Smelting	165/ton
Tranportation	? (from Yorktown to MO)

NOTES:
1) The smelter can not tolerate oversize > 1"
2) PCB under 50 ppm is not regulated.
3) Explosives residues of RDX and HMX are of no concern to Missouri DNR.

Please feel free to contact me if you have any questions.

606 Stagecoach Court
Lafayette, CA 94549
(925) 943-2460
(925) 930-2832
esklein@ibm.net

ARCADIS GERAGHTY & MILLER

ARCADIS Geraghty & Miller, Inc.
14497 North Dale Mabry Hwy.
Suite 240
Tampa
Florida 33618
Tel 813 264 3506
Fax 813 962 0867

TELEFAX

ART

To:
Ellen Bjerklie

Copies:
Copies

Fax:
412 269-2002

Date:
8 October 1998

From:
Mike Mann

Total pages:
2

Extension:
813 264 3571

Our ref.:
OurRef

Subject:
Soil Washing

If you do not receive all pages, please call to let us know as soon as possible.

Attached is our response to your inquiry about soil washing. Please feel free to call Mike Mann at the above number with any further questions.

I will send you our Statement of Qualifications and Experience by overnight mail. It contains a comprehensive description of the process and previous project experience with some of the contaminants you listed.

THIS MESSAGE IS INTENDED ONLY FOR THE USE OF THE INDIVIDUAL OR ENTITY TO WHICH IT IS ADDRESSED AND MAY CONTAIN INFORMATION THAT IS PRIVILEGED, CONFIDENTIAL, AND EXEMPT FROM DISCLOSURE UNDER APPLICABLE LAW.
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ARCADIS GERAGHTY & MILLER

ARCADIS Geraghty & Miller, Inc.
14497 North Dale Mabry Hwy.
Suite 240
Tampa
Florida 33618
Tel 813 264 3506
Fax 813 962 0867

ART

Ms. Ellen Bjerklie
Baker Environmental Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, PA 15108

Tampa,
8 October 1998

Contact:
Michael J. Mann, PE

Extension:
813-264-3571

Subject:
Feasibility Study - Yorktown

Dear Ellen:

Thank you for the opportunity to respond to your request for work you are doing for the U.S. Navy at Yorktown.

The site you have referenced is difficult in several aspects, in that it is a relatively small volume with fairly difficult contaminants. ARCADIS has dealt with all of these contaminants in various forms and combinations. The actual system to be used will depend upon the physical characteristics of the soil matrix and upon the form of the primary contaminants. Maximum feed concentrations are very high and the treatment standards are very low. Even achieving a 99% removal efficiency will not achieve the standards in some cases. It is unlikely that soil washing alone can meet the requirements. However, a combination of hot-spot removal, matrix separation, and ultimate disposal of a much smaller mass, may be possible. Treatability studies would be essential to make this determination.

Because the volume is so small, the unit price will be deceivingly high. We estimate that if separation and treatment are feasible that the unit price for mob/demob, provision of the plant, labor, utilities, chemicals, and process analytical, but exclusive of residual disposal, the price will be approximately $500 per ton.

Please feel free to contact us at anytime with questions or comments.

Sincerely,

ARCADIS Geraghty & Miller, Inc.

Michael J. Mann, P.E.
Vice President

Our ref.:
g:/proposal/baker.doc

Baker

Phone Call Report

Project/Location:	Sites 2, 8 and SSA 14	S.O. No.:	62470
	WPNSTA, Yorktown	Date:	10/8/98
		Contract No.:	0356

To:	Mr. Mike Mann	From:	Ellen Bjerklie
Repres.:	Arcadis: Geraghty & Miller	Repres.:	Baker Environmental, Inc.
Phone No.:	(813) 264-3571	Phone No.:	(412) 269-6117

Subject: soil washing for treatment of contaminated soils

The response to a request for a cost estimate from Arcadis Geraughty & Miller included a single unit cost of $500/ton for capital and O&M costs. Further breakdown was required for the FS cost estimate. Mr. Mann estimated that $75,000 was required for mobilization/demobilization of the soil washing plant/equipment. The remainder of the cost would include the plant, labor, utilities, chemicals and process analytical. For the volume of soil at all three sites, this would work out to approximately $450/ton for treatment.

Prepared by: Ellen Bjerklie Title: Engineer Page: 1 of 1

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IGT

FAX COVER PAGE

Date: Oct 12, 1998

To: Ellen Bjerklie

Company:

From: Vipul Srivastava **Phone #**

Total Number of Pages Including Cover Page 2

Enclosed is a brief summary of the approach IGT recommends for treatment of the Yorktown soil and the associated costs. I will mail more detailed information describing results obtained in related projects.

INSTITUTE OF GAS TECHNOLOGY
1700 S. Mt. Prospect Road
Des Plaines, IL 60018-1804
847/768-0500 FAX 847/768-0546

Proposal#: 18700-04 Remediation of Soil Contaminated with Metals and Organics at the Yorktown, VA Naval Facility

Soil at this site contains a mixture of organic and inorganic contaminants. Organics include PAHs, PCBs, RDX, and HMX while the inorganic contaminants include Cu, Co, Pb, Hg, and Zn. Organic contaminants have a maximum concentration of 17,000 ppm but are generally present at 100 ppm or less. Inorganic contaminants are present at 15 to 500 ppm. The soil is stated to be silty sand and total volume of 870 yd^3 of contaminated soil is present at three locations at the site. What is wanted is a destruction of organics and removal of inorganic contaminants. Immobilization of inorganic contaminants is not being considered at this site. Therefore a soil slurry treatment approach is recommended that will allow for destruction of organic contaminants through the use of Chemical Biological Treatment (CBT), and removal of inorganic contaminants by leaching them from the soil and subsequently precipitating them from the leaching solution.

The CBT process employs hydrogen peroxide as an oxidizing agent to initiate the oxidative destruction of organic contaminants and then biodegradation completes the destruction of organic contaminants. The chemical oxidation step of the CBT process works best at a pH of 4 and has successfully been employed to treat soil slurries. In this case as the pH of the soil slurry is adjusted to 4 a chelating agent, EDTA, will be added to the slurry to facilitate extraction of metals from the soil. The liquid, which will then contain metals leached from the soil, will be separated from the soil. The soil will then be treated in a landfarming or composting mode to complete the chemical oxidation and biodegradation process resulting the destruction of organic contaminants. The liquid will contain chelated metals as well as any organic contaminants that may have leached from the soil. The liquid will first be subjected to chemical oxidation to destroy residual organic contaminants and then it will be treated under anaerobic conditions using sulfate reducing bacteria to remove the metals from solution.

The treatment time for a batch of soil will be 90 days or less. The number of batches, and hence the size of treatment vessels, will be determined when more details of the project become available. An estimate of the total project cost is $200,000 to $400,000. These costs are rough estimates that may require adjustment once actual site conditions and specific cleanup objectives are known. The enclosed information describes in greater detail the use of the CBT process in both slurry and landfarming mode for the treatment of contaminated soil, and the use of chelating agents to efficiently leach metals from soil followed by the subsequent treatment of the leachate.

Key issues that should be resolved by laboratory treatability tests are the soil type and the leachability of mercury in this soil. The clay content of the soil can dramatically effect the quality of water obtained from the soil leaching step and could complicate subsequent treatment of the liquid. Additionally it has been IGT's experience that leaching of mercury from some soils can be difficult while the leaching of other metals is rarely a problem. Since the regulatory standards for mercury are so low it is important to verify in laboratory treatability tests that effective removal of mercury from this soil can be accomplished. A suitable laboratory treatability test can be performed within 90 days for a total cost of $20,000.

Baker

Phone Call Report

Project/Location:	Sites 2, 8 and SSA 14 WPNSTA, Yorktown	S.O. No.:	62470
		Date:	
		Contract No.:	0356

To:	Mr. Vipul Srivastava	From:	Ellen Bjerklie
Repres.:	Institute of Gas Technology	Repres.:	Baker Environmental, Inc.
Phone No.:	(847) 768-0539	Phone No.:	(412) 269-6117

Subject: biotechnology for treatment of contaminated soils

September 22, 1998:

Mr. Vipul was named as a contact for a biological and chemical process developed for the remediation of metal-contminated solids and liquids.

Mr. Vipul stated that the pH of the soil has to be high enough so the metals will be soluble to be available for the microbes to treat the soil. The Institute of Gas Technology (IGT) has full scale remediation going on. Information regarding the site contaminants will be sent to Mr. Vipul.

October 12, 1998:

Mr. Vipul called with John Kilbane (IGT) and Tom Hayes (Gas Research Institute -GRI) to discuss the process that they think is most appropriate for treating the contaminated soils at WPNSTA, Yorktown. A treatability study would be required to determine the exact process and if the remediation goals can be met. The study would cost approximately $20,000. The process would be a two stge treatment because both inorganic and organic contaminants are present in the soil. A landfarming process would be used to destroy the organics and a leaching/bioslurry process will separate the inorganics. Mobilization and demobilization costs were not defined because they do not know what facilities are available at the site. They estimated the total project cost to be between $200,000 and $400,000.

Prepared by: Ellen Bjerklie Title: Engineer Page: 1 of 1

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IGT

Headquarters

October 12, 1998

Ms. Ellen Bjerklie
Baker Environmental Inc.
Airport Office Park, Bldg 3
420 Rouser Road
Coraopolis, PA 15108

Dear Ms. Bjerklie:

Thank you for the opportunity to submit a proposal to perform work with Baker Environmental. The Institute of Gas Technology (IGT) is pleased to submit its proposal No. 18700-04 entitled "Remediation of Soil Contaminated with Metals and Organics at the Yorktown, VA Naval Facility" which we believe meets all of Baker's requirements to provide treatment of soil contaminated at the Yorktown, VA site. The estimated total cost of the project is $200,000 to $400,000, but a treatability test costing $20,000 is recommended prior to initiating this project in the field. The duration of the project can't be specified until more information is available, but the enclosed information will allow you to get an idea of the time that will be required. The enclosed information also describes some past projects IGT has performed that involve the leaching of metals from soil and the use of the CBT process in slurry or landfarming mode.

If this treatment approach is acceptable to you I suggest that a meeting should be arranged at which time we can visit the site and discuss details of the treatability study. If I can be of further assistance please let me know.

Sincerely,

John J. Kilbane II, Ph.D.
Senior Environmental Scientist
(847) 768-0723 phone
(847) 768-0546 fax

cc: Vipul Srivastava

Tom Hayes

Proposal#: 18700-04 Remediation of Soil Contaminated with Metals and Organics at the Yorktown, VA Naval Facility

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The CBT process employs hydrogen peroxide as an oxidizing agent to initiate the oxidative destruction of organic contaminants and then biodegradation completes the destruction of organic contaminants. The chemical oxidation step of the CBT process works best at a pH of 4 and has successfully been employed to treat soil slurries. In this case as the pH of the soil slurry is adjusted to 4 a chelating agent, EDTA, will be added to the slurry to facilitate extraction of metals from the soil. The liquid, which will then contain metals leached from the soil, will be separated from the soil. The soil will then be treated in a landfarming or composting mode to complete the chemical oxidation and biodegradation process resulting the destruction of organic contaminants. The liquid will contain chelated metals as well as any organic contaminants that may have leached from the soil. The liquid will first be subjected to chemical oxidation to destroy residual organic contaminants and then it will be treated under anaerobic conditions using sulfate reducing bacteria to remove the metals from solution.

The treatment time for a batch of soil will be 90 days or less. The number of batches, and hence the size of treatment vessels, will be determined when more details of the project become available. An estimate of the total project cost is $200,000 to $400,000. These costs are rough estimates that may require adjustment once actual site conditions and specific cleanup objectives are known. The enclosed information describes in greater detail the use of the CBT process in both slurry and landfarming mode for the treatment of contaminated soil, and the use of chelating agents to efficiently leach metals from soil followed by the subsequent treatment of the leachate.

Key issues that should be resolved by laboratory treatability tests are the soil type and the leachability of mercury in this soil. The clay content of the soil can dramatically effect the quality of water obtained from the soil leaching step and could complicate subsequent treatment of the liquid. Additionally it has been IGT's experience that leaching of mercury from some soils can be difficult while the leaching of other metals is rarely a problem. Since the regulatory standards for mercury are so low it is important to verify in laboratory treatability tests that effective removal of mercury from this soil can be accomplished. A suitable laboratory treatability test can be performed within 90 days for a total cost of $20,000.

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United States Patent [19]

Kelley et al.

[11] Patent Number: 5,610,065

[45] Date of Patent: Mar. 11, 1997

[54] INTEGRATED CHEMICAL/BIOLOGICAL TREATMENT OF ORGANIC WASTE

[75] Inventors: **Robert L. Kelley**, Mt. Prospect; **Andy H. Hill**, Glen Ellyn; **Vipul J. Srivastava**, Forest Park; **W. Kennedy Gauger**, Pflugerville; **John J. Kilbane, II**, Woodstock, all of Ill.

[73] Assignee: **Institute of Gas Technology**, Chicago, Ill.

