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FINAL GROUNDWATER FOCUSED FEASIBILITY STUDY AT SITE 28 NSWC INDIAN HEAD
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CH2MHILL

Final

Site 28 Groundwater Focused Feasibility Study

Naval Support Facility Indian Head Indian Head, Maryland

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Prepared by



Chantilly, Virginia

Executive Summary

This report presents the Focused Feasibility Study (FFS) for the shallow groundwater at Site 28, also referred to as the “Original Naval Ordnance Station Burning Ground,” the “Slavins Dock Area,” and the “Wildlife Area,” at the Naval Support Facility Indian Head (NSF-IH), in Indian Head, Maryland. This FFS report has been prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division, Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract 62470-02-D-3052, Contract Task Order 0079, for submittal to the United States Navy (Navy), the United States Environmental Protection Agency (EPA), and the Maryland Department of the Environment (MDE).

This study uses information gathered from various investigations conducted at Site 28 to document the analyses and evaluations used to develop remedial action objectives (RAOs) and remedial alternatives (RAs) for the site. The information presented here will be used by the Navy and regulatory agencies to select for the site an RA that complies with the requirements of the National Contingency Plan (NCP; 40 Code of Federal Regulations [CFR] 300).

In 2005, a remedial investigation (RI) was conducted at Site 28 (CH2M HILL, 2005). The RI and accompanying screening-level ecological risk assessment (SERA) concluded that there are potentially unacceptable human health and ecological risks associated with soil, sediment, groundwater, and surface water at Site 28. Risks in the sediment were further evaluated in a baseline ecological risk assessment (BERA) (CH2M HILL, 2006a). The BERA results indicated that metals in the shoreline sediments pose an unacceptable risk to ecological receptors.

Consequently, an Engineering Evaluation/Cost Analysis (EE/CA), completed in September 2006 (CH2M HILL, 2006b), resulted in a non-time-critical removal action (NTCRA) of soil and sediment that was completed in December 2008 (Shaw, 2009). The purpose of the removal action was to reduce risks to human health and ecological receptors to acceptable levels through excavation and removal of affected soil and sediment.

Because the unacceptable risks to human health and ecological receptors from exposure to Site 28 soil and sediment were mitigated by the NTCRA, this FFS addresses primarily risks from Site 28 shallow groundwater to human health receptors.

The constituent of concern (COC) addressed in the FFS is arsenic in groundwater. The site-specific RAOs for the shallow groundwater at Site 28 are the following:

- Eliminate human health exposure pathways to arsenic in the shallow groundwater
- Return aquifer to beneficial use to the extent practicable

Potential RAs that would be suitable to address the RAOs were selected and evaluated based on the criteria set forth in the NCP to assemble and evaluate technical and policy

considerations and to develop the rationale for selecting a remedy for Site 28. The RAs considered for Site 28 are the following:

Alternative 1: No Action

Alternative 2: Institutional Controls (ICs): Alternative 2 involves a continuous implementation of ICs in the form of groundwater-use restrictions. As part of the five-year review process, groundwater conditions will be evaluated to determine the need for continued implementation of ICs.

The alternatives were evaluated against the nine criteria set forth in the NCP. The criteria permit comparison of the relative performance of the alternatives and provide a means to identify their advantages and disadvantages.

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Acronyms and Abbreviations

AA	area of attainment
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/sec	centimeters per second
COC	constituent of concern
DO	dissolved oxygen
DOC	dissolved organic carbon
DPT	direct-push technology
EE/CA	Engineering Evaluation / Cost Analysis
EPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
FFS	Focused Feasibility Study
ft	foot
GIS	Geographic Information System
GRA	general response actions
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IAS	Initial Assessment Study
IC	institutional control
LUC	land use control
LUCIP	land use control implementation plan
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
mg/kg	milligram per kilogram
mg/L	milligrams per liter
MPPEH	material potentially presenting an explosive hazard
mV	millivolts
µg/L	micrograms per liter
Navy	United States Navy
NCP	National Contingency Plan (40 CFR 300)

NOS	Naval Ordnance Station
NSF-IH	Naval Support Facility Indian Head
NTCRA	non-time-critical removal action
O&M	operation and maintenance
ORP	oxidation-reduction potential
PRG	preliminary remediation goal
RA	remedial alternative
RAO	remedial action objectives
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SERA	screening-level ecological risk assessment
SVOC	semivolatile organic compound
SRG	site remediation goal
TAL	target analyte list
TBC	to be considered
TCL	Target Compound List
TOC	total organic carbon
UTL	upper tolerance limit
VOC	volatile organic compound

Introduction

This report presents the Focused Feasibility Study (FFS) for shallow groundwater at Site 28, Naval Support Facility Indian Head (NSF-IH) in Indian Head, Maryland. This FFS report was prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division, Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62470-02-D-3052, Contract Task Order 0079, for submittal to the United States Navy (Navy), the United States Environmental Protection Agency (EPA), and the Maryland Department of the Environment (MDE). This FFS is part of the overall Installation Restoration Program being implemented at Site 28.

The FFS for Site 28 has been developed to the extent applicable in accordance with *Interim Final, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1998); other Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requirements, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and implemented by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; 40 Code of Federal Regulations [CFR] 300); and other relevant EPA guidance.

1.1 Objective

This report uses information gathered from various investigations, described in Section 2, to develop and evaluate cost-effective alternatives to address shallow groundwater contamination at Site 28. The remedial alternatives (RAs) developed in this FFS address the remedial action objectives (RAOs) and risks associated with the groundwater at the site. This FFS includes a site-specific explanation of how each alternative satisfies NCP's nine site-specific remedy-selection criteria.

This FFS documents the analyses and evaluations used to develop remedial action alternatives for Site 28. The information presented herein will be used by the Navy and regulatory agencies to select an RA for Site 28 that complies with the requirements of the NCP. The FFS report is not intended to serve as a design document; rather, it gives a conceptual overview of RAs and an assessment of their feasibility. The FFS report discusses criteria used to evaluate RAs and to determine the benefits of implementing them.

Soil and sediment contamination associated with Site 28 was addressed by a non-time-critical removal action (NTCRA), described in an Engineering Evaluation/Cost Analysis (EE/CA) (CH2M HILL, 2006b). The NTCRA, which included excavation and disposal of approximately 4,400 cubic yards of soil, 490 pounds of propellant grains, and 34 tons of material potentially presenting an explosive hazard (MPPEH; rings, lids, cans, etc.) was completed in December 2008 (Shaw, 2009).

This FFS report addresses the shallow groundwater contamination at Site 28 through the completion of the following tasks:

- Development of RAOs
- Identification of remedial technologies that alone or in combination can treat, contain, or dispose of contaminated media
- Screening of potentially applicable remedial technologies based on the effectiveness, implementability, and cost criteria
- Assembly of RAs that, to the maximum extent practicable, utilize permanent solutions and alternative technologies
- Performance of a detailed analysis of the RAs using the nine evaluation criteria listed in the NCP

Following completion of the FFS, a recommended alternative that best satisfies the RAOs will be presented in a Proposed Plan that will be submitted for public comment. The resulting comments will be reviewed and a remedy will be selected and formally documented in a Record of Decision (ROD).

1.2 Report Organization

This FFS report is organized into six sections:

1. Introduction
2. Background information
3. RAOs, Applicable or Relevant and Appropriate Requirements (ARARs), and site remediation goals
4. Technology screening and development of RAs
5. Description and detailed analysis of RAs
6. References

Figures and tables are provided at the end of each section. Appendices follow Section 6.

Background Information

This section summarizes base history, site history and characteristics, previous investigations, previous removal actions, human health and ecological risks, and nature and extent of contamination at Site 28. Detailed information is provided in the following documents:

- CH2M HILL. 2005. *Final Remedial Investigation Report, Site 28, Naval District Washington, Indian Head, Indian Head, Maryland*. April. Herein referred to as the remedial investigation (RI) report.
- CH2M HILL. 2006a. *Final Baseline Ecological Risk Assessment, Site 28, Naval District Washington, Indian Head, Indian Head, Maryland*. September. Herein referred to as the baseline ecological risk assessment (BERA) report.
- CH2M HILL. 2006b. *Final Engineering Evaluation/Cost Analysis, Site 28, Naval District Washington, Indian Head, Indian Head, Maryland*. September. Herein referred to as the EE/CA report.
- Tetra Tech NUS. 2002. *Background Soil Investigation Report for Indian Head and Stump Neck Annex, Naval Surface Warfare Center, Indian Head, Maryland*. October.
- Shaw. 2009. *Final Closeout Report. Removal Action at Site 28, Naval Support Facility, Indian Head, Indian Head, Maryland*. August.

2.1 Base Location and History

NSF-IH is located in northwestern Charles County, Maryland, approximately 25 miles southwest of Washington, DC (Figure 2-1). NSF-IH is a Navy facility consisting of the Main Installation on Cornwallis Neck Peninsula and the Stump Neck Annex on Stump Neck Peninsula. The Main Installation encompasses approximately 2,500 acres and is bounded by the Potomac River to the northwest, west, and south; Mattawoman Creek to the south and east; and the town of Indian Head to the northeast. Included as part of the Main Installation are Marsh Island and Thoroughfare Island, which are located in Mattawoman Creek. Site 28 is located on the Main Installation (Figure 2-1).

NSF-IH was established in 1890 and is the Navy's oldest continuously operating ordnance station. At various times during its operation, NSF-IH has served as a gun and armor proving ground, a powder factory, a propellant plant, and a research facility. Stump Neck Annex, which was acquired in 1901, provided a safety buffer for testing larger naval guns that were tested by firing into the Potomac River, and at Stump Neck. The production of gunpowder and development of new explosives during the onset of World War II resulted in the construction of several new facilities at Indian Head, as well as the construction of Route 210 as a Defense Access Road in 1943. Development and improvements at Indian

Head continued throughout the 1950s and 1960s, and in 1966, NSF-IH was renamed the Naval Ordnance Station (NOS).

After the Vietnam conflict, the mission of NSF-IH shifted from primarily a production facility to a highly technical engineering support operation. In 1987, the NOS was established as a Center for Excellence to promote technological excellence in the following specialized fields: energetic chemicals; guns, rockets and missile propulsion; ordnance devices; explosives; safety and environmental protection; and simulators and training (Parsons, 2000). Current Navy land uses are operations and training; production; maintenance and utilities; research, development, testing, and evaluation; explosive storage; supply and nonexplosive storage; administration; community facilities and services; housing; and open space.

2.2 Site History and Characteristics

2.2.1 Site History

Site 28, also referred to variously as the “Original NOS Burning Ground,” the “Slavins Dock Area,” and the Wildlife Area,” is located on the main installation of NSF-IH (Figure 2-1). The site encompasses the former site of a zinc recovery furnace, observation Well 14, and a shoreline burning cage (Figure 2-2).

During World War I, the Navy initiated a metal-recycling program, which was vital during World War II and continues to the present day. In 1928, a zinc recovery furnace, designated Building 415, was erected at Site 28. The last station map on which the building appears is dated on October 31, 1952, indicating that the building was demolished in the early 1950s (Dolph, 2001).

Well 14 was installed in 1918 to a depth of 430 feet (ft) using cable drilling (Public Works of the Navy, date unknown). Initially, this was used as a potable well, but it became an observation well in 1988 and remains so today. The small shoreline burning cage to the south of Well 14 was used to burn debris (e.g., wooden crates). The exact location of the former burning cage is unknown. The burning ground is shown outside of the existing perimeter fence on at least one historical map; however, burned debris, glass, and slaglike materials were observed inside the fence in an area adjacent to the mouth of Swale 4 (Figure 2-2).

2.2.2 Site Characteristics

Information on the geology and hydrogeology summarized below are taken from the RI Report. Site conditions have changed as a result of the removal action that occurred in 2008.

Geology

Geologic information for the site was obtained from 41 direct-push technology (DPT) soil-boring locations and five monitoring well soil-boring locations. The locations of these soil borings and monitoring wells are presented in Figure 2-3. Detailed information on the site geology can be obtained from Section 2.4 of the RI Report. Appendix A of the RI Report contains the soil-boring logs.

The northeast section of the site did not contain any vegetation and had been extremely eroded. The shallow subsurface geology in this area was characterized by moist light gray, highly plastic, silty clay. The southern section of the site was characterized by fine-grained sand and silty sand with occasional trace clay. The soil on either side of the dirt road (old railroad tracks) contained fill and consisted of fine to coarse sand and gravel. The entire site is underlain by dense, gray, highly plastic clay. The depth to the clay ranges from 4 to 26 feet below ground surface (bgs), depending on surface. This unit is likely part of the Quaternary deposit. Figure 2-3 shows the locations of soil borings used to obtain geologic data and the location of two geologic cross-sections (A-A' and B-B'). Figure 2-4 presents cross-section A-A', oriented approximately northwest-southeast through the site. Figure 2-5 shows cross-section B-B', oriented approximately west-east through the site.

Hydrogeology

Site 28 is immediately underlain by fine-grained to silty sand that is underlain by a clay layer. The sand acts as the primary water-bearing unit and the underlying clay acts as a confining layer.

The water table was encountered at the site at depths ranging from approximately 0.85 feet bgs in IS28MW02 to approximately 12.72 feet bgs in IS28MW03 when measured on September 10, 2003. The groundwater lies at relatively low elevations (3.4 ft above mean sea level near the shoreline of Mattawoman Creek to 40.99 feet above mean sea level on the west side of the dirt road) and the flow is to the southeast toward Mattawoman Creek (Figure 2-6). The hydraulic gradient of the site is roughly 0.1.

Two Shelby tube samples (IS28MW04 and IS28MW07) were collected from the underlying clay layer to estimate its vertical hydraulic conductivity. At both locations, the clay was penetrated by approximately 2 feet. At location IS28MW04, a sample was collected from 6 to 8 feet bgs; the vertical hydraulic conductivity was 4.92×10^{-8} centimeters per second (cm/sec). At location IS28MW07, a sample was collected from 26 to 28 feet bgs; the vertical hydraulic conductivity was 1.89×10^{-9} cm/sec. The mean hydraulic conductivity was 2.55×10^{-8} cm/sec. This value reflected the very low permeability of the clay unit, which indicated that it is a confining layer.

2.3 Previous Investigations

A detailed discussion of each investigation is provided in the referenced document. A summary is provided below.

2.3.1 Initial Assessment Study

An Initial Assessment Study (IAS) was conducted in 1983 to evaluate sites at NSF-IH and to determine if a potential threat to human health or the environment existed at these sites. File searches and a site reconnaissance were conducted at Site 28; however, the report concluded that there was not enough information to characterize the potential hazard of the site. Furthermore, Site 28 was not recommended for a Navy Assessment and Control of Installation Pollutants Confirmation Study (Fred C. Hart Associates, 1983).

Several soil-sampling events were conducted by base personnel at the site following the IAS. In August 1993, a soil sample from Site 28, referred to at that time as the "Slavins Dock area," was collected about 20 ft southwest of "Well #14" and analyzed for soil texture, pH, and fertility. The pH for the sandy loam soil was 6.7. The soil test results indicated that copper, magnesium, sulphate, and zinc were present in amounts of 25, 30, 22.7, and 14,700 pounds per acre, respectively. For zinc, this translates into 7,350 milligrams per kilogram (mg/kg). In May 2000, the analytical results of total lead and total zinc in a soil sample (soil sample 1) collected from Site 28 near "Wildlife Area Well #14" indicated concentration levels of 9.37 and 515 mg/kg, respectively. In July 2000, a soil sample (IR2855-000712) was collected and analyzed for various metals. The analysis detected cadmium (1.2 mg/kg), lead (3.8 mg/kg), and selenium (1.8 mg/kg) in the sample.

2.3.2 Sediment Toxicity Identification Evaluation Demonstration

In October 2000, a sediment sample was collected in Mattawoman Creek just off the shoreline of Site 28 for a Toxicity Identification Evaluation associated with Site 42. The sediment sample had a measured pore water concentration of zinc of 25,000 micrograms per liter ($\mu\text{g/L}$) (SAIC, 2001).

2.3.3 Mattawoman Creek Study

Tetra Tech NUS's study of Mattawoman Creek included use of the Rapid Sediment Screening technology developed by Space and Naval Warfare Systems Command (Tetra Tech NUS, 2004). A review of the data collected for the Mattawoman Creek study indicated that no VOCs, pesticides, or PCBs were detected in any of the sediment samples collected from the creek in the vicinity of Site 28. However, certain metals, primarily cadmium, copper, lead, and zinc, were found to be elevated in the sediments of Mattawoman Creek adjacent to the site. It was determined that additional site-specific data were required to evaluate the effect of Site 28 on the environment. These data were collected by CH2M HILL during the RI activities described below.

2.3.4 Remedial Investigation (2005)

RI field activities were conducted at Site 28 between May and August 2003 (CH2M HILL, 2005). Because of different past activities at the site, it was divided into Zones A and B (Figure 2-3) for the RI. The area where the zinc recovery furnace and the small burning cage were located is referred to as Zone A. Zone A comprises the area between the north and south fence lines, the area outside of the fence line to the north, and shoreline to the east. Zone B includes the area referred to as the "Original Burning Ground" in the IAS and as the "Shoreline Burning Cage" by Dolph (2001). This area, outside the NSF-IH fence line but within Navy property, is south of Zone A. Figure 2-2 shows the site, swales, and other features.

The objectives of the RI were to the following:

- Verify the presence of contamination in soil, groundwater, surface water, and sediment resulting from past activities at the site
- Define the extent of contamination

- Evaluate the need for remediation based on the information developed in the human health and ecological risk assessments

Surface soil, subsurface soil, groundwater, surface water, and sediment sampling were conducted as part of the RI. The sample locations are shown in Figure 2-3. Five groundwater-monitoring wells (IS28MW01 through IS28MW05) were installed in the shallow aquifer to assess groundwater contamination. Monitoring well IS28MW05 was installed hydraulically upgradient of the site.

A detailed summary of the detected constituents is provided in Section 4 of the RI report (CH2M HILL, 2005). The following were key findings of the RI:

- The area around the former zinc recovery furnace contained significant metals contamination, especially zinc.
- The concentrations of metals were significantly higher in the surface soils than the subsurface soil (1–3 ft deep).
- Significant metals contamination, especially zinc, was also present in the sediment downgradient of the former zinc recovery furnace.

Soil

In Zone A, 29 surface soil and 29 subsurface soil samples, including background samples (i.e., samples in areas considered to be uncontaminated), were collected and analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), target analyte list (TAL) inorganics, and explosives. Several samples were also sampled for total organic carbon (TOC) and pH. In Zone B, 10 surface and 10 subsurface soil samples were collected. The samples were analyzed for TCL VOCs, TCL SVOCs, total TAL metals, TOC, pH, and explosives.

