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Final

Background Study Work Plan

Naval Weapons Station Yorktown
Yorktown, Virginia and
Cheatham Annex
Williamsburg, Virginia

Naval Facilities Engineering Command
NAVFAC MID-ATLANTIC

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic Division

Contract No. N62470-02-D-3052
CTO-0148

July 2009

Prepared by

CH2MHILL

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Contract Task Order 0148

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Department of the Navy
Naval Facilities Engineering Command
Atlantic

Under the

NAVFAC CLEAN III Program
Contract N62470-02-D-3052

Prepared by

CH2MHILL

Virginia Beach, Virginia

Executive Summary

This Work Plan describes the approach to conduct a background investigation for soil, sediment, surface water, and groundwater at Naval Weapons Station (WPNSTA) Yorktown and Cheatham Annex (CAX). In accordance with the *Navy Interim Final Policy on the Use of Background Chemical Levels* (Navy, 2000) and the United States Environmental Protection Agency's (USEPA's) *Role of Background in the CERCLA Cleanup Program* guidance (USEPA, 2002a) the risk management and remedial actions for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites should account for the influence of natural and anthropogenic background. The purpose of this study is to establish representative background concentrations that can be compared to individual site-specific data to assess whether constituents detected at an Installation Restoration (IR) CERCLA site are attributable to site-specific release(s).

Because WPNSTA Yorktown and CAX share a common Bases boundary with the same physiographic, hydrogeologic, and soil association characteristics, and because much of the background data collected as part of the 2001 CAX Background Study in 2001 (Baker, 2003) is from samples collected on WPNSTA Yorktown, all available background data from both WPNSTA Yorktown and CAX are combined to establish the most robust background data set for natural and anthropogenic constituents. A summary of the rationale for the development of background concentrations is provided by media:

Soil

Five soil associations were identified at WPNSTA Yorktown and four soil associations were identified at CAX. Soil Association 5 (WPNSTA Yorktown) comprises a relatively small portion of the facility with no known CERCLA sites, and therefore is not evaluated as part of this study. Based on a review of existing background soil data from the 1995 WPNSTA Yorktown Background Study (Baker, 1995) and the 2001 CAX Background Study (Baker, 2003), it was determined that no additional background soil data were needed, but that statistical evaluations be completed to maximize sample size by combining soil association data sets as appropriate, if statistically determined to reflect the same populations. Statistical analyses will also be conducted on a parameter-specific basis to determine if surface and subsurface soils can also be combined. Background soil concentrations will then be established as upper tolerance limits (UTLs) for comparison to site data. The objective of establishing soil UTLs is not to re-evaluate or re-visit past use of background data but rather to supplement existing data to establish a more robust and representative background threshold value for future application to CERCLA investigations.

Sediment and Surface Water

A base-wide background investigation for surface water and sediment is not proposed in this work plan. The approach for surface water and sediment is to build up a base-wide reference data set using existing background data and, through accumulation of site-specific reference data as site-specific investigation of surface waster and sediment are completed at

CAX and WPNSTA Yorktown CERCLA sites. Over time, this will allow for the incremental development of a more comprehensive background data set for these media that in site-specific instances are supported by toxicity assessments. A multi-step process is proposed:

- **Compile and Evaluate Available Information**: The existing background report for WPNSTA Yorktown will be reviewed to determine the amount and type of existing reference data for surface water and sediment.
- **Site-Specific Evaluation**: For evaluation of sites with potential aquatic exposures, the habitat type(s) present will be evaluated relative to the compiled background data set. If adequate data exist in the current background data set for surface and/or sediment of similar habitat type, the existing data will be used. If not, additional background/reference data will be collected as part of that particular aquatic habitat, adding to the accumulation of site-specific reference data.
- **Background Data Base:** Background/reference data collected as part of specific site evaluations will be added to the background data base, as appropriate. Care will be used to differentiate data that are reference only for a particular site or group of sites (such as data collected upgradient of a site or group of sites from a uni-directionally flowing stream) from data that are more broadly representative of background conditions (i.e., not directly influenced from any know CERCLA point source). This will allow the data base to be built up over time for use with future site assessments.

Groundwater

The background groundwater study will focus on the shallow aquifer system consisting of the Cornwallis Cave, and Yorktown-Eastover aquifers. A total of 15 samples will be collected in the Cornwallis Cave aquifer and 13 samples will be collected in the Yorktown-Eastover aquifer to ensure a minimum of 10 usable background samples should it be necessary to excluded samples from the data set. Nine background groundwater samples will be collected from the existing wells from the previous background investigations at WPNSTA Yorktown and CAX (Baker, 1995 and 2003). Sixteen wells installed during a United States Geological Survey (USGS) study of the shallow aquifer system (Brockman et al., 1997). In addition, three new monitoring wells will be installed. All groundwater samples will be analyzed for total and dissolved Target Analyte List (TAL) metals, Target Compound List (TCL) semivolatile organic compounds (SVOCs), and TCL pesticides to establish background UTLs for these natural and anthropogenic constituents. To ensure that samples are representative of background, sample analyses will also include TCL volatile organic compounds (VOCs) and explosives.

Following sample analysis and data validation, summary statistics will be calculated for the mean, median, standard deviation, frequency of detection, and probabilities for normality and lognormality, and the background threshold will be calculated as the 95 percent UTL. While establishing a background UTL is a critical endpoint of the study, it is recognized that determining if a CERCLA release has occurred is a multi-faceted process where geologic and geochemical conditions may vary with a localized influence on background conditions. Establishing a CERCLA release will consider background UTLs as well as all available information including historical knowledge of site operations, local geologic and

geochemical factors, site and background population-to-population comparisons, and other technically defensible evaluations.

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Acronyms and Abbreviations

ANOVA	analysis of variance
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
CAX	Cheatham Annex
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-term Environmental Action—Navy
COC	chemical of concern
COPC	chemical of potential concern
DO	dissolved oxygen
ERA	Ecological Risk Assessment
ft	foot/feet
IQR	interquartile range
IR	Installation Restoration
NAVFAC	Naval Facilities Engineering Command
ORP	oxidation reduction potential
PCB	polychlorinated biphenyl
QAPP	Quality Assurance Project Plan
SVOC	semivolatile organic compound
TAL	target analyte list
TCL	target compound list
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTL	upper tolerance limit
VOC	volatile organic compound
WP	Work Plan
WPNSTA	Naval Weapons Station

SECTION 1

Introduction

This Work Plan (WP) describes the approach for a background study of soil, sediment, surface water, and groundwater at the Naval Weapons Station (WPNSTA) Yorktown in Yorktown, Virginia and Cheatham Annex (CAX) in Williamsburg, Virginia. The WP is prepared under the Naval Facilities Engineering Command (NAVFAC), Atlantic, Comprehensive Long-term Environmental Action—Navy (CLEAN) Contract N62470-02-D-3052, Contract Task Order 148. The technical approach is based on *Guidance for Environmental Background Analysis, Volume I: Soil* (Navy, 2002), *Guidance for Environmental Background Analysis, Volume II: Sediment* (Navy, 2003 and *Guidance for Environmental Background Analysis, Volume III: Groundwater* (Navy, 2004). A regional location map is provided as Figure 1-1.

1.1 Purpose and Objectives

The purpose of this study is to establish representative background concentrations in soil and groundwater, and present an approach for developing a background/reference data set for sediment and surface water. Background concentrations for natural and anthropogenic constituents are used for comparison to site data to support the determination of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) release. The *Navy Interim Final Policy on the Use of Background Chemical Levels* (Navy, 2000) and the United States Environmental Protection Agency's (USEPA's) *Role of Background in the CERCLA Cleanup Program* guidance (USEPA, 2002a) acknowledge risk management and remedial actions for CERCLA sites should account for the influence of natural and anthropogenic background, and that cleanup goals for natural and anthropogenic chemicals of concern (COCs) from an identified CERCLA releases should not be set below corresponding background concentrations.

Existing background data for WPNSTA Yorktown soil, groundwater, surface water, and sediment are documented in the 1995 WPNSTA Yorktown Background Study (Baker, 1995). Existing background data for CAX soil and groundwater are documented in the 2001 CAX Background Study (Baker, 2003). These reports document calculation of a 95 percent upper confidence limit (UCL) of the mean using the individual WPNSTA and CAX data sets, and these data have been conservatively used for previous CERCLA release/risk management assessments and remedial actions. The objective of this background study is not to re-evaluate or re-visit past use of background data but rather to supplement existing data to establish a more robust and representative background data set for future application to CERCLA investigations/actions based on the following:

- The 95 percent UCL of the mean estimates a value in the center of a given population and therefore excludes from consideration those background concentrations that would fall between the maximum and the 95 percent UCL.

- An upper tolerance limit (UTL) is considered a more appropriate background threshold value because it represents a UCL of an upper percentile, specifically, the 95 percent UCL of the 95th percentile.
- The greatest possible sample size, and therefore more robust background data set, can be realized by combining existing background data from WPNSTA Yorktown and CAX, facilities that share a common geographic boundary and the same physiographic, hydrogeologic, and soil association characteristics, which is further demonstrated by the fact that much of the background data collected as part of the CAX study is from samples collected on WPNSTA Yorktown.
- There are insufficient existing background groundwater data for the Yorktown-Eastover aquifer relevant to future CERCLA groundwater investigations, and more current background data from existing and new wells for this transient media are preferred.
- Existing background surface water and sediment data (Baker, 1995) were collected off Navy property in pristine environments of the York River watershed, and development over time of a more representative surface water and sediment reference data set through site-specific investigations is considered a more representative and cost effective approach.

Existing background soil sample locations were not re-evaluated and are considered appropriate to reflect typical WPNSTA Yorktown and CAX conditions not impacted by site-specific or other point-source releases. Based on a review of all existing background soil data for the soil associations identified by Virginia Polytechnic Institute and State University, statistical evaluations were completed to identify statistically similar populations that could be combined to maximize sample size for establishing a more robust and representative UTL concentration for natural and anthropogenic constituents in soil. The statistical analysis of the data populations and methodology for calculation of UTLs for soil are provided in this plan.

This plan proposes the collection of groundwater samples from existing and newly installed background wells to provide a more current and robust background groundwater data set for the aquifers relevant to the CERCLA groundwater investigations. Existing background wells were evaluated to identify the aquifer monitored by the wells. Proposed locations for new background wells were evaluated to ensure they would not be affected by potential point sources of contamination. To ensure data used to establish background UTL concentrations are reflective of background conditions, groundwater samples will include analysis of volatile organic compounds (VOCs) and explosives, and for natural and anthropogenic constituents, statistical outliers will be identified. This plan also presents an approach for building over time a surface water and sediment background/reference data base. These background data will be compiled using existing reference data generated during site-specific investigations and from reference data collected as part of future site-specific investigations, taking into account similar habitat types and existing and future site-specific toxicity testing results. This plan presents the sampling rationale, data evaluation process, and statistical methodology for identification of outliers and calculation of the UTLs. While establishing a background UTL data set is a critical endpoint of the study, it is recognized that determining if a CERCLA release has occurred is a multi-faceted process where geologic and geochemical conditions may vary with a localized influence on

background conditions. Establishing a CERCLA release will consider all available information including historical knowledge of site operations, local geologic and geochemical factors, site and background population-to-population comparisons, and other technically defensible assessments.

1.2 Work Plan Organization

This WP is organized into six sections. Section 2 summarizes the previous background studies and provides describes soils and hydrogeology. Sections 3, 4, and 5 present the rationale for development of background concentrations in soil, surface water/sediment, and groundwater, respectively. Section 6 lists references and tables and figures are provided at the end of each section. The site-specific Quality Assurance Project Plan (QAPP) is provided as Appendix A. Figures showing the sampling locations from the previous background studies are provided in Appendix B. Statistical analyses completed for combining soil data sets are provided in Appendix C.

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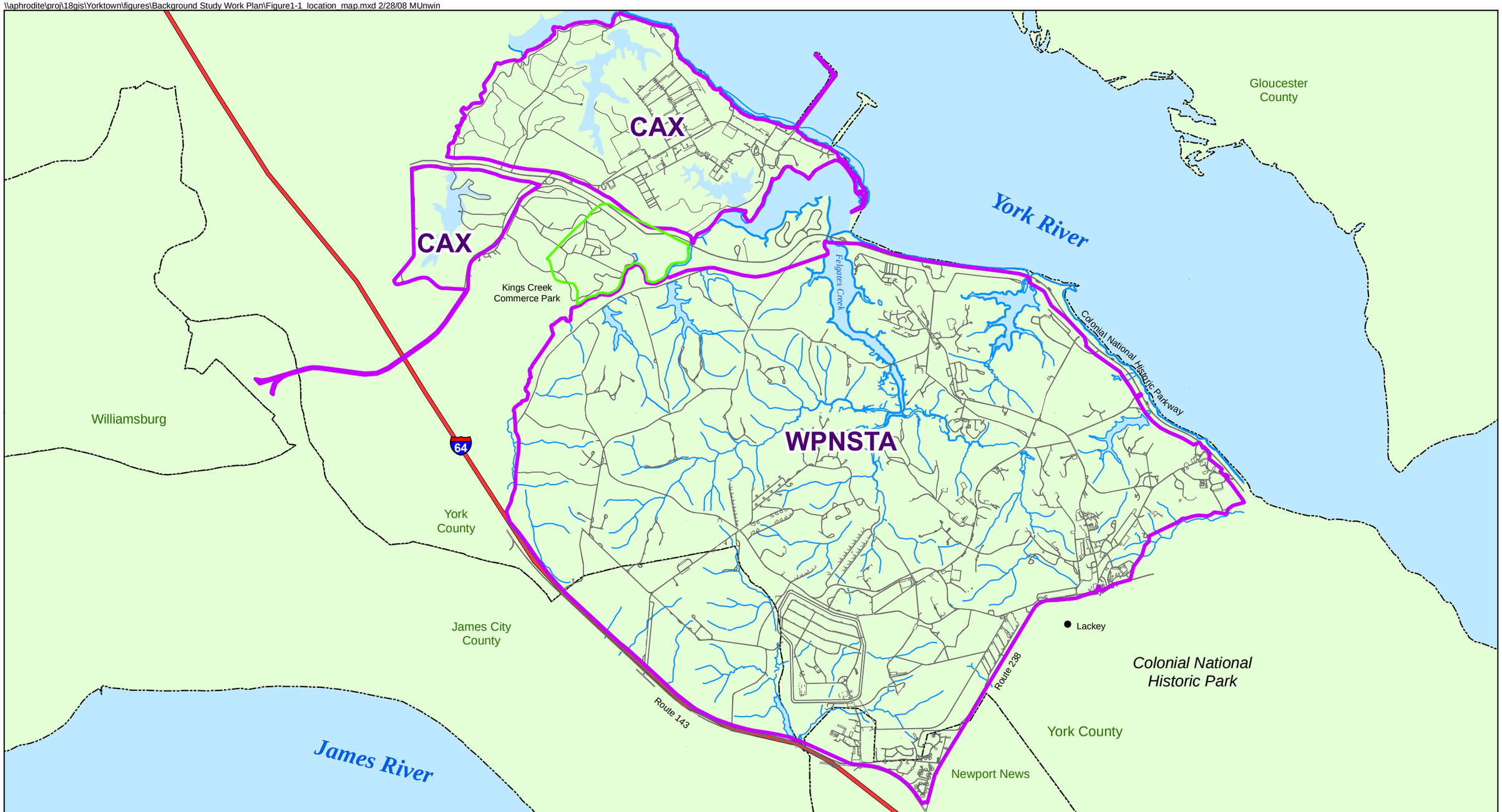

Legend

- Activity Boundaries
- Roads
- Shoreline and Water Bodies
- Interstate 64
- Kings Creek Commerce Park
- City / County Boundaries

N

0 4,000 8,000 Feet

Figure 1-1
Location of WPNSTA Yorktown and CAX
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

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SECTION 2

Conceptual Model

This section presents a conceptual model that describes the site characteristics, facility information, and rationale pertinent to selecting background sample locations and analyses to establish representative background concentrations for natural and anthropogenic constituents not influenced by site-specific or other point sources of contamination. The key components of the conceptual model are:

- Geology and soil type
- Local surface water features
- Hydrogeology
- Point sources of contamination

2.1 Geology and Soils

WPNSTA and CAX are located in the Coastal Plain Physiographic Province where topography consists of a series of broad terraces bounded by scarps. As shown in Figure 2-1, the majority of WPNSTA and CAX lay within the Lackey Plain terrace, and the adjacent Croaker Flat terrace. The Lackey Plain and Croaker Flat terraces are separated by the Camp Peary Scarp which trends nearly parallel to the York River (Brockman et al., 1997). The unsaturated soil and shallow aquifer systems are the media relevant to CERCLA investigations and this background study. Figure 2-2 illustrates the geologic units of the Lackey Plain and Croaker Flat terraces and how these formations are classified into hydrogeologic units based on aquifer and confining unit characteristics. A more detailed description of the geology at WPNSTA Yorktown and CAX is provided in Section 2 of the Master Project Plans (Baker, 2005).