[21] Appl. No.: **402,421**

[22] Filed: **Mar. 10, 1995**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 56,527, May 3, 1993, abandoned, which is a continuation-in-part of Ser. No. 718,330, Jun. 21, 1991, abandoned.

[51] **Int. Cl.**[6] **C12S 3/02**

[52] **U.S. Cl.** **435/264**; 435/262; 435/262.5

[58] **Field of Search** 435/264, 262, 435/262.5

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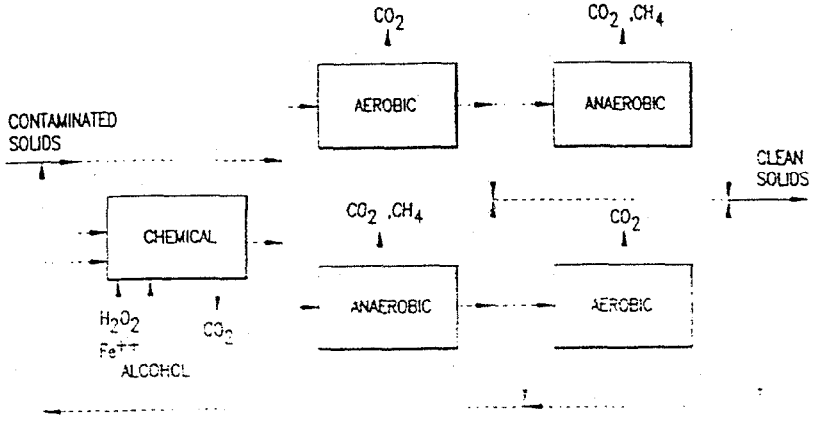
Primary Examiner—Helen Pratt

Attorney, Agent, or Firm—Speckman, Pauley & Fejer

[57] **ABSTRACT**

A process for improved remediation of polynuclear aromatic hydrocarbon and/or polychlorinated hydrocarbon contaminated solid materials by integrated chemical/biological treatment comprising contacting the polynuclear aromatic hydrocarbon and/or polychlorinated hydrocarbon for chemical treatment with hydrogen peroxide in the presence of ferrous ion in liquid solution at a temperature of about 10° C. to about 100° C., oxidizing the polynuclear aromatic hydrocarbon materials and/or polychlorinated hydrocarbon materials and producing more readily biodegradable hydrocarbon product materials, and then biodigesting the product materials by aerobic and/or anaerobic biodigestion. A lower alcohol added to the chemical treatment in accordance with one embodiment further enhances oxidation of 4- to 6-ring aromatic hydrocarbon contaminants.

27 Claims, 4 Drawing Sheets



NSMP PROCESS FOR REMEDIATION OF METAL-CONTAMINATED SOLIDS AND LIQUIDS

By

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ABSTRACT

The use of biotechnology for the removal and recovery of heavy metals from wastewater and leachates derived from metal contaminated solids was the focus of this study. The Natural Solution for Metals Pollution (NSMP) process was shown to remove metals from contaminated soil and from fly ash. Leaching conditions capable of treating soil that is heavily contaminated with metals such that it can pass the TCLP (EPA Method 1311) test are described and the subsequent treatment of metal-laden leachate is discussed. Of particular interest was the treatability of liquids containing chelated metals and/or metals associated with colloidal material. The use of sulfate reducing bacteria (SRB) in specially designed bioreactors termed the SRB Biosystem was shown to be effective in treating fly ash and soil leachates. The system can treat wastewater with pH values as low as 1.70 and can tolerate high concentrations of toxic heavy metals with heavy metal removal efficiencies of 95% to 100%. The heavy metals removed from waste solid leachates and contaminated water were recovered as metal sulfides, which can be further processed for heavy metal recovery. This study shows that toxic non-metals such as boron and selenium can also be removed from wastewater by the SRB Biosystem.

Keywords: heavy metals, wastewater, sulfate reduction, radionuclide

INTRODUCTION

Biological treatment studies of water contaminated with heavy metals have been reported by a number of researchers[1,6,7,16] and the mechanisms of biological removal of heavy metals from water are well understood[2,3,4,7] but, on the other hand, the treatment of solids containing inorganic pollutants, particularly heavy metals, has not been as well studied and solids contaminated with heavy metals are increasingly becoming environmental concerns and are among the most challenging pollution problems. As more and more stringent environmental regulations are enacted, treatment technologies with higher efficiencies are required and technologies that convert waste to recyclable materials are particularly desirable.

There are numerous physical and chemical techniques for the removal of metals from contaminated liquids, such as filtration, flocculation, chemical precipitation, electrodeposition, and ion exchange, and many of these processes have been successfully implemented on an industrial scale.[19] However, fewer treatment processes involve biological approaches for heavy metal removal. Moreover, these processes are ineffective or show reduced ability to treat chelated[14] or colloid-associated[9,13,18] metal solutions which can be expected to result from attempts to elute metals from contaminated soils. This is because metals and radionuclides present in soil leachates and contaminated groundwater are generally associated with colloidal materials.[9,18] Colloid-associated metals and metal-chelate complexes can be dissociated/degraded by microorganisms, albeit at various efficiencies[8,15] and because a microbiological approach is considered to be more environmentally benign it may be preferable to a physico-chemical approach. In this study, an innovative and efficient biological treatment system, the NSMP process was developed for the leaching of metals from solids and the treatment of both metal-contaminated wastewater and solutions resulting from leaching of metals from contaminated solids. The treatment system utilizes a bioreactor containing sulfate reducing bacteria (SRB) to precipitate heavy metals from wastewater streams and collects metal precipitates as sludge in a settling tank.

The idea of utilizing microbial sulfate reduction as a pollution abatement procedure for acid mine water treatment has been reported as early as 1969.[21] Under anaerobic

conditions, SRBs generate alkalinity and produce hydrogen sulfide which makes them capable of removing metal ions from solutions at low pH.[7] Additionally, SRBs can alter the oxidation states of certain metals such as Cr^{6}, and convert the more toxic and soluble metal ion Cr^{+6} and radionuclide ion U^{+4} to the less toxic and less soluble Cr^{+3} and U^{+2} ions. SRBs are also capable of degrading some organic pollutants[10,20] and may therefore be useful in degrading organic contaminants that may be present in soil leachates and contaminated groundwater. Constructed wetlands which contain SRB are now commonly used to treat acid mine drainage (AMD)[16], and in Pennsylvania alone there are several hundred constructed wetlands[11]; however, space is not always available for a wetland. Recently bioreactor systems have been proposed to solve certain metal pollution problems using SRBs[6,7], but neither constructed wetlands nor previously described bioreactor systems are capable of treating the full diversity of metal-containing wastewater problems nor do they provide for the recovery and recycle of metals. The SRB Biosystem was designed to address these concerns.

In this study, wastewater containing heavy metals and leachates eluted from heavy metal-contaminated soils and coal fly ash were treated in the SRB Biosystem. The capabilities of the SRB Biosystem to remove the heavy metals from the water stream and recover them as metal sulfides, as well as its acid neutralization ability were investigated.

MATERIALS AND METHODS

Wastewater: Two wastewaters were tested. One is acid mine drainage (AMD) which was produced by adding 2 liters of distilled water to a kilogram of pyrite-rich mine gob waste, mixing thoroughly, and incubating at ambient temperatures for one week. Naturally occurring microorganisms oxidized the pyrite and produced a supernatant which after being diluted ten-fold with distilled water had a pH value of 3.00 and contained 11 ppm Cd^{2+}, 14 ppm Ni^{2+}, 21 ppm Zn^{2+}, 4.3 ppm Mn^{2+}, 560 ppm Fe^{3+}, 52 ppm Al^{3+}, 310 ppm Ca^{2+}, and 820 ppm SO_4^{2+}. Before treatment in the SRB Biosystem, the following nutrients were dissolved in 17 liter AMD to support SRB growth: 60 g citric acid, 20 ml lactic acid, 8 g NH_4Cl, 4 g K_2HPO_4, and 8 g yeast extract.

Soil Leachate Treatment: Two soil leachate treatment tests were conducted in this study. In the first treatment test, 200 g of Contaminated Soil I was leached with 4 L Solution A (6 g citric acid/L water) at a V(ml)/Wt(g) ratio of 20:1 for 24 hours, the derived leachate was treated in the SRB Biosystem using the Recycling Mode for 5 days and then aerated. The treatment data are given in Table 4, which show that concentrations of Al, Cd and Zn in the reactor effluent were reduced to below the detection limits, Ni concentration was decreased to 0.83 ppm. Other metal ion concentrations were also decreased sharply. The pH of the SRB bioreactor effluent was increased from 3.72 to 6.40 and was further increased to 8.23 after aeration. Figure 5 shows the soil leachate treatment efficiency of the SRB Biosystem in terms of percent removal of individual metals from the soil leachate. One hundred percent of Al, Cd, and Zn were removed from the leachate (which as reported in Table 4 as stated above, these three metals were also totally recovered as dry metal sulfides), while 99% of Fe, 93% of Ni, 85% of Ca, 49% of Mg, and 15% of S were also removed.

A second test was performed to evaluate the ability of the SRB Biosystem to treat a soil leachate that contains 13 ppm Cd, 42.5 ppm Hg, 11 ppm Ni, 23 ppm Pb, 22 ppm Se, and 12 ppm Zn derived from the leaching of Contaminated Soil II with Solution B.

The sequential leaching test results are shown in Table 5 and Figure 6. As can be seen in Figure 6, more than 60% of the Pb, Se, Cd, Ni, and Zn were released from the soil in the first leaching cycle; however, the Hg was only released by 20%.

In the second leaching cycle, the amounts of Pb, Se, Cd, Ni, and Zn released from the soil are between 25% and 30%, but Hg was only released by 9%. In the third and fourth leaching cycles, the amounts of Pb, Se, Cd, Ni, and Zn that were released from the soil are about 10% in each of the leaching cycles, and the amounts of Hg released from the soil is less than 5%. No significant amount of heavy metals was released from the soil during the water rinse; however, the water may help to remove the leaching agent from the soil after treatment.

Table 4. SRB BIOSYSTEM TREATMENT OF SOIL LEACHATE (Recycling Mode)

SAMPLE	ELEMENT CONCENTRATIONS IN THE LEACHATE (ppm)							
	Al	Ca	Cd	Fe	Mg	Ni	S(total)	Zn
Soil Leachate (pH 3.72)	28	340	6.9	150	77	13	260	14
Day 3 Effluent (pH 6.20)	18	230	*<0.20	88	54	1.83	250	1.9
Day 4 Effluent (pH 6.23)	1.1	210	<0.20	32	51	1.13	230	<0.50
Day 5 Effluent (pH 6.40)	0.87	210	<0.20	35	51	1.33	230	<0.50
Aerated Day 5 Effluent (pH 8.23)	<0.50	51	<0.20	1.7	46	0.83	220	<0.50
Dried Sludge (2.95 g)	57700	26800	13900	46200	2600	2000	42300	21000
Percent Removal from Water	100	85	100	99	40	93	15	100
Percent Recovery as Metal Sulfides	100	6.8	100	23	6.2	12.1	78	100

Note : 1. < sign indicates the concentrations are below the detection limit.
2. The soil used in this experiment is Contaminanted Soil I.