VOCs were detected in 22 of the 39 surface soil samples (including one duplicate sample) collected with concentrations ranging between 0.4 µg/kg and 11 µg/kg. Of the 39 surface soil samples, 31 had detected concentrations of SVOCs ranging from 20 µg/kg to 12,000 µg/kg. Explosive compounds were detected in 12 of the 39 surface soil samples at Site 28 in concentrations ranging from 57 µg/kg to 670 µg/kg. Most of the explosive detects were in the center of the former zinc recovery furnace area, extending south to the fence line between Zone A and Zone B. All 39 surface soil samples had detected concentrations of metals.

VOCs were detected in 20 of the 38 subsurface soil samples, with concentrations ranging from 0.5 µg/kg to 31 µg/kg. SVOCs were detected in 22 of the subsurface soil samples, with concentrations ranging from 15 µg/kg to 2,000 µg/kg. Of the 38 subsurface soil samples, explosives were detected in 17 at values ranging from 41 µg/kg to 390 µg/kg. Multiple metals were detected in all 38 subsurface soil samples collected. Lead and zinc were detected in all samples, and arsenic was detected in 36 of the 38 samples.

Groundwater

Groundwater samples were collected from the five monitoring wells and analyzed for TCL VOCs, TCL SVOCs, total and filtered TAL inorganics, dissolved organic carbon (DOC), and explosives. One VOC (toluene) was detected in one of the monitoring well samples at 2

µg/L. One detection for carbon tetrachloride was reported at 1 µg/L, but this was in the background sample upgradient of Site 28. Two SVOCs (4-methylphenol and caprolactam) were detected in the monitoring well samples. No explosives were detected in any of the monitoring well samples. The four monitoring well samples had widespread metal detections in both total and dissolved metals. Arsenic concentrations were highest directly downgradient of the former zinc recovery furnace area. Total (unfiltered) arsenic was detected in three of the four samples in concentrations ranging from 12.1 µg/L to 347 µg/L and in the background upgradient monitoring well at 28 µg/L. Dissolved arsenic was detected in three of the four samples in concentrations ranging from 4.2 µg/L to 317 µg/L and in the background upgradient monitoring well at 13.7 µg/L. Figure 2-7 shows the analytical results for total and dissolved arsenic in the monitoring wells and DPT groundwater samples.

Fourteen DPT groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, filtered TAL organics, DOC, and explosives. The two sample locations west of the road (IS28GW01 and IS28GW16) are site background in situ groundwater samples that are upgradient of Site 28. Three VOCs (acetone, carbon tetrachloride, and methylene chloride) were detected in the DPT groundwater samples. These VOCs were detected in 10 of the 14 DPT samples with concentrations ranging from 1 µg/L to 5 µg/L. Acetone and carbon tetrachloride were detected in the upgradient groundwater samples at similar levels. Two SVOCs (di-n-butylphthalate and bis(2-ethylhexyl)phthalate) were detected in the in situ samples. Nitrobenzene was detected in one of the 14 DPT samples at 0.23 µg/L. Although filtered metals were collected at several of the in situ groundwater sampling locations, their purpose was primarily as a screening tool. The detections of metals in groundwater, based on DPT samples, did follow a spatial pattern. Almost all of the highest metal detections (especially arsenic, lead, and zinc) were on the downgradient side of the former zinc recovery furnace area. One exception was sample IS28GW23; it also contained elevated levels of arsenic levels and zinc, but was taken on the southern end of the former zinc recovery furnace area, close to the forest line.

Sediment

Four sediment samples (including one duplicate sample) were collected from the swales located in Zone A and analyzed for TCL VOCs, TCL SVOCs, TAL inorganics, explosives, TOC, and pH. Thirty-one sediment samples (including two duplicate samples) were collected from 15 locations in Mattawoman Creek adjacent to Site 28 and analyzed for SVOCs, explosives, and TAL inorganics.

VOCs were detected in all four swale sediment samples ranging from 1 µg/kg to 3 µg/kg. SVOCs were detected in three of the four swale sediment samples and ranged from 26 µg/kg to 820 µg/kg. Explosives were detected only in one swale sample taken from the groundwater daylighting into Swale 4. Metals were detected in all four swale sediment samples with concentrations ranging from 0.38 mg/kg for mercury to 31,900 mg/kg for iron. Zinc was detected at high levels in all four samples, in concentrations of 1,420 mg/kg to 14,200 mg/kg.

The Mattawoman Creek sediment samples were not analyzed for VOCs. Six Mattawoman Creek sediment samples were analyzed for SVOCs. Five of the six samples contained SVOC concentrations ranging from 28 to 160 µg/kg. None of the three Mattawoman Creek

samples location contained any samples with explosive detects. Metals were detected in all 31 Mattawoman Creek sediment samples. Concentrations ranged from 0.13 mg/kg for beryllium to 39,600 mg/kg for iron. Elevated level of arsenic (up to 36 mg/kg), lead (up to 716 mg/kg), and zinc (up to 10,700 mg/kg) were seen in the sediment samples taken on the shore of Mattawoman Creek downgradient of the former zinc recovery furnace.

Surface Water

Four surface water samples (including one duplicate sample) were collected and analyzed for TCL VOCs, TCL SVOCs, total and filtered TAL inorganics, explosives, DOC, and hardness. VOCs and SVOCs were not detected in any samples. Nitrobenzene was detected at 0.15 µg/L in IS28SW02. No other explosives were detected in any surface water samples. All four surface water samples had detected concentrations of both total and dissolved metals. The surface water contained only one detection of arsenic at 3.8 µg/L for total metals, and no arsenic detections for dissolved metals.

As part of the RI, a baseline human health risk assessment (HHRA) and a Screening Ecological Risk Assessment (SERA) were also performed for Site 28. The HHRA and SERA activities are summarized in Section 2.4 of this report. Detailed descriptions of the baseline HHRA and SERA are presented in Sections 6 and 7 of the RI report, respectively.

2.3.5 Engineering Evaluation and Cost Analysis (2006)

An EE/CA was prepared for a non-time-critical removal action for soil and sediment in Zone A (CH2M HILL, 2006). This action was to remove the potential source for contaminants in the soil, groundwater, and sediment at and adjacent to the site (Figure 2-8). The overall objectives of the EE/CA were to reduce potential risks to human health and ecological receptors associated with site soil contaminants to acceptable levels, represented by the agreed upon preliminary remediation goals, and to restore the site to existing, but improved, conditions (e.g., grading and vegetation).

Soil removal for human health and ecological risks was selected because the removal of soil and sediment at and adjacent to the site and offsite disposal would decrease lead and zinc concentrations in these media to acceptable levels, thereby reducing risks to human health and ecological receptors.

2.3.6 Baseline Ecological Risk Assessment (2006)

A BERA was performed for Site 28 because the results of the SERA (Steps 1–3A of the ERA) indicated potentially unacceptable risks to ecological receptors from exposures to surface soil, surface water, and surface sediment in Mattawoman Creek adjacent to the site.

Surface soil and the sediment in the onsite swales were not included in the BERA because a removal action was planned to mitigate human health risk from lead in surface/subsurface soil and to mitigate ecological risk from various COPCs in the surface soil and sediment in the swales. Further evaluation of the groundwater-to-surface-water pathway and the potential ecological risk from cadmium and zinc in the surface water in the swales was initially considered for the BERA but was removed following discussion at the June 30, 2005, Partnering Meeting. A consensus was reached to defer additional investigation of ecological risk from contaminants in surface water until after the soil removal action had

been completed. It was agreed that further evaluation of surface water would be conducted as part of a post-removal monitoring effort, rather than as part of the BERA investigation, because this approach would provide a post-source control assessment of ecological risk.

The BERA field activities were performed in October 2005. The activities involved the collection of sediment and fish samples from the locations shown in Figure 2-9. Sediment samples were collected and analyzed for TAL metals, TOC, pH, sulfide, and grain size. To evaluate direct toxicity to benthic invertebrates, laboratory toxicity tests with the amphipod *Hyalella azteca* were conducted on split samples from all the sediment sampling locations, and benthic grab samples were collected to examine the benthic community structure. To evaluate the bioaccumulation of chemicals from the sediments into the aquatic food chain, laboratory bioaccumulation bioassays were conducted with the aquatic worm *Lumbriculus variegates*, and fish were collected for fish tissue chemical analysis from the shoreline and reference sample locations. Detailed results of the BERA are presented in the BERA report (CH2M HILL, 2006). The results are summarized in Section 2.4.2 of this report.

2.3.7 Non-Time-Critical Removal Action

In December 2008, the Navy completed the NTCRA, which executed the recommended alternative of the EE/CA. Approximately 5,734 tons of contaminated soil and sediment (3,200 yd³) were removed and disposed of offsite. In addition to the contaminated soil, approximately 490 pounds of propellant grains and 34 tons of MPPEH were also removed from the site (Shaw, 2009). Figure 2-10 shows the removal area. The removal of the contaminated soil resulted in a reduction of risks to human health and ecological receptors identified during the RI.

2.4 Summary of Risk Assessments

2.4.1 Human Health Risk Assessment

The baseline HHRA prepared as part of the Site 28 RI included an evaluation of the potential human health risks associated with exposure to site-related surface soil, combined surface and subsurface soil, groundwater, sediment, and surface water. Exposure pathways evaluated included current utility worker, current and future adult and adolescent trespasser, current/future adult and adolescent recreational user, future adult resident, future child resident, future lifetime resident, and future construction worker.

The HHRA concluded that there were no risks or hazards that exceed acceptable levels for the utility worker exposed to site soil, adult and adolescent trespassers exposed to site soil (current or future), or adult and adolescent recreationalists exposed to surface water. All potential exposures to surface soil and surface water result in hazards and risks within acceptable levels. Exposure to sediment was not quantified since it is not a complete exposure pathway.

Potentially unacceptable risk was present for future adults, children, lifetime residents, and construction workers exposed to soil and groundwater at Site 28. Risks to commercial and industrial workers from soil were not quantitatively evaluated in the risk assessment. However, based on the calculated risk to an adult resident exposed to soil (i.e., a noncarcinogenic hazard that only marginally exceeded the acceptable hazard level), which

is the most directly analogous receptor to a commercial worker, the potential risk to this receptor is likely acceptable. The analysis of the elevated lead concentrations in the Swale 3 area concluded that exposure to surface and subsurface soil in this area would potentially be a concern for fetuses of expectant construction workers, utility workers (if they are exposed at the upper end of the estimated range of parameter values), and adult trespassers (if they are exposed at the upper end of the estimated range of parameter values), and for future child residents. The reasonable maximum exposure and central tendency exposure potential hazards and risks to each receptor are provided in the RI Report.

Based on the baseline HHRA, exposure to groundwater would result in an unacceptable hazard (i.e., a hazard index [HI] greater than 1.0) for adult (HI = 40) and child (HI = 94) residents. The main hazard contributors are arsenic, iron, and vanadium, all contributing individual hazard quotients (HQs) over 1.0. Both the ingestion and dermal contact routes contribute hazards above 1.0. The main contributors to the noncarcinogenic HI for the child are aluminum, arsenic, cadmium, iron, manganese, and vanadium, all contributing individual HQs over 1.0.

The maximum detected constituent concentrations were used as the exposure point concentrations for groundwater due to the limited number of samples available, which may result in an overestimation of the risk. The maximum detected concentrations of cadmium, iron, and vanadium were not much higher than the 90 percent upper tolerance limit (UTL) of the background groundwater data presented in the Background Investigation Report (Tetra Tech NUS, 2002). The maximum detected concentrations of aluminum and manganese in Site 28 groundwater were less than that of the 95 percent UTL of the background groundwater data. Therefore, all of the constituents of potential concern, and calculated hazards, may not be solely associated with Site 28 but may also be associated with background groundwater conditions. However, based on arsenic alone, which was not detected in the background groundwater samples, the hazard would still be above 1.0 for the adult and child resident. Exposure to groundwater through potable use by a lifetime resident would result in a carcinogenic risk (7.8×10^{-3}) above the acceptable risk range of 1×10^{-4} to 1×10^{-6} , based on reasonable maximum exposure assumptions. The groundwater risk driver, therefore, is arsenic.

2.4.2 Ecological Risk Assessment

A SERA was conducted as part of the RI to estimate the potential risks posed to ecological receptors from constituents at the site. Section 7 of the RI Report presents a detailed discussion of the ERA.

In general, the results of the SERA suggested the potential for unacceptable ecological risk at the site, including potential risks from several metals in the shoreline sediments at the site and from silver in Mattawoman Creek sediment across from the site. Antimony, cadmium, copper, lead, mercury, nickel, silver, and zinc were identified as potential risk-driving chemicals of concern in Site 28 surface soil. Cadmium and zinc were identified as potential risk-driving COPCs in surface water in the swales. Arsenic, cadmium, copper, lead, mercury, and zinc were identified as potential risk-driving COPCs in sediment along the immediate shoreline of the site, and only silver was identified as a COPC for sediment in Mattawoman Creek across from the site.

The results from the BERA indicated that the metals in sediments along a portion of the shoreline of the site pose unacceptable risk to benthic invertebrates and omnivorous birds. The portion of the shoreline includes the area in the vicinity of sample location IS28SD03 and the area immediately upstream of this location where unacceptable risk was identified based on previous toxicity testing in the location of an apatite treatment pilot study. Three ecological constituents of concern (COCs) were identified for this area (cadmium, lead, and zinc). Lead and zinc were identified as COCs for both the benthic invertebrate community and omnivorous birds and cadmium was identified as a COC for the benthic invertebrate community. The concentrations of these metals were found to pose low risk to fish and piscivorous (fish-eating) wildlife. Metals in the sediments along the rest of the site were found to pose low risk to ecological receptors.

Silver in the sediment along the vegetated bar across from Site 28 was found to not pose unacceptable risk to the benthic invertebrate community of the creek. Silver was analyzed in samples from the vegetated bar across the channel (IS28SD11 and IS28SD13) because it was the only COPC identified for these two locations in the SERA. Although the silver concentrations at IS28SD11 and IS28SD13 previously exceeded the screening value, the concentrations measured in the BERA sampling effort did not exceed the screening value and the toxicity testing and benthic community structure analysis revealed no risk to the benthic invertebrate community.

2.5 FFS Constituent of Concern

Based on the risk assessment conclusions, arsenic is the only COC to be addressed in the FFS for shallow groundwater at Site 28. Arsenic, therefore, is the FFS COC. The extent of arsenic in the shallow groundwater at Site 28 was determined based on the RI data collected from 14 DPT groundwater samples and five monitoring well (four site-specific and one background monitoring wells) groundwater samples in 2003, before the NTCRA (i.e., source removal) was completed, in 2008. Discussion of the complete analytical results is presented in Section 4.6.3 of the RI Report (CH2M HILL, 2005). The DPT groundwater samples were analyzed only for dissolved metals whereas the monitoring well groundwater samples were analyzed for both total and dissolved metals. Tables 2-1 and 2-2 summarize the detected constituent concentrations in in situ groundwater samples and monitoring well groundwater samples, respectively. Figure 2-5 shows the locations of the arsenic detections. Raw analytical groundwater data are presented in Appendix A.

Dissolved arsenic was detected at five DPT sample locations at concentrations ranging from 1.8 µg/L (IS28GW01) to 213 µg/L (IS28GW20). Total arsenic was detected in three of the four monitoring well samples at concentrations of 12.1 µg/L (IS28MW03), 135 µg/L (IS28MW02), and 347 µg/L (IS28MW01), and in the background upgradient monitoring well, IS28MW05, at 28 µg/L. Dissolved arsenic was detected in three of the four monitoring well samples at concentrations of 4.2 µg/L (IS28MW03), 93.5 µg/L (IS28MW02), and 317 µg/L (IS28MW01), and in the background upgradient monitoring well at 13.7 µg/L. For both total and dissolved metals, arsenic concentrations are highest directly downgradient of the former zinc recovery furnace area.

The elevated arsenic concentrations were likely caused by a reducing, or oxygen-deprived, aquifer condition. This condition is typically indicated by low oxidation-reduction potential

(ORP) and dissolved oxygen (DO) values. In well IS28MW04, the ORP and DO values were observed at 295 millivolts (mV) and 8.63 milligrams per liter (mg/L), respectively, which suggest that the condition of groundwater in this well is aerobic, or oxygen rich. Both total and dissolved arsenic concentrations in this well were observed below the detection limit. In well IS28MW01, the ORP and DO values were observed at -10 mV and 2.43 mg/L, respectively, which suggests that the groundwater condition in this well is reducing, or oxygen deprived. Total and dissolved arsenic concentrations in this well were observed at 347 and 317 $\mu\text{g/L}$, respectively.

The presence of the propellant grains in soil likely drove the shallow groundwater into a reducing condition. The propellant (explosives and fuel) contained in propellant grains is a mixture of organic compounds, such as nitrocellulose, dinitrotoluene, trinitrotoluene, nitroglycerin, nitroguanidine, dibutylphthalate, triacetin, diphenylamine, and ethyl centralite (Army, 1967). The specific composition of the mixture varies based on the manufacturer. The presence of the organic compounds in the propellant grains increases both biological and chemical oxygen demand in the subsurface, changing the geochemical condition into an oxygen-deprived condition. This condition further drives down the ORP, which subsequently causes the mobilization of metals, such as arsenic, in the shallow groundwater. The removal of the propellant grains as part of the NTCRA would indirectly mitigate the mobilization of metals.

Table 2-1
 Detected Compounds in *In Situ* Groundwater Samples
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MM02	IS28MM03	IS28MM05	IS28MM06	IS28MM07		IS28MM11	IS28MM14
Sample ID	IS28GW02-0503	IS28GW03-0503	IS28GW05-0503	IS28GW06-0503	IS28GW07-0503	IS28GW07-0503P	IS28GW11-0503	IS28GW14-0503
Sample Date	05/12/03	05/12/03	05/12/03	05/15/03	05/16/03	05/16/03	05/21/03	05/15/03
Chemical Name								
Volatile Organic Compounds (UG/L)								
Acetone	5 J	10 U	4 J	10 U	10 U	10 U	10 U	4 J
Carbon tetrachloride	10 U	5 J	2 J	2 J	10 U	1 J	10 U	10 U
Methylene chloride	10 U	10 U	10 U					
Semi-volatile Organic Compounds (UG/L)								
Di-n-butylphthalate	10 U	10 U	1 J	0.6 JB	1 J	2 J	NA	10 U
bis(2-Ethylhexyl)phthalate	10 U	41	10 U	10 U	10 U	10 U	NA	10 U
Explosives (UG/L)								
Nitrobenzene	0.26 U	0.26 U	0.26 U	0.26 U	0.23 J	0.26 U	NA	0.26 U
Dissolved Metals (UG/L)								
Aluminum	35 B	31.7 B	20.8 B	36.7 B	75.6 B	35.3 B	12,000	62.2 B
Arsenic	2.3 B	1.8 U	1.8 U	1.8 U	1.8 U	2.3 B	142	1.8 U
Barium	29.7 B	27.1 B	30.4 B	27.1 B	25.6 B	26.7 B	239	30.9 B
Cadmium	3.66 U	22.9	3.66 U					
Calcium	1,800 B	1,180 B	1,080 B	888 B	870 B	919 B	7,780	1,140 B
Chromium	0.57 U	17.3	0.57 U					
Copper	2.38 U	3 B	61	2.38 U				
Iron	1,080	332	208	328	219	312	16,400	359
Lead	0.91 U	367	0.91 U					
Magnesium	881 B	834 B	814 B	647 B	614 B	641 B	3,280 B	701 B
Manganese	75.6	38.4	81	34.2	24.1	28.1	133	45.8
Mercury	0.08 B	0.03 U	0.05 B	0.06 B	0.08 B	0.03 U	0.25	0.1 B
Sodium	15,500	14,700	14,000	16,500	13,900	14,200	10,600	15,200
Zinc	94	24.3	46.6	26.3	18.3 B	30.6	15,700	60.4
Wet Chemistry (MG/L)								
Dissolved organic carbon	NA	NA	NA	NA	NA	NA	NA	NA
Total organic carbon (TOC)	1	1 U	1 U	1	1 U	1 U	NA	1

B - Not detected above blank
 J - Estimated
 JB - Estimated, not detected above blank

U - Not detected
 Shaded cell indicates detected constituent.