Five soil associations were identified on WPNSTA Yorktown (Soil Associations 1-5) and four soil associations on CAX (Soil Associations 1-4). Soil Associations 1 and 2 are the same for WPNSTA Yorktown and CAX with respect to physical characteristics and geographic features and are directly comparable. Characteristics of the remaining soil associations are similar but not directly comparable. The following summarizes soil association descriptions for WPNSTA Yorktown and CAX:

2.1.1 WPNSTA Yorktown Soils

The soil associations identified for WPNSTA Yorktown (VPI, 1982) are shown on Figure 2-3 and described below:

1. **Bohicket, Johnston, and Axis Association.** This association consists of sediments deposited in the low-lying areas on marshes and floodplains by fluvial processes and consists of silty, clayey, and sandy loam underlain by sandy clay, silty clay loam, and stratified sand and silt. This sediment is poorly drained with slow to moderate permeability. The sediment along the tidal areas of the creeks and river is nearly horizontal, saturated, and flooded by the daily tidal events. In addition, the sediment in

the upper tributaries is frequently flooded by runoff. The sediment is associated with the channels of the King, Felgates, and Indian Field, and Ballard Creeks as well as some areas of the York River.

2. **Dogue, Pamunky, and Uchee Association.** The soil of this association was deposited on stream terraces and consists of moderate to well-drained loam and sandy loam soil underlain by clayey and sandy loam. This soil is primarily located along King, Felgates, Indian Field, and Ballard Creeks as well as the York River in gently sloping or level non-flooded ridges.

3. **Emporia, Kempsville, and Craven-Uchee Complex Association.** This soil association consists of deep Coastal Plain sediments. The soil consists of moderate to well-drained sandy loam surface soil underlain by clay and sandy clay loam. The permeability of this association ranges from moderate to moderately low. These soils are found upland from the surface water bodies in ridges with steep side slopes.

4. **Slagle, Emporia, and Emporia Complex Association.** This soil association consists of deep Coastal Plain sediments. The soil consists of moderate to well-drained sandy loam surface soil underlain by loam, clay loam, and sandy clay loam. The permeability of this association ranges from moderately low to low. These soils are found upland from the surface water bodies in ridges with steep side slopes.

5. **Slagle, Bethera, and Craven-Uchee Association.** This soil association consists of deep Coastal Plain sediments. The soil consists of moderately well-drained surface soil of silty and sandy loam underlain by poorly-drained clay, clayey loam, silty loam, and sandy clay loam. The permeability of this association ranges from moderately slow to slow. These soils are found upland from the surface water bodies in broad ridges and depressions.

2.1.2 CAX Soils

The soil associations identified for CAX (VPI, 1985) are shown on Figure 2-3 and described below:

1. **Bohicket, Johnston, and Axis Association.** This association consists of sediments deposited in the low-lying areas on marshes and floodplains by fluvial processes and consists of silty, clayey, and sandy loam underlain by sandy clay, silty clay loam, and stratified sand and silt. This sediment is poorly drained with slow to moderate permeability. The sediment along the tidal areas of the creeks and river is nearly horizontal, saturated, and flooded by the daily tidal events. In addition, the sediment in the upper tributaries is frequently flooded by runoff. The sediment is associated with the channels of the King, Queen, and Cub Creeks as well as some areas of the York River.

2. **Dogue, Pamunky, and Uchee Association.** The soil of this association was deposited on stream terraces and consists of moderate to well-drained loam and sandy loam soil underlain by clayey and sandy loam. This soil is primarily located along King, Queen, and Cub Creeks as well as the York River in gently sloping or level non-flooded ridges.

3. **Emporia, Slagle, and Craven-Uchee Complex Association.** This soil association consists of moderate to well-drained loamy and clayey Coastal Plain sediments. These soils formed on the Coastal Plain uplands and are found on medium to narrow ridges with gentle to very steep side slopes. Emporia and Slage soils are located on medium width ridges. Craven and Uchee soils are located on the narrow ridge points and sloping area between the ridges.
4. **Kempsville, Emporia, Emporia Complex, and Craven-Uchee Complex Association.** This soil association consists of well to moderately well-drained soils underlain by loamy and clayey subsoils. These soils formed on the Coastal Plain uplands and are found on medium to narrow ridges with gentle to very steep side slopes. Kempsville and Emporia soils are located on medium width ridges. Emporia Complex soils are located on the steep to very steep side slopes. Craven and Uchee soils are located on the narrow ridge points as well as the sloping area between the ridges.

2.2 Hydrologic Features

2.2.1 WPNSTA Yorktown

WPNSTA Yorktown is located within two drainage basins (Figure 2-1): the York River Basin to the north and the James River Basin to the south (Johnson and CH2M HILL, 1984). Wetlands have been identified along the York and James River tributaries as well as shoreline areas of the York River. The York River and James River Basin tributaries are tidally-influenced to approximately 1 mile inland from the riverbanks. The majority of the facility, including all of the CERCLA sites, lie within the York River Basin.

Surface water drainage in the York River Basin is to the north along several tributaries of the York River, and comprises Kings Creek along the northwest boundary, Ballard Creek on the eastern boundary, and Felgates Creek and Indian Field Creek within the northeast portion of the facility. Felgates Creek traverses the north central portion of WPNSTA Yorktown and is the primary drainage feature associated with CERCLA sites on the facility. Other surface water bodies within the York River Basin include Ponds 10, 11, and 12 located proximal to King Creek in the northwest section of the facility, Lee Pond located proximal to Felgates Creek in the northeast section of the facility, and Roosevelt Pond located proximal to the York River on the northeast boundary of the facility (Figure 2-1).

Surface water drainage in the James River Basin is to the south along tributaries of the James River, located approximately 1.5 miles south of the facility. The main drainage feature is Blows Mill Run which discharges into Skiffies Creek Reservoir and ultimately the James River.

2.2.2 CAX

CAX is also located within the York River Basin (Figure 2-1). Surface water drainage occurs along several tributaries of the York River: Cub Creek and Queens Creek to the north, King Creek to the south, and the York River to the east. Surface water features within CAX include Cheatham Pond (108 acres) and Penniman Lake (43 acres), created in 1943 by dams constructed on the tidally-influenced Queen and King Creeks. In addition, the freshwater non-tidal Jones Mill Pond (69 acres) was created by damming a potion of Cub Creek. Three small man-made ponds (Youth Pond [2 acres], Rodgers Pond [1 acre], and Upstream Pond

[upstream of Youth Pond and < 1 acre in size] are also present at the facility. Numerous small creeks flow through the wooded ravines throughout CAX and drain into the tidal tributaries of the York River.

2.3 Hydrogeology

As shown in Figure 2-2, the geologic strata were grouped into hydrogeologic units based upon their hydrologic characteristics as described in *Groundwater Resources of the York-James Peninsula of Virginia, USGS Water Resources Investigation Report* (Lazniak and Meng, 1988) and the *Geohydrology of the Shallow Aquifer System* (Brockman et al., 1997). The shallow aquifer system comprises the following units:

- Columbia aquifer
- Cornwallis Cave confining unit
- Cornwallis Cave aquifer
- Yorktown confining unit
- Yorktown-Eastover aquifer
- Eastover-Calvert confining unit

This shallow aquifer system sequence is present in the Lackey Plain. However, on Croaker Flat the Camp Peary Scarp truncates the Columbia aquifer, the Cornwallis Cave confining unit, the Cornwallis Cave aquifer, and some to all of the Yorktown confining unit; hence, the upper units are missing and either the Yorktown-Eastover aquifer or a thin portion of the Yorktown confining unit occurs at the surface throughout Croaker Flat. The Columbia Aquifer is present in limited areas directly overlying the Yorktown confining unit. Figure 2-4 illustrates an idealized cross section of the shallow aquifer system at the facility.

The Columbia aquifer consists of very fine to very coarse-grained sands, silty/clayey sand, and sandy clay. As shown in Figure 2-1, the Columbia aquifer is thin, discontinuous and saturated in isolated areas throughout the Facility. Where present within the study area boundary, the Columbia aquifer ranges in thickness from 5 to 20 feet (ft) thick. Groundwater flow appears radial within the isolated areas of the aquifer. In addition, perched aquifers can temporarily form in the Columbia sediments above the Yorktown and Cornwallis Cave confining units.

The Cornwallis Cave confining unit consists of silts and clays that impede the vertical flow of groundwater between the Columbia and Cornwallis Cave aquifers. This unit is present only south and west of the Camp Peary scarp. The unit is absent from Croaker Flat and beneath many of the stream valleys. Gaps in the unit are also present as a result of ancient stream erosion. Where present, the unit is typically 8 ft thick and attains a maximum thickness of 22 ft.

The Cornwallis Cave aquifer consists of shell hash, clayey or sandy shell hash, very fine to medium-grained sands, and shelly clay. As with the Cornwallis Cave confining unit, the aquifer is only present south and west of the Camp Peary scarp. The aquifer thickness ranges from 60 ft in the western portion of the Facility and thins to less than 5 ft in the northeastern portion of the facility. The aquifer is generally confined in areas of higher elevation, but is unconfined where the confining unit is absent at the stream valleys. A

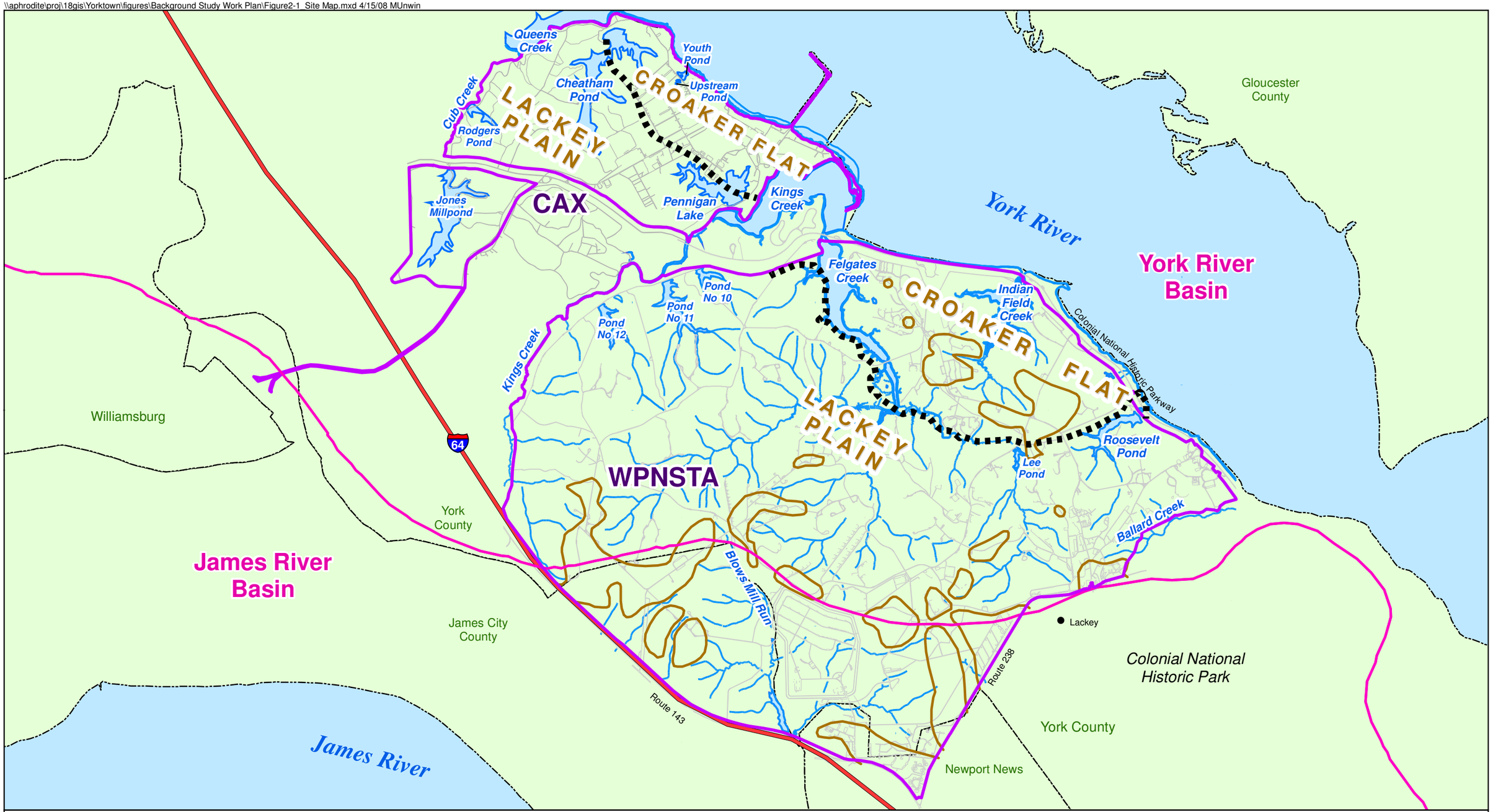
potentiometric high extends west to east and divides the groundwater flow north toward the York River and south toward the James River. The flow appears to be locally influenced by the surface water features.

The Yorktown confining unit is composed of clay and silt. Typically, it is distinguishable by its dark greenish gray color and lithology. The confining unit extends across the entirety of WPNSTA Yorktown except low-lying areas where erosion during a past low sea level removed all to most of the unit. Specifically, the Yorktown confining unit is absent north of Turkey Road between the west and south branches of Felgates Creek, along the streambeds of Felgates Creek, Indian Field Creek and their unnamed tributaries, along the ancestral York River channel and in the western portion of the Station near Ringfield Road (Brockman et al., 1997). The thickness of the unit across the Station ranges from 0 to 36 ft. Where present and of sufficient thickness, the Yorktown confining unit restricts flow to the underlying Yorktown-Eastover aquifer.

The Yorktown-Eastover aquifer consists of very fine to coarse-grained sand, silty sand, silt, sandy clay, shell hash, and clay. The aquifer extends across the entirety of WPNSTA Yorktown and ranges from 60 to 100 ft thick. Groundwater flow in the Yorktown-Eastover aquifer is separated by an east-west trending potentiometric high that divides the groundwater flow north toward the York River and south toward the James River.

The upper strata discussed above are separated from the deeper strata by the Eastover-Calvert confining unit, which is approximately 140 to 166 ft thick in the vicinity of WPNSTA Yorktown and CAX. This extensive confining unit separates the shallow aquifer system from the deeper, pre-Miocene Virginia Coastal Plain aquifers. The deeper pre-Miocene sediments are excluded from evaluation in this study because previous site investigations indicate there is no potential impact by past site activities through the Eastover-Calvert confining unit to underlying strata, due to the thickness of the confining unit and its low permeability.