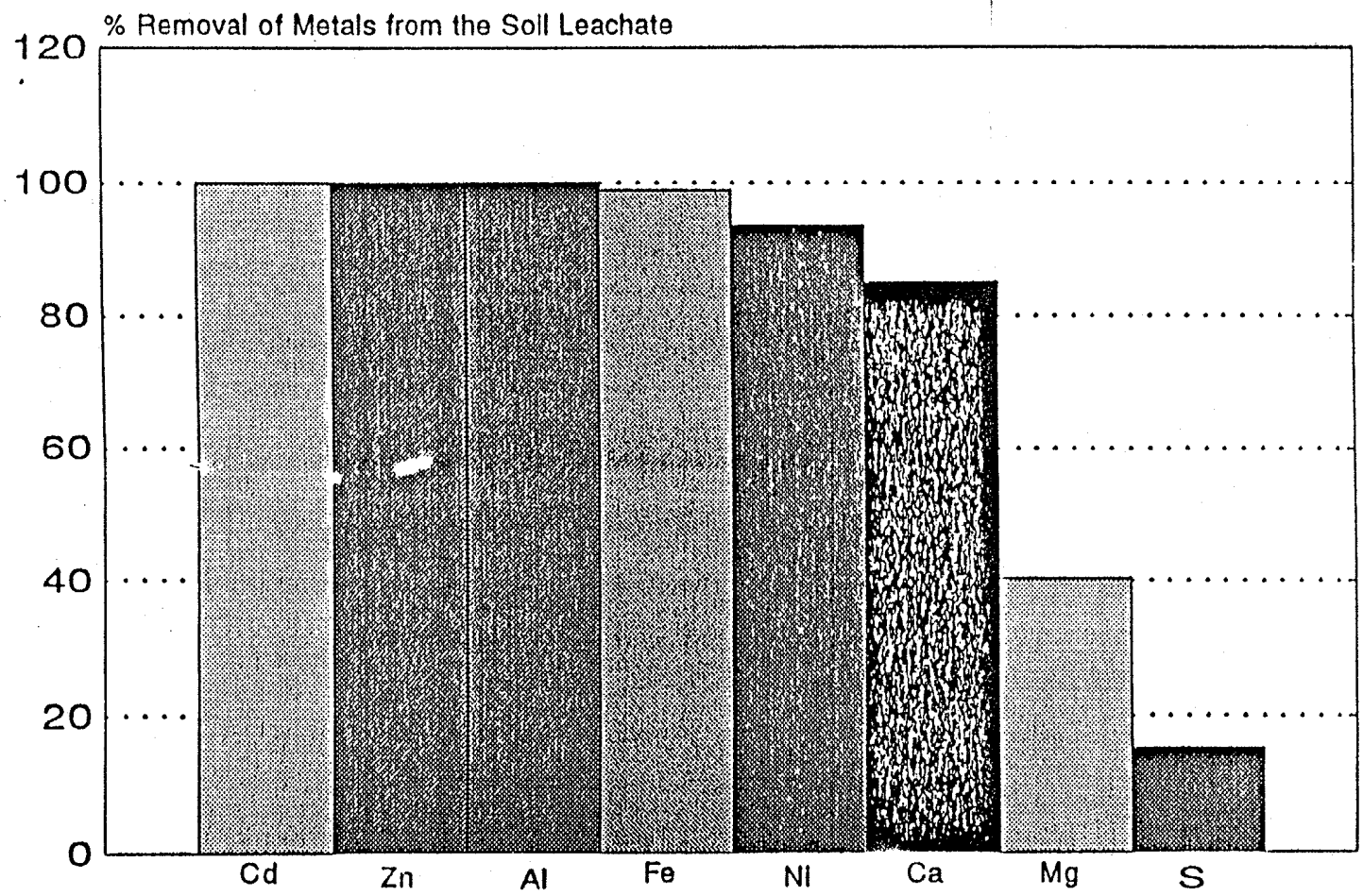

Figure 5. CONTAMINATED SOIL 1 LEACHATE TREATMENT EFFICIENCY OF THE SRB BIOSYSTEM

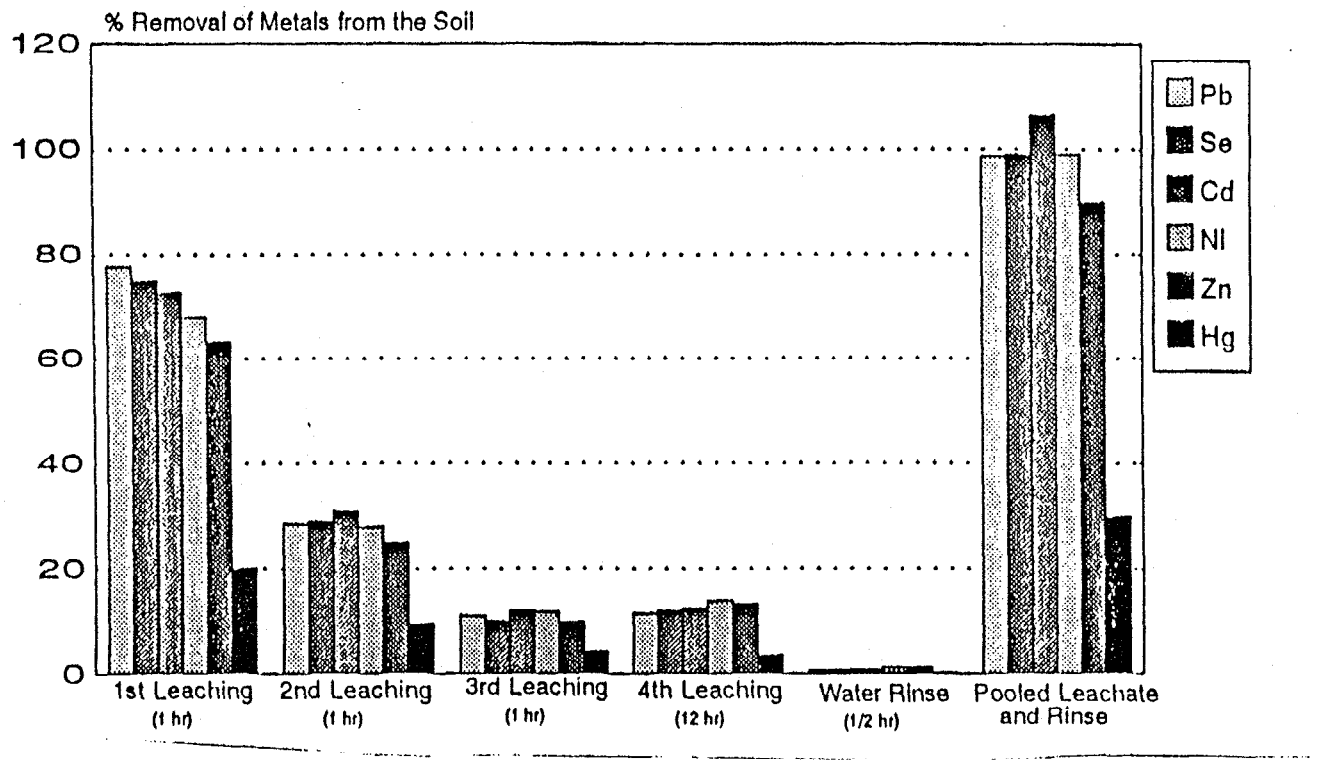

Figure 6. CONTAMINATED SOIL-LEACHING TEST RESULTS: EFFECT OF SEQUENTIAL LEACHING
(Notes: 1. The leaching solution used in this leaching test is Solution B. The v(ml)/wt(g) ratio of the leaching solution versus soil is 20:1 except for the water rinse, for which a ratio of 10:1 is used.
2. The removal of metals is expressed as percent of initial content of each metal in soil.)

Table 5. SEQUENTIAL LEACHING EXPERIMENTAL RESULTS

Sample	Cd	Hg	Ni	Pb	Se	Zn
	ppm					
1st Leaching (1 h)	40	135	34	81.5	75	38
2nd Leaching (1 h)	17	63	14	30	29	15
3rd Leaching (1 h)	6.6	29.5	5.9	11.5	10	5.85
4th Leaching (12 h)	6.9	25.5	7.0	12	12	8.05
Water Rinse (1/2 h)	0.89	3.2	1.27	1.41	1.7	1.55
Pooled Leachates and Water Rinse	13	42.5	11	23	22	12

Notes: 1. The leaching solution used in this leaching test is Solution B. The v (ml)/wt (g) ratio of the leaching solution versus the soil is 20:1 for each leaching except for the water rinse, for which a ratio of 10:1 is used.

2. Please see Figure 6 for percent removal of metals from the soil.

The leachates from the four leaching cycles and the water rinse were pooled together and then treated using sulfate-reducing bacteria in a specially designed SRB Biosystem for heavy metal removal and recovery. The results of the SRB Biosystem treatment of the pooled leachate will be discussed later in this report. The total volume of the pooled leachate was 18 liters. As shown in Figure 6, the percent removal data obtained from analyzing the pooled leachate indicate that Pb, Se, Cd, Ni, and Zn were almost completely removed from the soil, but Hg was only removed by about 30%. After the water rinse, the leached soil was air-dried and was subjected to the EPA TCLP test. The test results are discussed below.

EPA TCLP Test Results

The EPA TCLP test results for the leached soil obtained from the sequential leaching experiment are given in Table 6. The toxic heavy metals that are regulated by the EPA include Ag, Ar, Ba, Cd, Cr, Hg, Pb, and Se. For the contaminated soil used here, Cd, Hg, Pb, and Se are the major concern. Table 6 shows that the untreated soil failed the TCLP test because the leachate had a much higher concentration of Cd, Hg, and Se than the

landfarming
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IGT

BIOTECHNOLOGY

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REMEDIATION OF METAL-CONTAMINATED SOLIDS AND LIQUIDS

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Background

Of today's environmental pollution problems, the remediation of metal-contaminated solids and liquids has been one of the most difficult because of the lack of efficient technologies. IGT, however, has developed a process called METALS–LPB — a suite of technologies that forms an integrated system for remediating metal-contamination problems. The process is not only environmentallly benign, it also creates resources out of materials that would otherwise be considered waste.

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IGT Approach

The approach IGT has taken in developing its technologies involves converting waste materials into resources through the use of natural self-sustaining microbiological activity. The METALS– LPB remediation process uses both biological and chemical processes to produce recoverable/recyclable metals (including radionuclides) and other clean products.

This integrated approach has three components: the controlled leaching of metals from contaminated solids, the precipitation of metals from solution, and the removal of metal ions from solution using biosorbents.

The removal of metals from contaminated solids (*e.g.*, soil, fly ash, spent catalysts, etc.) is accomplished through natural microbiological processes that convert organic and/ or inorganic wastes into solutions which are capable of efficiently and effectively leaching metals from solids within minutes. After the contaminated solids have been leached, the resultant metals in solution or metal-contaminated ground/surface water are treated in a novel bioreactor designed to precipitate

metals and allow for their recovery in essentially pure form with nearly 100% yields.

The METALS–LPB process can treat a broad range of contaminated liquids that, besides containing heavy metals, have pH values from 1 to 9 or contain organic contaminants, particulate/colloidal matter, and/or chelated metals. To further remove even trace (ppb) concentrations of metals, IGT developed a variety of biosorbents derived from waste material which act in a manner analogous to ion exchange resins that can remove both anions and cations from water.

The process is also very efficient: Treated solids can pass the U.S. Environmental Protection Agency's (EPA) Toxicity Characteristic Leaching Procedure (TCLP) test, and treated water meets all National Pollutant Discharge Elimination System (NPDES) and EPA regulations regarding metals.

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Technology Status

In demonstration tests, IGT's biotechnologists proved the effectiveness of the METALS–LPB process using kilogram quantities of solids and about 15 liters of liquid. Metal species tested include the cations Al, Au, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb, Sr, U, V, and Zn. Anions tested include As, Cr, Mo, Se, and W. The process is now available for laboratory-scale treatability studies, optimization, and scale-up.

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Capabilities

The Biotechnology and Environmental Engineering Research and Development group at IGT has the necessary capabilities to undertake all aspects of site remediation studies. This includes a cross-disciplinary team of scientists and engineers experienced in laboratory-scale research, bench-scale development, pilot- and field-scale demonstration, and technoeconomic assessment programs. To conduct such work, IGT has well-equipped laboratories and bench- and pilot-scale facilities, as well as a full in-house complement of analytical, design, and engineering support services. The cost-effective, results-oriented problem-solving capabilities of IGT's Biotechnology and Environmental Engineering Research and Development group are recognized by a wide range of government, institutional, and industrial clients.

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Contract Research

IGT is a not-for-profit research center that conducts contract work clients in government and industry. The Biotechnology and Environmental Engineering Research and Development group will be glad to work with you in finding solutions to your problems in the areas of energy supply, energy utilization, and environmental protection and remediation.

An IGT biotechnologist conducts a test of the METALS–LPB process for the remediation of metal-contaminated solids and liquids.

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MANUFACTURED GAS PLANT SITE REMEDIATION (SOLID PHASE/LANDFARMING)

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Background

The gasification of coal and oil in manufactured-gas plants (MGP) was a widespread means of producing medium- and high-Btu gas for much of the last two centuries in the United States and Europe. During that time, some of the plants' wastes and less valuable by-products were disposed of onsite.

These wastes and by-products include tar components; polynuclear aromatic hydrocarbons (PAHs); volatile hydrocarbons, such as benzene; light oils; and purification-box wastes consisting of free and complex cyanides and certain heavy metals. Some of the wastes or by-products were modified and degraded over time by the action of natural biological or chemical/physical processes. Today, several components of the remaining waste are considered hazardous, and sites contaminated with them may need to be remediated.

Conventional techniques for the remediation of MGP waste sites include chemical fixation, soil washing, *in-situ* thermal treatment, incineration of excavated soil, disposal in landfills, and biodegradation. In general, these techniques do not sufficiently degrade the waste or are costly. IGT's technology, on the other hand, remediates PAHs, benzene, and cyanide contaminants in an environmentally friendly and cost-effective manner.

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IGT's Technology

IGT has named its technology the MGP–REM process. This process is based on the enhancement and acceleration of indigenous biological activity and the application of chemical treatment to promote the subsequent biological degradation of the chemically modified compounds. The process is faster and achieves a significantly higher degree of degradation than the conventional biological process alone, yet costs no more.

Since 1986, IGT has performed many laboratory- and bench-scale studies and conducted four years

of field experimentation. This work was funded primarily by the Gas Research Institute (GRI), the U.S. Environmental Protection Agency, IGT's Sustaining Membership Program, and various gas companies. As a result of this work, researchers developed reliable methods to predict the treatment end points, identify the required field procedures and alternatives, estimate treatment costs, design field studies, and implement suggested remediation procedures to the satisfaction of the regulatory agencies and MGP site owners.