Table 2-1
Detected Compounds in *In Situ* Groundwater Samples
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MM20	IS28MM23	IS28MM27		IS28MM28	IS28MM42
Sample ID	IS28GW20-0503	IS28GW23-0503	IS28GW27-0503	IS28GW27-0503P	IS28GW28-0503	IS28GW42-0503
Sample Date	05/20/03	05/20/03	05/20/03	05/20/03	05/20/03	05/14/03
Chemical Name						
Volatile Organic Compounds (UG/L)						
Acetone	5 J	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	10 U	10 U	2 J	2 J	10 U	10 U
Methylene chloride	10 U	1 J	1 J	10 U	10 U	10 U
Semi-volatile Organic Compounds (UG/L)						
Di-n-butylphthalate	0.9 JB	1 JB	1 JB	10 U	0.9 JB	2 J
bis(2-Ethylhexyl)phthalate	10 U	10 U	10 U	13	10 U	10 U
Explosives (UG/L)						
Nitrobenzene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
Dissolved Metals (UG/L)						
Aluminum	45.4 B	39.7 B	50.9 B	28.8 B	168 B	27.8 B
Arsenic	213	19.7	2.5 B	1.8 U	1.9 B	10.4
Barium	55.2 B	77.9 B	35 B	37 B	54.6 B	466
Cadmium	3.66 U	5.2	3.66 U	3.66 U	3.66 U	3.66 U
Calcium	7,220	3,600 B	1,240 B	1,290 B	2,510 B	21,200
Chromium	0.57 U	0.57 U	0.57 U	0.57 U	0.57 U	0.57 U
Copper	2.38 U	2.38 U	2.9 B	2.38 U	5.9 B	2.38 U
Iron	32,200	12,700	57.3 B	37.4 B	65.7 B	7,490
Lead	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	3.4
Magnesium	4,180 B	1,050 B	982 B	997 B	2,380 B	5,190
Manganese	271	542	59.8	56.4	84.7	501
Mercury	0.03 U	0.06 B	0.11 B	0.03 U	0.03 U	0.03 B
Sodium	15,300	14,900	14,500	14,600	13,400	14,600
Zinc	216	14,100	118	102	667	10,900
Wet Chemistry (MG/L)						
Dissolved organic carbon	5.8	1 U	1 U	1 U	2	NA
Total organic carbon (TOC)	NA	NA	NA	NA	NA	5.8

B - Not detected above blank
J - Estimated
JB - Estimated, not detected above blank

U - Not detected
Shaded cell indicates detected constituent.

Table 2-2
 Detected Compounds in Monitoring Well Groundwater Samples
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
Sample ID	IS28MW010903	IS28MW010903P	IS28MW020903	IS28MW030903	IS28MW040903	IS28MW050903
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
Volatile Organic Compounds (UG/L)						
Carbon tetrachloride	10 U	10 U	10 U	10 U	10 U	1 K
Toluene	10 U	10 U	2 J	10 U	10 U	10 U
Semi-volatile Organic Compounds (UG/L)						
4-Methylphenol	10 U	10 U	0.6 J	10 U	10 U	10 U
Caprolactam	10 U	10 U	9	3 J	10 U	90
Total Metals (UG/L)						
Aluminum	553	692	8,590	19,300	4,520	32,800
Antimony	1.74 U	1.74 U	2.1 J	1.74 U	1.74 U	1.74 U
Arsenic	342	347	135	12.1 K	2.13 U	28
Barium	32.4 J	32.9 J	109 J	241	90.4 J	158 J
Beryllium	0.22 U	0.22 U	0.4 J	2.4 J	0.54 J	4.7 J
Cadmium	0.61 B	0.59 B	0.75 B	3.3 J	0.25 U	2.66 U
Calcium	4,620 J	4,620 J	9,330	10,600	3,120 J	2,230 J
Chromium	2.2 J	1.7 J	11.4 K	27.4	13.8 K	44.1
Cobalt	7.2 J	5.8 J	3.9 B	59.8 K	34.9 J	73.6 K
Copper	36.2 K	21.7 J	30 K	50.8	16.5 J	46.8 K
Iron	11,500	11,700	6,870	36,400	4,810	125,000
Lead	4.9 K	6.8	16.3	29.9	4.8 K	17.4
Magnesium	3,420 J	3,440 J	8,710	9,690	2,340 J	3,030 J
Manganese	434	434	143	601	281	627
Nickel	7.4 J	6 J	8.6 J	31.6 B	12.9 J	68.5 B
Potassium	2,050 B	1,570 B	5,170	6,290	2,950 J	2,930 J
Sodium	23,000	24,600	19,400	25,000	11,500	17,400
Vanadium	0.74 U	1.3 B	18.9 J	61.8 K	14.5 J	71.5 K
Zinc	951	969	580	1,620	100	153
Dissolved Metals (UG/L)						
Aluminum	252	338	3,840	8,190	1,130	17,300
Antimony	1.74 U	1.74 U	3.1 J	1.74 U	1.74 U	1.74 U

B - Not detected above blank
 J - Estimated
 K - Biased high

U - Not detected
 Shaded cell indicates detected constituent.

Table 2-2
 Detected Compounds in Monitoring Well Groundwater Samples
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
Sample ID	IS28MW010903	IS28MW010903P	IS28MW020903	IS28MW030903	IS28MW040903	IS28MW050903
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
Arsenic	317	292	93.5	4.2 J	2.13 U	13.7 K
Barium	31.9 J	31.6 J	107 J	182 J	68.8 J	119 J
Beryllium	0.22 U	0.22 U	0.33 J	0.88 B	0.33 J	2.5 J
Cadmium	0.4 B	0.56 B	10 K	8 K	0.25 U	10 K
Calcium	4,530 J	4,430 J	8,960	9,260	2,740 J	2,000 J
Chromium	1.5 J	0.93 J	6.1 J	12.2 K	3.4 J	23.4
Cobalt	6.6 J	6.4 J	3.6 B	41.1 J	27.3 J	50.4 K
Copper	10.3 J	7.6 B	22 J	31 K	14.8 J	36
Iron	12,900	13,200	3,870	15,100	981	65,300
Lead	2.2 J	2.2 J	7.8	12.5	1.56 U	9.1
Magnesium	3,390 J	3,320 J	8,630	7,590	1,940 J	2,280 J
Manganese	441	434	127	376	218	436
Nickel	5.1 J	4.8 J	6.4 J	28.9 B	8.5 J	38.6 B
Potassium	1,200 B	1,390 B	4,750 J	5,370	2,460 B	2,490 J
Sodium	20,500	19,400	20,400	25,500	11,700	17,700
Vanadium	0.74 U	0.74 U	10.7 J	23.5 J	3.1 B	38.8 J
Zinc	886	868	320	1,230	75.1	82.8
Wet Chemistry (MG/L)						
Dissolved organic carbon	6.6	6	NA	NA	1 U	2

B - Not detected above blank
 J - Estimated
 K -Biased high

U - Not detected
 Shaded cell indicates detected constituent.

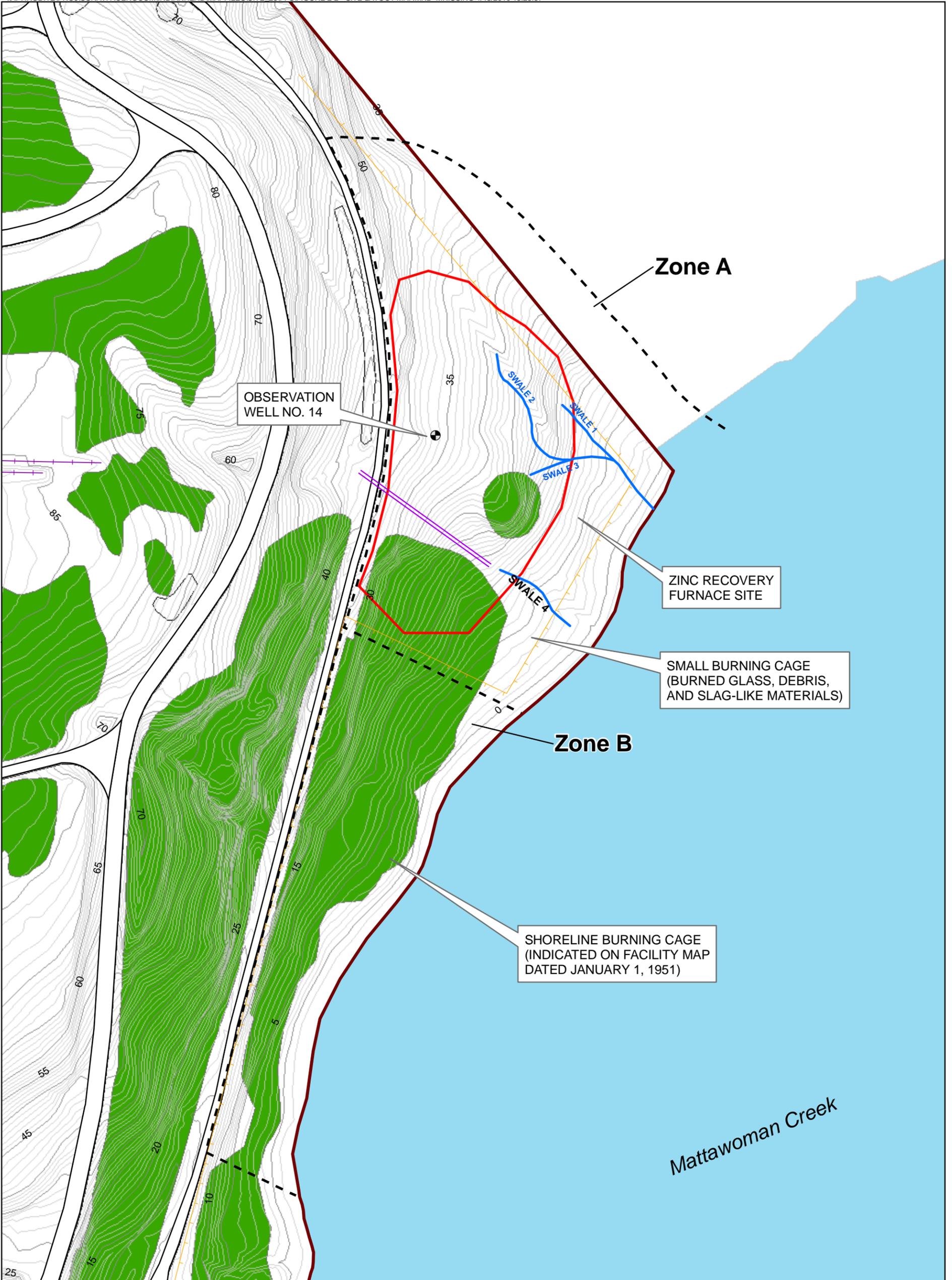


Legend

- Streams
- Topographic Contours
- Buildings
- Roads and Paved Areas
- Wooded Area
- Densely Wooded Area
- Approximate Site 28 Boundary
- Water Bodies
- Installation Boundary



Figure 2-1
 Facility Map
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland



Legend

- Approximate Observation Well
- ~ Swale
- - - Zone Boundary
- - - Fence Line
- - - 24-Inch Culvert
- - - Road
- ~ Contours (5 ft)
- ~ Contours (1 ft)
- Wooded Area
- Approximate Site Boundary
- Installation Boundary

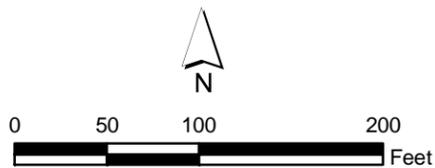
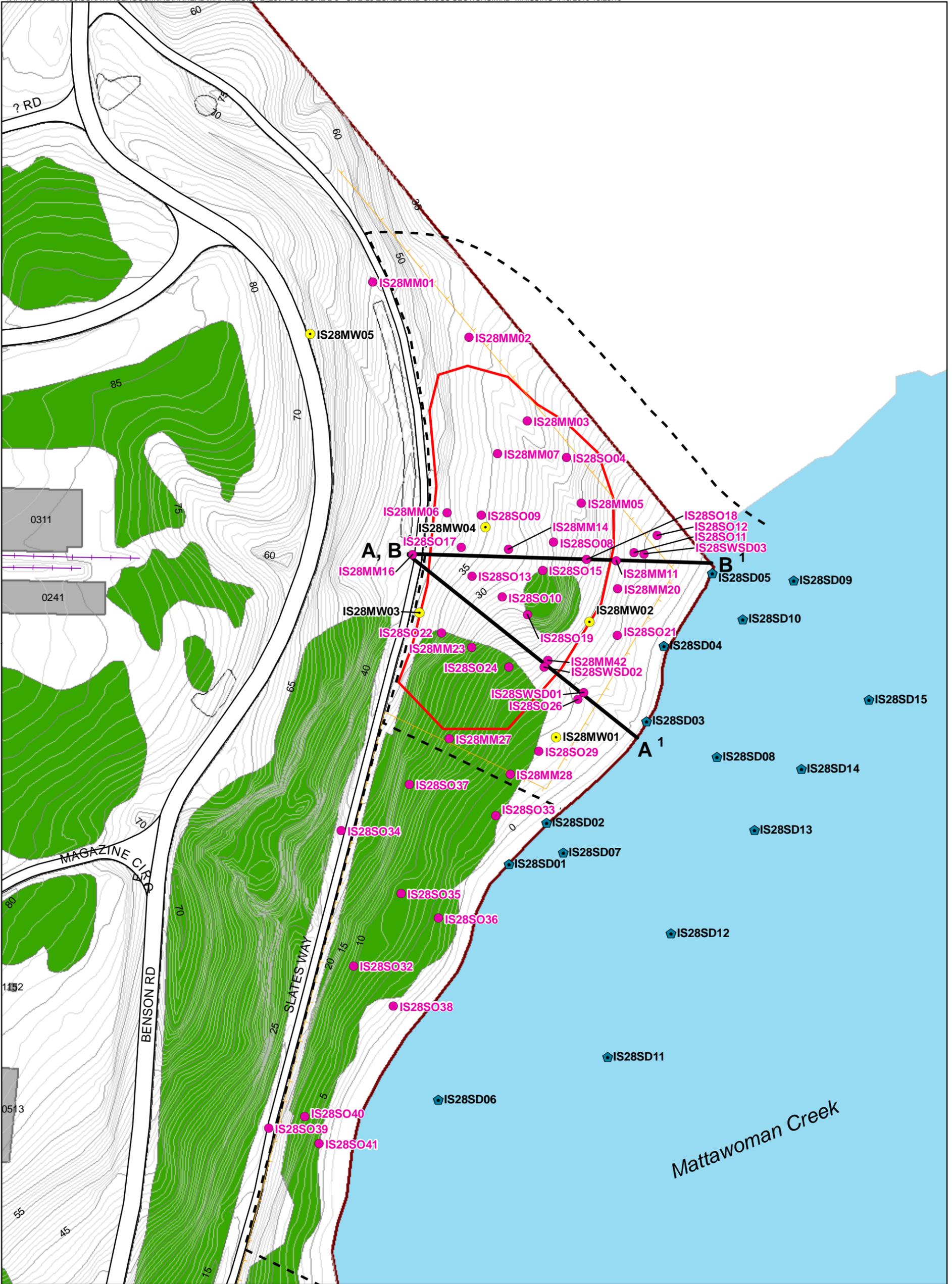


Figure 2-2
Site Layout Map
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland



Legend

- | | |
|--|--|
| <ul style="list-style-type: none"> Mattawoman Creek Sediment Sample Location Onshore Sample Location Monitoring Well Location Transect Zone Boundary Fence Line Road | <ul style="list-style-type: none"> Contours (5 ft) Contours (1 ft) Buildings Wooded Area Approximate Site Boundary Installation Boundary |
|--|--|

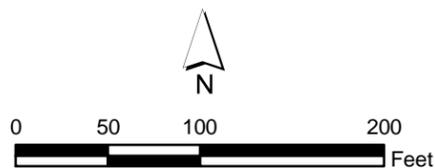


Figure 2-3
Locations of Site 28 Zones and Cross Sections
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