\\aphrodite\proj\18gis\Yorktown\figures\Background Study Work Plan\Figure2-1_Site Map.mxd 4/15/08 MUnwin



Legend

- Activity Boundaries
- Camp Peary Scarp
- Watershed Boundaries
- Interstate 64
- Approximate Boundary of Columbia Aquifer, February 3, 1997
- Roads
- Shoreline and Water Bodies
- City / County Boundaries

N

0 4,000 8,000 Feet

Figure 2-1
Site Map
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

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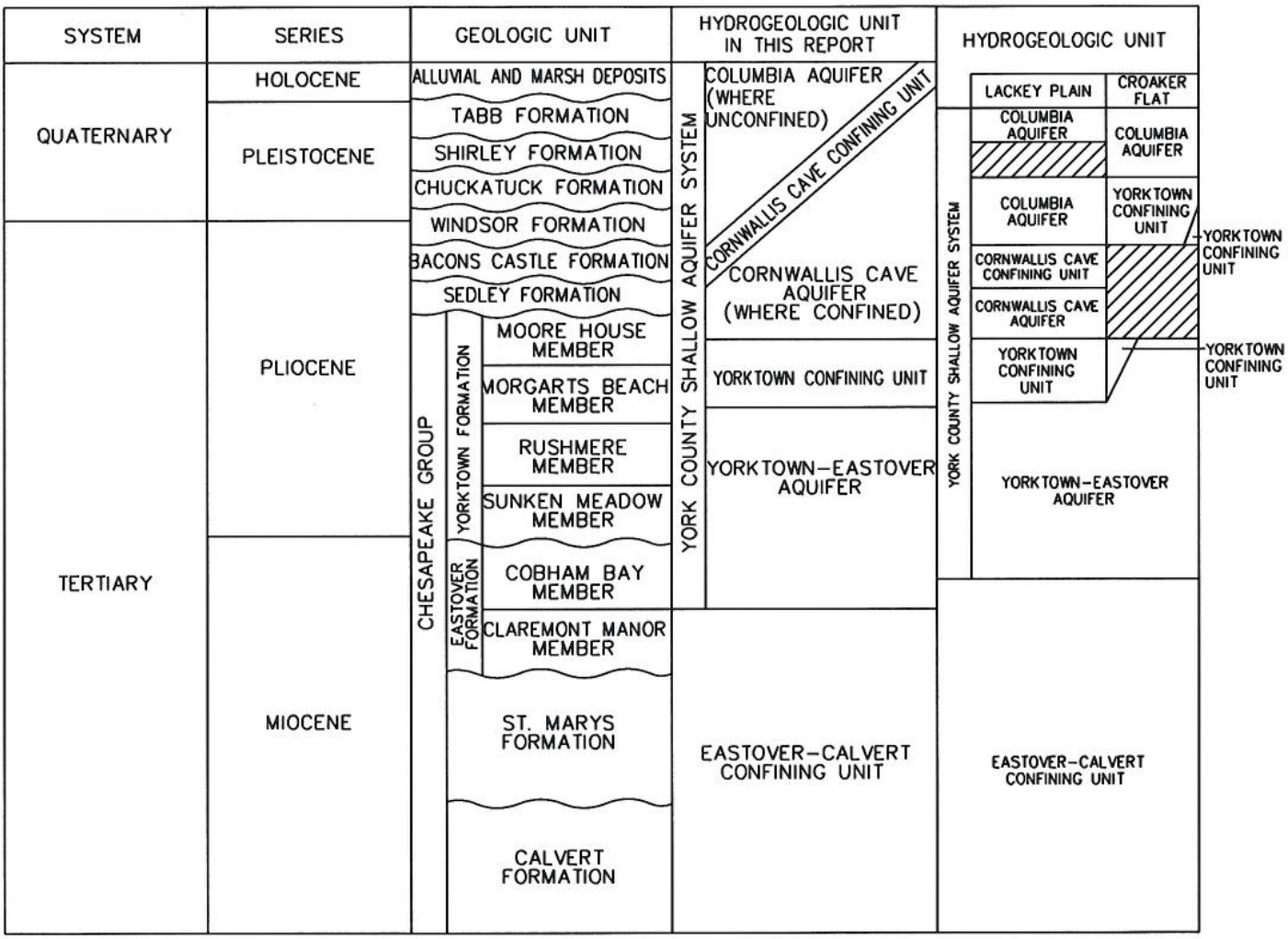

Source: Brockman, ET AL 1997 GEOHYDROLOGY OF THE SHALLOW AQUIFER SYSTEM, NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Figure 2-2
Hydrogeologic Units in York County
Background Study Work Plan
WPNSTA Yorktown
Yorktown, Virginia

NOT TO SCALE

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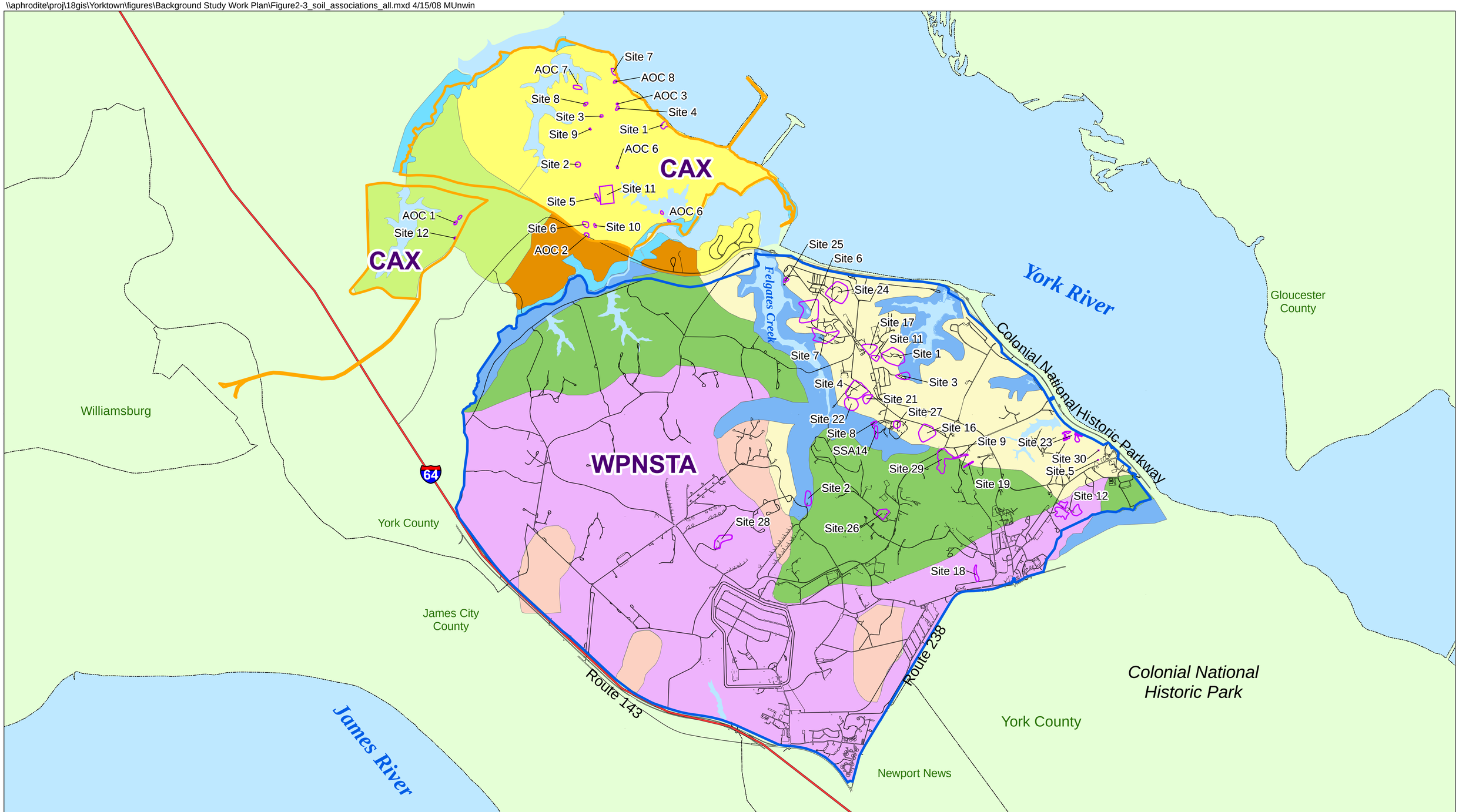


Legend

Yorktown Soil Associations
- Bohicket, Johnson, and Axis (1)
- Dogue, Pamunkey, and Uchee (2)
- Emporia, Kempsville, and Craven-Uchee Complex (3)
- Slagle, Emporia, and Emporia Complex (4)
- Slage, Berthera, and Craven-Uchee (5)

Cheatham Annex Soil Associations
- Bohicket, Johnson, and Axis (1)
- Dogue, Pamunkey, and Uchee (2)
- Slagle, Emporia, and Craven-Uchee Complex (3)
- Emporia, Emporia Complex, Kempsville, and Craven-Uchee Complex (4)

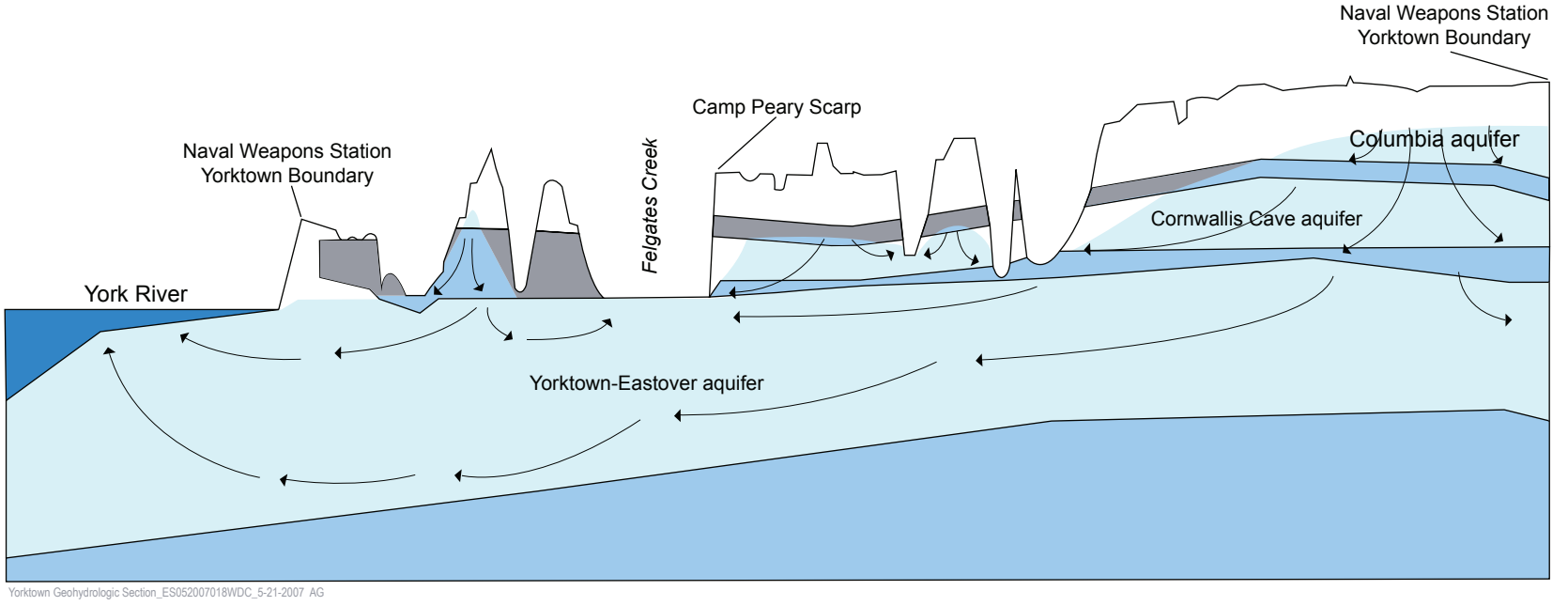
- Site Boundaries
- WPNSTA Yorktown Boundary
- CAX Boundary

N

0 4,000 8,000 Feet

Figure 2-3
General Soil Association Map
Background Study Work Plan
WPNSTA Yorktown
Yorktown, Virginia

CH2MHILL



EXPLANATION

- UNSATURATED CONFINING UNIT
- AQUIFER
- SATURATED CONFINING UNIT
- GENERALIZED GROUND-WATER FLOW PATH

Figure 2-4
Geohydrologic Section of the Shallow Aquifer System
Background Study Work Plan
WPNSTA Yorktown
Yorktown, Virginia

NOT TO SCALE

SECTION 3

Soil Background Evaluation

The development of background soil concentrations will be conducted by combining existing data from WPNSTA Yorktown (Baker, 1995) and CAX (Baker, 2003). Combining all available background data from both WPNSTA Yorktown and CAX to establish the most robust background data set for natural and anthropogenic constituents is warranted for the following reasons:

- WPNSTA Yorktown and CAX share a common boundary with the same physiographic, hydrogeologic, and soil association characteristics.
- Much of the background data collected as part of a 2001 CAX Background Study (Baker, 2003) is from samples collected on WPNSTA Yorktown.

3.1 Summary of Existing Soil Data

A summary of existing surface and subsurface soil background data for the applicable Soil Association is provided in Table 3-1. Figures from the previous background investigations (Baker 1995 and 2003) showing these existing sample locations are provided in Appendix B. The soil analytical data from previous investigations is provided in Appendix C. As part of the WPNSTA Yorktown background investigation, a total of 40 surface soil and 15 sub-surface soil samples were collected from each of the five soil associations. A total of 12 surface soil samples were also collected along former railroad tracks to evaluate anthropogenic conditions. The surface soil samples were collected from 0 to 6 inches below ground surface (bgs) and the subsurface soils were collected at varying depths (1 to 33 ft bgs). No further use of the railroad sample data set will be deemed necessary as any site contamination near and related to railroad tracks will not be evaluated because no CERCLA release has occurred.

The data from Soil Association 5 at WPNSTA Yorktown was excluded from the data set because this soil association comprises a relatively small portion of the Facility and there are no known CERCLA sites located within the areas of this soil association. Because subsurface soils were collected at varying depths (as much as 33 ft bgs) as part of the WPNSTA Yorktown background investigation, only two subsurface samples collected from WPNSTA Yorktown at the 1-3 feet bgs interval were retained for inclusion in the combined background data set to be consistent with the 40 subsurface samples collected from 6 to 24 inches bgs as part of the CAX background investigation. There is not enough data below the three-foot depth to allow for statistical comparison, and subsurface soil samples below three feet generally are not collected. However, the data will be maintained in the Yorktown/CAX database if future site investigations evaluate soils below the three-foot depth and a non-statistical comparison of the site data could be made if the soil is from the same soil type.

As part of the CAX background investigation, 10 surface and 10 subsurface soil samples were collected from each of the four soil associations. As shown in the background sample location figure in Appendix B, some of the samples for Soil Associations 1, 2, and 4 were collected within the boundary of WPNSTA Yorktown. All of the CAX soil data were included in the combined data set.

3.2 Statistical Analysis

Overall, statistical approaches are dependent upon the distribution of the data and could vary from what is proposed in this work plan. The subsections below present the intended approach for calculating the soil UTLs. However, the Navy and EPA have agreed to review the data and decide together on the best statistical approach.

3.2.1 Determination of Data Combinations, Soil Type, and Depth Groupings

The samples will be segregated based on soil characteristics. There are four soil associations located at both WPNSTA Yorktown and CAX - 1 (Bohicket, Johnston, Axis), 2 (Dogue, Pamunkey, Uchee), 3 (Emporia, Slagle, Craven-Uchee Complex), and 4 (Slagle, Emporia, Emporia Complex. WPNSTA Yorktown has a fifth soil association (5 - Slagle, Bethera, Craven-Uchee); however, data from Soil Association 5 at WPNSTA Yorktown was excluded from the BG data set because this soil association comprises a relatively small portion of the Facility and there are no known CERCLA sites located with the areas of this soil association.

When determining the suitability to combine soil types and soil depths, the largest determining factor is the soil composition (i.e. grain size, organic content). The soil grain size distribution and organic content can impact a contaminant's transport properties as well as alter the contaminant's properties. Soil types are closely associated to the geographic features which represent varying deposition environments (i.e. wetlands are associated with low, quiet waters producing predominantly silt to mud deposits). The highest variability in a contaminant's characteristics within a soil occurs between soils composed of sands to those composed of silts and muds. Soils with higher organic contents generally have the capacity to accumulate inorganic compounds and as such would produce higher concentrations of naturally occurring metals. For this reason, high organic soils (Bohicket, Johnston, Axis) are not combined with sandier, low-organic content soils (Slagle, Emporia).