A typical remediation program for an MGP site would include the following:

- Collecting representative soil samples from the contaminated site
- Determining treatment end points and rate of clean up by using an accelerated treatability protocol IGT and GRI developed for this process
- Recommending treatment options for field-scale evaluation
- Conducting field demonstrations and analyzing field data to determine the best treatment option for full-scale site remediation

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Experience

IGT has conducted remediation research in laboratory- and bench-scale systems with a variety of MGP soils. IGT has also conducted field studies to evaluate the MGP-REM process in bioslurry-phase systems and in managed landfarming modes. The levels of carcinogenic and noncarcinogenic PAHs were reduced up to 99% in some soils with the integrated treatment.

Preliminary cost estimates of the integrated treatment process compare favorably to other, conventional technologies, including incineration. IGT is currently conducting bench-scale studies to evaluate a novel concept of transporting nutrients, surfactants, chemicals, and other amendments to the subsurface environment with minimum potential for groundwater contamination. This technique will be used for the *in-situ* remediation of MGP sites.

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Capabilities

The Biotechnology and Environmental Engineering Research Group at IGT has the necessary capabilities and partnerships with full-scale engineering and remediation companies to undertake all aspects of MGP site remediation studies. This includes a cross-disciplinary team of scientists and engineers experienced in conducting laboratory-scale research, bench-scale development, pilot- and field-scale demonstration, and technoeconomic assessment programs. To conduct such work, IGT has well-equipped laboratories and bench- and pilot-scale facilities, as well as a full in-house complement of analytical, design, and engineering support services. The cost-effective, results-oriented problem-solving capabilities of the Group are recognized by a wide range of government, institutional, and industrial clients.

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Contract Research

IGT is a not-for-profit research center that conducts contract work for government and industrial clients. Its Biotechnology and Environmental Engineering Research and Development Group will be glad to work with you in finding solutions to your problems in the areas of energy supply, energy

utilization, and environmental protection and remediation.

After extensive laboratory- and bench-scale testing, IGT successfully fieldtested its integrated chemical/biological treatment process for PAH-contaminated soils at a Midwest Gas site in Iowa.

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MANUFACTURED GAS PLANT SITE REMEDIATION (SLURRY PHASE)

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Background

IGT has developed and demonstrated a cost-effective remediation technology for contaminated soils at former manufactured gas plant (MGP) sites. The technology, which is known as the MGP-REM process, is based on the enhancement and acceleration of indigenous biological activity and the application of chemical treatment. The chemical treatment uses hydrogen peroxide and iron salt (Fenton's reagent) to oxidize polynuclear aromatic hydrocarbons (PAHs), making them more amenable to biological treatment.

The MGP-REM process is faster and achieves a significantly higher degree of cleanup than the conventional biological process alone. Moreover, it costs no more than conventional bioremediation and is considerably less expensive than incineration. IGT successfully fieldtested the technology in the landfarming mode from 1991 to 1993 and in the soil-slurry mode in 1993-1994. *In-situ* fieldtests are expected to start in 1995. The work is being funded primarily by the Gas Research Institute (GRI), IGT's Sustaining Membership Program, various gas companies, and the U.S. Environmental Protection Agency.

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Bioslurry Remediation

To test the treatment of PAH-contaminated soils, IGT first conducted a bench-scale treatability test

developed by IGT and GRI. Upon a successful outcome to the test, IGT and its commercial partners operated a pilot-scale bioslurry reactor system based on the MGP-REM process at a MGP site in New Jersey. One project goal was to demonstrate that the technology is capable of reducing PAH levels to proposed standards set by the New Jersey Department of Environmental Protection. Another goal was to ensure that the system does not emit volatile organic carbons (VOCs) above allowable levels.

The flow diagram below depicts the pilot-scale bioslurry reactor system. The slurry tank system is divided into three independent but interconnected reactor units. Each unit can be operated as either the bioreactor or the chemical reactor. One of the three units is the slurry reactor.

The treatment process starts with the excavation of the soil, which is screened through a 2-inch screen before being mixed with water in the attrition scrubber. Slurry from the attrition scrubber passes a 20-mesh shaker screen, which removes particles as small as 0.1 mm, and enters the slurry reactor. In the reactor, the sieved slurry is mixed with water to reach a desired solids content. The slurry is then pumped to the respective reactors for either biological or chemical treatment. After treatment, the slurry is pumped to a thickener where the water is removed. The water is stored for reuse, and the thickened solids are made available for backfill at the site.

Off-gas from the reactor system is collected and treated by two granular activated carbon (GAC) canisters operated in series. The GAC adsorbs any VOCs released during the process and prevents their emission into the air. Off-gas monitoring devices connected in front of the GAC canisters look for contaminant emission and help make the process very safe.

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Capabilities

IGT's Biotechnology and Environmental Engineering Research Group has the capabilities to undertake all aspects of MGP site remediation studies. Its resources includes a cross-disciplinary team of scientists and engineers experienced in conducting laboratory-scale research, bench-scale development, pilot- and field-scale demonstration, and technoeconomic assessment of environmental programs. To conduct such work, IGT has modern well-equipped laboratories and bench- and pilot-scale facilities, as well as a full in-house complement of analytical, design, and engineering support services. IGT's cost-effective, results-oriented problem-solving capabilities are recognized by a wide range of government, institutional, and industrial clients. IGT has also established business relationships with remediation and engineering companies to transfer the technical knowledge for full-scale site remediation.

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Contract Research

IGT is a not-for-profit research center that conducts contract work for government and industrial clients. The Institute's Biotechnology and Environmental Engineering Research Group will be glad to work with you in finding solutions to your problems in the areas of energy supply, energy utilization, and environmental protection and remediation.

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For more information, contact —

Vipul J. Srivastava

Shamrock Environmental Corporation

6106 Corporate Park Drive
Browns Summit, NC 27214
(800) 881-1098 or (336) 375-1989
Fax: (336) 375-1801

FAX TRANSMISSION COVER SHEET

Date:	*October 7, 1998*
To:	*Ellen Bjerklie - Baker Environmental*
Fax:	*(412) 269-2002*
Re:	*Yorktown (VA) Naval Weapons Station - Soil Disposal* *Shamrock Proposal Number PR98-80946*
Sender:	*Kenn Webb*

YOU SHOULD RECEIVE 5 PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL (800) 881-1098 or (336) 375-1989.

Dear Ellen,

Sorry for the delay on this proposal. The "explosive" compounds have generated a certain amount of concern from disposal vendors. Prior to firm pricing, it will be necessary to evaluate the RDX and HMX concentrations more closely.

Please call (800) 881-1098 with questions.

Thanks!

Kenn

SHAMROCK
ENVIRONMENTAL CORPORATION

October 7, 1998

Ms. Ellen Bjerklie
Baker Environmental, Inc.
420 Rouser Road
Airport Office Park, Building 3
Coraopolis, PA 15108
Phone (412) 269-6117
Fax (412) 269-2002

Ref: Waste Disposal (Yorktown, VA)
Shamrock Proposal Number PR98-80946

Dear Ms. Bjerklie:

Shamrock Environmental Corporation (Shamrock) is pleased to provide Baker Environmental, Inc. (Baker) with this proposal for transportation and disposal of contaminated soil from a project site in Yorktown, Virginia. This proposal is based upon information provided by Baker.

It is the understanding of Shamrock that Baker requires pricing for the transportation and disposal of approximately 136 cubic yards of contaminated soil from an impacted site in Yorktown, VA. The soil contains maximum concentrations of items listed in Table 1. The soil will be loaded by Baker. Shamrock will provide transportation and disposal services.

Table 1 : Maximum Values, in total ppm

Total PAH's	64 ppm
RDX (explosive compound)	30 ppm
HMX (explosive compound)	17,000 ppm
PCB's	11 ppm
Lead	371 ppm
Mercury	16 ppm
Cobalt	168 ppm
Copper	14,700 ppm
Zinc	504 ppm

P.O. Box 14987 • Greensboro, NC 27415 • 6106 Corporate Park Dr. • Browns Summit, NC 27214 • 336-375-1989 • 800-881-1098 • Fax 336-375-1801
Website: www.shamrockenviro.com
E-mail: shamrockenviro@worldnet.att.net

10/07/98 11:50 FAX 9103751801 SHAMROCK ENVIRON 002

It is unknown whether this material will be listed as a hazardous waste or not; however, the EPA waste code of K044 for "wastewater treatment sludges from the manufacture of explosives should be evaluated during review of possible process codes that may apply to RCRA characterization.

Shamrock's estimate for the transportation and disposal of this material follows in the attached Price Schedule. Please call me at (800) 881-1098 with any questions regarding this project.

Sincerely,

Kenn Webb
Shamrock Environmental Corporation

Price Schedule
Waste Disposal (Yorktown, VA)
Shamrock Proposal Number PR98-80946
October 7, 1998

Hazardous Waste Soil for Incineration

Transportation	$2,950.00/load
Disposal	$895.00/ton

Non-Hazardous Soil for Thermal Desorption

Transportation	$1,975.00/load
Disposal	$255.00/ton

Hazardous Waste Soil for Sub-Title C Landfill

Transportation	$2,650.00/load
Direct Landfill	$98.00/ton

Hazardous Waste Soil for Stabilization and Sub-Title D Landfill

Transportation	$2,650.00/load
Treatment and Disposal[1]	$135.00/ton

Non-Hazardous Soil for Sub-Title D Landfill

Transportation	$330.00/load
Direct Landfill	$45.00/ton

---

[1]assumes mercury at <260 ppm total

Contingencies:

Based on disposal acceptance in facilities as noted.

Based upon clarification of "explosive" compounds. Pricing assumes this material is not defined as an explosive material by EPA, DOT or disposal facility.

Pricing does not include excavation or loading.

Disposal price includes applicable disposal taxes.

Transportation demurrage after two hours on site at $75.00/hour.

Disposal approval at applicable disposal facilities as noted.

Pricing valid for 60 days.

Pricing does not include debris disposal.

Transportation pricing based upon 22 ton minimum per load in end dumps.

safety-kleen.

FAX COVER SHEET

DATE: 9/25

TO: Ellen Bjerklie FAX NO: 412/269-2002

FROM: ** Chuck Cormack FAX NO: 336/342-7767
PHONE NO: 804/347-8370

NUMBER OF PAGES INCLUDING COVER SHEET (3)

RE: Yorktown Naval Base

safety-kleen

September 25, 1998

Ellen Bjerklie
Baker Environmental
420 Rouser Rd
Coropolis, PA 15108

Dear Ellen:

I am enclosing some Estimated Pricing for the Soil from the Yorktown, VA Project for your planning purposes. There are still plenty of questions that need to be answered before we can accept this for disposal but this should help you out.

135 Yd3 of soil with the following laboratory results:

Constituent mg/kg (ppm)	**Maximum Concentration (ppb)**		**UTS**
Naphthalene	1,600	5.6	
Acenapththylene	75		3.4
Acenapthene	1,500	3.4	
Fluorene	2,600	3.4	
Phenanthrene	14,000	5.6*	
Anthrecene	2,900	3.4	
Carbazole	2,000	N/A	
Fluoranthene	11,000	3.4*	
Pyrene	6,000	8.2	
Benzo(a)anthracene	4,500	3.4*	
Chrysene	5,000	3.4*	
Benzo(b)fluorantnene	4,200	6.8	
Benzo(k)fluorantnene	2,600	6.8	
Benzo(a)fluorantnene	3,400	3.4*	

Ideno(123cd)pyrene	1,100	3.4
Dibenz(a,h)anthracene	540	8.2
Benzo(g,h,i)perylene	740	1.8
Total PCB	10,000	10
HMX	17,000,000	??
RDX (Explosive)	30,000	??
Lead	129 mg/kg	0.75 –TCLP ?*
Mercury	16.6 mg/kg	0.025 –TCLP ?*
Zinc	??	4.3 – TCLP

* results exceed the UTS limits for NWW

Note: we will need some kind of Explosive test done.

Landfill -- Subtitle C

Waste approval at the Pinewood landfill must meet the Universal Treatment Standards (UTS) prior to Landfilling if it carries any of the Characteistic Waste Codes D004 thru D043. We can Stabilize the D004 thru D011 Metals but the UTS for organics must be below the Standards listed above.

Hazardous

Disposal for Stabilization	@ $155.00 -195.00 / ton
SC Tax	@ 39.00 / ton
Transportation	@ 1150.00 / load (20 tons)

NonHaz

Disposal for direct landfill	@ $ 65.00 / ton
SC Tax	@ 15.70 / ton
Transportation	@ 1150.00 / load

Incineration

Disposal at the S-K Aragonite, Utah facility.	@ $ 600.00 - 1,200.00 / ton
Utah Tax	@ 28.00 / ton
Transportation	@ 7,000 / load (20 tons)

NOTE : Both facilities will need a preshipment sample for approvals

An Idea may be to excavate the material and place in rolloffs and then we can assist you in the additional sampling and testing required.for disposal approval.