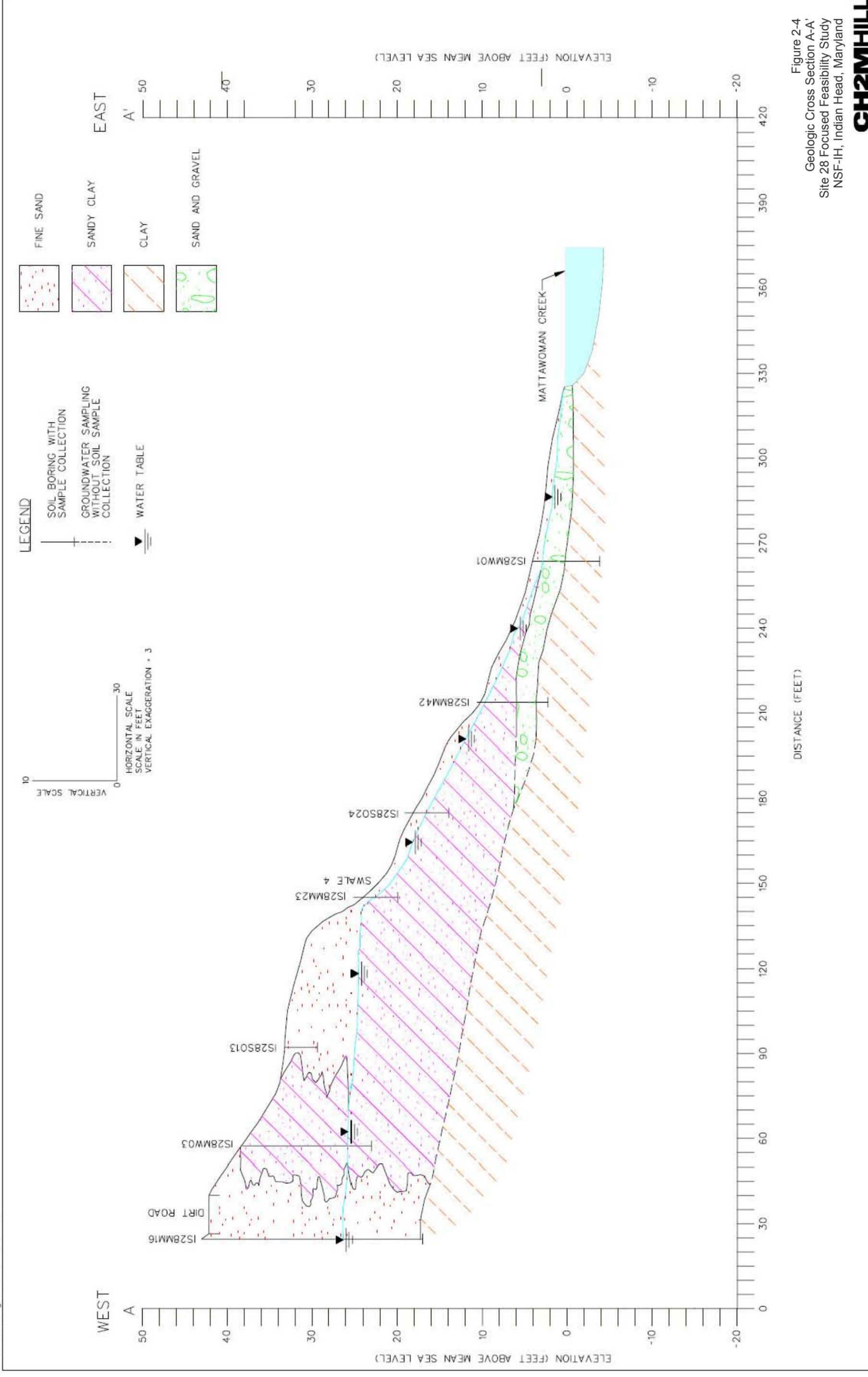


Figure 2-4
Geologic Cross Section A-A'
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

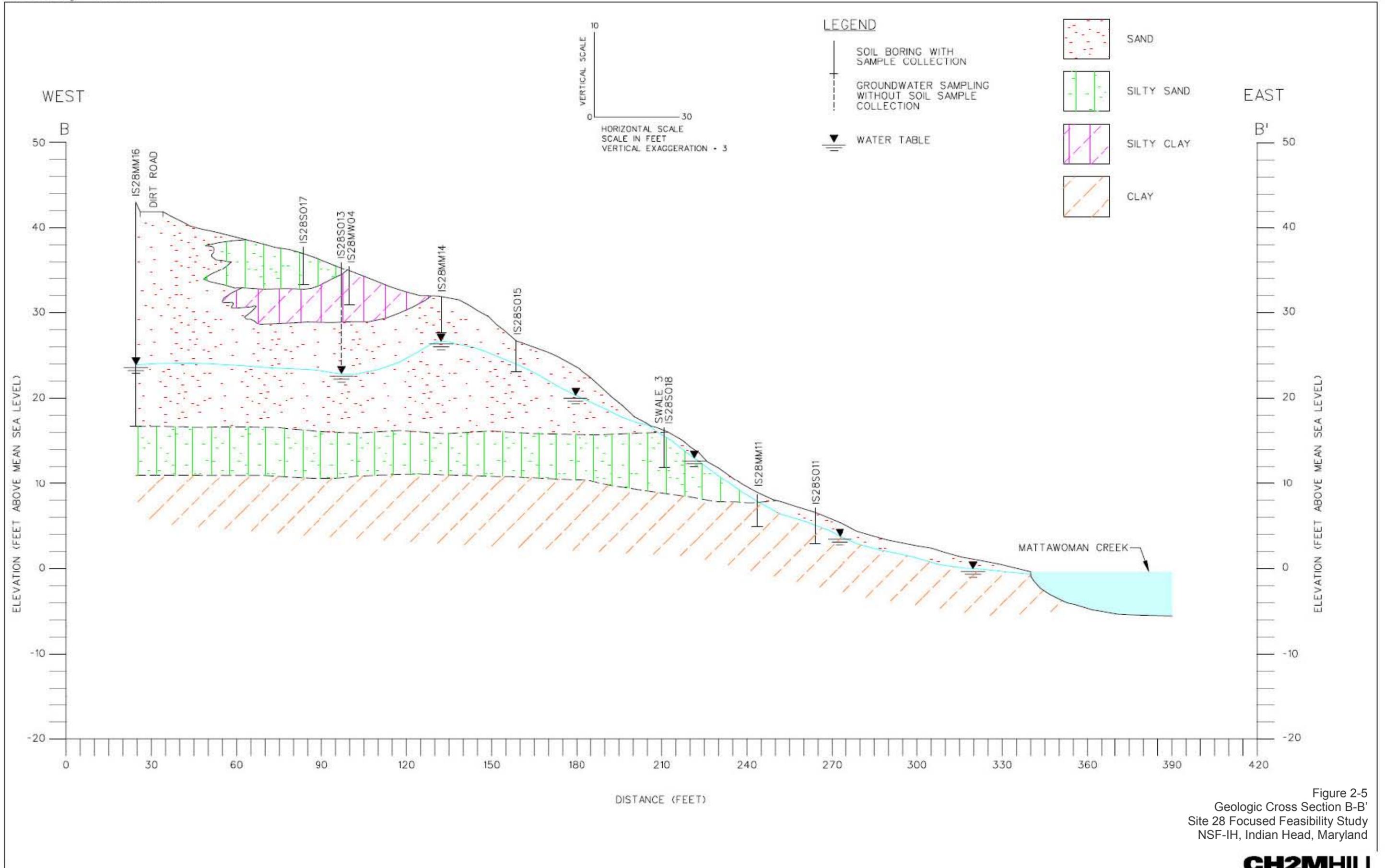
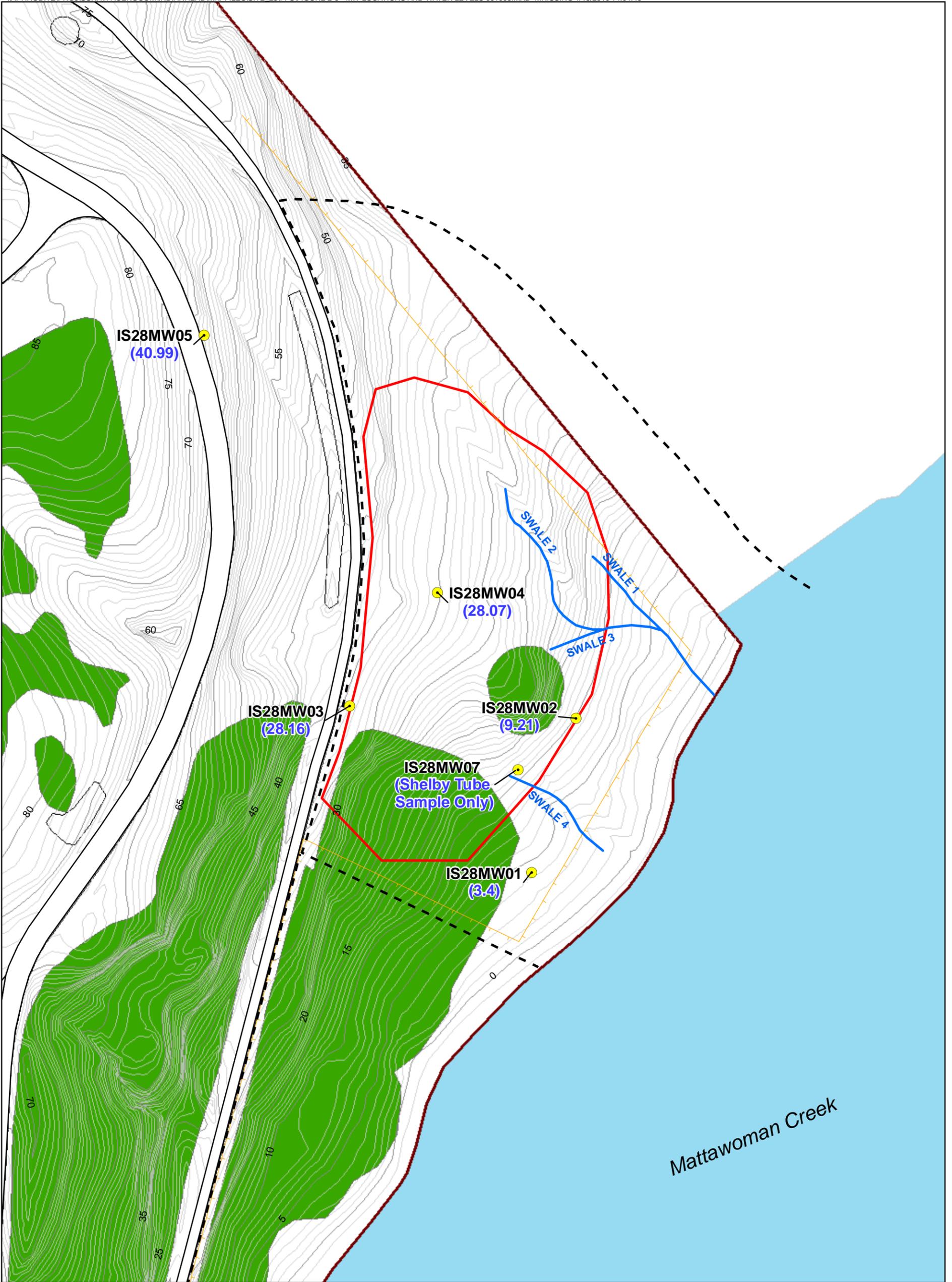


Figure 2-5
 Geologic Cross Section B-B'
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland



Legend

- Monitoring Well Location
- (groundwater elevation in feet above mean sea level)
- Swale
- Zone Boundary
- Fence Line
- Contours (5 ft)
- Contours (1 ft)
- Road
- Approximate Site Boundary
- Wooded Area
- Installation Boundary

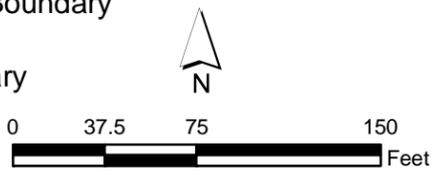
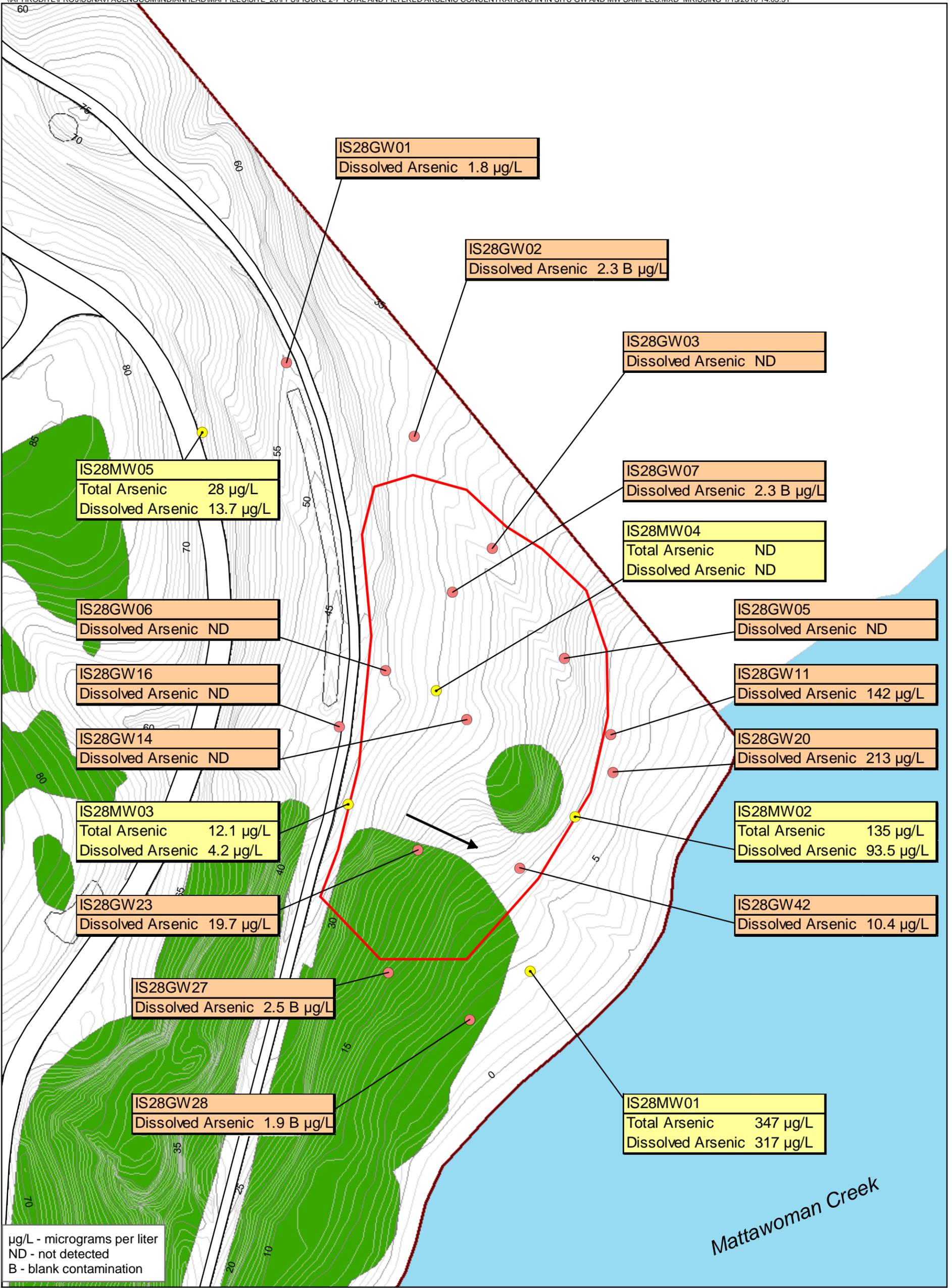


Figure 2-6
Monitoring Well Locations and Water Levels (September 10, 2003)
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland



µg/L - micrograms per liter
 ND - not detected
 B - blank contamination

Legend

- Monitoring Well Location
- Sample Location *In Situ* Groundwater
- ~ Contours (5ft)
- ~ Contours (1ft)
- ~ Road
- Groundwater Flow Direction
- Approximate Site Boundary
- Wooded Area
- Installation Boundary

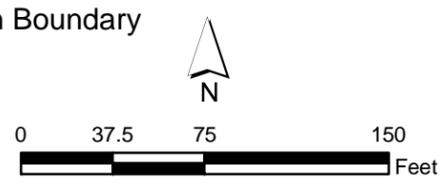
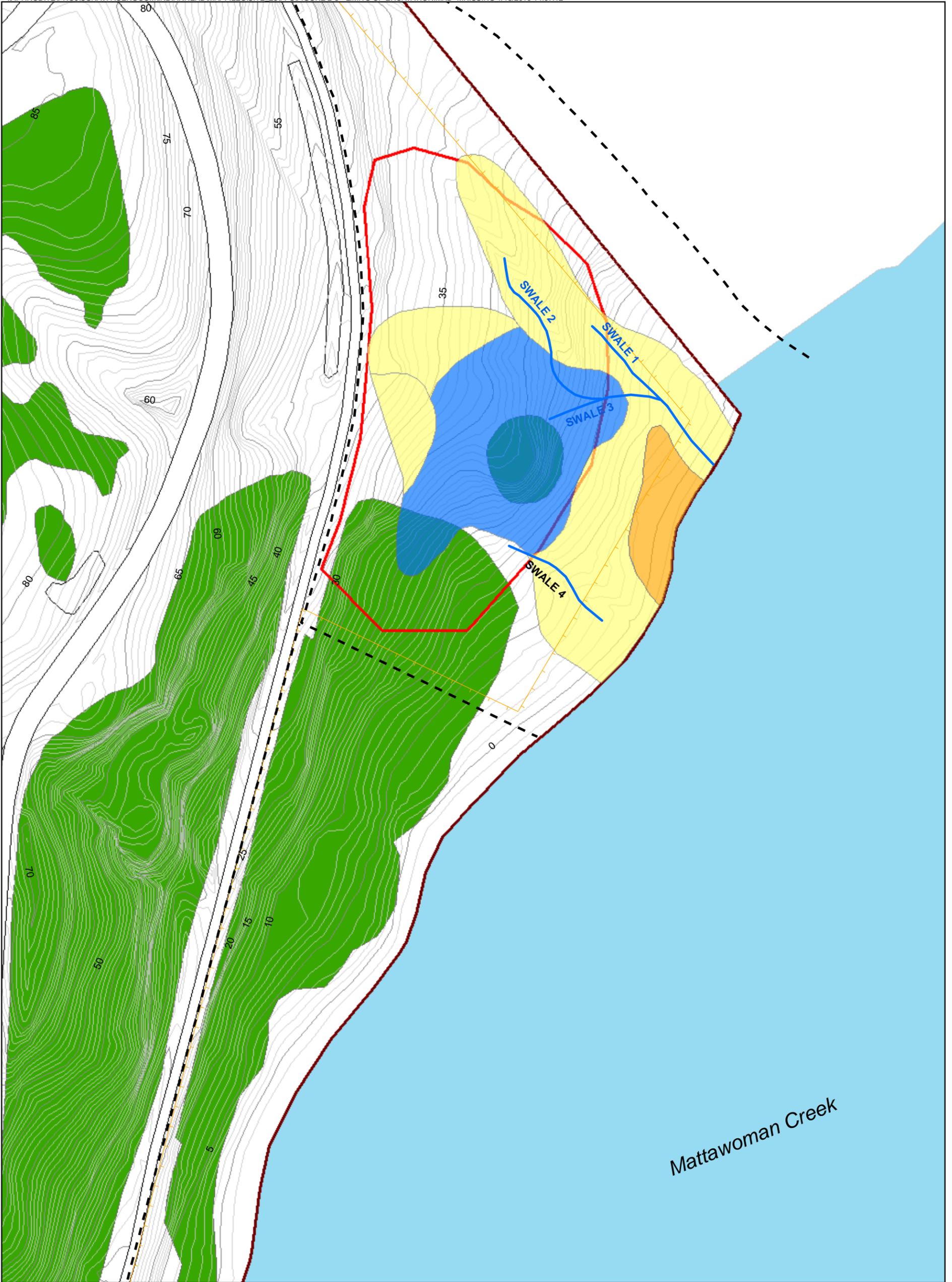