Soils which are considered similar in their physical composition are then compared statistically. This process is repeated to determine if soil depths may also be considered for combination based on their physical composition. The purpose of conducting this process is to increase the statistical pool of data leading to a higher confidence in the statistics.

To determine which soil association groups (e.g., Soil Association 1, Soil Association 2) and soil depths (surface and subsurface) should be combined when calculating background summary statistics, analysis of variance (ANOVA) and box and whisker plots were used to establish whether significant differences exist among soil associations and soil depths.

ANOVA is a technique designed to determine whether the mean values of multiple groups are statistically different from one another. Environmental data are often not consistently normally nor lognormally distributed, particularly because the data contain non-detects and

outliers (USEPA, 2002b). Thus, a nonparametric ANOVA, using the ranks of the data, was used for the background data. For instance, the lowest of 10 concentrations would have the rank of 1 while the highest would have the rank of 10.

The ANOVA was performed on each constituent where at least 50 percent of the concentrations were detected measurements. Navy guidance (Navy, 2002) and USEPA guidance (USEPA, 2002b) recommends this for the Wilcoxon Rank-Sum test, which is essentially a two-group version of the multi-group non-parametric ANOVA. When few detects are available, quantitative methods of evaluating differences between groups carry an increasing level of uncertainty as the number of detects decreases. Therefore, for constituents that shared a detect percentage of less than 50 percent, soil associations and depths were combined since there was not convincing evidence to group them separately. When ANOVA was applied, a similar default decision, that significant differences were not found between these partitions, was made when no significant differences were demonstrated.

For those constituents where ANOVA was applied, the probability (p-value) that observed differences between the soil types or depths could be due to random variability in the data was calculated. This p-value was compared to a significance level of 0.05 which limits the potential false conclusion that the populations are not different (when they actually are) to one in 20 times. If the p-value for the comparison by soil type or depth was less than 0.05, the soil types or depths, respectively, were considered to be significantly different. Otherwise they were determined to be statistically similar to one another and consequently combined for summary statistics calculations.

Box and whisker plots offering a visual comparison of the soil associations are presented in Appendix C; Figure C-1, for inorganics, and Figure C-2 for organics. These were constructed following traditional protocol as follows:

- The height of the box represents the interquartile range (IQR). The IQR is the distance between the 25th and the 75th percentiles.
- The horizontal line in the box interior represents the median.
- The vertical lines issuing from the box extend to the minimum and maximum measured values (as long as these minimum and maximum values do not extend further from the box than a distance of 1.5 times the interquartile range).
- Individual data symbols are used for concentrations that exceed the whiskers.

These box and whisker plots reveal an obvious upward shift for many parameters in the Soil Association 1 concentrations. Thus, Soil Association 1 concentrations were determined to be handled separately without formal statistical testing. However, ANOVA comparing Soil Associations 2, 3, and 4 were performed with the results reported in Appendix C, Table C-7. This table presents conclusions of differences for both soil association and depth, since one of the positives of ANOVA is that it simultaneously considers the effects of all variables (in this case soil association group and depth) to avoid the effect of any individual effect from being confounded by the effect of other variables. Despite the inclusion of the depth probabilities during this analysis, the purpose of this ANOVA was to determine whether soil association groups could typically be combined, and the conclusion was they should not

(due to the large number of cases with significant soil association differences and visual confirmation from the box and whisker plots that the statistical differences appeared meaningful.

The box and whisker plots suggested that the greatest differences in soil association groups occurred between Soil Association 2 and the other two (3 and 4). Thus, another ANOVA was performed with these three soil association groups with the results presented in Appendix C, Table C-8. These ANOVA results demonstrate a significant difference for only one parameter, sodium. Since one expects to have a false alarm (indication of a significant difference when one does not actually exist) about one of 20 times when using a significance level of 0.05 with pure random data, and because sodium is not a critical inorganic in the background evaluation, the overall conclusion for background inorganics was made that soil associations 3 and 4 could be combined.

Thus, based on those parameters (in this case inorganics) with at least 50 percent detections, separate summary statistics for Soil Association 1, Soil Association 2, and Soil Associations 3 and 4 (combined) were calculated. That strategy was used for any parameters with fewer than 50 percent detections (including some inorganics and all organics).

Decisions by depth were determined by performing a second round of ANOVA on the data after subdivision into the three soil association groups. This ANOVA determined whether (for each of the three soil association groups, the surface and subsurface data would be combined or the two depth groups would be treated separately in the calculation of summary statistics. When there were fewer than 50 percent detections, the decision was made to combine the two depths since there was insufficient data to indicate that separate groupings were necessary. These depth groupings are provided in the summary statistics presented in Appendix C, Table C-9.

3.2.2 Establishing Statistical Distributions

An important characteristic of a data set is the underlying distribution of the data. For this evaluation, a distributional assumption will be used to determine the type of UTL to be calculated as a background threshold value. Two common distributions for tests involving environmental data are the normal distribution and the lognormal distribution. Typically, the Shapiro-Wilk test for normality is used to test adherence to these distributions.

The recommendations in the Technical Guide for ProUCL Version 4.0 (USEPA, 2007) in general suggest that the gamma distribution be considered. For some applications, such as in calculating an upper confidence limit of the mean, this makes sense. Currently, however, there is not an accepted protocol for calculating a UTL using an assumption of a gamma distribution. Thus, in this evaluation, any cases recommending the gamma will either revert to another parametric approach (e.g. the normal or lognormal distribution assuming the alternate parametric distribution is approved by the distributional test), or employ a nonparametric approach.

These recent recommendations (USEPA, 2007) also suggest that the distributional assumptions be tested on detected data only. That practice will be followed in this evaluation. All data, both detected and non-detected will be used in the calculation of the summary statistics.

3.2.3 Summary Statistics and Background Threshold Calculations

Summary statistics for the background data, by constituent, will be calculated. These summary statistics will include the mean, median, standard deviation, frequency of detection, and minimum and maximum values. Also, the UTL, the background threshold statistic, will be calculated and presented. The background threshold statistics will be calculated as a 95 percent/95 percent background UTL; that is, an upper bound (with 95 percent confidence) of the background 95th percentile. The calculation of the UTLs depends on the distributional assumption. For instance, the normal UTL can be calculated using the following equation:

$$UTL = \bar{x} + (K \times s)$$

where:

$\bar{x}$ = sample mean
K = tolerance factor
s = sample standard deviation

Besides the simple normal UTL, other approaches will be used (USEPA, 2007) which include calculating a lognormal UTL. For either the normal or lognormal UTLs, maximum likelihood estimates of proxy values for non-detects will be used when applicable. (No such proxies are necessary when all values are detected.) When neither the normal nor lognormal distributions are appropriate, nonparametric UTLs will be calculated using either traditional rank-based approach (with all detects) or the Kaplan-Meier approach (when non-detects are present).

For the other summary statistics, which will present useful descriptive information but without any inferential connotation (they will not be used in confidence comparisons with site data), non-detects will be handled via substitution of a proxy of half the detection limit, which has been a traditional method of handling non-detects.

Table 3-1
Summary of Background Soil Data Set
Background Study Work Plan

Summary of Samples Included in the Soil Background Data Set

WPNSTA Yorktown

Soil Association		Number of Samples	Analysis
	Surface Soils (0-6")		
#1	Bohicket, Johnston, Axis	5	inorganics
#2	Dogue, Pamunkey, Uchee	10	
#3	Emporia, Kempsville, Craven-Uchee Complex	10	
#4	Slagle, Emporia, Emporia Complex	11	
	Subsurface Soil Samples (1-3')		
#2	Dogue, Pamunkey, Uchee	1	Inorganics
#3	Emporia, Kempsville, Craven-Uchee Complex	1	

CAX

Soil Association		Number of Samples	Analysis
	CAX Surface Soils (0-6")		
#1	Bohicket, Johnston, Axis	10	SVOCs, pesticides/PCBs, inorganics
#2	Dogue, Pamunkey, Uchee	10	
#3	Emporia, Slagle, Craven-Uchee	10	
#4	Kempsville, Emporia, Craven-Unchee Complex, Emporia Complex	10	
	CAX Subsurface Soil Samples (6-24")		
#1	Bohicket, Johnston, Axis	10	SVOCs, pesticides/PCBs, inorganics, TOC
#2	Dogue, Pamunkey, Uchee	10	
#3	Emporia, Slagle, Craven-Uchee	10	
#4	Kempsville, Emporia, Craven-Unchee Complex, Emporia Complex	10	

Summary of Samples Excluded from the Soil Background Data Set

WPNSTA Yorktown

		Number of Samples	Analysis
	Railtoad Background Samples (0-6", Collected proximal to Main Road)	12	VOCs, SVOCs, pest/PCBs, explosives, inorganics
Soil Assocation			
	Surface Soils		
#5	Slagle, Bethera, Craven-Uchee	4	Inorganics
	Subsurface Soil Samples (collected at varying depths 3-33')		
#1	Bohicket, Johnston, Axis	3	inorganics
#2	Dogue, Pamunkey, Uchee	2	
#3	Emporia, Kempsville, Craven-Uchee Complex	1	
#4	Slagle, Emporia, Emporia Complex	3	
#5	Slagle, Bethera, Craven-Uchee	3	

SECTION 4

Sediment and Surface Water Background Evaluation

Background/reference surface water and sediment will be addressed on a site-specific basis, as CERCLA investigations of these media progress at CAX and WPNSTA Yorktown. Over time, this will allow for the incremental development of a more comprehensive background/ reference data set.

4.1 Background/Reference Data Set

For development of the background/reference data set a multi-step process is proposed as follows:

4.1.1 Step 1—Compile and Evaluate Existing Data

The existing background report for WPNSTA Yorktown will be reviewed to determine the amount and type of existing data for surface water and sediment. Surface water and sediment data were not collected as part of the 2001 background investigation conducted for CAX. Surface water and sediment data collected as part of the background investigation conducted for WPNSTA Yorktown will be reviewed for the following parameters of interest:

- Water body type (e.g., stream, pond, tidal estuary)
- Salinity (fresh, brackish, marine)
- Physical characteristics (e.g., grain size, pH, total organic carbon [TOC])
- Analytes
- Sample sizes
- Any associated biological or toxicological data

The surface water and sediment sample data for the WPNSTA Yorktown background study were collected from locations off of the base in pristine watersheds of the York River in 1994 (Appendix B), and comprise the following data:

- **Surface Water**
  - Shallow and deep (if water depth >3 feet) samples
  - Two freshwater ponds (6 total sample locations)
  - Four freshwater streams (5 total sample locations)
  - Two tidal streams (12 total sample locations [range of salinities])
  - Samples analyzed for VOCs, SVOCs, pesticides/ polychlorinated biphynels (PCBs), nitramine compounds, inorganics (total and dissolved), hardness, and TOC

- **Sediment**
  - Shallow (0-4 inches) and deep (4-8 inches) samples
  - Two freshwater ponds (6 total sample locations)
  - Four freshwater streams (5 total sample locations)
  - Two tidal streams (12 total sample locations [range of salinities])
  - Samples analyzed for VOCs, SVOCs, pesticides/PCBs, nitramine compounds, inorganics, TOC, pH, and grain size

In addition to the offsite data, the surface water/sediment data collected onsite from Soil Association 1 (saturated soil/sediment) during the previous background studies will be considered. Available site-specific reports (particularly Baseline Ecological Risk Assessment [BERA] reports) will also be reviewed for the purpose of compiling and evaluating background/reference surface water and sediment data that have been collected for specific site assessments. Once compiled, all of the existing data will be evaluated in terms of usability, and data gaps will be identified.

4.1.2 Step 2—Site-Specific Evaluation

As a specific site investigation of surface water and/or sediment is conducted to address potential aquatic exposures, the habitat type(s) present will be evaluated relative to the compiled background data base. If adequate data exist in the current background data base, the existing data will be used. If not, additional background data will be collected as part of the site-specific work plan for the particular aquatic habitat types that occur on the site. This would typically occur as part of follow-on (e.g., Step 4 of the Ecological Risk Assessment [ERA] process) WPs at later stages of the site evaluation process, where these data are more relevant to risk assessment and risk management.

4.1.3 Step 3—Background Data Base

Background/reference data from specific site evaluations will be added to the background data base, as appropriate. Care will be used to differentiate data that are reference only for a particular site or group of sites (such as data collected upgradient of a site or group of sites from a uni-directionally flowing stream) from data that are more broadly representative of background conditions (i.e., not directly influenced from any know CERCLA point source). This will allow the data base to be built up over time for use with future site assessments.

Selection of a background/reference sample location will include an evaluation to identify any potential point sources of contamination to ensure that constituent concentrations representative background conditions; Detections of anthropogenic constituents or elevated concentrations will be closely evaluated as prior to inclusion into a reference data base.

4.2 Statistical Analysis

The background data base will be utilized for comparison to site samples, and as they are collected, to site-specific reference samples. Statistical evaluations will be performed in accordance with USEPA and Navy guidance (USEPA, 2002b; Navy, 2003) for those

chemicals identified as COPCs during the media or food web evaluations. Statistical comparisons will include descriptive summaries of each data set (site, reference, and facility background), tests of the mean of the distribution (two sample t-tests, Wilcoxon rank sum tests, or Gehan tests), and tests of the right tail of the distribution (slippage and quantile tests). When censoring of the data sets is required (majority of samples were non-detects), proportional statistics (two-sample test of proportions) are performed. The significance level (α) will be conservatively set *a priori* at 0.05 for all tests. Disagreements between statistical tests are not uncommon during examinations regarding the relationship of site media to background or reference conditions, especially considering the potential for censored data (data sets with many non-detects), the small size of the data sets available, and the frequency of data sets which do not conform to the underlying univariate assumptions (normality, homogeneity of variance). Should disagreements between tests occur, a more detailed examination of the power and significance of each test and the distribution of the data within and between data sets will be performed.

SECTION 5

Groundwater Background Evaluation

Existing background groundwater data are available from both WPNSTA Yorktown and CAX previous background studies. The WPNSTA Yorktown background groundwater sampling locations (Appendix B) consist of 16 monitoring wells installed in the Columbia, Cornwallis Cave, and Yorktown-Eastover Aquifers. Samples were analyzed for Target Compound List (TCL) VOCs, TCL SVOCs, pesticides/PCBs, nitramine compounds, total and dissolved inorganics, nitrate, nitrite, total dissolved solids (TDS) and total suspended solids (TSS).

The CAX background groundwater study consisted of samples from 11 newly-installed monitoring wells and one well (BGGW01) from the WPNSTA Yorktown background study. Samples were analyzed for TCL VOCs, TCL SVOCs, pesticides/PCBs and total and dissolved inorganics. The existing data set provides only six samples from the Yorktown-Eastover aquifer which is insufficient to calculate UTLs. In addition, the chemical concentrations in groundwater are dynamic with fluctuations in concentrations that may result from attenuation of constituents, changes in water level elevations, and/or groundwater parameters (e.g., pH). Therefore a more current data set for evaluation of background groundwater quality will be collected as part of this study.

5.1 Sampling Rationale

The approach for background groundwater data is to obtain the greatest sample size by combining WPNSTA Yorktown and CAX as appropriate for the relevant aquifers, install three new background wells, and sample new and existing wells to establish a current background groundwater data set to support anticipated future site groundwater investigations. Increasing the sample size strengthens the statistical estimate representative of a background concentration (Navy, 1998) and allows for a more comprehensive screening for outliers.