APPENDIX E
COST ESTIMATES

APPENDIX E.1
SITE 2 COST ESTIMATES

TABLE E.1-1

SITE 2 COST ESTIMATE: RAA 2 - NO ACTION WITH MONITORING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Work, E&S, & QC Plans
Mobilization/Demobilization	LS	1	$3,000	$3,000		Engr. Est.	Drillers, Samplers
Contract Administration	LS	1	$10,000	$10,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$5,000	$5,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$28,000		
Surface Soil, Surface Water, Sediment Monitoring							
Sampling - Labor	Hrs.	160	$40.00	$6,400		Engr. Est.	2 geo./eng. samplers @ $40/hr ea.; 4 days/event; 2 events/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	2	$2,200	$4,400		Engr. Est.	Airfare, per diem, hotel, rental car for 4 days for 2 people
Soil/Sediment Sampling - Analysis							
SVOCs	Sample	68	$230	$15,640		Baker Average BOAs	28 soil samples + 6 sediment samples; 2 events/year
PCBs	Sample	68	$100	$6,800		Baker Average BOAs	28 soil samples + 6 sediment samples; 2 events/year
Inorganics	Sample	68	$100	$6,800		Baker Average BOAs	28 soil samples + 6 sediment samples; 2 events/year
Surface Water Sampling - Analysis							
SVOCs	Sample	12	$220	$2,640		Baker Average BOAs	6 surface water samples; 2 events/year
PCBs	Sample	12	$90	$1,080		Baker Average BOAs	6 surface water samples; 2 events/year
Inorganics	Sample	12	$100	$1,200		Baker Average BOAs	6 surface water samples; 2 events/year
Miscellaneous Expenses	Event	2	$500	$1,000		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Surface Soil, Surface Water, Sediment Monitoring - Subtotal					$50,960		
DIRECT CAPITAL COSTS - TOTAL					$78,960		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$4,738	$4,738		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$11,844	$11,844		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$16,582		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$95,542**		

TABLE E.1-1 (continued)

SITE 2 COST ESTIMATE: RAA 2 - NO ACTION WITH MONITORING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

ANNUAL OPERATION AND MAINTENANCE COSTS							
Surface Soil, Surface Water, Sediment Monitoring							
Sampling - Labor	Hrs.	160	$40.00	$6,400		Engr. Est.	2 geo./eng. samplers @ $40/hr ea.; 4 days/event; 2 events/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	2	$2,200	$4,400		Engr. Est.	Airfare, per diem, hotel, rental car for 4 days for 2 people
Soil/Sediment Sampling - Analysis							
SVOCs	Sample	68	$230	$15,640		Baker Average BOAs	28 soil samples + 6 sediment samples; 2 events/year
PCBs	Sample	68	$100	$6,800		Baker Average BOAs	28 soil samples + 6 sediment samples; 2 events/year
Inorganics	Sample	68	$100	$6,800		Baker Average BOAs	28 soil samples + 6 sediment samples; 2 events/year
Surface Water Sampling - Analysis							
SVOCs	Sample	12	$220	$2,640		Baker Average BOAs	6 surface water samples; 2 events/year
PCBs	Sample	12	$90	$1,080		Baker Average BOAs	6 surface water samples; 2 events/year
Inorganics	Sample	12	$100	$1,200		Baker Average BOAs	6 surface water samples; 2 events/year
Miscellaneous Expenses	Event	2	$500	$1,000		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Surface Soil, Surface Water, Sediment Monitoring - Subtotal					$50,960		
ANNUAL O&M COSTS - 30 years of maintenance					**$50,960**		
TOTAL NET PRESENT WORTH: RAA 2					**$880,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.1-2

SITE 2 COST ESTIMATE: RAA 3 - SOIL WASHING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$20,000	$20,000		Engr. Est.	Soil washing treatment bench-scale study
Mobilization/Demobilization	LS	1	$75,000	$75,000		Engr. Est.; vendor quote	Includes mob/demob for soil washing subcoctractor
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est.	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$185,000		
Site Work							
Clearing and Grubbing	Acre	0.5	$1,300	$650		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 2
Temporary Safety Fencing	LF	1,300	$3.32	$4,316		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	1,600	$0.82	$1,312		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient from excavated areas
Site Restoration:							
Backfill	CY	395	$5.60	$2,212		Engr. Est.; A12.1-724-1400	Assumes 6" backfill
Topsoil	CY	395	$17.04	$6,731		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	2,225	$2.19	$4,873		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetate all disturbed areas
Site Work - Subtotal					$20,094		

TABLE E.1-2 (continued)

SITE 2 COST ESTIMATE: RAA 3 - SOIL WASHING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Treatment - Soil Washing							
Excavation of Contaminated Soil	CY	785	$1.32	$1,036		Engr. Est.; Means Site Work, 1998, 022-242-2000	Assuming 1 foot deep excavation
Confirmation Sampling - Analysis							
SVOCs	Sample	50	$440	$22,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
PCBs	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Inorganics	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Sampling - Labor	Hrs.	80	$40	$3,200		Engr. Est.	2 geo./eng. samplers @ $40/hr ea; 4 days; 10 hrs/day
Sampling - Travel/Per Diem	LS	1	$2,200	$2,200		Engr. Est.	Airfare, per diem, hotel, rental car for 4 days for 2 people
Treatment Process Sampling - Analysis							
SVOCs	Sample	52	$440	$22,880		Baker Average BOAs	Assumes 1 sample/week for 1 year; add 100% to cost for quick turn analysis
PCBs	Sample	52	$200	$10,400		Baker Average BOAs	Assumes 1 sample/week for 1 year; add 100% to cost for quick turn analysis
Inorganics	Sample	52	$200	$10,400		Baker Average BOAs	Assumes 1 sample/week for 1 year; add 100% to cost for quick turn analysis
Miscellaneous Expenses	LS	1	$500	$500		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Loading into Soil Washing Unit	CY	1040	$6.39	$6,646		Engr. Est.; Means Site Work, 1998, 022-216-4000	Assumes 10% increase due to additives
Soil Washing Operation	TON	1685	$450	$758,250		Engr. Est.; vendor quote	Assumes 120 pcf
Disposal of Filter Cake	LS	1	$123,775	$123,775		Engr. Est.; vendor quote	Assume 300 CY filter cake @ 120 pcf = 485 tons; 22 truckloads; assume hazardous; $2650/load + $135/ton treat and dispose
Wastewater Treatment Unit	EA	1	$6,490	$6,490		Engr. Est.; Means Site Work, 1998, 027-354-0100	Assume 1500 gallon fiberglass tank
Soil Washing - Subtotal					$992,777		
DIRECT CAPITAL COSTS - TOTAL					$1,197,870		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$71,872	$71,872		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$179,681	$179,681		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$251,553		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$1,449,423**		
TOTAL NET PRESENT WORTH: RAA 3					**$1,450,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.1-3

SITE 2 COST ESTIMATE: RAA 4 - ON-SITE BIOLGICAL TREATMENT
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatbility Study	LS	1	$20,000	$20,000		Engr. Est.; vendor quote	Biological treatment bench-scale study
Mobilization/Demobilization	LS	1	$50,000	$50,000		Engr. Est	Includes mob/demob for all subcontractors
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est.	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$160,000		
Site Work							
Clearing and Grubbing	Acre	0.50	$1,300	$650		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 2
Temporary Safety Fencing	LF	1,300	$3.32	$4,316		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	1,600	$0.82	$1,312		Engr. Est., Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient from excavated areas
Site Restoration							
Backfill	CY	395	$5.60	$2,212		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 12" backfill from on-site borrow pit (no material costs)
Topsoil	CY	395	$17.04	$6,731		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	2,225	$2.19	$4,873		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over all disturbed areas
Site Work - Subtotal					$20,094		

TABLE E.1-3 (continued)

SITE 2 COST ESTIMATE: RAA 4 - ON-SITE BIOLGICAL TREATMENT
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

On-Site Biological Treatment							
Excavation of Contaminated Soil	CY	785	$1.68	$1,319		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1' deep excavation.
Confirmatory Sampling - Labor	HR	80	$40	$3,200		Engr. Est.	2 geo./eng. samplers @ $40/hr ea.; 4 days, 10 hrs/day
Confirmatory Sampling - Analysis							
SVOCs	Sample	50	$440	$22,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
PCBs	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Inorganics	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$2,200	$2,200		Engr. Est.	Airfare, per diem, hotel, rental car for 4 days for 2 people
Transport to Bioslurry Area	CY	942	$4.84	$4,559		Engr. Est.; Means Site Work, 1998, 022-266-0500	Assumes 12 CY dump trailer, 4 mile round trip to existing biocell at Site 22; assumes 1.2 bulking factor of 785 cubic yards in place
Biological Treatment Operation	CY	1130	$100	$113,000		Engr. Est.; vendor quote	Operation of the existing biocell. Includes additives and labor. Assumes 20% increase in volume due to additives.
Transport to Landfarming Area	CY	942	$4.84	$4,559		Engr. Est.; Means Site Work, 1998, 022-266-0500	Assumes 12 CY dump trailer, 4 mile round trip from Site 22 biocell to landfarming area at Site 24
Landfarming Operation	CY	1130	$50	$56,500		Engr. Est.	
Treatment Process Sampling - Analysis							
SVOCs	Sample	40	$220	$8,800		Baker Average BOAs	Assume 20 samples from biocell and 20 samples from landfarm
PCBs	Sample	40	$100	$4,000		Baker Average BOAs	Assume 20 samples from biocell and 20 samples from landfarm
Inorganics	Sample	40	$100	$4,000		Baker Average BOAs	Assume 20 samples from biocell and 20 samples from landfarm
Miscellaneous Expenses	LS	1	$500	$500		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
On-Site Biological Treatment - Subtotal					$249,637		
DIRECT CAPITAL COSTS - TOTAL					$429,731		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$25,784	$25,784		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$64,460	$64,460		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$90,243		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$519,974**		
TOTAL NET PRESENT WORTH: RAA 4					**$520,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.1-4

SITE 2 COST ESTIMATE: RAA 5 - INCINERATION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.5	$1,300	$650		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 2
Temporary Safety Fencing	LF	1,300	$3.32	$4,316		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	1,600	$0.82	$1,312		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient from excavated areas
Site Restoration							
Backfill	CY	395	$5.60	$2,212		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill from on-site borrow pit (no material costs)
Topsoil	CY	395	$17.04	$6,731		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	2,225	$2.19	$4,873		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over all dis+I50turbed areas
Site Work - Subtotal					$20,094		

TABLE E.1-4 (continued)

SITE 2 COST ESTIMATE: RAA 5 - INCINERATION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Incineration (Assuming Hazardous)							
Excavation of Contaminated Soil	CY	785	$1.68	$1,319		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assuming 1 foot deep excavation
Confirmatory Sampling - Analysis							
SVOCs	Sample	50	$440	$22,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
PCBs	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Inorganics	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Confirmatory Sampling - Labor	HR	80	$40	$3,200		Engr. Est.	2 geo./eng. samplers @ $40/hr ea.; 4 days, 10 hrs/day
Sampling - Travel/Per Diem	LS	1	$2,200	$2,200		Engr. Est.	Airfare, per diem, hotel, rental car for 4 days for 2 people
Miscellaneous Expenses	Event	1	$500	$500		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Loading of Soil	CY	942	$6.39	$6,019		Engr. Est.; Means Site Work, 1998, 022-216-4000	Assumes 1.2 bulking factor of in place cubic yards
Incineration Fees	Ton	1530	$895	$1,369,350		Engr. Est.; vendor quote	Includes disposal costs; 120 pcf
Transportation	Load	70	$2,950	$206,500		Engr. Est.; vendor quote	22 tons/load
Incineration - Subtotal					$1,631,088		
DIRECT CAPITAL COSTS - TOTAL					$1,751,182		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$105,071	$105,071		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$262,677	$262,677		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$367,748		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$2,118,930**		
TOTAL NET PRESENT WORTH: RAA 5					**$2,120,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.1-5

SITE 2 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.5	$1,300	$650		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 2
Temporary Safety Fencing	LF	1,300	$3.32	$4,316		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	1,600	$0.82	$1,312		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient from excavated areas
Site Restoration							
Backfill	CY	395	$5.60	$2,212		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill from on-site borrow pit (no material costs)
Topsoil	CY	395	$17.04	$6,731		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	2,225	$2.19	$4,873		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over all disturbed areas
Site Work - Subtotal					$20,094		

TABLE E.1-5 (Continued)