Figure 2-7
 Total and Dissolved Arsenic Concentrations in *In Situ* Groundwater and Monitoring Well Samples
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland



Legend

-  Swale
-  Zone Boundary
-  Fence Line
-  Contours (5ft)
-  Contours (1ft)
-  Road
-  Limits of excavation based on potential ecological risk
-  Limits of excavation based on potential human health risk
-  Limits of sediment/soil excavation based on potential ecological risk (BERA results)
-  Wooded Area
-  Approximate Site Boundary
-  Installation Boundary

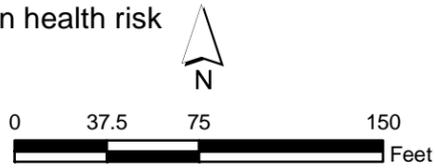
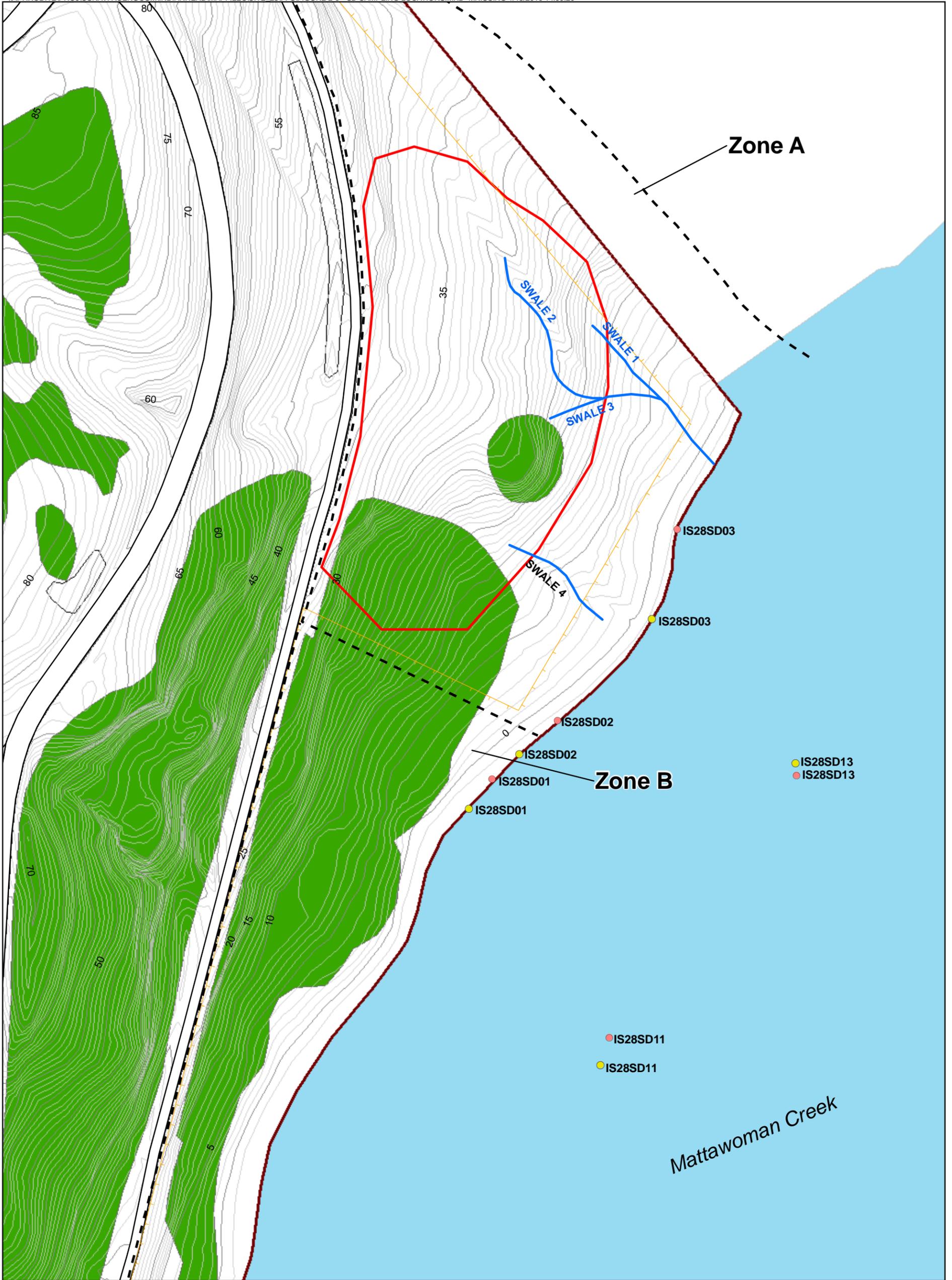


Figure 2-8
Limits of Excavation (Site 28 EE/CA)
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland



Legend

- BERA Sample Location
- RI Sample Location (CH2M HILL, 2005)
- ~ Swale
- - - Zone Boundary
- - - Fence Line
- ~ Contours (5ft)
- ~ Contours (1ft)
- ~ Road
- Approximate Site Boundary
- Wooded Area
- Installation Boundary

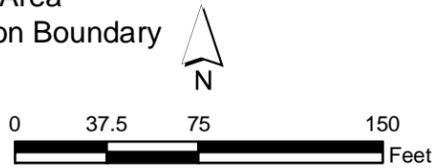
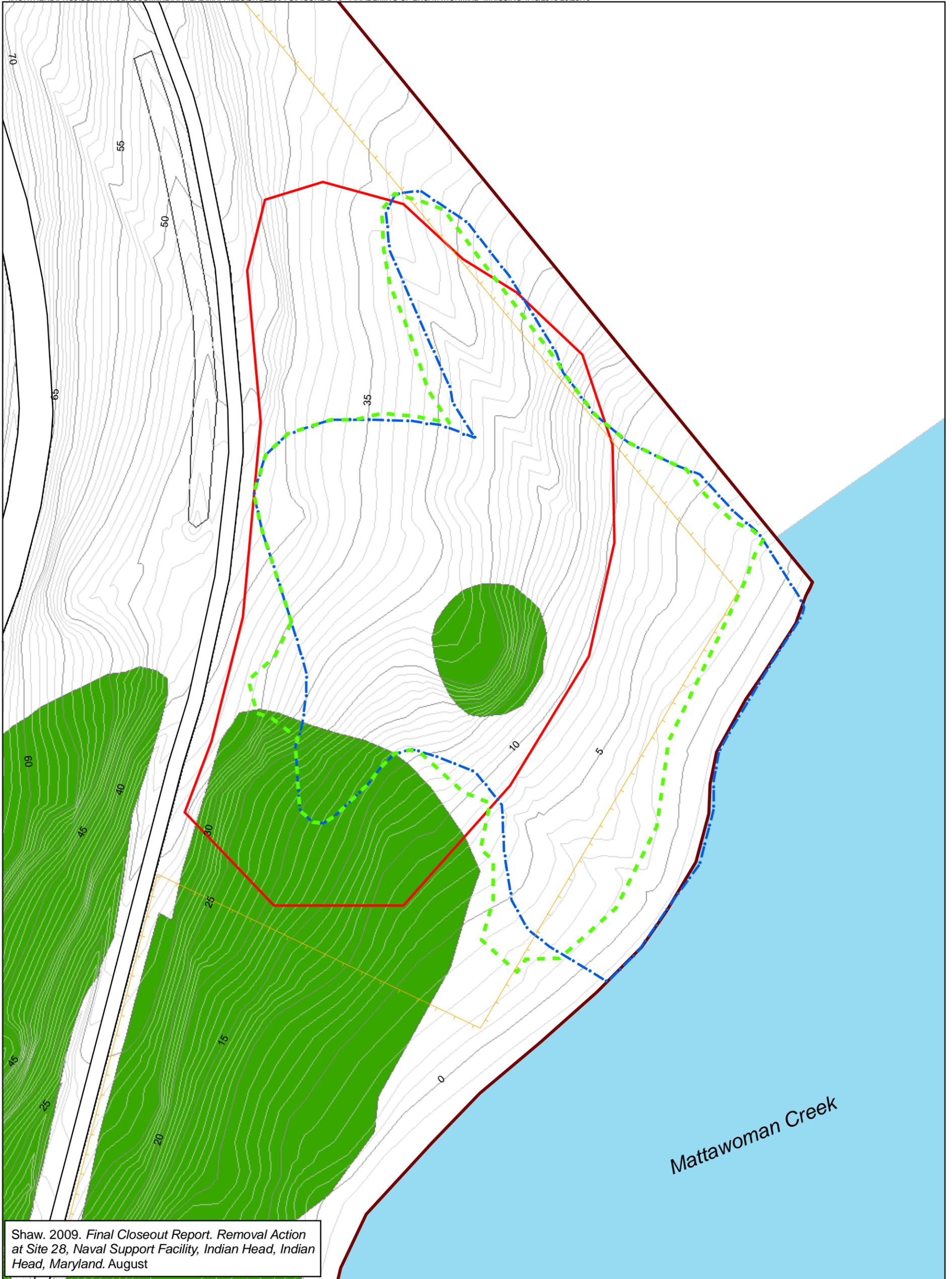


Figure 2-9
Sediment Sampling Locations (Site 28 BERA)
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland



Legend

- Fence Line
- Road
- Contours (5 ft)
- Contours (1 ft)
- Final Limits of Excavation
- Original Limits of Excavation
- Wooded Area
- Approximate Site Boundary
- Installation Boundary

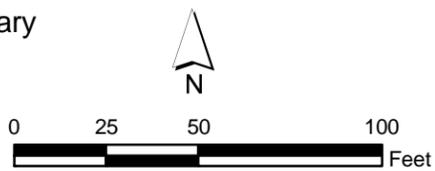


Figure 2-10
Final Limits of Excavation
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

SECTION 3

Remedial Action Objectives, Applicable or Relevant and Appropriate Requirements, Site Remediation Goals, and Areas of Attainment

This section presents general and site-specific RAOs and identifies corresponding ARARs for Site 28. General RAOs are defined by the NCP (40 CFR 300.430 et seq.) and CERCLA (42 USC 9601 et seq.), as amended by SARA.

CERCLA Section 121(d) of SARA mandates that site remediation under CERCLA must achieve a level or standard of control for hazardous substances that at least attains such levels as specified in ARARs. Only promulgated federal and state of Maryland laws and regulations can be considered ARARs. In addition to ARARs, proposed rules, guidance documents, directives, and similar documents that might affect a CERCLA remedial action are “to-be-considered” (TBC) documents.

ARARs and the facility-wide background concentration of the COC in the shallow groundwater determine the site remediation goal (SRG). The SRG was then used to determine the area of attainment (AA).

3.1 NCP Requirements

The NCP requires the selected remedy to meet the following objectives:

- Each remedial action selected shall be protective of human health and the environment [40 CFR 300.430 (f)(1)(ii)(A)].
- Onsite remedial actions that are selected must attain those ARARs that are identified at the time of the record of decision signature [40 CFR 300.430(f)(1)(ii)(B)].
- Each remedial action selected shall be cost-effective, provided that it first satisfies the threshold criteria set forth in 40 CFR 300.430 (f)(1)(ii)(A) and (B). A remedy shall be cost-effective if its costs are proportional to its overall effectiveness [40 CFR 300.430 (f)(1)(ii)(D)].
- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technology to the maximum extent practicable [40 CFR 300.430(f)(1)(ii)(E)].

The statutory scope of CERCLA was amended by SARA to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions “shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a

minimum which assures protection of human health and the environment” [CERCLA Section 121(d)].

- Remedial actions “in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element” [CERCLA Section 121(b)] are preferred. If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published.
- The least-favored remedial actions are those that include “off-site transport and disposal of hazardous substances or contaminated materials without treatment where practicable treatment technologies are available” [Section 121(b)].
- The selected remedy must comply with or attain the level of any “standard, requirement, criteria, or limitation under any federal environmental law or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any federal standard, requirement, criteria, or limitation” [Section 121(d)(2)(A)].

3.2 Site-Specific RAOs

The development of the site-specific RAOs for protecting public health and the environment considers both the level of contamination and the potential exposure routes. The future protection of environmental resources and the means of minimizing long-term disruption to existing facility operations are also considered.

As summarized in Sections 2.3 and 2.4, arsenic is identified as the only COC for the shallow groundwater at Site 28. The potential exposure routes of arsenic have been identified as the use of shallow groundwater as potable water by future child and adult residents, as well as construction workers.

Based on the concentrations of arsenic and its associated potential exposure routes, the site-specific RAOs for the shallow groundwater at Site 28 are the following:

- Eliminate human health exposure pathways to arsenic in the shallow groundwater
- Return aquifer to beneficial use to the extent practicable

The RAs screened and evaluated in this FFS were selected with the objective of meeting the site-specific RAOs. The RAs must also meet the standards defined by EPA and MDE ARARs. If the ARARs do not address a particular situation, remedial actions may be based on the TBC criteria or guidelines. ARARs and TBC criteria are described below.

3.3 Applicable or Relevant and Appropriate Requirements

As required by Section 121 of CERCLA, remedial actions carried out under Section 104 or secured under Section 106 must attain the levels of standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal and state of Maryland environmental laws and state facility-siting laws unless waivers are obtained. According to EPA guidance, remedial actions also must be based on nonpromulgated TBC

criteria or guidelines if the ARARs do not address a particular situation. ARARs are distinguished by the EPA as either being applicable to a situation or relevant and appropriate to it. These distinctions are critical to understanding the constraints imposed on RAs by environmental regulations other than CERCLA. The definitions of ARARs below are from EPA guidance (1988).

“Applicable requirements” are standards and other environmental protection requirements of federal or state of Maryland law dealing with a hazardous substance, pollutant, or contaminant and its remedial action. “Relevant and appropriate requirements” are standards and environmental protection criteria associated with federal or state of Maryland law that, although not “applicable” to a hazardous substance or remedial action, address situations sufficiently similar to those at the site that their use is suitable. A requirement may be “relevant” to a particular situation but not “appropriate” because of differences in the duration of the regulated activity or the physical characteristics of the affected media. A requirement that is relevant and appropriate must be met as if it were applicable. Relevant and appropriate requirements that are more stringent than applicable requirements take precedence. However, determining the relevancy and appropriateness of these requirements is an inherently subjective process.

Another factor in determining which response or remedial requirement must be met is whether the requirement is substantive or administrative. CERCLA response actions must meet substantive requirements but not administrative requirements. Substantive requirements are those dealing directly with actions or with conditions in the environment. Administrative requirements implement the substantive requirements by prescribing procedures such as fees, permitting, and inspection that make substantive requirements effective. This distinction applies to onsite actions only; offsite response actions are subject to all applicable standards and regulations, including administrative requirements, such as permits.

3.3.1 Other Criteria or Guidelines to Be Considered

Many federal and state of Maryland programs have criteria, advisories, guidelines, and proposed standards that provide recommended procedures if no ARARs exist or if existing ARARs are inadequate. In such instances, the TBC criteria or guidelines may be used to set remedial action levels.

3.3.2 Determination of ARARs

Federal and state ARARs are summarized in Tables 3-1 and 3-2. The tables summarize the potential ARARs by classification and the TBC criteria, which are included as appropriate for each classification. There are three classifications of ARARs: chemical specific, location specific, and action specific, as further described in this section.

The RAs developed in this FFS report were analyzed for compliance with federal and state ARARs. The analyses involved identifying potential requirements for each of the alternatives, evaluating their applicability or relevance, and determining if the RAs can achieve the ARARs. Results of that analysis are presented in Section 4 of this report. Any remedial action at the site must meet standards as defined by the ARARs of EPA and MDE

because Site 28 is located within the state of Maryland. If the ARARs do not address a particular situation, remedial actions must be based on the TBC criteria or guidelines.

Chemical-Specific ARARs

Chemical-specific ARARs set health-based concentration limits or discharge limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples of federal chemical-specific ARARs for Site 28 are Safe Drinking Water Act maximum contaminant levels (MCLs) and MCL goals that are enforceable standards for drinking water sources and water quality criteria, which set limits for the discharge of water to surface water bodies. TBC criteria would include EPA Regional Screening Levels and other site-specific, human health risk-based criteria developed for Site 28 shallow groundwater. Chemical-specific ARARs and TBC criteria for Site 28 are presented in Table 3-1.

Location-specific ARARs

Location-specific ARARs are design requirements or activity restrictions that are based on the geographical position of a site. An example is Resource Conservation and Recovery Act location requirements that set EPA policy for carrying out provisions of Executive Order 11988 (Flood Plain Management) and Executive Order 11990 (Protection of Wetlands). Location-specific ARARs for Site 28 are presented in Table 3-2.

Action-specific ARARs

Action-specific ARARs set performance, design, or other standards for particular activities in managing hazardous substances or pollutants. There are no action-specific ARARs for Site 28 because no active remediation is being proposed.

3.4 Development of SRG for Arsenic

This section presents a discussion of how the SRG for arsenic in the shallow groundwater was developed. An SRG is typically determined based on the greater of site-specific, risk-based preliminary remediation goal (PRG), facilitywide background concentration, or state of Maryland or federal groundwater MCL, unless this value is determined to provide insufficient protection of human health. If this is the case, an SRG that is protective and/or conforms to EPA, MDE, and Navy guidance¹ will be selected by risk managers. Although arsenic in groundwater was determined to be a risk driver for human health receptors, as described in Section 2.3.1, shallow groundwater at Site 28 will not likely be used as a potable water source. Therefore, a PRG was not calculated for arsenic in groundwater. The greater of the facilitywide background concentration and MCL for arsenic is the MCL. Therefore, the MCL of 10 µg/L was selected as the SRG for arsenic.