The background groundwater study will focus on the shallow aquifer system: the Cornwallis Cave and Yorktown-Eastover aquifers. The extent of the Columbia aquifer is thin and saturated over limited, discontinuous portions of the facility (Figure 2-1), and there are few CERCLA sites potentially affecting the aquifer, therefore basewide background levels will not be established for the Columbia aquifer. Background/upgradient groundwater quality for CERCLA sites overlying the Columbia aquifer will be evaluated on a site-specific basis. Background concentrations will be established for natural and anthropogenic constituents based on samples from wells constructed in areas not impacted by potential point or non-point sources of contamination. Potential point sources include CERCLA sites, areas potentially influenced by underground storage tanks, or waste water discharge outfalls, or other industrial activities. Previous background investigations have established that existing background wells are installed in locations appropriate to characterize background conditions. The existing United States Geological Survey (USGS) study wells (Brockman et al, 1997) and the new well locations proposed for this study were

identified using facility knowledge to ensure locations are representative of background conditions. Additionally to ensure all background groundwater samples are reflective of background groundwater quality, in addition to natural and anthropogenic compound analysis for TCL SVOCs, metals, and pesticides, samples will be analyzed for VOCs and explosives, whereby the absence of detection is an indicator of acceptable background conditions.

To ensure a minimum of ten representative background samples are available for each aquifer, a total of 15 samples will be collected in the Cornwallis Cave aquifer and a total of 13 samples will be collected in the Yorktown-Eastover aquifer. The samples will be collected from the existing background and USGS wells except for three. Two new background wells are proposed for the Yorktown-Eastover aquifer (BGGW09A and BGGW10A), and one new well in the Cornwallis Cave aquifer (BGGW10) to ensure adequate sample size for statistical analyses. Additionally, the new wells will provide groundwater quality data on Croaker Flat, to supplement the existing wells installed on the Lackey Plain. The location of CERCLA sites and the existing and proposed new background monitoring wells are shown on Figures 5-1 (Cornwallis Cave aquifer) and 5-2 (Yorktown-Eastover aquifer). Table 5-1 provides a listing of all wells to be sampled, including aquifer and well designations.

The rationale for proposed new well locations is based on:

- **Spatial Extent.** Locations were chosen to provide spatial variability over the extent of the aquifer to evaluate the range of background concentrations in undeveloped and industrialized areas and still ensure concentrations potentially attributable to point-sources are identified and eliminated from the background data set.
- **IR Sites and Other Potential Point Sources of Contamination.** Locations were chosen upgradient or side-gradient of areas potentially impacted by potential CERCLA releases, and avoiding any other known or suspected non-site-specific point source of contamination.

The samples will be analyzed for natural and anthropogenic constituents consisting of: Target Analyte List (TAL) metals (total and dissolved) by method ILM05.4, TCL SVOCs by method SOM01.2, and TCL pesticides by method SOM01.2. In addition, samples will be analyzed for TCL VOCs by method SOM01.2 and explosives by method SW846 8330 to verify that the locations have not been impacted by unknown point sources. During purging, groundwater field parameters will be measured using a Horiba U-22 water quality meter and a flow through cell. These parameters comprise pH, dissolved oxygen (DO), temperature, specific conductivity, turbidity, oxidation/reduction potential (ORP) and salinity. Because mobility of metals in groundwater is highly dependent on the geochemistry of the aquifer, additional field testing will be conducted to accurately determine the oxidative state of the groundwater at each well location. Additional DO data will be collected using Chemets® colorimetric DO test kits. Ferrous iron concentrations, which also provide an indication of the oxidative state of groundwater, will also be measured in the field using HACH® ferrous iron kits. Prior to groundwater sampling, the wells will be redeveloped. The redevelopment will remove particles from the well screen and gravel pack that may have accumulated during the period of inactivity to ensure that the samples collected are representative of the aquifer chemical characteristics.

5.2 Data Evaluation

Background groundwater data will be evaluated with respect to detections of VOCs and explosives, and significantly elevated "outlier" concentrations to ensure that data are representative of background conditions to establish background threshold values. The VOC and explosives data serve as an indication of potential contamination. UTLs will not be established for VOCs or explosives. If the data indicate that a sample location has been influenced by potential non-anthropogenic contamination, these data will be excluded from the background data set. A desktop audit will be conducted for those locations with detections of VOCs and/or explosives to identify potential sources; audits will be conducted outside the scope of the background study.

5.3 Statistical Analysis

Overall, statistical approaches are dependent upon the distribution of the data and could vary from what is proposed in this work plan. The subsections below present the intended approach for calculating the groundwater UTLs. However, the Navy and EPA have agreed to review the data and decide together on the best statistical approach.

5.3.1 Aquifer-Specific Data Sets

To determine if background data from the Cornwallis Cave and Yorktown-Eastover aquifers represent similar populations of data and can be combined for calculating groundwater background summary statistics, ANOVA (refer to Section 3.2 for detailed discussion) and a visual review of box and whisker plots will be used to establish whether significant differences exist between the aquifers. For constituents with a detect percentage of less than 50 percent, professional judgment will be used to decide how their aquifer assignment (pooled or separate) will be assigned. A review of the plots and the available ANOVA results may suggest that concentrations should have a default of being combined or being separate. Typically, one would prefer to combine the results unless there is good evidence that keeping one or more aquifers separate is the appropriate choice (and data with a low frequency of detection typically does not offer good evidence of that).

5.3.2 Evaluation of Outliers

Data analysis and statistical testing may identify outliers in the background data set. Outliers are extreme elevated measurements that are sometimes referred to as "spurious" data because they are mathematically divergent from the main population of data. Outliers may arise from matrix interferences or errors in transcription, sampling technique, data coding, analytical methods, or instrument calibration.

Any mathematical outliers identified will be reviewed for potential exclusion from background calculations. Identification as a mathematical outlier does not necessarily mean that an elevated value is inappropriate for the background data set. Such values may be legitimate members of the upper tail of the background distribution. Nevertheless, to maintain a conservative background data set, mathematical outliers are sometimes excluded. Outlier tests will be applied to the collected data set and recommendations made,

as applicable, regarding outliers. If an outlier concentration is identified in a particular sample, then the data from that sample will be excluded from the background data set.

The mathematical outlier tests applied will be in accordance with applicable guidance. Methods such as Dixon's test will be applied. Most such tests, including Dixon's, assume that the remaining concentrations represent a normal distribution (after the potential outlier is excluded). This assumption is often not true in application, based on the Shapiro-Wilk test using a significance level of 0.05. An effort will be made to transform the data (USEPA, 2000) to obtain an improved adherence to normality.

A variety of potential transformations will be considered. These can include the square root transformation, the cubic root transformation, and the natural logarithmic transformation. The logarithmic transformation is a standard transformation in environmental applications, while the square root and cubic root offer options appropriate for intermediate levels of skewness in the data.

Each transformation will be evaluated for each potential outlier. The transformation offering the greatest p-value for normality will be chosen for each individual case. (Different transformations may be determined for each value considered as a potential outlier.) The reported mathematical status as an outlier will be reported based on the transformation of choice.

In addition to the statistical tests, the data will be plotted as probability plots. Probability plots graph the measured concentrations against those expected if the data (or the transformed data) are normally distributed. As such, the data points tend to form straight lines when the data resemble a normal distribution. Hence, these probability plots can be helpful in understanding whether the data should be evaluated as untransformed or transformed during the statistical evaluations. Primarily, they will be used as a visual check of which elevated values should be considered for potential exclusion from the background data set. A discussion of all outliers will be included in the Background Investigation Report.

5.3.3 Establishing Statistical Distributions

An important characteristic of a data set is the underlying distribution of the data. For this evaluation, a distributional assumption will be used to determine the type of UTL to be calculated as a background threshold value. Two common distributions for tests involving environmental data are the normal distribution and the lognormal distribution. Typically, the Shapiro-Wilk test for normality is used to test adherence to these distributions.

The recommendations in the Technical Guide for ProUCL Version 4.0 (USEPA, 2007) in general suggest that the gamma distribution be considered. For some applications, such as in calculating an upper confidence limit of the mean, this makes sense. Currently, however, there is not an accepted protocol for calculating a UTL using an assumption of a gamma distribution. Thus, in this evaluation, any cases recommending the gamma will either revert to another parametric approach (e.g., the normal or lognormal distribution assuming the alternate parametric distribution is approved by the distributional test), or employ a nonparametric approach.

These recent recommendations (USEPA, 2007) also suggest that the distributional assumptions be tested on detected data only. That practice will be followed in this evaluation. All data, both detected and non-detected will be used in the calculation of the summary statistics.

5.3.4 Summary Statistics and Background Threshold Calculations

Summary statistics for the groundwater background data, by constituent, will be calculated. These summary statistics will include the mean, median, standard deviation, frequency of detection, and minimum and maximum values. Also, the UTL, the background threshold statistic, will be calculated and presented. Calculation of UTLs is described in Section 3.

Table 5-1
Summary of Background Study
Wells to be Sampled

Aquifer	Well ID (listed basically left to right as they appear on Figures 5-1 or 5-2)	Existing Well? Yes	Existing Well? No
Cornwallis Cave (Figure 5-1)	CXBG3-MW01[1]	X	
	CXBG1-MW01[1]	X	
	58G57 (N3)[2]	X	
	58G58 (N4)[2]	X	
	58F120 (I3)[2]	X	
	BGGW07A[3]	X	
	BGGW07[3]	X	
	BGGW01[3]	X	
	BGGW06A[3]	X	
	58F110 (G3)[2]	X	
	58F115 (H3)[2]	X	
	BGGW03A[3]	X	
	BGGW05A[3]	X	
	58F105 (E3)[2]	X	
	BGGW10[4]		X
Yorktown-Eastover (Figure 5-2)	58G55 (N1)[2]	X	
	58G56 (N2)[2]	X	
	58F118 (I1)[2]	X	
	58F119 (I2)[2]	X	
	BGGW01A[3]	X	
	58F108 (G1)[2]	X	
	58F109 (G2)[2]	X	
	58F113 (H1)[2]	X	
	58F114 (H2)[2]	X	
	58F103 (E1)[2]	X	
	58F104 (E2)[2]	X	
	BGGW09A[4]		X
	BGGW10A[4]		X

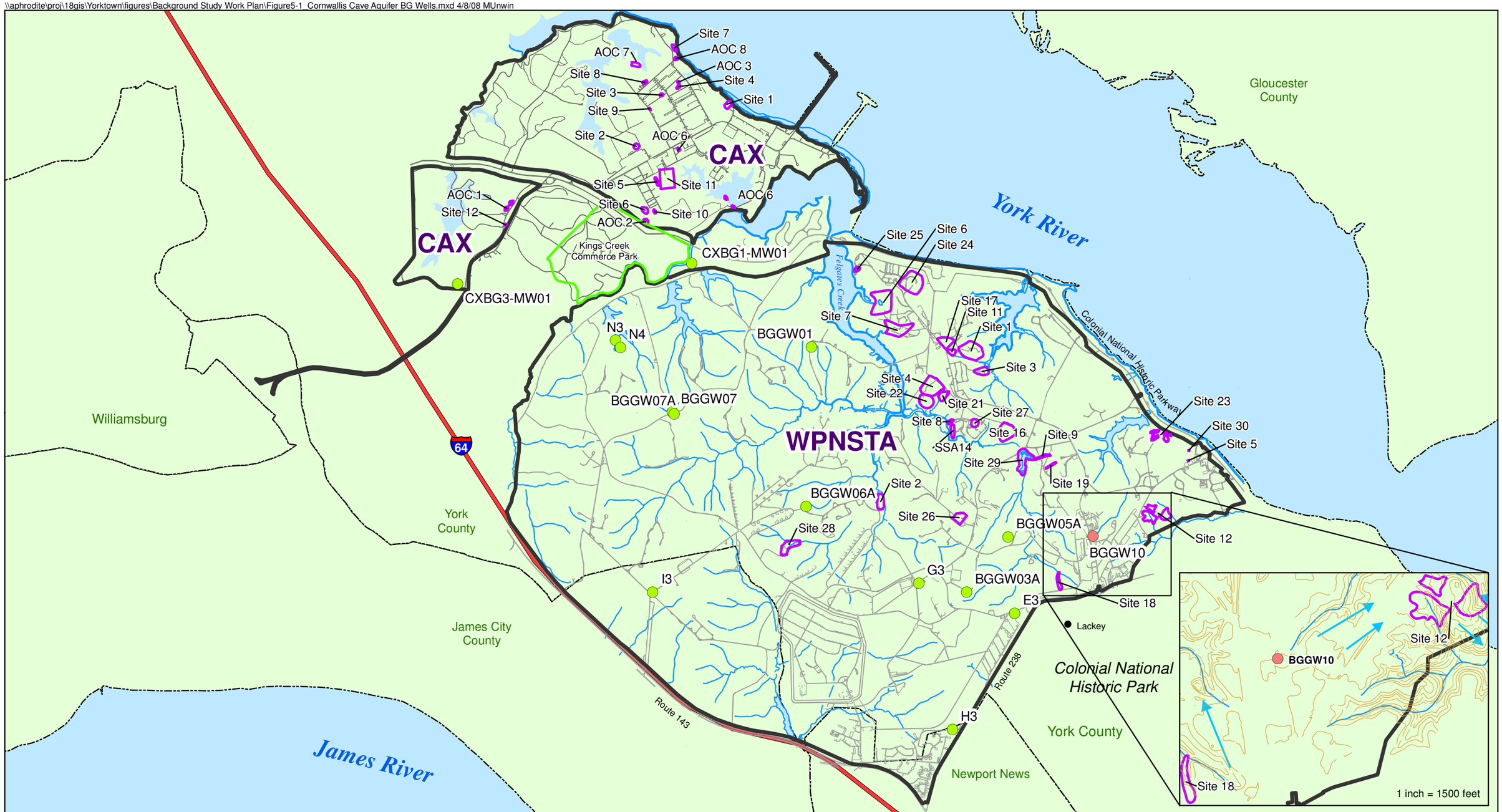
[1]Installed as part of the CAX Background Study (Baker, 2003). This is the well identification assigned by Baker for the study.

[2]Installed as part of the USGS Shallow Aquifer Study of Naval Weapons Station Yorktown (Brockman et. al, 1997). The USGS installed seven four-well clusters (labeled B, E, F, G, H, I, and N) and gave each well within the cluster its own unique identifier (e.g., 58F105), along with a cluster designation (e.g., E3). The cluster designation has been used on Figures 5-1 and 5-2 for brevity and less "clutter."

[3]Installed as part of the Yorktown Background Study (Baker, 1995). This is the well identification assigned by Baker for the study.

[4]New well to be installed as part of 2009 Background Study. The well identification number follows Baker's nomenclature for the Yorktown Background Study and starts sequentially where that study ended (i.e., Baker's study ended at BGGW08A).