SITE 2 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Off Site Disposal							
Soil Excavation	CY	785	$2	$1,570		Engr. Est.; Means Site Work, 1998, 022-242-2000	Assuming 1 foot deep excavation
Confirmatory Sampling - Labor	HR	80	$40	$3,200		Engr. Est.	2 geo./eng. samplers @ $40/hr ea.; 4 days; 10 hrs/day
Confirmatory Sampling - Analysis							
SVOCs	Sample	50	$440	$22,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
PCBs	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Inorganics	Sample	50	$200	$10,000		Baker Average BOAs	Assumes samples from bottom and walls of excavation areas; add 100% to cost for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$2,200	$2,200		Engr. Est.	Airfare, per diem, hotel, rental car for 4 days for 2 people
Miscellaneous Expenses	LS	1	$500	$500		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Off Site Disposal (Non-Hazardous)	Ton	1530	$45	$68,850		Engr. Est.; vendor quote	Assumes 1.2 bulking factor of in place cubic yards; assumes non-hazardous; assumes 120 pcf
Transportation (Non-Hazardous)	Load	70	$330	$23,100		Engr. Est.; vendor quote	22 tons/load
Off Site Disposal (Hazardous)	Ton	1530	$98	$149,940		Engr. Est.; vendor quote	Assumes 1.2 bulking factor of in place cubic yards; assumes hazardous; assumes 120 pcf
Transportation (Hazardous)	Load	70	$2,650	$185,500		Engr. Est.; vendor quote	22 tons/load
Off Site Disposal (Non-Hazardous) - Subtotal					$141,420		
Off Site Disposal (Hazardous) - Subtotal					$384,910		

TABLE E.1-5 (Continued)

SITE 2 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

DIRECT CAPITAL COSTS (NON-HAZARDOUS) - TOTAL					$261,514		
DIRECT CAPITAL COSTS (HAZARDOUS) - TOTAL					$505,004		
INDIRECT CAPITAL COSTS (NON-HAZARDOUS)							
Engineering and Design	LS	1	$15,691	$15,691		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$39,227	$39,227		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS (NON-HAZARDOUS) - TOTAL					$54,918		
CAPITAL COSTS - NON-HAZARDOUS (DIRECT AND INDIRECT)					**$316,431**		
INDIRECT CAPITAL COSTS (HAZARDOUS)							
Engineering and Design	LS	1	$30,300	$30,300		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$75,751	$75,751		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS (HAZARDOUS) - TOTAL					$106,051		
CAPITAL COSTS - HAZARDOUS (DIRECT AND INDIRECT)					**$611,054**		
TOTAL NET PRESENT WORTH (NON-HAZARDOUS): RAA 6a					**$320,000**	By: ELB Chk:	Date Completed: October , 1998
TOTAL NET PRESENT WORTH (HAZARDOUS): RAA 6b					**$610,000**	By: ELB Chk:	Date Completed: October , 1998

APPENDIX E.2
SITE 8 COST ESTIMATES

TABLE E.2-1

SITE 8 COST ESTIMATE: RAA 2 - NO ACTION WITH MONITORING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Work, E&S, & QC Plans
Mobilization/Demobilization	LS	1	$3,000	$3,000		Engr. Est.	Drillers, Samplers
Contract Administration	LS	1	$10,000	$10,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$5,000	$5,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$28,000		
Surface Soil, Surface Water, Sediment Monitoring							
Sampling - Labor	Hrs.	40	$40.00	$1,600		Engr. Est.	Semi-annual sampling; 2 day/sevent; 1 geo./eng. sampler @ $40/hr.; 2 event/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	2	$900	$1,800		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Soil/Sediment Sampling - Analysis							
SVOCs	Sample	20	$230	$4,600		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
PCBs	Sample	20	$100	$2,000		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
Explosives	Sample	20	$95	$1,900		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
Inorganics	Sample	20	$100	$2,000		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
Surface Water Sampling - Analysis							
SVOCs	Sample	6	$220	$1,320		Baker Average BOAs	3 surface water samples; 2 events/yr
PCBs	Sample	6	$90	$540		Baker Average BOAs	3 surface water samples; 2 events/yr
Explosives	Sample	6	$95	$570		Baker Average BOAs	3 surface water samples; 2 events/yr
Inorganics	Sample	6	$100	$600		Baker Average BOAs	3 surface water samples; 2 events/yr
Miscellaneous Expenses	Event	2	$200	$400		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	2	$5,000	$10,000		Engr. Est.	Letter report
Surface Soil, Surface Water, Sediment Monitoring - Subtotal					$27,330		
DIRECT CAPITAL COSTS - TOTAL					$55,330		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$3,320	$3,320		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$8,300	$8,300		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$11,619		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$66,949**		

TABLE E.2-1 (continued)

SITE 8 COST ESTIMATE: RAA 2 - NO ACTION WITH MONITORING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

ANNUAL OPERATION AND MAINTENANCE COSTS							
Surface Soil, Surface Water, Sediment Monitoring							
Sampling - Labor	Hrs.	40	$40.00	$1,600		Engr. Est.	Semi-annual sampling; 2 days/event; 1 geo./eng. sampler @ $40/hr.; 2 event/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	2	$900	$1,800		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Soil/Sediment Sampling - Analysis							
SVOCs	Sample	20	$230	$4,600		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
PCBs	Sample	20	$100	$2,000		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
Explosives	Sample	20	$95	$1,900		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
Inorganics	Sample	20	$100	$2,000		Baker Average BOAs	4 soil + 3 sediment (@2 depths)= 10 samples/event
Surface Water Sampling - Analysis							
SVOCs	Sample	6	$220	$1,320		Baker Average BOAs	3 surface water samples; 2 events/yr
PCBs	Sample	6	$90	$540		Baker Average BOAs	3 surface water samples; 2 events/yr
Explosives	Sample	6	$95	$570		Baker Average BOAs	3 surface water samples; 2 events/yr
Inorganics	Sample	6	$100	$600		Baker Average BOAs	3 surface water samples; 2 events/yr
Miscellaneous Expenses	Event	2	$200	$400		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	2	$5,000	$10,000		Engr. Est.	Letter report
Surface Soil, Surface Water, Sediment Monitoring - Subtotal					$27,330		
ANNUAL O&M COSTS - 30 years of maintenance					**$27,330**		
TOTAL NET PRESENT WORTH: RAA 2					**$490,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.2-2

SITE 8 COST ESTIMATE: RAA 3 - SOIL WASHING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$20,000	$20,000		Engr. Est.	Soil washing treatment bench-scale study
Mobilization/Demobilization	LS	1	$75,000	$75,000		Engr. Est.; vendor quote	Includes mob/demob for soil washing subcontractor
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est.	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$185,000		
Site Work							
Clearing and Grubbing	Acre	0.05	$2,600	$130		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 8; add 100% for small area
Temporary Safety Fencing	LF	120	$3.32	$398		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing by access road
Temporary Silt Fencing	LF	190	$0.82	$156		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavation areas
Site Restoration:							
Backfill	CY	15	$11.20	$168		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill; add 100% for small area
Topsoil	CY	15	$34.08	$511		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting; add 100% for small area
Fine Grading/Seeding (Revegetation)	SY	185	$4.38	$810		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed areas; add 100% for small area
Site Work - Subtotal					$2,174		

TABLE E.2-2 (continued)

SITE 8 COST ESTIMATE: RAA 3 - SOIL WASHING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Treatment - Soil Washing							
Excavation of Contaminated Soil	CY	30	$3.36	$101		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assume 1' deep excavation
Confirmation Sampling - Analysis							Assume bottom and walls of excavation
SVOCs	Sample	6	$440	$2,640		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
PCBs	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Explosives	Sample	6	$190	$1,140		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Inorganics	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Sampling - Labor	Hrs.	20	$40.00	$800		Engr. Est.	1 geo./eng. sampler @ $40/hr.; 2 days, 10 hrs/day
Sampling - Travel/Per Diem	LS	1	$900	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Loading Into Soil Washing Unit	CY	36	$12.78	$460		Engr. Est.; Means Site Work, 1998, 022-216-4000	add 100% for small volume
Soil Washing Operation	Ton	58	$450	$26,100		Engr. Est.; vendor quote	Assumes provision of plant, labor, utilities, chemicals, process analytical
Treatment Process Sampling - Analysis							
SVOCs	Sample	12	$220	$2,640		Baker Average BOAs	Assumes 1 sample/week for 12 weeks
PCBs	Sample	12	$100	$1,200		Baker Average BOAs	Assumes 1 sample/week for 12 weeks
Explosives	Sample	12	$95	$1,140		Baker Average BOAs	Assumes 1 sample/week for 12 weeks
Inorganics	Sample	12	$100	$1,200		Baker Average BOAs	Assumes 1 sample/week for 12 weeks
Miscellaneous Expenses	Event	1	$200	$200		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Disposal of Filter Cake	LS	1	$5,000	$5,000		Engr. Est.; vendor quote	Assume 10 cy filter cake @ 120 pcf = 16 tons; 1 truckload; assume hazardous; $2650/load transportation + $135/ton treatment and disposal
Wastewater Treatment Unit	LS	1	$6,490	$6,490		Engr. Est.; Means Site Work, 1998, 027-354-0100	Assumes 1500 gallon fiberglass tank
Treatment - Soil Washing - Subtotal					$57,411		
DIRECT CAPITAL COSTS - TOTAL					$244,585		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$14,675	$14,675		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$36,688	$36,688		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$51,363		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$295,947**		
TOTAL NET PRESENT WORTH: RAA 3					**$295,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.2-3
SITE 8 COST ESTIMATE: RAA 4 - ON-SITE BIOLOGICAL TREATMENT
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$20,000	$20,000		Engr. Est.; vendor quote	Biological bench-scale study
Mobilization/Demobilization	LS	1	$50,000	$50,000		Engr. Est.	Includes mob/demob for all subcontractors
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est.	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$160,000		
Site Work							
Clearing and Grubbing	Acre	0.05	$2,600	$130		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 8; add 100% for small area
Temporary Safety Fencing	LF	120	$3.32	$398		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing by access road
Temporary Silt Fencing	LF	190	$0.82	$156		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavation areas
Site Restoration							
Backfill	CY	15	$11.20	$168		Engr. Est.; A12.1-724-1400	Assumes 6" backfill; add 100% for small area
Topsoil	CY	15	$34.08	$511		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting; add 100% for small area
Fine Grading/Seeding (Revegetation)	SY	185	$4.38	$810		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetate disturbed areas; add 100% for small area
Site Work - Subtotal					$2,174		

TABLE E.2-3 (continued)
SITE 8 COST ESTIMATE: RAA 4 - ON-SITE BIOLOGICAL TREATMENT
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Treatment - Bioslurry and Soil Washing							
Excavation of Contaminated Soil	CY	30	$1.68	$50		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1' deep excavation.
Confirmatory Sampling - Labor	HR	20	$40	$800		Engr. Est.	1 geo./eng. sampler @ $40/hr.; 2 days, 10 hrs/day
Confirmatory Sampling - Analysis							
SVOCs	Sample	6	$440	$2,640		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
PCBs	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Explosives	Sample	6	$190	$1,140		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Inorganics	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$790	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Transport to Bioslurry Area	CY	36	$9.68	$348		Engr. Est.; Means Site Work, 1998, 022-266-5000	Assumes 1.2 swelling factor; 12 CY dumptruck, 4 mile round trip; add 100% for small volume
Biological Treatment Operation	CY	43	$100	$4,300		Engr. Est.; vendor quote	Operation of the existing biocell. Incl additives and labor. Assumes 20% increase in volume due to additives; 120 pcf
Transport to Landfarming Area	CY	36	$9.68	$348		Engr. Est.; Means Site Work, 1998, 022-266-0500	Assumes 12 CY dump trailer, 4 mile round trip from Site 22 biocell to landfarming area at Site 24; add 100% for small volume
Landfarming Operation	CY	43	$50	$2,150		Engr. Est.	
Treatment Process Sampling - Analysis							
SVOCs	Sample	20	$220	$4,400		Baker Average BOAs	Assume 10 samples from biocell and 10 samples from landfarm
PCBs	Sample	20	$100	$2,000		Baker Average BOAs	Assume 10 samples from biocell and 10 samples from landfarm
Explosives	Sample	20	$95	$1,900		Baker Average BOAs	Assume 10 samples from biocell and 10 samples from landfarm
Inorganics	Sample	20	$100	$2,000		Baker Average BOAs	Assume 10 samples from biocell and 10 samples from landfarm
Miscellaneous Expenses	Event	1	$200	$200		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Treatment - Bioslurry and Soil Washing - Subtotal					$30,577		
DIRECT CAPITAL COSTS - TOTAL					$192,751		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$11,565	$11,565		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$28,913	$28,913		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$40,478		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$233,229**		
TOTAL NET PRESENT WORTH: RAA 4					**$235,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.2-4

SITE 8 COST ESTIMATE: RAA 5 - INCINERATION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.05	$2,600	$130		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 8: add 100% for small area markup
Temporary Safety Fencing	LF	120	$3.32	$398		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing by access road
Temporary Silt Fencing	LF	190	$0.82	$156		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavation areas
Site Restoration							
Backfill	CY	15	$11.20	$168		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill; add 100% for small area markup
Topsoil	CY	15	$34.08	$511		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting: add 100% for small area markup
Fine Grading/Seeding (Revegetation)	SY	185	$4.38	$810		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed areas; add 100% for small area
Site Work - Subtotal					$2,174		

TABLE E.2-4 (continued)