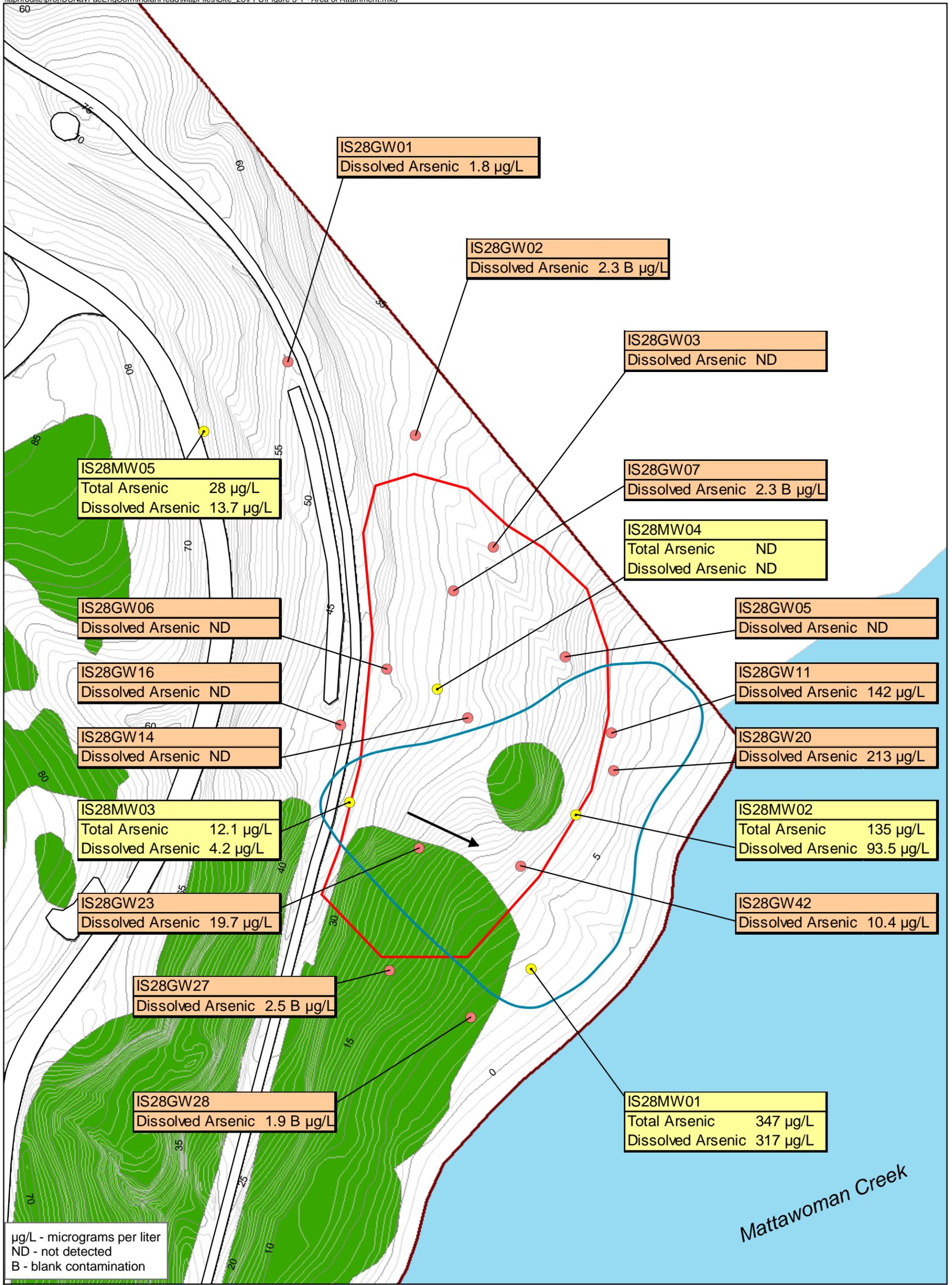
¹ The Navy's policy generally is not to remediate to levels below background concentrations. MCLs are the minimum levels required by federal law. The NSF-IH risk managers (i.e., EPA, MDE, NSF-IH, and NAVFAC Washington) can make decisions based on guidance and/or site conditions.

3.5 Area of Attainment

The AA is defined as the area over which RAOs and, therefore the SRG, are to be met. The AA may not necessarily become the area of remediation, depending on the effectiveness, implementability, and cost for a particular RA. Figure 3-1 shows the AA where the arsenic MCL of 10 µg/L is exceeded. The AA encompasses an area of approximately 1.17 acres.

**Table 3-1
Chemical-Specific ARARs
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland**

Chemicals & Relevant Media	Requirement	Prerequisites	Citation	ARAR or TBC	Comments
Groundwater, residential water supplies	Meet National Primary Drinking Standards for maximum contaminant levels (MCLs).	Drinking water source or potential potable source	Safe Drinking Water Act (SDWA): 40 CFR 141.62 National Primary Drinking Water Regulations for inorganics	Relevant and appropriate	MCLs are considered in the determination of SRGs for Site 28 groundwater.
Surface waters of the State	Protect and maintain the quality of surface water in the State of Maryland. Criteria and standards for discharges. Limitations and policy for antidegradation of the State's surface water.	Activities that will pollute the State's surface waters	COMAR 26.08.02.04-1 antidegradation policy, 26.08.02.13 (general water quality certification for placement of rip rap for shoreline protection) (Mattawoman Creek is a Tier II water body per MD regulations)	Relevant and appropriate	Necessary measures will be implemented to minimize impact to surface water quality.
<p>Notes:</p> <p>The chemical-specific ARARs are the substantive requirements included in the regulations cited in this table.</p> <p>ARAR - Applicable or relevant and appropriate requirement OSHA - Occupational Safety and Health Administration RCRA - Resource Conservation and Recovery Act CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act CFR - Code for Federal Regulations SDWA - Safe Drinking Water Act CWA - Clean Water Act SMCLs - Secondary Maximum Contaminant Levels EPA - U.S. Environmental Protection Agency TBC - To be considered</p>					



µg/L - micrograms per liter
 ND - not detected
 B - blank contamination

Legend

- Monitoring Well Location
- Sample Location *In Situ* Groundwater
- ~ Contours (5ft)
- ~ Contours (1ft)
- ~ Road
- Groundwater Flow Direction
- Area of Attainment (1.17 Acres)
- Approximate Site Boundary
- Wooded Area
- Installation Boundary

0 37.5 75 150 Feet

Figure 3-1
 Area of Attainment
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

CH2MHILL

Identification and Screening of Remedial Technologies and Assembly of Remedial Alternatives

This section discusses the general response actions (GRAs) developed to address the RAOs outlined in the previous section. Potential remedial technologies and specific process options, which underwent a preliminary screening to determine their suitability as part of an RA, are identified and described for each response action.

4.1 General Response Actions

GRAs are broad classes of responses or remedies developed to meet the site-specific RAOs defined for Site 28 shallow groundwater in Section 3. Each action is intended to address specific constituents and the possible migration pathways and exposure routes in groundwater. Although an action may be capable of meeting an objective, combinations of actions may be more cost-effective in meeting all the objectives.

Table 4-1 presents the GRAs and the preliminary screening of various technologies within each GRA. *Ex situ* treatment technologies of contaminated groundwater were not considered in the preliminary screening of technologies and process options because they involve pumping, and this would likely not be supported by the thin saturated soil thickness. In addition, the capital costs for a pump and treat system are relatively high and given the thinness of the saturated zone, it is assumed that the costs would outweigh the benefits.

The GRAs listed below have been identified as being potentially applicable for Site 28 shallow groundwater:

- No action
- ICs
- Containment
- In situ treatment

The *no-action* response is included in the study because the NCP requires that a no-action alternative be developed as a baseline for evaluating the RAs.

The *ICs* response action is a category of alternatives that can be used solely or as part of another response action. ICs include activities such as restricting groundwater use through land-use or deed restrictions, access restrictions, and surface water monitoring.

Containment response actions are technologies that prevent the migration of contaminated groundwater. Containment technologies include physical barriers to flow, such as slurry

walls or sheet piling; hydraulic barriers, such as extraction wells; and chemical barriers, such as permeable reactive barriers that allow groundwater flow but remove contaminants.

In situ treatment response actions are in situ methods of reducing the toxicity, mobility, or volume of contaminants in groundwater. Treatment technologies include biological, chemical, and physical processes.

4.2 Identification and Screening of Remedial Technologies and Process Options and Development of RAs

The next step in the FFS process is to identify remedial technologies and process options for each GRA. *Remedial technologies* are general categories of technologies such as chemical treatment, thermal destruction, or immobilization. *Process options* are specific processes within each technology type. For example, the chemical treatment remedial technology includes process options such as precipitation, ion exchange, and oxidation/reduction.

Technologies and process options that potentially apply to Site 28 shallow groundwater were screened on the basis of their effectiveness, implementability, and relative cost for treating the FFS COCs requiring remediation. Specific remedial technologies or process options were evaluated on the basis of their potential performance relative to other remedial technologies and process options within the same GRA.

In the screening process, *effectiveness* pertains to the following:

- The capability of the technology to attain RAOs for groundwater
- The capability of a remedial technology to handle the estimated areas or volumes of groundwater and to prevent or minimize the release of hazardous substances to potential receptors
- The degree of protection afforded to human health and the environment during construction and implementation of the remedial technology
- The reliability and performance of the technology with respect to the site conditions

Implementability pertains to the following:

- The availability and capacity of treatment, storage, and disposal services
- The constructability of the remedial technology under facility conditions
- The time needed to implement the remedial technology, to achieve beneficial results, and to satisfy the RAOs

Relative cost screening considers the general capital and operation and maintenance (O&M) costs associated with the process options. During the screening phase, detailed, site-specific cost estimates were not developed. The relative cost of process options was considered only if the cost of an option was believed to be significantly higher than the cost for other process options comparably effective or implementable.

Table 4-1 presents the screening of the groundwater technologies and process options, as well as the rationale for why a technology or option is eliminated or retained for further consideration. Where possible, a single process option was selected as representative of a GRA. In some cases, more than one process option was selected because the options could not be differentiated in terms of effectiveness, implementability, or relative cost. The following sections briefly discuss the remedial technologies and process options that passed the effectiveness, implementability, and cost screening for each GRA.

4.2.1 No Action

The no action response is required by the NCP and was retained to provide a basis for comparison with the other actions. This alternative, however, does not reduce COC migration or concentrations, and would not meet the RAOs for the shallow groundwater.

4.2.2 ICs

The ICs retained are composed of administrative and groundwater use restrictions. These restrictions do not reduce groundwater contaminant migration or concentrations, but can minimize or eliminate the potential exposure pathways to the contaminated groundwater, thus, meeting the RAOs. Therefore, ICs will be carried forward for further consideration in the RA assemblies.

Because NSF-IH is an active naval installation, some IC measures are currently in place, such as master plan regulations, base access restrictions, and a safety program. Specific IC measures applicable for Site 28 would be included in an NSF-IH land use control implementation plan (LUCIP).²

4.2.3 Development of RAs

The remedial technologies and process options that passed the initial screening process were assembled into RAs. The RAs for Site 28 shallow groundwater are the following:

Alternative 1:	No Action
Alternative 2:	ICs: Alternative 2 involves a continuous implementation of ICs in the form of groundwater-use restrictions. As part of the five-year review process, groundwater conditions will be evaluated to determine the need for continued implementation of ICs.

² The conditions and boundaries of sites subject to land use controls (LUCs), as well as the terms and conditions of the LUCs themselves, must be recorded on appropriate installation maps, master plans, real estate records, and geographic information systems (GISs) (Navy, 1999).

**Table 4-1
Screening of Remedial Process Options for Groundwater
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland**

General Response Action	Technology	Process Options	Effectiveness	Implementability	Relative Cost	Evaluation Action		Screening Comments
						Retain	Reject	
No Action	None	Not applicable	Does not protect human health or the environment; does not satisfy RAO	Easily implemented	None	X		Retained as baseline alternative per NCP
Institutional Controls	Administrative restrictions	Deed or groundwater use restrictions	Effectiveness depends on continued future implementation regardless of property use or ownership; does not reduce contaminant levels	Easily implemented on NSF-IH property	Low	X		Retained to mitigate risks from COC to human health
Containment	Vertical barriers	Slurry wall (trench around areas of contamination filled with a low-permeability soil-bentonite or cement bentonite slurry material)	Effective for containment of COC plume	Relatively easy implementation due to shallow contamination	High capital		X	Rejected because the 2008 NTCRA removed the sources for groundwater contamination
		Permeable reactive barrier (downgradient reactive barrier using ORC Advanced® or EHC-O™)	Effective for containment of COC plumes	Relatively easy implementation due to shallow contamination; may require multiple applications of treatment reagent	High capital		X	Rejected because the 2008 NTCRA removed the sources for groundwater contamination
Removal	Removal	Excavation and Off-site Disposal	Effective because contaminant mass would be removed	Relatively easy implementation due to shallow contamination	High capital and disposal cost		X	Rejected because the 2008 NTCRA removed the sources for groundwater contamination
In-Situ Treatment	Physical/Chemical Treatment	Air sparging (air or oxygen is injected into the aquifer to maintain aerobic conditions in the shallow groundwater)	Effective to maintain the shallow groundwater in an aerobic (oxidizing) condition; thereby maintaining the valence state of arsenic as As(V), a less toxic and mobile form of arsenic	Not easily implemented because subsurface composition is high in clay, thereby reducing the effective or uniform distribution of air or oxygen in the treatment interval	Moderate capital, moderate O&M		X	Rejected because the 2008 NTCRA removed the sources for groundwater contamination. The geochemistry of the groundwater is anticipated to return to its natural aerobic setting, thereby, allowing arsenic to remain in its less toxic As(V) valence state.

Descriptions and Detailed Analysis of Remedial Alternatives

5.1 Descriptions of RAs

The two RAs discussed in Section 4 are further described and evaluated both individually and comparatively in this section. It is expected that at least one CERCLA statutory 5-year review would be conducted under the ICs alternative if it were implemented.

5.1.1 Alternative 1: No Action

The no-action alternative is required by the NCP and serves as the baseline alternative to which Alternative 2 is compared. Under this alternative, no controls or remedial technologies will be implemented. NSF-IH is an active Navy installation that has certain ICs in place, such as access and land use restrictions.

5.1.2 Alternative 2: ICs

Alternative 2 consists of continued implementation of ICs. The components of this alternative are conceptually described below.

The ICs would be in the form of groundwater use restrictions. The AA would be designated a “restricted use” area in the base geographic information system (GIS) database. This designation would prohibit the use of groundwater as a potable water source. Records of the groundwater contamination would also be kept in the base GIS/environmental database.

Sampling would be conducted to monitor groundwater conditions. As part of the five-year review process, sampling data would be evaluated to determine the need for continued implementation of ICs. The details of the sampling program, evaluation of the data, and decision rules for an exit strategy would be presented in a work plan to be approved by the Navy, EPA, and MDE.

5.2 Evaluation Criteria

Each alternative was developed to address potential threats to human health and the environment posed by contaminated groundwater. The NCP requires the RAs be evaluated against the nine criteria [40 CFR 300.430(e)(9)(iii)(A) through (I)] listed below:

- Threshold Criteria
 - Protection of human health and the environment
 - Compliance with ARARs

- Balancing Criteria
 - Long-term effectiveness and permanence
 - Reduction of toxicity, mobility, and volume through treatment
 - Short-term effectiveness
 - Implementability
 - Cost
- Modifying Criteria
 - State acceptance
 - Community acceptance

The first two criteria – the threshold criteria – are requirements that must be met unless specific ARARs are waived. The first seven criteria are addressed in this FFS. The last two criteria – the modifying criteria – will be addressed in the Proposed Plan and Record of Decision. Figure 5-1 summarizes the NCP criteria.

It should be noted that the cost estimates presented in this FFS provide an accuracy of only +50 percent to -30 percent. The alternative cost estimates are in 2009 dollars and are based on conceptual design from information available at the time of this study. The actual cost of the project would depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. Most of these factors are not expected to affect the relative cost differences between alternatives. The cost estimates were prepared in general conformance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000).

5.3 Detailed Evaluation of RAs

This section analyzes in detail the two RAs assembled in Section 4.

5.3.1 Alternative 1: No Action

This alternative is required under the NCP. Under this alternative, no further effort or resources would be expended to remediate contaminated shallow groundwater at Site 28.

Overall Protection of Human Health and the Environment

This alternative does not contain measures to prevent potential future exposures to the shallow groundwater at Site 28. The risks posed by arsenic in the shallow groundwater to the future human receptors would not be minimized or eliminated because no measure is proposed under the no-action alternative. Accordingly, the no-action alternative is not considered protective of human health and the environment.

Compliance with ARARs

Because the 2008 NTCRA removed the sources of groundwater contamination, the geochemistry of the shallow groundwater at Site 28 would likely return to its natural aerobic setting, which would mitigate the mobilization of metals, such as arsenic. Therefore, this alternative would comply with the chemical-specific ARARs identified in Table 3-1 in the long-term; however, the timeframe is unknown. There are no applicable location- and action-specific ARARs because no remedial actions will be undertaken.

Long-Term Effectiveness and Permanence

The residual risk associated with arsenic groundwater contamination under this alternative would be reduced over time. Because this alternative involves no controls and relies solely on natural processes, the adequacy and reliability of this alternative is very low.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative satisfies this criterion because the 2008 NTCRA removed the sources of groundwater contamination from Site 28.

Short-Term Effectiveness

There is no construction associated with this alternative, so there are no short-term impacts on workers, the community, or the environment. However, the RAOs will not be achieved because this alternative will not minimize or eliminate the exposures to the shallow groundwater by potential future receptors.

Implementability

This alternative does not have a monitoring or construction component associated with it. Therefore, there are no issues concerning its technical implementation.

Cost

Taking no action would require no capital expenditure.

5.3.2 Alternative 2: ICs

Alternative 2 consists of continued implementation of ICs in the form of groundwater use restrictions. As part of the five-year review process, groundwater conditions will be evaluated to determine the need for continued implementation of ICs.

Overall Protection of Human Health and the Environment

Alternative 2 is considered protective of human health because the shallow groundwater is not a potable resource, and groundwater use restrictions would prevent or minimize future exposure to the shallow groundwater. Sampling will be conducted, and a review of available data will be conducted during the five-year review process to evaluate the groundwater conditions and determine the need for continued implementation of ICs. The removal and off site disposal of the sources of groundwater contamination during the 2008 NTCRA would indirectly mitigate the elevated arsenic concentrations in the shallow groundwater; therefore, the risks posed by arsenic to the future human receptors calculated during the RI may be overestimated and may not represent the potential risks after the completion of the NTCRA.

Compliance with ARARs

This alternative will comply with the chemical-specific ARARs identified in Table 3-1. This alternative would meet all the location-specific ARARs identified in Table 3-2. There are no action-specific ARARs because no active remedial actions will be undertaken.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. The residual risk associated with groundwater contamination under this alternative would be reduced over time. The 2008 NTCRA, which removed the sources of groundwater contamination from Site 28, would indirectly reduce the residual risks in the shallow groundwater.

Adequacy and Reliability of Controls. The ICs in place are expected to be adequate and reliable, particularly given the lack of a need for this groundwater as a potable source during the foreseeable future. The adequacy of groundwater use restrictions is based on their continued implementation. Use restrictions, which prevent future installation or use of wells for potable water, must be enforced.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative satisfies this criterion because the 2008 NTCRA removed the sources of groundwater contamination from Site 28.

Short-Term Effectiveness

There is very minimal impact on workers, the community, or the environment during implementation of this alternative. The RAOs will be achieved shortly after the ICs are in place and enforced.

Implementability

Alternative 2 is both technically and administratively implementable because the components of the alternative have become standard practices in numerous remedial activities.

Cost

This alternative has an approximate total cost of \$26,750. This cost consists of the IC components of the alternative and a five-year review. The IC activities include establishing site-specific groundwater-use restrictions and incorporating them into the Base Master Plan. The five-year review will be conducted to assess the groundwater conditions and determine the need for continued implementation of ICs. The cost estimate details are provided in Table 5-1.