\\aphrodite\proj\18gis\Yorktown\figures\Background Study Work Plan\Figure5-1_Cornwallis Cave Aquifer BG Wells.mxd 4/8/08 MUnwin



Legend

- Proposed New Well for Background
- Proposed Existing Well for Background
- Roads
- Shoreline and Water Bodies
- Contours
- Interstate 64
- City / County Boundaries
- Groundwater Flow Arrow (the surface water body to which flow was going)
- Site Boundaries
- Activity Boundaries
- Kings Creek Commerce Park

N

0 4,000 8,000 Feet

Figure 5-1
Cornwallis Cave Aquifer Background Wells
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

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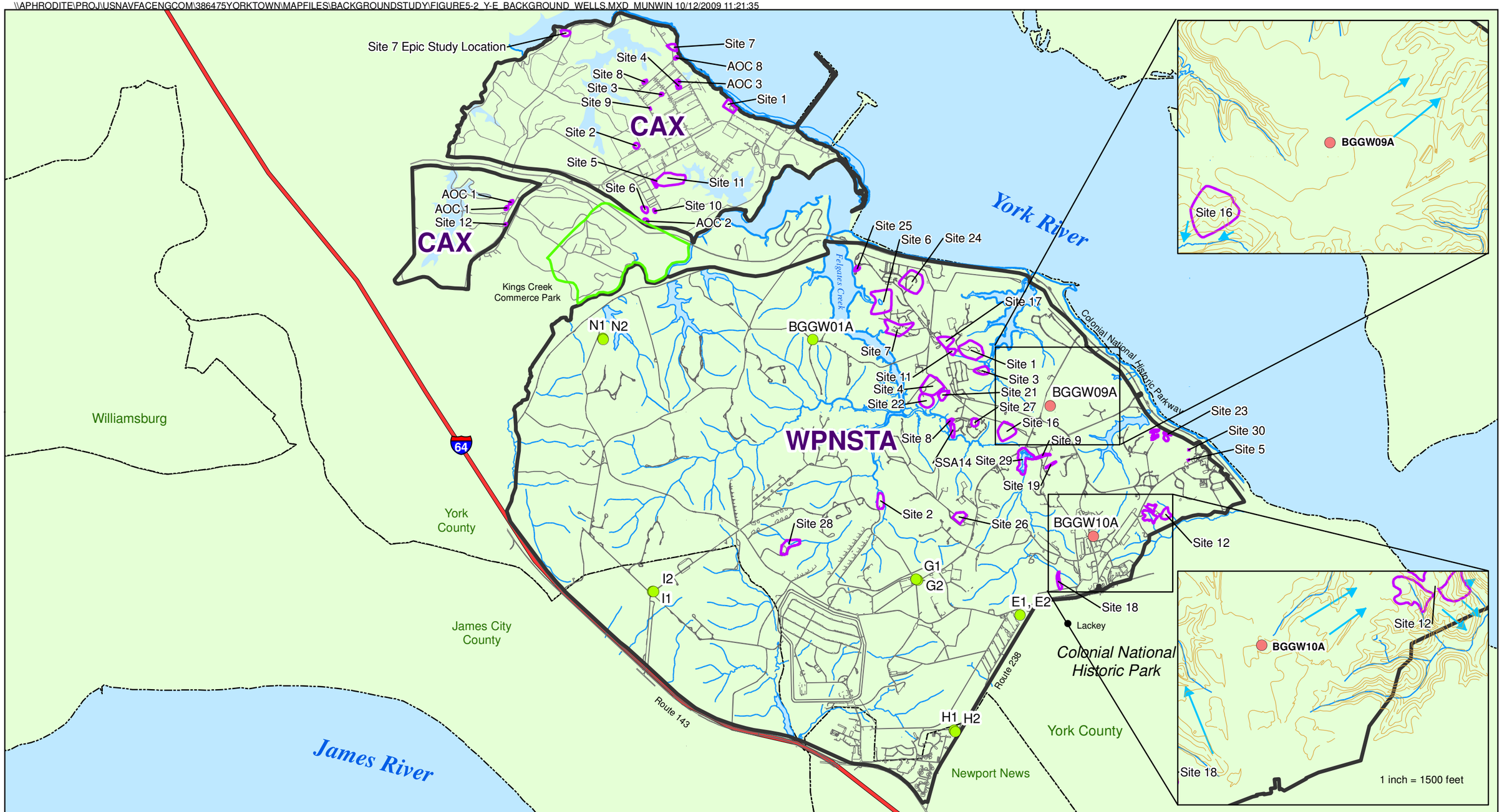
\\APHRODITE\PROJ\USNAVFACENGCOM\386475YORKTOWN\MAPFILES\BACKGROUNDSTUDY\FIGURE5-2_Y-E_BACKGROUND_WELLS.MXD MUNWIN 10/12/2009 11:21:35



Legend

- Proposed New Well for Background
- Proposed Existing Well for Background
- Roads
- Shoreline and Water Bodies
- Interstate 64
- Contours
- City / County Boundaries
- Groundwater Flow Arrow (the surface water body to which flow was going)
- Site Boundaries
- Activity Boundaries
- Kings Creek Commerce Park

N

0 4,000 8,000 Feet

Figure 5-2
Yorktown-Eastover Aquifer Background Wells
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

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SECTION 6

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Appendix A
Quality Assurance Project Plan

Final

Background Study
Quality Assurance Project Plan

Based on the Intergovernmental Data Quality Task Force Uniform Federal Policy for Quality Assurance Project Plans (Final Version 1, May 2005)

Naval Weapons Station Yorktown
Yorktown, Virginia
and
Cheatham Annex Site
Williamsburg, Virginia

Contract Task Order 148

July 2009

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Atlantic Division

Under the

LANTDIV CLEAN III Program
Contract N62470-02-D-3052

Prepared by

CH2MHILL

Virginia Beach, Virginia

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Attachments (included on CD-ROM)

Attachment 1 Laboratory Standard Operating Procedures, Field Standard Operating Procedures

Figures:

1-1, 5-1, 5-2 (located in Work Plan)

Abbreviations and Acronyms

ºC	degrees Celsius
CAX	Cheatham Annex
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLP	Contract Laboratory Program
COC	chain of custody
COPC	chemical of potential concern
DO	dissolved oxygen
DoD	Department of Defense
DQI	data quality indicator
EDD	electronic data deliverable
EIS	Environmental Information Specialist
ERP	Environmental Restoration Program
FTL	Field Team Leader
IDW	investigation-derived waste
IR	Installation Restoration
LQM	laboratory quality manual
MCL	maximum contaminant level
MDL	method detection limit
NAD	North American Datum
NAVFAC	Naval Facilities Engineering Command
Navy	United States Navy
ORP	oxidation reduction potential
PQO	project quality objective
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QL	quantitation limit
RBC	risk-based criteria
RPM	Regional Project Manager
SOP	standard operating procedure
SOW	scope of work
SSC-HW	Site Safety Coordinator—Hazardous Waste
SVOC	semivolatile organic compound

TBD	to be determined
UTL	upper tolerance limit
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USEPA	U.S. Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
WPNSTA	Naval Weapons Stations

Introduction

This site-specific Quality Assurance Project Plan (QAPP) is being submitted to provide a systematic data collection and analysis structure for the groundwater background study at Naval Weapons Station (WPNSTA) Yorktown, Yorktown, Virginia and the Cheatham Annex Site (CAX), Williamsburg, Virginia. The background study will be conducted as a single field mobilization. In accordance with the Uniform Federal Policy for QAPPs (UFP-QAPP, March 2005), the background study QAPP includes 37 worksheets that detail various aspects of the environmental investigation process and serves as guidelines for the field work. The site-specific laboratory and field standard operating procedures (SOPs) are located in Attachment 1 of this QAPP.

The United States Navy (Navy), Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic, is conducting the background study under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA work is being conducted with the United States Environmental Protection Agency (USEPA) Region III as the lead regulatory agency.

This document will help ensure that environmental data collected or compiled are scientifically sound, of known and documented quality, and suitable for intended uses. The laboratory information cited in this QAPP is for an analytical laboratory (Test America-Burlington) that is currently contracted to provide analytical services for this investigation.

The general background and physical setting of WPNSTA Yorktown and CAX are described in Section 2 of the Master Project Plans (Baker, 2005). A regional location map of the facilities is provided as Figure 1-1 of the background study work plan.

QAPP Worksheet #1
Title and Approval Page

Background Study
WPNSTA Yorktown, Yorktown, Virginia, and CAX, Williamsburg, Virginia

Document Title

U.S. Navy

Lead Organization

Marlene Ivester, CH2M HILL

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07/03/2008

Preparation Date (Day/Month/Year)

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Lead Organization's Project Manager Tom Kowalski/U.S. Navy	*Signature*
Printed Name/Organization/Date	
Approval Signatures	*Signature*
	Printed Name/Title/Date
	Approval Authority
Other Approval Signatures	*Signature*
	Printed Name/Title/Date

QAPP Worksheet #2
QAPP Identifying Information

1. Identify guidance used to prepare QAPP:

Uniform Federal Policy for Quality Assurance Project Plans (Parts 1 and 2A), Data Quality Objectives Process (EPA QA/G-4), Guidance for Quality Assurance Project Plans (EPA QA/G-5), Guidance for Data Quality Assessment (EPA QA/G-9), Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA October 1988).

2. Identify regulatory program:

USEPA Region III

3. Identify approval entity:

USEPA Region III

4. Indicate whether the QAPP is a generic or a project-specific QAPP. (underline one)

5. List dates of scoping sessions that were held:

4/25/07, 5/24/07, 6/7/07, 11/15/07, 2/29/08

6. List dates and titles of QAPP documents written for previous site work, if applicable:

Title	Approval Date
Not applicable	

7. List organizational partners (stakeholders) and connection with lead organization:

U.S. Navy (NAVFAC, Mid-Atlantic), Lead Agency; USEPA Region III, Lead Regulatory Agency; Department of Defense (DoD), Land Owner

8. List data users:

Same as above, and their contractors

9. If any required QAPP elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusion below:

N/A

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
Project Management and Objectives		
2.1 Title and Approval Page	- Title and Approval Page	#1
2.2 Document Format and Table of Contents	- Table of Contents	Intro/ ii
2.2.1 Document Control Format	- Document control	#2
2.2.2 Document Control Numbering System	- QAPP Identifying Information	#2
2.2.3 Table of Contents		ii-iv
2.2.4 QAPP Identifying Information		#2
2.3 Distribution List and Project Personnel Sign-Off Sheet	- Distribution List	#3
2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	- Project Personnel Sign-Off Sheet	#4
2.4 Project Organization		
2.4.1 Project Organizational Chart	- Project Organizational Chart	#5
2.4.2 Communication Pathways	- Communication Pathways	#6
2.4.3 Personnel Responsibilities and Qualifications	- Personnel Responsibilities and Qualifications Table	#7

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
2.4.4 Special Training Requirements and Certification	- Special Personnel Training Requirements Table	#8
2.5 Project Planning/Problem Definition	- Project Planning Session Documentation	#10
2.5.1 Project Planning (Scoping)	- Project Scoping Session Participants Sheet	#9
2.5.2 Problem Definition, Site History, and Background	- Problem Definition, Site History, and Background	S2/#10
	- Site Maps (historical and present)	Figures 1-1, 5-1, 5-2
2.6 Project Quality Objectives (PQOs) and Measurement Performance Criteria	- Site-Specific PQOs	#11
2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	- Measurement Performance Criteria Table	#12
2.7 Secondary Data Evaluation	- Secondary Data Criteria and Limitations Table	#13
2.8 Project Overview and Schedule	- Summary of Project Tasks	#14

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
2.8.1 Project Overview	- Reference Limits and Evaluation Table	#15
2.8.2 Project Schedule	- Project Schedule/ Timeline Table	#16
Measurement/Data Acquisition		
3.1 Sampling Tasks	- Sampling Design and Rationale	S2/#17
3.1.1 Sampling Process Design and Rationale	- Sample Location Maps	S2/#17
3.1.2 Sampling Procedures and Requirements	- Sampling Locations and Methods/ Standard Operating Procedures (SOP) Requirements Table	Figures 5-1, 5-3/ #13,#17,#18
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3.1.2.2 Sample Containers, Volume, and Preservation	- Field Quality Control Sample Summary Table	#20
3.1.2.3 Equipment/Sample Containers	- Sampling SOPs	Att.1, #21

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
Cleaning and Decontamination Procedures	- Project Sampling SOP References Table	Att.1, #21
3.1.2.4 Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures 3.1.2.5 Supply Inspection and Acceptance Procedures 3.1.2.6 Field Documentation Procedures	- Field Equipment Calibration, Maintenance, Testing, and Inspection Table	#22
3.2 Analytical Tasks		
3.2.1 Analytical SOPs	- Analytical SOPs	Att. 1, #23
3.2.2 Analytical Instrument Calibration Procedures	- Analytical SOP References Table	Att. 1, #23 #24
3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures	- Analytical Instrument Calibration Table	#25
3.2.4 Analytical Supply Inspection and Acceptance Procedures	- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
3.3 Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	- Sample Collection Documentation Handling, Tracking, and Custody SOPs - Example Chain-of-Custody (CoC)Form	Att. 1, #26&27 #27
3.4 Quality Control Samples 3.4.1 Sampling Quality Control Samples 3.4.2 Analytical Quality Control Samples	- QC Samples Table	#28
3.5 Data Management Tasks 3.5.1 Project Documentation and Records 3.5.2 Data Package Deliverables	- Project Documents and Records Table	#29
3.5.3 Data Reporting Formats 3.5.4 Data Handling and Management	- Analytical Services Table	#30
3.5.5 Data Tracking and Control	- Data Management	n/a
Assessment/Oversight		
4.1 Assessments and Response Actions 4.1.1 Planned Assessments	- Assessments and Response Actions	#31, #31-2
4.1.2 Assessment Findings and Corrective Action Responses	- Planned Project Assessments Table	#31

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
	- Assessment Findings and Corrective Action Responses Table	#32
	- Audit Checklist	#32-2
4.2 QA Management Reports	- QA Management Reports Table	#33
4.3 Final Project Report		#33
Data Review		
5.1 Overview		
5.2 Data Review Steps 5.2.1 Step I: Verification	- Verification (Step I) Process Table	#34
5.2.2 Step II: Validation 5.2.2.1 Step IIa Validation Activities 5.2.2.2 Step IIb Validation Activities	- Validation (Steps IIa and IIb) Process Table	#35
5.2.3 Step III: Usability Assessment 5.2.3.1 Data Limitations and Actions from Usability Assessment 5.2.3.2 Activities	- Validation (Steps IIa and IIb) Summary Table	#36
	- Usability Assessment	#37

QAPP Worksheet #2
QAPP Identifying Information

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Work Plan Section/ Worksheet#
5.3 Streamlining Data Review 5.3.1 Data Review Steps to Be Streamlined 5.3.2 Criteria for Streamlining Data Review 5.3.3 Amounts and Types of Data Appropriate for Streamlining		

QAPP Worksheet #3
Distribution List

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QAPP Worksheet #4-1
Project Personnel Sign-Off Sheet

Organization: U.S. Navy

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
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Chris Murray	Remedial Project Manager	(757) 445-6680		

QAPP Worksheet #4-2
Project Personnel Sign-Off Sheet

Organization: CH2M HILL

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Marlene Ivester	Activity Manager, CAX and Background Study Project Manager	757-873-1442 x34		
Adam Forshey	Deputy Activity Manager, Yorktown	757-671-6267		
Cecilia Landin	Deputy Activity Manager, CAX	757-671-6226		
Paul Favara	Program QA Officer	(352) 335-5877 x52396		
Anita Dodson	Program Chemist	757-671-6218		
Brett Doerr	Senior Consultant	757-671-6219		
Steve Beck	Health and Safety Officer	414-272-2426 x277		
Megan Morrison	Project Chemist	703-376-5053		
Rebekha Shaw	Environmental Information Specialist (EIS)	757-671-6279		
Toby Stewart	Field Team Leader (FTL)	225-663-5208		