SITE 8 COST ESTIMATE: RAA 5 - INCINERATION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Incineration (Assuming Hazardous)							
Excavation of Contaminated Soil	CY	30	$3.36	$101		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1' deep excavation.; add 100% for small area
Confirmatory Sampling - Labor	HR	20	$40	$800		Engr. Est.	1 geo./eng. sampler @ $40/hr.; 2 days, 10 hrs/day
Confirmatory Sampling - Analysis							
SVOCs	Sample	6	$440	$2,640		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
PCBs	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Explosives	Sample	6	$190	$1,140		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Inorganics	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$900	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Miscellaneous Expenses	Event	1	$200	$200		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Loading of Soil	CY	36	$12.78	$460		Engr. Est.; Means Site Work, 1998, 022-216-4000	Assumes 1 2 bulking factor of in place cubic yards; add 100%
Incineration Fees	Ton	58	$895	$51,910		Engr. Est.; vendor quote	Includes disposal costs; assumes 120 pcf
Transportation	Load	3	$2,950	$8,850		Engr. Est.; vendor quote	22 tons/load
Incineration - Subtotal					$69,401		
DIRECT CAPITAL COSTS - TOTAL					$171,575		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$10,294	$10,294		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$25,736	$25,736		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$36,031		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$207,605**		
TOTAL NET PRESENT WORTH: RAA 5					**$210,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.2-5

SITE 8 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.05	$2,600	$130		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 8; add 100% for small area
Temporary Safety Fencing	LF	120	$3.32	$398		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing by access road
Temporary Silt Fencing	LF	190	$0.82	$156		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavation areas
Site Restoration							
Backfill	CY	15	$11.20	$168		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill; add 100% for small area
Topsoil	CY	15	$34.08	$511		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting; add 100% for small area
Fine Grading/Seeding (Revegetation)	SY	185	$4.38	$810		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed areas; add 100% for small area
Site Work - Subtotal					$2,174		

TABLE E.2-5 (continued)

SITE 8 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Off Site Disposal							
Soil Excavation	CY	30	$3.36	$101		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assuming 1 foot deep excavation; add 100% for small volume
Confirmatory Sampling - Labor	HR	20	$40	$800		Engr. Est.	1 geo./eng. sampler @ $40/hr.; 2 days, 10 hrs/day
Confirmatory Sampling - Analysis							
SVOCs	Sample	6	$440	$2,640		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
PCBs	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Explosives	Sample	6	$190	$1,140		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Inorganics	Sample	6	$200	$1,200		Baker Average BOAs	6 samples;100% cost increase for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$900	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Miscellaneous Expenses	Event	1	$200	$200		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Off Site Disposal (Non-Hazardous)	Ton	58	$45	$2,610		Engr. Est.; vendor quote	Includes disposal costs; assumes 1.2 bulking factor of in place cubic yards; assumes non-hazardous; assumes 120 pcf
Transportation (Non-Hazardous)	Load	3	$330	$990		Engr. Est.; vendor quote	22 tons/load
Off-Site Disposal (Hazardous)	Ton	58	$98	$5,684		Engr. Est.; vendor quote	Includesdisposal costs; assumes 1.2 bulking factor of in place cubic yards; assumes hazardous; assumes 120 pcf
Transportation (Hazardous)	Load	3	$2,650	$7,950		Engr. Est.; vendor quote	22 tons/load
Off Site Disposal (Non-Hazardous) - Subtotal					$11,781		
Off Site Disposal (Hazardous) - Subtotal					$21,815		

TABLE E.2-5 (continued)

SITE 8 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

DIRECT CAPITAL COSTS (NON-HAZARDOUS) - TOTAL					$113,955		
DIRECT CAPITAL COSTS (HAZARDOUS) - TOTAL					$123,989		
INDIRECT CAPITAL COSTS (NON-HAZARDOUS)							
Engineering and Design	LS	1	$6,837	$6,837		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$17,093	$17,093		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS (NON-HAZARDOUS) - TOTAL					$23,930		
CAPITAL COSTS - NON-HAZARDOUS (DIRECT AND INDIRECT)					**$137,885**		
INDIRECT CAPITAL COSTS (HAZARDOUS)							
Engineering and Design	LS	1	$7,439	$7,439		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$18,598	$18,598		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS (HAZARDOUS) - TOTAL					$26,038		
CAPITAL COSTS - HAZARDOUS (DIRECT AND INDIRECT)					**$150,026**		
TOTAL NET PRESENT WORTH (NON-HAZARDOUS): RAA 6a					**$140,000**	By: ELB Chk:	Date Completed: October , 1998
TOTAL NET PRESENT WORTH (HAZARDOUS): RAA 6b					**$150,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.2-6
SITE 8 COST ESTIMATE: RAA 7 - CAPPING AND DRAINAGE DIVERSION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.07	$2,600	$182		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at Site 8; add 100% for small area
Temporary Safety Fencing	LF	155	$3.32	$515		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing by access road
Temporary Silt Fencing	LF	230	$0.82	$189		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of disturbed and excavated areas
Site Work - Subtotal					$885		
Soil Cover Installation & Site Restoration							
Backfill	CY	76	$11.20	$851		Engr. Est., Means Site Work, 1998, A12.1-724-1400	Backfill for soil cover (18") & existing drainage area from on-site borrow pit (no matl costs); add 100% small volume
Topsoil	CY	55	$34.08	$1,874		Engr. Est.; Means Site Work, 1998, 022-216-7000	6" of top soil for soil cover/disturbed areas; incl mat'l, hauling from stockpile & compacting; add 100% small volume
Fine Grading/Seeding (Revegetation)	SY	320	$4.38	$1,402		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetate disturbed areas (incl soil cover, cleared/grubbed areas, and pipe excavation areas) ; add 100% for small area
Soil Cover Installation - Subtotal					$4,127		
Drainage Diverion							
Excavation for Existing Pipe Removal	LF	40	$10.16	$406		Engr. Est.; Means Site Work, 1998, A12.3-110-1430	Assume 6' deep, 4' wide trench excavation
Excavation for New Pipe	LF	80	$10.16	$813		Engr. Est.; Means Site Work, 1998, A12.3-110-1430	Assume 6' deep, 4' wide trench excavation
Pipe Removal	LF	40	$6.29	$252		Engr. Est.; Means Site Work, 1998, 020-554-2960	Assume 2' diameter pipe
Backfill	CY	35	$7.98	$279		Engr. Est.; Means Site Work, 1998, A12.1-724-1000	Backfill of former pipe trench and new pipe trench; add 100% for small volume
Concrete Headwall Removal	SF	30	$10.14	$304		Engr. Est.; Means Site Work, 1998, 020-754-2500	Assume 12" thick concrete headwall
Disposal of Pipe and Concrete	LS	1	$500	$500		Engr. Est.	Assume Subtitle D landfill
New Pipe	LF	80	$23.74	$1,899		Engr. Est.; Means Site Work, 1998, 027-162-1080	Assume 2' diameter concrete pipe
Pipe Bedding	LF	80	$5.23	$418		Engr. Est.; Means Site Work, 1998, A12.3-310-1640	Assumes 2' diameter pipe in a 4' wide trench
Install New Headwall	LS	1	$1,810	$1,810		Engr. Est.; Means Site Work, 1998, A12.3-750-2000	Assume cast-in-place concrete, 3' wingwalls
Manholes	EA	2	$1,020	$2,040		Engr. Est.; Means Site Work, 027-152-1900	Assume 6' deep, 4' wide manholes + 2' diameter frams and covers
Drainage Diversion - Subtotal					$8,722		

TABLE E.2-6 (continued)

SITE 8 COST ESTIMATE: RAA 7 - CAPPING AND DRAINAGE DIVERSION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

DIRECT CAPITAL COSTS - TOTAL					$113,734		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$6,824	$6,824		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$17,060	$17,060		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$23,884		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$137,619**		
ANNUAL OPERATION AND MAINTENANCE COSTS							
Long-Term Maintenance							
Inspection	EVENT	2	$500	$1,000		Engr. Est.	
Cap Repair	LS	1	$500	$500		Engr. Est	Assume 10% of cap requires repair per year
Mowing	EVENT	2	$50	$100		Engr. Est.	
Long-Term Maintenance - Subtotal					$1,600		
ANNUAL O&M COSTS - 30 years of maintenance					**$1,600**		
TOTAL NET PRESENT WORTH: RAA 7					**$160,000**	By: ELB Chk:	Date Completed: October , 1998

APPENDIX E.3
SSA 14 COST ESTIMATES

TABLE E.3-1

SSA 14 COST ESTIMATE: RAA 2 - NO ACTION WITH MONITORING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Work, E&S, & QC Plans
Mobilization/Demobilization	LS	1	$3,000	$3,000		Engr. Est.	Drillers, Samplers
Contract Administration	LS	1	$10,000	$10,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$5,000	$5,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$28,000		
Surface Soil, Surface Water, Sediment Monitoring							
Sampling - Labor	Hrs.	30	$40.00	$1,200		Engr. Est.	Semi-annual sampling; 1.5 day/event; 1 geo./eng. sampler @ $40/hr; 2 events/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	2	$900	$1,800		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Soil/Sediment Sampling - Analysis							
Explosives	Sample	6	$95	$570		Baker Average BOAs	3 samples at SSA 14; 2 events/yr
Inorganics	Sample	6	$100	$600		Baker Average BOAs	3 samples at SSA 14; 2 events/yr
Surface Water Sampling - Analysis							
Explosives	Sample	8	$95	$760		Baker Average BOAs	4 samples at SSA 14; 2 events/yr
Inorganics	Sample	8	$100	$800		Baker Average BOAs	4 samples at SSA 14; 2 events/yr
Miscellaneous Expenses	Event	2	$200	$400		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	2	$5,000	$10,000		Engr. Est.	Letter report
Surface Soil, Surface Water, Sediment Monitoring - Subtotal					$16,130		
DIRECT CAPITAL COSTS - TOTAL					$44,130		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$2,648	$2,648		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$6,620	$6,620		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$9,267		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$53,397**		

TABLE E.3-1 (continued)

SSA 14 COST ESTIMATE: RAA 2 - NO ACTION WITH MONITORING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

ANNUAL OPERATION AND MAINTENANCE COSTS							
Surface Soil, Surface Water, Sediment Monitoring							
Sampling - Labor	Hrs.	30	$40.00	$1,200		Engr. Est.	Semi-annual sampling; 1.5 day/event; 1 geo./eng. sampler @ $40/hr; 2 events/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	2	$900	$1,800		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Soil/Sediment Sampling - Analysis							
Explosives	Sample	6	$95	$570		Baker Average BOAs	3 samples at SSA 14; 2 events/yr
Inorganics	Sample	6	$100	$600		Baker Average BOAs	3 samples at SSA 14; 2 events/yr
Surface Water Sampling - Analysis							
Explosives	Sample	8	$95	$760		Baker Average BOAs	4 samples at SSA 14; 2 events/yr
Inorganics	Sample	8	$100	$800		Baker Average BOAs	4 samples at SSA 14; 2 events/yr
Miscellaneous Expenses	Event	2	$200	$400		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	2	$5,000	$10,000		Engr. Est.	Letter report
Surface Soil, Surface Water, Sediment Monitoring - Subtotal					$16,130		
ANNUAL O&M COSTS - 30 years of maintenance					**$16,130**		
TOTAL NET PRESENT WORTH: RAA 2					**$300,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.3-2

SSA 14 COST ESTIMATE: RAA 3 - SOIL WASHING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$20,000	$20,000		Engr. Est.	Bench-scale study
Mobilization/Demobilization	LS	1	$75,000	$75,000		Engr. Est.; vendor quote	Includes mobe/demobe forsoil washing subcontractor
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est.	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$185,000		
Site Work							
Clearing and Grubbing	Acre	0.1	$1,300	$130		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at SSA 14
Temporary Safety Fencing	LF	250	$3.32	$830		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	200	$0.82	$164		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavated areas
Site Restoration:							
Backfill	CY	35	$5.60	$196		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill
Topsoil	CY	35	$17.04	$596		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	535	$2.19	$1,172		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed area
Site Work - Subtotal					$3,088		

TABLE E.3-2 (continued)