5.4 Comparative Analysis of RAs

In the following analysis, the RAs are evaluated in relation to one another based on each of the seven criteria. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. Table 5-2 presents the results of the comparative analysis of the RAs.

5.4.1 Overall Protection of Human Health and the Environment

Alternative 1 is not protective of human health and the environment. Alternative 2 is considered protective of human health and the environment because the groundwater at the site is not a potable resource, and IC measures to restrict the groundwater use for potable

water would be in place to minimize or eliminate the potential exposures by future receptors.

5.4.2 Compliance with ARARs

Alternatives 1 and 2 would equally comply with the chemical-specific ARARs over time. Location-specific ARARs would not be applicable for Alternative 1 because no planned activities will be performed. Alternative 2 would meet all the location-specific ARARs. Action-specific ARARs will not be applicable for both alternatives because no remedial actions will be undertaken.

5.4.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. Under Alternatives 1 and 2, the magnitude of residual risks would diminish over time because of the 2008 NTCRA, which removed contaminated soil and other potential sources of groundwater contamination.

Adequacy and Reliability of Controls. The adequacy and reliability of controls under Alternative 1 is poor. Under Alternative 2, continued implementation of groundwater-use restrictions is expected to be adequate and reliable to prevent the potential exposures by future receptors to the shallow groundwater.

5.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 1 and 2 would not provide any reduction in toxicity, mobility, or volume of the arsenic in groundwater.

5.4.5 Short-Term Effectiveness

There is no construction associated with Alternative 1, so there are no short-term impacts on workers, the community, or the environment. Under Alternative 2, there is very minimal impact on workers, the community, or the environment during implementation of the ICs.

5.4.6 Implementability

Alternatives 1 and 2 are both technically and administratively implementable. However, Alternative 2 would entail a long-term allocation of administrative resources for continuous maintenance of the IC measures.

5.4.7 Cost

Alternative 1 implies zero cost, although it should be noted that the cost for performing the 5-year reviews as required by CERCLA when the contamination is left in place would not be included in the no-action alternative cost.

Alternative 2 has a total cost of approximately \$26,750, including capital and O&M costs.

Table 5-1
Detailed Cost Estimate
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

REMEDIAL ALTERNATIVE 2	LOCATION: Site 28						MEDIA: Groundwater	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">Construction time:</td> <td style="text-align: center;">None</td> </tr> <tr> <td>Operation time:</td> <td style="text-align: center;">1 year</td> </tr> </table>					Construction time:	None	Operation time:	1 year
Construction time:	None															
Operation time:	1 year															
ICs	NSF-IH, Indian Head, Maryland															
DESCRIPTION OF ALTERNATIVE: 1) The ICs will be in the form of groundwater use restrictions 2) A five-year review will be conducted to evaluate groundwater conditions and determine the need for continued implementation of ICs 3) The AA would be designated a "restricted use" area in the base geographic information system (GIS) database. This designation would prohibit the use of groundwater as a potable water source. 4) Records of the groundwater contamination would also be kept in the base GIS/environmental database																
Cost Component	Qty	Unit	Cost Source	Estimated Activity Duration (day)	Labor Unit Cost	Labor Total Cost	Equipment Unit Cost	Equipment Total Cost	Material Unit Cost	Material Total Cost	Subcontractor	Total Cost				
CAPITAL COSTS																
Institutional Controls/Planning																
Site-Specific LUC	1	lump sum	Professional Judgment		\$10,000.00	\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00				
SUBTOTAL CAPITAL COST						\$10,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$10,000.00				
Scope Contingency	5%											\$500.00				
Bid Contingency	5%											\$500.00				
TOTAL CAPITAL COST												\$11,000.00				
O&M Costs																
Five-Year Review	1	lump sum	Professional Judgment		\$15,000.00	\$15,000.00						\$15,000.00				
Subtotal O&M Cost												\$15,000.00				
O&M Contingency	5%											\$750.00				
TOTAL O&M COST												\$15,750.00				
TOTAL COST												\$26,750.00				

Table 5-2
Comparative Analysis of Remedial Alternatives
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Evaluation Criteria	Alternative 1	Alternative 2
	No Action	ICs
Overall Protection of Human Health and the Environment	Not protective of human health and the environment	Protective of human health through ICs
Compliance With ARARs	Would comply with chemical-specific ARARs in the long-term; location- and action-specific ARARs are not relevant	Would comply with chemical- and location - specific ARARs in the long-term; action-specific ARARs are not relevant
Long-Term Effectiveness and Permanence	Provides poor long-term effectiveness, permanence, and reliability The residual risk associated with arsenic groundwater contamination under this alternative would be reduced over time; however, no control to prevent future human exposures to the shallow groundwater	Provides adequate long-term effectiveness and permanence The magnitude of residual risks would diminish over time because of the 2008 NTCRA, which removed contaminated soil and other potential sources of groundwater contamination Would not provide any reduction in toxicity, mobility, or volume of the arsenic in groundwater
Reduction of Toxicity, Mobility, or Volume Through Treatment	Satisfies this criterion because the 2008 NTCRA removed the sources of groundwater contamination from Site 28, which likely caused the reducing condition in the shallow groundwater and mobilized metals such as arsenic	Satisfies this criterion because the 2008 NTCRA removed the sources of groundwater contamination from Site 28, which likely caused the reducing condition in the shallow groundwater and mobilized metals such as arsenic
Short-Term Effectiveness	No impact to community, workers, and the environment because this alternative involves doing nothing; however, the RAO will not be achieved because this alternative will not minimize or eliminate the exposures to the shallow groundwater by potential future receptors	Very minimal impact to the community, workers, and the environment during implementation of ICs; RAO will be achieved immediately after the ICs are in place
Implementability	Easily implemented	Easily implemented
Cost	\$0	Capital: \$11,000
		O&M: \$15,750
		Total Cost: \$26,750

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternatives Provide Human Health and Environmental Protection

COMPLIANCE WITH ARARs

- Compliance With Chemical-Specific ARARs
- Compliance With Action-Specific ARARs
- Compliance With Location-Specific ARARs
- Compliance With Other Criteria, Advisories, and Guidance (TBC Guidance)

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of Residual Risk
- Adequacy and Reliability of Controls

REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

- Treatment Process Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degree of Expected Reductions in Toxicity, Mobility, and Volume
- Degree to Which Treatment is Irreversible
- Type and Quantity of Residuals Remaining After Treatment

SHORT-TERM EFFECTIVENESS

- Protection of Community During Remedial Construction
- Protection of Workers During Remedial Construction
- Environmental Impacts
- Time Until Remedial Action Objectives Are Achieved

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additional Remedial Action, if Necessary
- Ability to Monitor Effectiveness of Remedy
- Ability to Obtain Approvals From Other Agencies
- Coordination With Other Agencies
- Availability of Off-site Treatment, Storage, and Disposal Services and Capacity
- Availability of Necessary Equipment, Materials, and Personnel
- Availability of Prospective Technologies

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

STATE ⁽¹⁾ ACCEPTANCE

COMMUNITY ⁽¹⁾ ACCEPTANCE

¹ These criteria are assessed following comment on the FFS and the Proposed Plan.

Figure 5-1
 Detailed Evaluation Criteria
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland
 CH2MHILL

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Appendix A
Raw Analytical Data from In Situ Groundwater
and Monitoring Well Samples

Appendix A-1
Monitoring Well Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
Sample ID	IS28MW010903	IS28MW010903P	IS28MW020903	IS28MW030903	IS28MW040903	IS28MW050903
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
Volatil Organic Compounds (UG/L)						
1,1,1-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromoethane	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	10 U	10 U	1 B	10 U	10 U	10 U
Benzene	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	10 U
Bromoform	10 U	10 U	10 U	10 U	10 U	10 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	10 U	10 U	10 U	10 U	10 U	1 K
Chlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U
Cumene	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	10 U	10 U	10 U	10 U	10 U	10 U

NA - Not analyzed
B - Not detected above associated blank
J - Reported value estimated
K - Reported value biased high

U - Analyte not detected
UL - Not detected, biased low
Shaded cell indicates detected constituent

Appendix A-1
Monitoring Well Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
	Sample ID					
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
Dibromochloromethane	10 U					
Dichlorodifluoromethane(Freon-12)	10 U					
Ethylbenzene	10 U					
Methyl acetate	10 U					
Methyl-tert-butyl ether (MTBE)	10 U					
Methylcyclohexane	10 U					
Methylene chloride	10 U					
Styrene	10 U					
Tetrachloroethene	10 U					
Toluene	10 U	10 U	2 J	10 U	10 U	10 U
Trichloroethene	10 U					
Trichlorofluoromethane(Freon-11)	10 U					
Vinyl chloride	10 U					
Xylene, total	10 U					
cis-1,2-Dichloroethene	10 U					
cis-1,3-Dichloropropene	10 U					
m- and p-Xylene	10 U					
o-Xylene	10 U					
trans-1,2-Dichloroethene	10 U					
trans-1,3-Dichloropropene	10 U					
Semi-volatile Organic Compounds (UG/L)						
1,1-Biphenyl	10 U					
2,4,5-Trichlorophenol	25 U					
2,4,6-Trichlorophenol	10 U					
2,4-Dichlorophenol	10 U					
2,4-Dimethylphenol	10 U					
2,4-Dinitrophenol	25 U					
2,4-Dinitrotoluene	10 U					
2,6-Dinitrotoluene	10 U					
2-Chloronaphthalene	10 U					
2-Chlorophenol	10 U					
2-Methylnaphthalene	10 U					

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Appendix A-1
Monitoring Well Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
	Sample ID					
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
2-Methylphenol	10 U					
2-Nitroaniline	25 U					
2-Nitrophenol	10 U					
3,3'-Dichlorobenzidine	10 U					
3-Nitroaniline	25 U					
4,6-Dinitro-2-methylphenol	25 U					
4-Bromophenyl-phenylether	10 U					
4-Chloro-3-methylphenol	10 U					
4-Chloroaniline	10 U					
4-Chlorophenyl-phenylether	10 U					
4-Methylphenol	10 U	10 U	0.6 J	10 U	10 U	10 U
4-Nitroaniline	25 U					
4-Nitrophenol	25 U					
Acenaphthene	10 U					
Acenaphthylene	10 U					
Acetophenone	0.8 B	0.8 B	10 U	10 U	0.4 B	10 U
Anthracene	10 U					
Atrazine	10 U					
Benzaldehyde	10 U					
Benzo(a)anthracene	10 U					
Benzo(a)pyrene	10 U					
Benzo(b)fluoranthene	10 U					
Benzo(g,h,i)perylene	10 U					
Benzo(k)fluoranthene	10 U					
Bis(2-chloro-1-methylethyl) ether	10 U					
Butylbenzylphthalate	10 U					
Caprolactam	10 U	10 U	9	3 J	10 U	90
Carbazole	10 U					
Chrysene	10 U					
Di-n-butylphthalate	0.6 B	0.3 B	0.3 B	0.4 B	10 U	0.6 B
Di-n-octylphthalate	10 U					
Dibenz(a,h)anthracene	10 U					
Dibenzofuran	10 U					

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Appendix A-1
Monitoring Well Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
	Sample ID					
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
Diethylphthalate	10 U	0.3 B	0.3 B	0.4 B	10 U	0.3 B
Dimethyl phthalate	10 U					
Fluoranthene	10 U					
Fluorene	10 U					
Hexachlorobenzene	10 U					
Hexachlorobutadiene	10 U					
Hexachlorocyclopentadiene	10 U					
Hexachloroethane	10 U					
Indeno(1,2,3-cd)pyrene	10 U					
Isophorone	10 U					
Naphthalene	10 U					
Nitrobenzene	10 U					
Pentachlorophenol	25 U					
Phenanthrene	10 U					
Phenol	46 B	53 B	2 B	20 B	31 B	10 U
Pyrene	10 U					
bis(2-Chloroethoxy)methane	10 U					
bis(2-Chloroethyl)ether	10 U					
bis(2-Ethylhexyl)phthalate	250 J	290 J	2 B	6 B	0.6 B	2 B
n-Nitroso-di-n-propylamine	10 U					
n-Nitrosodiphenylamine	10 U					
Explosives (UG/L)						
1,3,5-Trinitrobenzene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
1,3-Dinitrobenzene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
2,4,6-Trinitrotoluene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
2,4-Dinitrotoluene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
2,6-Dinitrotoluene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
2-Amino-4,6-dinitrotoluene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
2-Nitrotoluene	0.52 UJ	0.52 UJ	0.52 UJ	0.52 U	0.52 UJ	0.52 U
3-Nitrotoluene	0.52 UJ	0.52 UJ	0.52 UJ	0.52 U	0.52 UJ	0.52 U
4-Amino-2,6-dinitrotoluene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
4-Nitrotoluene	0.52 UJ	0.52 UJ	0.52 UJ	0.52 U	0.52 UJ	0.52 U

NA - Not analyzed
B - Not detected above associated blank
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UL - Not detected, biased low
Shaded cell indicates detected constituent

Appendix A-1
Monitoring Well Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
Sample ID	IS28MW010903	IS28MW010903P	IS28MW020903	IS28MW030903	IS28MW040903	IS28MW050903
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
HMX	0.52 UJ	0.52 UJ	0.52 UJ	0.52 U	0.52 UJ	0.52 U
Nitrobenzene	0.26 UJ	0.26 UJ	0.26 UJ	0.26 U	0.26 UJ	0.26 U
Nitroglycerin	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U
Nitroguanidine	10 U	10 U	10 U	10 U	10 U	10 U
PETN	1.3 UJ	1.3 UJ	1.3 UJ	1.3 U	1.3 UJ	1.3 U
Perchlorate	4 U	4 U	12 U	20 U	4 U	20 U
RDX	0.52 UJ	0.52 UJ	0.52 UJ	0.52 U	0.52 UJ	0.52 U
Tetryl	0.52 UJ	0.52 UJ	0.52 UJ	0.52 U	0.52 UJ	0.52 U
Total Metals (UG/L)						
Aluminum	553	692	8,590	19,300	4,520	32,800
Antimony	1.74 U	1.74 U	2.1 J	1.74 U	1.74 U	1.74 U
Arsenic	342	347	135	12.1 K	2.13 U	28
Barium	32.4 J	32.9 J	109 J	241	90.4 J	158 J
Beryllium	0.22 U	0.22 U	0.4 J	2.4 J	0.54 J	4.7 J
Cadmium	0.61 B	0.59 B	0.75 B	3.3 J	0.25 U	2.66 U
Calcium	4,620 J	4,620 J	9,330	10,600	3,120 J	2,230 J
Chromium	2.2 J	1.7 J	11.4 K	27.4	13.8 K	44.1
Cobalt	7.2 J	5.8 J	3.9 B	59.8 K	34.9 J	73.6 K
Copper	36.2 K	21.7 J	30 K	50.8	16.5 J	46.8 K
Iron	11,500	11,700	6,870	36,400	4,810	125,000
Lead	4.9 K	6.8	16.3	29.9	4.8 K	17.4
Magnesium	3,420 J	3,440 J	8,710	9,690	2,340 J	3,030 J
Manganese	434	434	143	601	281	627
Mercury	0.15 B	0.11 B	0.1 B	0.18 B	0.07 B	0.21 B
Nickel	7.4 J	6 J	8.6 J	31.6 B	12.9 J	68.5 B
Potassium	2,050 B	1,570 B	5,170	6,290	2,950 J	2,930 J
Selenium	2.32 UL	3.6 B	3.7 B	2.32 U	3 B	2.32 U
Silver	1.16 U	1.16 U	1.16 U	3.6 U	1.16 U	3.6 U
Sodium	23,000	24,600	19,400	25,000	11,500	17,400
Thallium	4.8 B	4.2 B	3.1 B	3.6 B	2.77 U	2.77 U
Vanadium	0.74 U	1.3 B	18.9 J	61.8 K	14.5 J	71.5 K
Zinc	951	969	580	1,620	100	153

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Appendix A-1
Monitoring Well Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MW01		IS28MW02	IS28MW03	IS28MW04	IS28MW05 (Upgradient Background)
Sample ID	IS28MW010903	IS28MW010903P	IS28MW020903	IS28MW030903	IS28MW040903	IS28MW050903
Sample Date	09/09/03	09/09/03	09/09/03	09/10/03	09/09/03	09/10/03
Chemical Name						
Dissolved Metals (UG/L)						
Aluminum	252	338	3,840	8,190	1,130	17,300
Antimony	1.74 U	1.74 U	3.1 J	1.74 U	1.74 U	1.74 U
Arsenic	317	292	93.5	4.2 J	2.13 U	13.7 K
Barium	31.9 J	31.6 J	107 J	182 J	68.8 J	119 J
Beryllium	0.22 U	0.22 U	0.33 J	0.88 B	0.33 J	2.5 J
Cadmium	0.4 B	0.56 B	10 K	8 K	0.25 U	10 K
Calcium	4,530 J	4,430 J	8,960	9,260	2,740 J	2,000 J
Chromium	1.5 J	0.93 J	6.1 J	12.2 K	3.4 J	23.4
Cobalt	6.6 J	6.4 J	3.6 B	41.1 J	27.3 J	50.4 K
Copper	10.3 J	7.6 B	22 J	31 K	14.8 J	36
Iron	12,900	13,200	3,870	15,100	981	65,300
Lead	2.2 J	2.2 J	7.8	12.5	1.56 U	9.1
Magnesium	3,390 J	3,320 J	8,630	7,590	1,940 J	2,280 J
Manganese	441	434	127	376	218	436
Mercury	0.16 B	0.16 B	0.11 B	0.14 B	0.13 B	0.18 B
Nickel	5.1 J	4.8 J	6.4 J	28.9 B	8.5 J	38.6 B
Potassium	1,200 B	1,390 B	4,750 J	5,370	2,460 B	2,490 J
Selenium	2.5 B	2.6 B	2.32 U	2.32 U	2.32 U	2.32 U
Silver	1.16 U	1.16 U	1.16 U	3.6 U	1.16 U	3.6 U
Sodium	20,500	19,400	20,400	25,500	11,700	17,700
Thallium	2.77 U	2.77 U	2.77 U	2.77 U	5.2 B	2.77 U
Vanadium	0.74 U	0.74 U	10.7 J	23.5 J	3.1 B	38.8 J
Zinc	886	868	320	1,230	75.1	82.8
Wet Chemistry (MG/L)						
Dissolved organic carbon	6.6	6	NA	NA	1 U	2

NA - Not analyzed
B - Not detected above associated blank
J - Reported value estimated
K - Reported value biased high

U - Analyte not detected
UL - Not detected, biased low
Shaded cell indicates detected constituent

Appendix A-2
In Situ Groundwater Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MM02	IS28MM03	IS28MM05	IS28MM06	IS28MM07		IS28MM11	IS28MM14
Sample ID	IS28GW02-0503	IS28GW03-0503	IS28GW05-0503	IS28GW06-0503	IS28GW07-0503	IS28GW07-0503P	IS28GW11-0503	IS28GW14-0503
Sample Date	05/12/03	05/12/03	05/12/03	05/15/03	05/16/03	05/16/03	05/21/03	05/15/03
Chemical Name								
Volatile Organic Compounds (UG/L)								
1,1,1-Trichloroethane	10 U	10 U	10 U					
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U					
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	10 U	10 U	10 U					
1,1,2-Trichloroethane	10 U	10 U	10 U					
1,1-Dichloroethane	10 U	10 U	10 U					
1,1-Dichloroethene	10 U	10 U	10 U					
1,2,4-Trichlorobenzene	10 U	10 U	10 U					
1,2-Dibromo-3-chloropropane	10 U	10 U	10 U					
1,2-Dibromoethane	10 U	10 U	10 U					
1,2-Dichlorobenzene	10 U	10 U	10 U					
1,2-Dichloroethane	10 U	10 U	10 U					
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA	10 U	NA
1,2-Dichloropropane	10 U	10 U	10 U					
1,3-Dichlorobenzene	10 U	10 U	10 U					
1,4-Dichlorobenzene	10 U	10 U	10 U					
2-Butanone	10 U	10 U	10 U					
2-Hexanone	10 U	10 U	10 U					
4-Methyl-2-pentanone	10 U	10 U	10 U					
Acetone	5 J	10 U	4 J	10 U	10 U	10 U	10 U	4 J
Benzene	10 U	10 U	10 U					
Bromodichloromethane	10 U	10 U	10 U					
Bromoform	10 U	10 U	10 U					
Bromomethane	10 U	10 U	10 U					
Carbon disulfide	10 U	10 U	10 U					
Carbon tetrachloride	10 U	5 J	2 J	2 J	10 U	1 J	10 U	10 U
Chlorobenzene	10 U	10 U	10 U					
Chloroethane	10 U	10 U	10 U					
Chloroform	10 U	10 U	10 U					
Chloromethane	10 U	10 U	10 U					
Cumene	10 U	10 U	10 U					
Cyclohexane	10 U	10 U	10 U					
Dibromochloromethane	10 U	10 U	10 U					
Dichlorodifluoromethane(Freon-12)	10 U	10 U	10 U					
Ethylbenzene	10 U	10 U	10 U					
Methyl acetate	10 U	10 U	10 U					
Methyl-tert-butyl ether (MTBE)	10 U	10 U	10 U					
Methylcyclohexane	10 U	10 U	10 U					
Methylene chloride	10 U	10 U	10 U					
Styrene	10 U	10 U	10 U					
Tetrachloroethene	10 U	10 U	10 U					
Toluene	10 U	10 U	10 U					
Trichloroethene	10 U	10 U	10 U					

NA - Not analyzed
B - Analyte not detected above associated blank
J - Reported value is estimated
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Shaded cell indicates detected constituent.