QAPP Worksheet #4-3
Project Personnel Sign-Off Sheet

Organization: Subcontractors

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
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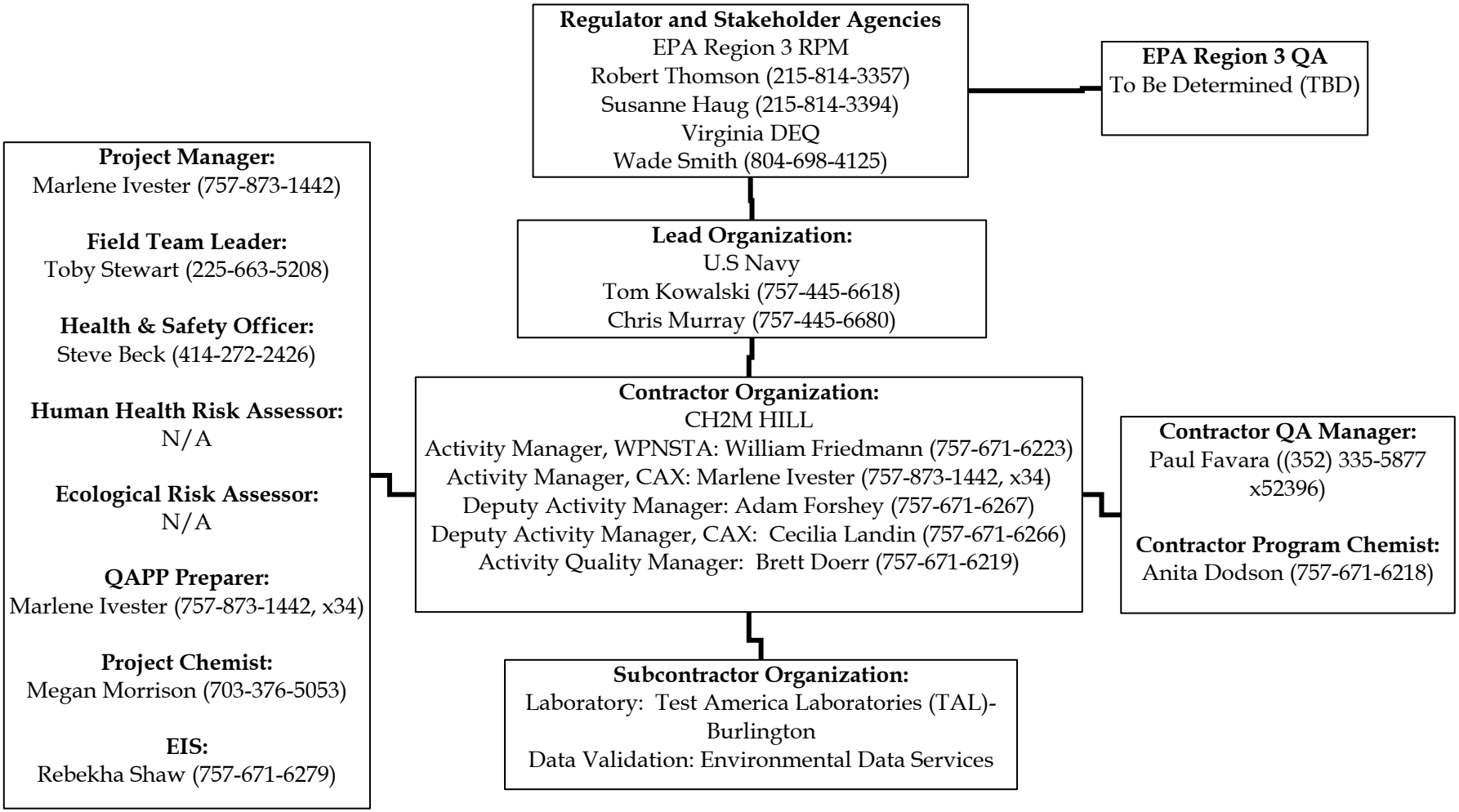
QAPP Worksheet #5
Project Organization Chart



QAPP Worksheet #6
Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Communication with Navy (lead agency)	Navy RPM for WPNSTA Yorktown	Tom Kowalski	(757) 445-6618	Primary point of contact for Navy; can delegate communication to other internal or external points of contact.
Communication with Navy (lead agency)	Navy RPM for CAX	Chris Murray	(757) 445-6680	Primary point of contact for Navy; can delegate communication to other internal or external points of contact.
Communication with USEPA Region III (lead regulatory agency)	RPM for WPNSTA Yorktown	Robert Thomson	(215) 814-3357	Primary point of contact for EPA; can delegate communication to other internal or external points of contact
Communication with USEPA Region III (lead regulatory agency)	RPM for CAX	Susanne Haug	(215) 814-3394	Primary point of contact for EPA; can delegate communication to other internal or external points of contact
Communication with VDEQ	RPM for WPNSTA Yorktown and CAX	Wade Smith	(804) 698-4125	Primary point of contact for VDEQ; can delegate communication to other internal or external points of contact

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Oversee Environmental Restoration Program (ERP) implementaiton	CH2M HILL Activity Manager for WPNSTA Yorktown	William Friedmann, P.G.	(757) 671-6223	Primary point of contact for stakeholder agency managers; can delegate agency communiccation to other contract staff, as appropriate.
Oversee Environmental Restoration Program (ERP) implementaiton	CH2M HILL Activity Manager for CAX	Marlene Ivester	(757) 873-1442, X34	Primary point of contact for stakeholder agency managers; can delegate agency communiccation to other contract staff, as appropriate.
Manage all Project Phases	CH2M HILL Project Manager for this project	Marlene Ivester	(757) 873-1442 x34	Primary modes of communication are phone, email, letter, document submittal; timing dependent on nature of communication and pre-defined schedules, as applicable and as requested by stakeholder agencies
QAPP changes in the field	FTL	Toby Stewart	(225) 663-5208	Documentation of deviations form the work plan made in field logbooks; deviations made only with approval for contractor project manager
Daily Field Progress Reports	FTL	Toby Stewart	(225) 663-5208	Field Team Leader will email or fax daily field progress reports to contractor project managers on a weekly basis; telephone communication with project managers on as-needed basis.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Data tracking from collection through upload to database	Environmental Information Specialist (EIS)	Rebekha Shaw	(757) 671-6279	EIS will track data from sample collection through upload to database, ensuring QAPP requirements are met by laboratory and field staff.
Reporting Analytical Lab Data Quality Issues	Laboratory Project Manager	Jim Madison, TAL-Burlington	(802) 923-1028	All QA/QC issues with project field samples will be reported by the second-tier subcontracted lab (Test America Burlington) to the Southern University, who will relay them to the EIS, Project Chemist, and Contractor Quality Assurance Officer within 2 business days.
Field and Analytical Corrective Actions	Contractor Program Chemist	Anita Dodson	(757) 671-6218	The need for corrective action for field and analytical issues will be determined by the Field Team Leader and/or Contractor Quality Assurance Officer.
Release of Analytical Data	Project Chemist	Megan Morrison	(703) 376-5053	No analytical data can be released until validation is completed and the Project Chemist has approved the release.

QAPP Worksheet #7
Personnel Responsibilities and Qualifications Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Tom Kowalski	Remedial Project Manager	U.S. Navy	Coordinates all environmental activities for/on Naval Weapons Station Yorktown
Chris Murray	Remedial Project Manager	U.S. Navy	Coordinates all environmental activities for/on CAX
William Friedmann, P.G.	Activity Manager, WPNSTA	CH2M HILL	Responsible for ERP at WPNSTA Yorktown
Marlene Ivester	Activity Manager, CAX	CH2M HILL	Responsible for ERP at CAX
Adam Forshey	Deputy Activity Manager, WPNSTA	CH2M HILL	Manages ERP projects; directs and oversees project staff
Cecilia Landin	Deputy Activity Manager, CAX	CH2M HILL	Manages ERP projects; directs and oversees project staff
Marlene Ivester	Project Manager	CH2M HILL	Directs and oversees staff, responsible for data evaluation process and has decision-making power.
Brett Doerr	Activity Quality Manager	CH2M HILL	Provides senior technical oversight
Anita Dodson	Program Chemist	CH2M HILL	Responsible for audits, corrective action, checks of QA performance
Megan Morrison	Project Chemist	CH2M HILL	Performs oversight of laboratory and data validators
Toby Stewart	Field Team Leader	CH2M HILL	Supervises field sampling and coordinates all field activities
Steve Beck	H&S Officer	CH2M HILL	Oversees H&S for field activities
Rebekha Shaw	EIS	CH2M HILL	Manages sample tracking; coordinates laboratory, data validator, and data management.

Name	Title/Role	Organizational Affiliation	Responsibilities
Jim Madison	Project Manager	TAL-Burlington	Coordinates between CH2M HILL and the analytical laboratory. Reports QA/QC issues.
Nancy Weaver	Senior Chemist	Environmental Data Services	Reviews analytical data.

QAPP Worksheet #8
Special Personnel Training Requirements Table

Project Function	Specialized Training—Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates[1]
Environmental Field Work at WPNSTA Yorktown and CAX	HAZWOPER 40-hour Training, 8 hour refreshers as applicable, CPR/First Aid Trained, Site safety coordinator-hazardous waste (SSC-HW)	Registered Training Organization	Project-specific	Toby Stewart, Mark Ost, others TBD	Field team leaders; Field team members; site safety coordinators/ all from CH2M HILL	CH2M HILL Human Resources Department

[1]If training records and/or certificates are on file elsewhere, document their location in this column. If training records and/or certificates do not exist or are not available, then this should be noted.

QAPP Worksheet #9-1
Project Scoping Session Participants Sheet

Project Name: WPNSTA Yorktown/CAX Background Study

Projected Date(s) of Sampling: Spring 2009

Site Name: Various Sites

Project Manager: Marlene Ivester

Site Location: Naval Weapons Station Yorktown, CAX

Date of Session: May 24, 2007

Scoping Session Purpose: Discussing the writing of the work plan

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Laura Cook	Deputy Activity Manager	CH2M HILL	757-671-6214	Laura.cook@ch2m.com	Overseeing UFP-QAPP production
Marlene Ivester	Project Manager	CH2M HILL	757-873-1442 x34	Marlene.ivester@ch2m.com	Overseeing UFP-QAPP production
Ben Francisco	Hydrogeologist	CH2M HILL	757-671-6220	Ben.francisco@ch2m.com	UFP-QAPP production
Megan Morrison	Project Chemist	CH2M HILL	401-619-2657	Megan.hilton@ch2m.com	UFP-QAPP production

Comments/Decisions: Megan and Ben will fill in the QAPP worksheets. Megan will procure laboratories and data validators. Marlene and Laura will be available for questions and information.

Action Items:

Consensus Decisions:

QAPP Worksheet #9-2
Project Scoping Session Participants Sheet

Project Name: WPNSTA Yorktown/CAX Background Study

Projected Date(s) of Sampling: Spring 2009

Site Name: Various Sites

Project Manager: Marlene Ivester

Site Location: Naval Weapons Station Yorktown, CAX

Date of Session: June 7, 2007

Scoping Session Purpose: Review and discuss QAPP requirements

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Ben Francisco	Hydrogeologist	CH2M HILL	757-671-6220	Ben.francisco@ch2m.com	UFP-QAPP production
Megan Morrison	Project Chemist	CH2M HILL	401-619-2657	Megan.hilton@ch2m.com	UFP-QAPP production

Comments/Decisions: Reviewed status of QAPP. Megan will work with laboratories and data validator for completion of worksheets.

Action Items:

Consensus Decisions:

QAPP Worksheet #9-3
Project Scoping Session Participants Sheet

Project Name: WPNSTA Yorktown/CAX Background Study

Projected Date(s) of Sampling: Spring 2009

Site Name: Various Sites

Project Manager: Marlene Ivester

Site Location: Naval Weapons Station Yorktown, CAX

Date of Session: November 15, 2007

Scoping Session Purpose: Presentation of Background Study Recommendations to WPNSTA Tier I Partnering team

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Linda Cole, P.E.	Remedial Project Manager	U.S. Navy	757-444-3826	Linda.cole@navy.mil	Navy Representative
Robert Thompson	Remedial Project Manager	U.S. EPA	215-814-3357	Thompson.bob@epa.gov	EPA Representative
Wade Smith	Remedial Project Manager	VDEQ	804-698-4125	wmsmith@deq.virginia.gov	VDEQ Representative
Donna Caldwell	Activity Manager	CH2M HILL	757-873-1442 ext. 28	Donna.Caldwell@ch2m.com	Overseeing UFP-QAPP production
Rebekah Ives	Staff Scientist	CH2M HILL	757-671-6235	Rebekah.Ives@ch2m.com	Meeting Recorder
Ben Francisco	Hydrogeologist	CH2M HILL	757-671-6220	Ben.francisco@ch2m.com	UFP-QAPP production
Bill Kappleman	Project Scientist	CH2M HILL	703-376-5152	William.Kappleman@ch2m.com	Technical Support

Comments/Decisions: Provided Team with recommendations for background study.

Action Items: Ben and Bill to address uncertainties in application of new background levels and potential for identification of new sources.

Consensus Decisions:

QAPP Worksheet #9-4
Project Scoping Session Participants Sheet

Project Name: WPNSTA Yorktown/CAX Background Study

Projected Date(s) of Sampling: Spring 2009

Site Name: Various Sites

Project Manager: Marlene Ivester

Site Location: Naval Weapons Station Yorktown, CAX

Date of Session: February 29, 2008

Scoping Session Purpose: Finalization of background groundwater sampling approach.

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Donna Caldwell	Activity Manager	CH2M HILL	757-873-1442 ext. 28	Donna.Caldwell@ch2m.com	Overseeing UFP-QAPP production
Ben Francisco	Hydrogeologist	CH2M HILL	757-671-6220	Ben.francisco@ch2m.com	Work Plan Production
Laura Cook	Deputy Activity Manager	CH2M HILL	757-671-6214	Laura.cook@ch2m.com	Overseeing UFP-QAPP production

Comments/Decisions: Background groundwater sampling will incorporate selected wells at both WPNSTA and CAX.

Action Items: Ben will update the work plan and QAPP to reflect most current sampling rationale.

Consensus Decisions:

QAPP Worksheet #10
Problem Definition

The Problem to be Addressed by the Project

Constituent concentrations attributable to contamination resulting from releases at Installation Restoration (IR) sites must be differentiated from constituent concentrations attributable to background in order to make appropriate risk management and remedial decisions.

The purpose of this investigation is to establish representative background concentrations in groundwater that can be compared to site-specific data to assess whether constituents detected at a particular IR site are attributable to site-specific release(s) or attributable to background. According to the *Navy Interim Final Policy on the Use of Background Chemical Levels* (NAVFACENGCOM, 2000) and EPA *Role of Background in the CERCLA Cleanup Program* guidance (EPA, 2002) the risk management and remedial actions for CERCLA sites should account for the influence of natural and anthropogenic background. Both guidance documents indicate cleanup goals for CERCLA site constituents are not set below the corresponding background concentrations. Therefore, the broader objective of the background investigation is to help ensure that risk management and remedial decisions are appropriately made to focus remediation on chemicals of potential concern (COPCs) associated with site-specific releases and to not include cleanup levels within the range of background concentrations.

The Environmental Questions Being Asked

- What are the background constituents for groundwater at the facility?
- What is the general range of concentrations for the background constituents?
- What is the 95% upper tolerance limit (UTL) for the background constituents?

Observations from any Site Reconnaissance Reports

No known or suspected point sources of contamination exist at the background sample locations.

A Synopsis of Secondary Data or Information from Site Reports

Information regarding the purpose of and methods for evaluating background can be found in the following reference documents:

- USEPA. 2002. *Role of Background in the CERCLA Cleanup Program.* Office of Solid Waste and Emergency Response and Office of Emergency Remedial Response, OSWER 9285.6-07P. April
- NAVFACENGCOM. 2000. *Navy Interim Final Policy on the Use of Background Chemical Levels*
- NAVFACENGCOM. 2004. *The Guidance for Environmental Background Analysis, Volume III: Groundwater.* April.

The Possible Classes of Contaminants and the Affected Matrices

This investigation is not evaluating the release of contaminants. The purpose is to collect sufficient data to calculate background concentrations for groundwater at WPNSTA and CAX. There are various potential classes of contaminants (e.g., semivolatile organic compounds [SVOCs], metals, and pesticides) in the groundwater that may be present at background concentrations at WPNSTA Yorktown and CAX. Because there are also naturally occurring, as well as potential non-point sources of constituents that are in the same classes as contaminants, background concentrations of these constituents are to be determined. Common constituents potentially present as site-specific contaminants as well as part of natural and/or anthropogenic background groundwater are:

- **SVOCs.** Can be associated with vegetation decomposition, petroleum hydrocarbons in air pollution, etc.
- **Pesticides.** Can be broadcast applied to control animal and vegetative pests
- **Metals (Inorganics).** Part of the natural composition of all rocks, soil, and groundwater. Can also be derived from broad sources such as air pollution and pesticide application.

In addition to the above analytes, samples will also be collected for volatile organic compounds (VOCs) and explosives. These constituents can be associated with point-sources of contamination and will help assess if the sampling locations are representative of background conditions.

The Rationale for Inclusion of Chemical and Non-chemical Analyses

See previous response.

Information Concerning Various Environmental Indicators

This study will provide the background threshold that will serve as the benchmark to assess environmental changes.

Project Decision Conditions ("If..., then..." Statements)

The study decisions will be made incorporating field observations, analytical data, and statistical analysis. The following decisions will be made during the study: If the data from the Cornwallis Cave and Yorktown Aquifers demonstrate similar chemical concentrations and statistics (similar means, medians, graphical plots, etc.), then the data sets will be combined to increase the power of the statistical analysis.

If there is evidence of potential point source of contamination observed at the background sampling locations during the field investigations, then the location will be altered (to avoid influence from the potential point source) or eliminated from the sampling.