SSA 14 COST ESTIMATE: RAA 3 - SOIL WASHING
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Treatment - Soil Washing							
Excavation of Contaminated Soil	CY	70	$3.36	$235		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1' deep excavation; add 100% for small area
Confirmation Sampling - Analysis							Assumes at bottom and walls of excavation
Explosives	Sample	14	$190	$2,660		Baker Average BOAs	14 samples; add 100% cost for quick turn analysis
Inorganics	Sample	14	$200	$2,800		Baker Average BOAs	14 samples; add 100% cost for quick turn analysis
Sampling - Labor	Hrs.	15	$40	$600		Engr. Est.	1 geo.eng sampler @ $40/hr; 1.5 days; 10 hrs/day
Sampling - Travel/Per Diem	LS	1	$900	$900		Eng. Est.	Airfare, per diem, rental car for 2 days for 1 person
Loading into Soil Washing Unit	CY	85	$6.39	$543		Engr. Est.; Means Site Work, 1998, 022-216-4000	
Soil Washing Operation	TON	140	$450	$63,000		Engr. Est.; vendor quote	Assumes 120 pcf
Treatment Process Sampling - Analysis							
Explosives	Sample	24	$95	$2,280		Baker Average BOAs	1 sample/week for 24 weeks of operation
Inorganics	Sample	24	$100	$2,400		Baker Average BOAs	1 sample/week for 24 weeks of operation
Miscellaneous Expenses	Event	1	$200	$200		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Disposal of Filter Cake	LS	1	$10,700	$10,700		Engr. Est.; vendor quote	Assume 25 CY filter cake @ 120 pcf = 40 tons; 2 truckloads; assume hazardous; $2650/load + $135/ton treat and dispose
Wastewater Treatment Unit	EA	1	$6,490	$6,490		Engr. Est.; Means Site Work, 1998, 027-354-0100	Assume 1500 gallon fiberglass tank
Treatment - Soil Washing - Subtotal					$90,613		
DIRECT CAPITAL COSTS - TOTAL					$278,701		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$16,722	$16,722		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$41,805	$41,805		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$58,527		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$337,228**		
TOTAL NET PRESENT WORTH: RAA 3					**$340,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.3-3

SSA 14 COST ESTIMATE: RAA 4 - ON-SITE BIOLOGICAL TREATMENT
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$20,000	$20,000		Engr. Estimate; vendor quote	Biological treatment bench-scale study
Mobilization/Demobilization	LS	1	$50,000	$50,000		Engr. Est.	Includes mob/demob for all subcontractors
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$160,000		
Site Work							
Clearing and Grubbing	Acre	0.70	$2,600	$1,820		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at SSA 14; add 100% for small area
Temporary Safety Fencing	LF	250	$3.32	$830		Engr. Est., Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	200	$0.82	$164		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavated areas
Site Restoration							
Backfill	CY	35	$11.20	$392		Engr. Est., A12.1-724-1400	Assumes 6" backfill; add 100% for small area
Topsoil	CY	35	$34.08	$1,193		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting; add 100% for small area
Fine Grading/Seeding (Revegetation)	SY	535	$4.38	$2,343		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed area; add 100% for small area
Site Work - Subtotal					$6,742		

TABLE E.3-3 (continued)

SSA 14 COST ESTIMATE: RAA 4 - ON-SITE BIOLOGICAL TREATMENT
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

On-Site Biological Treatment							
Excavation of Contaminated Soil	CY	70	$1.68	$118		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1' deep excavation.
Confirmatory Sampling - Labor	HR	15	$40	$600		Engr. Est.	1 geo./eng. sampler @ $40/hr; 1.5 days, 10 hrs/day
Confirmatory Sampling - Analysis							Assumes at bottom and walls of excavation
Explosives	Sample	14	$190	$2,660		Baker Average BOAs	14 samples; add 100% to cost for quick turn analysis
Inorganics	Sample	14	$200	$2,800		Baker Average BOAs	14 samples; add 100% to cost for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$900	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Transport to Bioslurry Area	CY	85	$9.68	$823		Engr. Est.; Means Site Work, 1998, 022-266-05000	Assumes 12 CY dump trailer, 4 mile round trip to existing biocell; assumes 1.2 bulking factor of 70 in place cubic yards; add 100% for small volume
Biological Treatment Operation	CY	100	$100	$10,000		Engr. Est.; vendor quote	Operation of the existing biocell. Includes additives and labor. Assumes 20% increase in volume due to additives.
Transport to Landfarming Area	CY	85	$9.68	$823		Engr. Est.; Means Site Work, 1998, 022-266-05000	Assumes 12 CY dump trailer, 4 mile round trip from Site 22 biocell to landfarming area at Site 24; add 100% for small volume
Landfarming Operation	CY	100	$50	$5,000		Engr. Est.	
Treatment Process Sampling - Analysis							
Explosives	Sample	12	$95	$1,140		Baker Average BOAs	Assume 6 samples from biocell and 6 samples from landfarm
Inorganics	Sample	12	$100	$1,200		Baker Average BOAs	Assume 6 samples from biocell and 6 samples from landfarm
Miscellaneous Expenses	Event	1	$200	$200		Engr. Est.	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
On-Site Biological Treatment - Subtotal					$31,263		
DIRECT CAPITAL COSTS - TOTAL					$198,005		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$11,880	$11,880		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$29,701	$29,701		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$41,581		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$239,586**		
TOTAL NET PRESENT WORTH: RAA 4					**$240,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.3-4

SSA 14 COST ESTIMATE: RAA 5 - INCINERATION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.1	$2,600	$260		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at SSA 14; add 100% small area
Temporary Safety Fencing	LF	250	$3.32	$830		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	200	$0.82	$164		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavated areas
Site Restoration							
Backfill	CY	35	$11.20	$392		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill; add 100% small area
Topsoil	CY	35	$34.08	$1,193		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting; add 100% for small area
Fine Grading/Seeding (Revegetation)	SY	535	$4.38	$2,343		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed area; add 100% for small area
Site Work - Subtotal					$5,182		

TABLE E.3-4 (continued)

SSA 14 COST ESTIMATE: RAA 5 - INCINERATION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Incineration (Assuming Hazardous)							
Excavation of Contaminated Soil	CY	70	$3.36	$235		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1' deep excavation; add 100% for small area
Confirmatory Sampling - Labor	HR	15	$40	$600		Engr. Est.	1 geo./eng. sampler @ $40/hr; 1.5 days, 10 hrs/day
Confirmatory Sampling - Analysis							Assumes at bottom and walls of excavation
Explosives	Sample	14	$190	$2,660		Baker Average BOAs	14 samples; add 100% for quick turn
Inorganics	Sample	14	$200	$2,800		Baker Average BOAs	14 samples; add 100% for quick turn
Sampling - Travel/Per Diem	LS	1	$900	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Miscellaneous Expenses	Event	1	$200	$200		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Loading of Soil	CY	85	$6.39	$543		Engr. Est.; Means Site Work, 1998, 022-216-4000	Assumes 1.2 bulking factor of in place cubic yards
Incineration Fees	Ton	140	$895	$125,300		Engr. Est.; vendor quote	Includes disposal costs; assumes 120 pcf
Transportation	Load	7	$2,950	$20,650		Engr. Est.; vendor quote	22 tons/load
Incineration - Subtotal					$153,888		
DIRECT CAPITAL COSTS - TOTAL					$259,070		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$15,544	$15,544		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$38,861	$38,861		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$54,405		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$313,475**		
TOTAL NET PRESENT WORTH: RAA 5					**$315,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.3-5

SSA 14 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.1	$2,600	$260		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at SSA 14; add 100% for small area
Temporary Safety Fencing	LF	250	$3.32	$830		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around excavated areas
Temporary Silt Fencing	LF	200	$0.82	$164		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing downgradient of excavated areas
Site Restoration							
Backfill	CY	35	$11.20	$392		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 6" backfill; add 100% for small area
Topsoil	CY	35	$34.08	$1,193		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil; cost includes mat'l, hauling from stockpile & compacting; add 100% for small area
Fine Grading/Seeding (Revegetation)	SY	535	$4.38	$2,343		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed area; add 100% for small area
Site Work - Subtotal					$5,182		

TABLE E.3-5 (continued)

SSA 14 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Off Site Disposal							
Soil Excavation	CY	70	$2	$140		Engr. Est.; Means Site Work, 1998, 022-242-2000	Assuming 1 foot deep excavation
Confirmatory Sampling - Labor	HR	15	$40	$600		Engr. Est.	1 geo./eng. sampler @ $40/hr; 1.5 days, 10 hrs/day
Confirmatory Sampling - Analysis							Assumes at bottom and walls of excavation
Explosives	Sample	14	$190	$2,660		Baker Average BOAs	14 samples; add 100% cost for quick turn analysis
Inorganics	Sample	14	$200	$2,800		Baker Average BOAs	14 samples; add 100% cost for quick turn analysis
Sampling - Travel/Per Diem	LS	1	$900	$900		Engr. Est.	Airfare, per diem, rental car for 2 days for 1 person
Miscellaneous Expenses	Event	1	$200	$200		Engineering Estimate	Includes Hnu rental, H&S equipment, sampling & decon expendables, ice & DI water
Off Site Disposal (Non-Hazardous)	Ton	140	$45	$6,300		Engr. Est.; vendor quote	Includes transportation, disposal costs; assumes 1.2 bulking factor of in place cubic yards; assumes non-hazardous; assumes 120 pcf
Transportation (Non-Hazardous)	Load	7	$330	$2,310		Engr. Est.; vendor quote	22 tons/load
Off Site Disposal (Hazardous)	Ton	140	$98	$13,720		Engr. Est.; vendor quote	Includes transportation, disposal costs; assumes 1.2 bulking factor of in place cubic yards; assumes hazardous; assumes 120 pcf
Transportation (Hazardous)	Load	7	$2,650	$18,550		Engr. Est.; vendor quote	22 tons/load
Off Site Disposal (Non-Hazardous) - Subtotal					$15,910		
Off Site Disposal (Hanzardous) - Subtotal					$39,570		

TABLE E.3-5 (continued)

SSA 14 COST ESTIMATE: RAA 6 - OFF-SITE LANDFILL DISPOSAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

DIRECT CAPITAL COSTS (NON-HAZARDOUS) - TOTAL					$121,092		
DIRECT CAPITAL COSTS (HAZARDOUS) - TOTAL					$144,752		
INDIRECT CAPITAL COSTS (NON-HAZARDOUS)							
Engineering and Design	LS	1	$7,266	$7,266		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$18,164	$18,164		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS (NON-HAZARDOUS) - TOTAL					$25,429		
CAPITAL COSTS - NON-HAZARDOUS (DIRECT AND INDIRECT)					**$146,521**		
INDIRECT CAPITAL COSTS (HAZARDOUS)							
Engineering and Design	LS	1	$8,685	$8,685		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$21,713	$21,713		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS (HAZARDOUS) - TOTAL					$30,398		
CAPITAL COSTS - HAZARDOUS (DIRECT AND INDIRECT)					**$175,150**		
TOTAL NET PRESENT WORTH (NON-HAZARDOUS): RAA 6a					**$150,000**	By: ELB Chk:	Date Completed: October , 1998
TOTAL NET PRESENT WORTH (HAZARDOUS): RAA 6b					**$175,000**	By: ELB Chk:	Date Completed: October , 1998

TABLE E.3-6

SSA 14 COST ESTIMATE: RAA 7 - CAPPING AND DRAINAGE DIVERSION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Mobilization/Demobilization	LS	1	$20,000	$20,000		Engr. Est.	Includes mob/demob for excavation equipment
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$100,000		
Site Work							
Clearing and Grubbing	Acre	0.02	$2,600	$52		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at SSA 14; add 100% for small area
Temporary Safety Fencing	LF	250	$3.32	$830		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around all excavation areas
Temporary Silt Fencing	LF	200	$0.82	$164		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assume silt fencing downgradient of all excavation areas
Site Work - Subtotal					$1,046		
Soil Cover Installation & Site Restoration							
Backfill	CY	220	$5.60	$1,232		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 18" of backfill from on-site borrow pit (no material costs)
Topsoil	CY	145	$17.04	$2,471		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 6" of top soil over all disturbed areas; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	875	$2.19	$1,916		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over disturbed areas (soil cover and all cleared and grubbed areas)
Soil Cover Installation - Subtotal					$5,619		
Drainage Diverion							
Excavation of New Drainage Way	LF	150	$4.65	$698		Engr. Est.; Means Site Work, 1998, A12.3-110-6600	Assume 2 to 1 slope; 2' wide, 2' deep, 3/8 CY bucket
Erosion Control (Jute Matting)	SY	200	$1.06	$212		Engr. Est.; Means Site Work, 1998, 022-704-0010	Assume 12' wide, 150 LF
Pipe Removal	LF	20	$4.31	$86		Engr. Est.; Means Site Work, 1998, 020-554-2900	Assume 20 LF, 12" diameter pipe
Disposal of Pipe	LS	1	$375	$375		Engr. Est.; vendor quote	1 truckload, 1 ton, Subtitle D landfill
Drainage Diversion - Subtotal					$1,371		

TABLE E.3-6 (continued)

SSA 14 COST ESTIMATE: RAA 7 - CAPPING AND DRAINAGE DIVERSION
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

DIRECT CAPITAL COSTS - TOTAL					$108,036		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$6,482	$6,482		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$16,205	$16,205		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$22,688		
CAPITAL COSTS (DIRECT AND INDIRECT)					**$130,723**		
ANNUAL OPERATION AND MAINTENANCE COSTS							
Long-Term Maintenance							
Inspection	EVENT	2	$500	$1,000		Engr. Est.	
Cap Repair	LS	1	$500	$500		Engr. Est.	
Mowing	EVENT	2	$50	$100		Engr. Est.	
Long-Term Maintenance - Subtotal					$1,600		
ANNUAL O&M COSTS - 30 years of maintenance					**$1,600**		
TOTAL NET PRESENT WORTH: RAA 7					**$155,000**	By: ELB Chk:	Date Completed: October , 1998