Appendix A-2
In Situ Groundwater Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MM02		IS28MM03		IS28MM05		IS28MM06		IS28MM07		IS28MM11		IS28MM14		
Sample ID	IS28GW02-0503		IS28GW03-0503		IS28GW05-0503		IS28GW06-0503		IS28GW07-0503		IS28GW07-0503P		IS28GW11-0503		
Sample Date	05/12/03		05/12/03		05/12/03		05/15/03		05/16/03		05/16/03		05/21/03		
Chemical Name															
Trichlorofluoromethane(Freon-11)	10	U	10	U	10	U									
Vinyl chloride	10	U	10	U	10	U									
Xylene, total	10	U	10	U	10	U									
cis-1,2-Dichloroethene	10	U	10	U	10	U									
cis-1,3-Dichloropropene	10	U	10	U	10	U									
m- and p-Xylene	NA		NA		10	U									
o-Xylene	NA		NA		10	U									
trans-1,2-Dichloroethene	10	U	10	U	10	U									
trans-1,3-Dichloropropene	10	U	10	U	10	U									
Semi-volatile Organic Compounds (UG/L)															
1,1-Biphenyl	10	U	10	U	NA	10	U								
2,4,5-Trichlorophenol	25	U	25	U	NA	25	U								
2,4,6-Trichlorophenol	10	U	10	U	NA	10	U								
2,4-Dichlorophenol	10	U	10	U	NA	10	U								
2,4-Dimethylphenol	10	U	10	U	NA	10	U								
2,4-Dinitrophenol	25	U	25	U	NA	25	U								
2,4-Dinitrotoluene	10	U	10	U	NA	10	U								
2,6-Dinitrotoluene	10	U	10	U	NA	10	U								
2-Chloronaphthalene	10	U	10	U	NA	10	U								
2-Chlorophenol	10	U	10	U	NA	10	U								
2-Methylnaphthalene	10	U	10	U	NA	10	U								
2-Methylphenol	10	U	10	U	NA	10	U								
2-Nitroaniline	25	U	25	U	NA	25	U								
2-Nitrophenol	10	U	10	U	NA	10	U								
3,3'-Dichlorobenzidine	10	U	10	U	NA	10	U								
3-Nitroaniline	25	U	25	U	NA	25	U								
4,6-Dinitro-2-methylphenol	25	U	25	U	NA	25	U								
4-Bromophenyl-phenylether	10	U	10	U	NA	10	U								
4-Chloro-3-methylphenol	10	U	10	U	NA	10	U								
4-Chloroaniline	10	U	10	U	NA	10	U								
4-Chlorophenyl-phenylether	10	U	10	U	NA	10	U								
4-Methylphenol	10	U	10	U	NA	10	U								
4-Nitroaniline	25	U	25	U	NA	25	U								
4-Nitrophenol	25	U	25	U	NA	25	U								
Acenaphthene	10	U	10	U	NA	10	U								
Acenaphthylene	10	U	10	U	NA	10	U								
Acetophenone	10	U	10	U	NA	10	U								
Anthracene	10	U	10	U	NA	10	U								
Atrazine	10	U	10	U	NA	10	U								
Benzaldehyde	10	U	10	U	NA	10	U								
Benzo(a)anthracene	10	U	10	U	NA	10	U								
Benzo(a)pyrene	10	U	10	U	NA	10	U								
Benzo(b)fluoranthene	10	U	10	U	NA	10	U								

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Appendix A-2
In Situ Groundwater Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MM02		IS28MM03		IS28MM05		IS28MM06		IS28MM07		IS28MM11		IS28MM14			
Sample ID	IS28GW02-0503		IS28GW03-0503		IS28GW05-0503		IS28GW06-0503		IS28GW07-0503		IS28GW07-0503P		IS28GW11-0503		IS28GW14-0503	
Sample Date	05/12/03		05/12/03		05/12/03		05/15/03		05/16/03		05/16/03		05/21/03		05/15/03	
Chemical Name																
Benzo(g,h,i)perylene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Benzo(k)fluoranthene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Bis(2-chloro-1-methylethyl) ether	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Butylbenzylphthalate	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Caprolactam	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Carbazole	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Chrysene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Di-n-butylphthalate	10	U	10	U	1	J	0.6	JB	1	J	2	J	NA		10	U
Di-n-octylphthalate	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Dibenz(a,h)anthracene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Dibenzofuran	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Diethylphthalate	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Dimethyl phthalate	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Fluoranthene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Fluorene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Hexachlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Hexachlorobutadiene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Hexachlorocyclopentadiene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Hexachloroethane	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Indeno(1,2,3-cd)pyrene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Isophorone	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Naphthalene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Nitrobenzene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Pentachlorophenol	25	U	25	U	25	U	25	U	25	U	25	U	NA		25	U
Phenanthrene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Phenol	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Pyrene	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
bis(2-Chloroethoxy)methane	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
bis(2-Chloroethyl)ether	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
bis(2-Ethylhexyl)phthalate	10	U	41		10	U	10	U	10	U	10	U	NA		10	U
n-Nitroso-di-n-propylamine	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
n-Nitrosodiphenylamine	10	U	10	U	10	U	10	U	10	U	10	U	NA		10	U
Explosives (UG/L)																
1,3,5-Trinitrobenzene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
1,3-Dinitrobenzene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
2,4,6-Trinitrotoluene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
2,4-Dinitrotoluene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
2,6-Dinitrotoluene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
2-Amino-4,6-dinitrotoluene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
2-Nitrotoluene	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	NA		0.52	U
3-Nitrotoluene	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	NA		0.52	U
4-Amino-2,6-dinitrotoluene	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	0.26	U	NA		0.26	U
4-Nitrotoluene	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	NA		0.52	U

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Appendix A-2
In Situ Groundwater Raw Data
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MM02	IS28MM03	IS28MM05	IS28MM06	IS28MM07		IS28MM11	IS28MM14
Sample ID	IS28GW02-0503	IS28GW03-0503	IS28GW05-0503	IS28GW06-0503	IS28GW07-0503	IS28GW07-0503P	IS28GW11-0503	IS28GW14-0503
Sample Date	05/12/03	05/12/03	05/12/03	05/15/03	05/16/03	05/16/03	05/21/03	05/15/03
Chemical Name								
HMX	0.52 U	NA	0.52 U					
Nitrobenzene	0.26 U	0.26 U	0.26 U	0.26 U	0.23 J	0.26 U	NA	0.26 U
Nitroglycerin	1,000 U	NA	1,000 U					
Nitroguanidine	10 U	NA	10 U					
PETN	1.3 U	NA	1.3 U					
Perchlorate	4 U	4 U	4 U	4 U	4 U	4 U	NA	4 U
RDX	0.52 U	NA	0.52 U					
Tetryl	0.52 U	NA	0.52 U					
Dissolved Metals (UG/L)								
Aluminum	35 B	31.7 B	20.8 B	36.7 B	75.6 B	35.3 B	12,000	62.2 B
Antimony	1.33 U	3.8 B	1.33 U					
Arsenic	2.3 B	1.8 U	1.8 U	1.8 U	1.8 U	2.3 B	142	1.8 U
Barium	29.7 B	27.1 B	30.4 B	27.1 B	25.6 B	26.7 B	239	30.9 B
Beryllium	0.31 U	0.31 U	0.31 U					
Cadmium	3.66 U	22.9	3.66 U					
Calcium	1,800 B	1,180 B	1,080 B	888 B	870 B	919 B	7,780	1,140 B
Chromium	0.57 U	17.3	0.57 U					
Cobalt	3.9 B	3.8 B	7.4 B	2.1 B	2.7 B	2.5 B	8.4 B	3.5 B
Copper	2.38 U	3 B	61	2.38 U				
Iron	1,080	332	208	328	219	312	16,400	359
Lead	0.91 U	367	0.91 U					
Magnesium	881 B	834 B	814 B	647 B	614 B	641 B	3,280 B	701 B
Manganese	75.6	38.4	81	34.2	24.1	28.1	133	45.8
Mercury	0.08 B	0.03 U	0.05 B	0.06 B	0.08 B	0.03 U	0.25	0.1 B
Nickel	11.7 U	17.3 B	11.7 U	11.7 U	11.7 U	11.7 U	13.4 B	11.7 U
Potassium	2,780 B	2,210 B	1,880 B	1,700 B	1,530 B	1,860 B	3,300 B	2,840 B
Selenium	2.1 U	2.1 U	2.1 U					
Silver	0.57 U	4.78 U	0.57 U					
Sodium	15,500	14,700	14,000	16,500	13,900	14,200	10,600	15,200
Thallium	6.6 B	4 B	6.1 B	6.7 B	4.1 B	7.9 B	5 B	3.8 B
Vanadium	4.7 U	30.4 B	4.7 U					
Zinc	94	24.3	46.6	26.3	18.3 B	30.6	15,700	60.4
Wet Chemistry (MG/L)								
Dissolved organic carbon	NA	NA	NA	NA	NA	NA	NA	NA
Total organic carbon (TOC)	1	1 U	1 U	1	1 U	1 U	NA	1

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Appendix A-2
In Situ Groundwater Raw Data
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MM20	IS28MM23	IS28MM27		IS28MM28	IS28MM42
Sample ID	IS28GW20-0503	IS28GW23-0503	IS28GW27-0503	IS28GW27-0503P	IS28GW28-0503	IS28GW42-0503
Sample Date	05/20/03	05/20/03	05/20/03	05/20/03	05/20/03	05/14/03
Chemical Name						
Volatile Organic Compounds (UG/L)						
1,1,1-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromoethane	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	5 J	10 U	10 U	10 U	10 U	10 U
Benzene	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	10 U
Bromoform	10 U	10 U	10 U	10 U	10 U	10 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	10 U	10 U	2 J	2 J	10 U	10 U
Chlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U
Cumene	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	10 U	10 U	10 U	10 U	10 U	10 U
Dichlorodifluoromethane(Freon-12)	10 U	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	10 U	10 U	10 U	10 U	10 U	10 U
Methyl acetate	10 U	10 U	10 U	10 U	10 U	10 U
Methyl-tert-butyl ether (MTBE)	10 U	10 U	10 U	10 U	10 U	10 U
Methylcyclohexane	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	10 U	1 J	1 J	10 U	10 U	10 U
Styrene	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U	10 U	10 U	10 U

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Appendix A-2
In Situ Groundwater Raw Data
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MM20	IS28MM23	IS28MM27		IS28MM28	IS28MM42
Sample ID	IS28GW20-0503	IS28GW23-0503	IS28GW27-0503	IS28GW27-0503P	IS28GW28-0503	IS28GW42-0503
Sample Date	05/20/03	05/20/03	05/20/03	05/20/03	05/20/03	05/14/03
Chemical Name						
Trichlorofluoromethane(Freon-11)	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U
Xylene, total	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U
m- and p-Xylene	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U
Semi-volatile Organic Compounds (UG/L)						
1,1-Biphenyl	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	25 U	25 U	25 U	25 U	25 U	25 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	25 U	25 U	25 U	25 U	25 U	25 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	10 U	10 U	10 U	10 U	10 U	10 U
3-Nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U
4,6-Dinitro-2-methylphenol	25 U	25 U	25 U	25 U	25 U	25 U
4-Bromophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	10 U	10 U	10 U	10 U	10 U	10 U
4-Chlorophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U
4-Nitrophenol	25 U	25 U	25 U	25 U	25 U	25 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	10 U	10 U	10 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U
Atrazine	10 U	10 U	10 U	10 U	10 U	10 U
Benzaldehyde	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U

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Appendix A-2
In Situ Groundwater Raw Data
Site 28 Focused Feasibility Study
NSF-IH, Indian Head, Maryland

Station ID	IS28MM20	IS28MM23	IS28MM27		IS28MM28	IS28MM42
Sample ID	IS28GW20-0503	IS28GW23-0503	IS28GW27-0503	IS28GW27-0503P	IS28GW28-0503	IS28GW42-0503
Sample Date	05/20/03	05/20/03	05/20/03	05/20/03	05/20/03	05/14/03
Chemical Name						
Benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloro-1-methylethyl) ether	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U
Caprolactam	10 U	10 U	10 U	10 U	10 U	10 U
Carbazole	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	0.9 JB	1 JB	1 JB	10 U	0.9 JB	2 J
Di-n-octylphthalate	10 U	10 U	10 U	10 U	10 U	10 U
Dibenz(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U
Dimethyl phthalate	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	25 U	25 U	25 U	25 U	25 U	25 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate	10 U	10 U	10 U	13	10 U	10 U
n-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U
n-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U
Explosives (UG/L)						
1,3,5-Trinitrobenzene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
1,3-Dinitrobenzene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
2,4,6-Trinitrotoluene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
2,4-Dinitrotoluene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
2,6-Dinitrotoluene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
2-Amino-4,6-dinitrotoluene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
2-Nitrotoluene	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U
3-Nitrotoluene	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U
4-Amino-2,6-dinitrotoluene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
4-Nitrotoluene	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U

NA - Not analyzed
B - Analyte not detected above associated blank
J - Reported value is estimated
U - Analyte not detected
Shaded cell indicates detected constituent.

Appendix A-2
In Situ Groundwater Raw Data
 Site 28 Focused Feasibility Study
 NSF-IH, Indian Head, Maryland

Station ID	IS28MM20	IS28MM23	IS28MM27		IS28MM28	IS28MM42
Sample ID	IS28GW20-0503	IS28GW23-0503	IS28GW27-0503	IS28GW27-0503P	IS28GW28-0503	IS28GW42-0503
Sample Date	05/20/03	05/20/03	05/20/03	05/20/03	05/20/03	05/14/03
Chemical Name						
HMX	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U
Nitrobenzene	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U
Nitroglycerin	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U
Nitroguanidine	10 U	10 U	10 U	10 U	10 U	10 U
PETN	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Perchlorate	4 U	4 U	4 U	4 U	4 U	4 U
RDX	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U
Tetryl	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U	0.52 U
Dissolved Metals (UG/L)						
Aluminum	45.4 B	39.7 B	50.9 B	28.8 B	168 B	27.8 B
Antimony	1.33 U	1.33 U	1.33 U	1.33 U	1.33 U	1.33 U
Arsenic	213	19.7	2.5 B	1.8 U	1.9 B	10.4
Barium	55.2 B	77.9 B	35 B	37 B	54.6 B	466
Beryllium	0.31 U	0.31 U	0.31 U	0.31 U	0.54 B	0.31 U
Cadmium	3.66 U	5.2	3.66 U	3.66 U	3.66 U	3.66 U
Calcium	7,220	3,600 B	1,240 B	1,290 B	2,510 B	21,200
Chromium	0.57 U	0.57 U	0.57 U	0.57 U	0.57 U	0.57 U
Cobalt	8.3 B	8.1 B	5.2 B	5.1 B	6.4 B	10.9 B
Copper	2.38 U	2.38 U	2.9 B	2.38 U	5.9 B	2.38 U
Iron	32,200	12,700	57.3 B	37.4 B	65.7 B	7,490
Lead	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	3.4
Magnesium	4,180 B	1,050 B	982 B	997 B	2,380 B	5,190
Manganese	271	542	59.8	56.4	84.7	501
Mercury	0.03 U	0.06 B	0.11 B	0.03 U	0.03 U	0.03 B
Nickel	11.7 U	11.7 U	11.7 U	11.7 U	11.7 U	31.6 B
Potassium	2,460 B	1,760 B	1,650 B	1,800 B	763 B	2,100 B
Selenium	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U
Silver	4.78 U	4.78 U	4.78 U	4.78 U	4.78 U	0.57 U
Sodium	15,300	14,900	14,500	14,600	13,400	14,600
Thallium	7.2 B	4.2 B	4.8 B	5 B	4 B	5.1 B
Vanadium	4.7 U	4.7 U	4.7 U	4.7 U	4.7 U	4.7 U
Zinc	216	14,100	118	102	667	10,900
Wet Chemistry (MG/L)						
Dissolved organic carbon	5.8	1 U	1 U	1 U	2	NA
Total organic carbon (TOC)	NA	NA	NA	NA	NA	5.8

NA - Not analyzed
 B - Analyte not detected above associated blank
 J - Reported value is estimated
 U - Analyte not detected
 Shaded cell indicates detected constituent.