If VOCs or explosives are detected, then the sample data will be further evaluated to determine if this location is representative of background conditions.

If the outlier testing indicates that a concentration is a mathematical outlier, then the constituent that is identified as the outlier will be excluded from the background data set.

QAPP Worksheet #11
Project Quality Objectives/Systematic Planning Process Statements

Who will use the data?

Data will be used by the Navy (and its contractors) and the other stakeholder agencies.

What will the data be used for?

The data from the Background Study will be used to establish representative background concentrations in groundwater that can be compared to site-specific data to assess whether constituents detected at a particular IR site are attributable to site-specific release(s) or attributable to background. This information, in turn, will be used to help make risk management and remedial decisions for IR sites.

What type of data is needed? (Target analytes, analytical groups, field screening, onsite analytical or offsite laboratory techniques, sampling techniques)

- A spatially (horizontally and vertically) and numerically robust data set (i.e., minimum of 10 samples per vertical horizon collected across facility).
- Groundwater samples will be analyzed for Total and Dissolved Metals, Cyanide, Pesticides and PCBs, VOCs, Explosives and SVOCs.
- Groundwater samples will be collected using low-flow techniques.
- Refer to Worksheet 20 for more details on analytical methods and sample numbers.
- All groundwater samples will be field analyzed for water quality parameters prior to sampling comprising dissolved oxygen (DO), oxidation reduction potential (ORP), specific conductance, pH, turbidity, temperature, and salinity.
- All sampling/field activities and analytical procedures will adhere to the SOPs for laboratory and sampling techniques provided in Attachment 1 and referenced in Worksheets 21 and 23.

How "good" do the data need to be in order to support the environmental decision?

The SVOC, VOC, explosive, pesticide, PCBs, and metals data will be of the quantity and quality necessary to provide technically sound and defensible statistical analysis of the facility background conditions. The quality of the data will be assessed by established criteria for performance measures. Laboratory methods will meet CERCLA, EPA Region III, and Navy guidance. In order to ensure data completeness, comparability, representativeness, sensitivity, accuracy/bias, and precision, the SVOC, VOC, explosive, pesticide, and metals data will be validated by a third-party validator (Environmental Data Services) taking guidance and qualifiers from *Region III Modifications to the National Functional Guidelines for Organic Data Review: Multi-Media, Multi-Concentration* (September 1994) and *Region III Modifications to the National Functional Guidelines for Inorganic Analysis*

(April 1993) and analytical methods as appropriate. See Worksheet 36 for more information on validation practices.

Because background data are used in conjunction with risk evaluations, the laboratory reporting limits for the background constituent concentrations will be below risk-based screening criteria, where possible. Where this is not possible due to exceptionally low risk-based screening criteria (see Worksheet 15), project stakeholders acknowledge that uncertainty exists.

How much data are needed? (Number of samples for each analytical group, matrix, and concentration)?

The data will be of the quantity and quality necessary to provide technically sound and defensible assessments of the background conditions. The background study will target a minimum of 10 samples per potential data grouping. These potential data groupings are: (1) Columbia Aquifer groundwater, (2) Cornwallis Cave Aquifer groundwater, and (3) Yorktown Aquifer groundwater. Additional samples will be collected to account for the possibility of sample container breakage, rejected data, or outlier elimination. If possible, the individual groundwater data groups will be combined to generate a more robust dataset. This determination will be made based on statistical analysis, which will be documented in the background investigation report.

Where, when, and how should the data be collected/generated?

The data will be collected as detailed in Section 2 of the work plan and following the SOPs provided in Attachment 1 and referenced in Worksheets 21 and 23.

Who will collect and generate the data?

On behalf of the Navy, CH2M HILL Field staff will collect the samples and ship them to the analytical laboratory. Test America Laboratories (TAL)-Burlington, subcontracted through Southern University, will analyze the samples. The analytical data will be validated by Environmental Data Services.

In some cases, field data, such as water quality parameters (e.g., DO, turbidity) and physical parameters (e.g., water levels) will be generated.

How will the data be reported?

A Background Report will be prepared that will include summaries of activities conducted, an evaluation of data collected with respect to the investigation objectives, and conclusions and recommendations.

How will the data be archived?

The data will be archived in accordance with federal law. Electronic data files are uploaded into a centralized database for Navy projects (EnDat). Hardcopies of the data are warehoused. At the end of the project, archived data will be returned to the Navy.

QAPP Worksheet #12-1
Measurement Performance Criteria Table

QC Sample	Analy-tical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	VOCs	One per 10 field samples	Precision	Should meet RPD criteria of 25%	S&A
Equipment Blank		One per day	contamination	Same as method blank	S&A
Ambient Field Blank		One per week of sampling	contamination	Same as method blank	S&A
Trip Blank		One per cooler	contamination	Same as method blank	S&A
Method Blank		One per batch of 20 or fewer samples	contamination/ bias	Should meet all internal standard and DMC criteria; all target compounds < ½ QL except methylene chloride, acetone, and 2-butanone which should be < the QL	A
Instrument blank		as necessary, after high concentration sample	contamination	Same as method blank	A
Deuterated Monitoring Compounds and Surrogates		Each sample	accuracy	Surrogate recovery should meet % recovery criteria in BR-MV-006 Table 4	A
MS/MSD		One pair per 20 samples	precision/ accuracy	Should meet % recovery and RPD criteria in BR-MV-006 Table 4	A
Storage Blank		1x per 12 hour window	contamination/ bias	same as method blank	A

[1]Reference number from QAPP Worksheet #21.

[2]Reference number from QAPP Worksheet #23

QL = Quantitation Limit

MS/MSD = Matrix Spike/ Matrix Spike Duplicate

RPD = Relative Percent Difference

QAPP Worksheet #12-2
Measurement Performance Criteria Table

QC Sample	Analy-tical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS/MSD	EXPLO	One pair per 20 samples	Precision	RPD ≤ 30%; %R within limits; see Table 1 of BR-LC-003	A
Surrogates		Per sample	Precision	%R within limits; see Table 1 of BR-LC-003	A
Equipment Blank		One per day	Accuracy/ Bias	Same as method blank	S&A
Ambient Field Blank		One per week of sampling	Accuracy / Bias	Same as method blank	S&A
Method Blanks		1x per 12 hour window	Accuracy/ Bias	Target analyte < QL	A
Laboratory control standards		One per batch of 20 samples	Accuracy/ Bias	Laboratory acceptance limits, see Table 1 in SOP	A
Laboratory replicates		One per 10 samples	Sensitivity / Representativeness	RSD ≤ 50% for analytes detected ≤ QL; RSD ≤20% at the QL	A
Second source laboratory standards		Per sample	Comparability	Laboratory acceptance limits; see BR-LC-003	

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23
RPD = Relative Percent Difference
MS/MSD = Matrix Spike/Matrix Spike Duplicate
LCS = Laboratory Control Sample
SOP = Standard Operating Procedure
QL = Quantitation Limit
RSD = Relative Standard Deviation

QAPP Worksheet #12-3
Measurement Performance Criteria Table

QC Sample	Analy-tical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
METAL and FMETAL (SW-846 6020 and SW-846 7470A)					
Equipment Blank	METAL / FMETAL	One per day	contamination	All analytes should be < QL	S&A
Ambient Field Blank		One per week of sampling	contamination	All analytes should be < QL	S&A
Field Duplicate		One per 10 field samples	precision	Should meet RPD criteria of 25% for water/groundwater	S&A
Initial Calibration Blank		Beginning of analytical sequence after ICV	contamination / bias	All analytes should be < QL	A
Calibration Blank		Beginning of sample run, after every 10 samples, and at end of the sequence	contamination / bias	All analytes should be < QL	A
Preparation blank		One per digestion batch	contamination / bias	All analytes should be < QL	A
Interference Check Sample		At the beginning of the analytical run	accuracy/ bias	Should be within ± 20% of the analyte's true value	A
Matrix Spike		One per 20 samples	accuracy/ bias	Spike recovery limits should be between 80-120%	S&A
Laboratory Control Sample		One per 20 samples	accuracy	Spike recovery limits should be between 80-120%	A

QC Sample	Analy-tical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Laboratory Duplicate	METAL / FMETAL	One per 20 samples	precision/ accuracy	RPD of 20%	A
Post Digestion Spike		One per 20 samples	Accuracy / bias	% recovery within 75-125%	A
Serial Dilution		One per group of samples	precision/ accuracy	Should agree within 10% of the undiluted sample	A
CYANIDE (SW-846 9012B)					
Equipment Blank	CYANIDE	One per day	contamination	< QL	S&A
Ambient Field Blank		One per week of sampling	contamination	< QL	S&A
Field Duplicate		One per 10 field samples	precision	Should meet RPD criteria of 25% for water/groundwater	S&A
Initial Calib. Blank		After ICV	contamination / bias	±10 ug/L	A
Continuing Calib. Blank		Every 10 samples and at the end of the analytical run	contamination / bias	±10 ug/L	A
Method Blank		Each distillation batch of 20 samples or less	contamination / bias	< ½ QL	A
Matrix Spike		One per 20 samples	accuracy/ bias	Spike recovery limits should be between 85-115%	S&A
Laboratory Duplicate		One per 20 samples	precision/ accuracy	RPD of 20%	A

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23
EPA = U.S. Environmental Protection Agency
QL = Quantitation Limit
RPD = Relative Percent Difference

QAPP Worksheet #12-4
Measurement Performance Criteria Table

QC Sample	Analy-tical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Equipment Blank	PEST/ PCB	One per day	contamination	Same as method blank	S
Ambient Field Blank		One per week of sampling	contamination	Same as method blank	S
Field Duplicate		One per 10 field samples	precision	Should meet RPD criteria of 25% for water/groundwater	S&A
Method Blank		One per extraction batch or group of 20 or fewer samples	contamination / bias	All target compounds should be < ½ QL; Surrogates should adhere to criteria in Table 2 of BR-GC-006 and Table 1A of BR-GC-005	A
Laboratory Control Sample		One per extraction batch or group of 20 or fewer samples	accuracy	Percent recovery criteria in Table 2 of BR-GC-006 and Table 1A of BR-GC-005	A
Surrogate Spikes		Each sample	accuracy	Percent recovery criteria in Table 2 of BR-GC-006 and Table 1A of BR-GC-005	A
Matrix spike/Matrix spike duplicate		One per extraction batch or group of 20 or fewer samples	precision/ accuracy	Percent recovery criteria in Table 2 of BR-GC-006 and Table 1A of BR-GC-005	S&A

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23
EPA = U.S. Environmental Protection Agency
QL = Quantitation Limit
RPD = Relative Percent Difference
RT = Retention Time

QAPP Worksheet #12-5
Measurement Performance Criteria Table

QC Sample	Analy-tical Group[1]	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Equipment Blank	SVOC	One per day	contamination	Same as method blank	S
Ambient Field Blank		One per week of sampling	contamination	Same as method blank	S
Field Duplicate		One per 10 field samples	precision	Should meet RPD criteria of 25% for water/groundwater	S&A
Method Blank		One per extraction batch of 20 or fewer samples	contamination/ bias	No analyte > ½ QL except for common laboratory contaminants	A
Surrogate standards		Each sample	accuracy	%R criteria outlined in BR-MS-001 Table 5	A
Matrix spike/Matrix spike duplicate		One per extraction batch of 20 or fewer samples	precision/ accuracy	%R and RPD criteria outlined in BR-MS-001 Table 5	S&A

[1]Reference number from QAPP Worksheet #21.

[2]Reference number from QAPP Worksheet #23

MS/MSD = Matrix Spike/Matrix Spike Duplicate
QL = Quantitation Limit
RPD = Relative Percent Difference

QAPP Worksheet #13
Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Aquifer Data	USGS, Geohydrology of the Shallow Aquifer System, Naval Weapons Station Yorktown, Yorktown, Virginia, 1997	USGS, Lithologic data on the shallow aquifer system, 1995, 1996	To guide the selection of sampling locations for this investigation.	Data used for planning purposes only
Background Groundwater Data	Baker, Background Investigation Naval Weapons Station Yorktown Yorktown, Virginia Cheatham Annex Site Williamsburg, Virginia, September 2003	Baker, VOCs, SVOCs, pesticides/PCBs, total and dissolved inorganics, 2001	To guide the selection of sampling locations for this investigation.	Due to the dynamic nature of groundwater concentrations, this data will not be incorporated into the background data set.
Background Groundwater Data	Baker, Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin Naval Weapons Station Yorktown, Yorktown, Virginia, July 1995	Baker, VOCs, SVOCs, pesticides/PCBs, nitramine compounds, metals, total dissolved solids, total suspended solids, nitrates, 1994	To guide the selection of sampling locations for this investigation.	Due to the dynamic nature of groundwater concentrations, this data will not be incorporated into the background data set.

QAPP Worksheet #14
Summary of Project Tasks

Sampling Tasks

The SOPs for the sampling tasks are provided in Attachment 1 and referenced in Worksheets 21 and 23.

1. Utility clearance for new monitoring well installation.
2. Install 3 new monitoring wells at selected locations at WPNSTA Yorktown. Monitoring well locations are shown on Figures 5-1 and 5-2 of the Work Plan.
3. Develop the three newly installed monitoring wells. Redevelop the 25 selected existing monitoring wells.
4. Monitor groundwater quality parameters of temperature, pH, DO, turbidity, ORP, salinity, and specific conductance.
5. Collect 28 groundwater samples from monitoring wells at various locations around the base.
6. Decontaminate reusable equipment that comes in contact with environmental samples.
7. Horizontally and vertically locate newly installed monitoring wells. All survey data will be correlated to the Virginia State Plane and North American Datum 1983 (NAD 83) coordinate systems.
8. The background investigation focuses on those areas not anticipated to have been impacted by IR Site activities; however, soil and groundwater will be containerized during the investigation as a precaution.

Analysis Tasks

1. The laboratory will process, prepare, and analyze groundwater samples according to Contract Laboratory Program (CLP) and SW846 methodologies.
2. Groundwater samples will be analyzed using the methods below:
    i. SVOCs by SW-846 8270C
    ii. Low-Level VOCs by SW-846 8260B
    iii. Explosives by SW-846 8330
    iv. Pesticides and PCBs by SW-846 8081A and 8082
    v. Total Metals/CN and Filtered Metals by SW-846 6020/7470A/9012B

vi. Significant interferences due to salinity, if present, will necessitate analysis of sodium, potassium, magnesium, iron, and calcium by ICP-AES (SW-846 6010B) instead of ICP-MS (SW-846 6020).

Quality Control Tasks

1. Implement SOPs for field and laboratory activities being performed.
2. Quality control (QC) samples are described on Worksheet #20 and 28.

Secondary Data

1. N/A, See Worksheet #13.

Data Management Tasks

1. Analytical data will be entered into an Electronic Data Deliverable (EDD). The format is shown below in Table 1.
2. The EDD will be placed in CH2M HILL's Endat system Oracle database and in Navy IR Information Solution (NIRIS) database after validation.

Documentation and Records

1. See Worksheet #29.

Assessment/Audit Tasks

1. See Worksheets #31 and #32.

Data Review Tasks

1. See Worksheets #35 and #36 for data validation tasks.
2. See Worksheet #37 for data usability assessment tasks.

TABLE 1
Analytical Data Electronic Deliverable

CH2M HILL SNEDD Format			
Field Name	**Field Format**	**REQ**	**Field Description**
Contract_ID	A13	R	Contract ID assigned by Division Contracting Office: format is UIC (6 char.) + FY (2 char.) + FAR code (1 char.) + Number (4 char.). (e.g. D459559365800)
DO_CTO_Number	A4	R	CTO or TO # assigned by Navy. (e.g. CTO-12 = 0012)
Phase	A8	RA	Task Phase, SubTask Number or Annual Quarter. (e.g. QTR1)
Installation_ID	A20**	R	Unique identifier for installation. (e.g. WHIDBEY)
Sample_Name	A50	R	CH2M HILL Sample ID (from Chain Of Custody).
CH2M_Code	A4*	R	CH2M HILL Preparation Method Code (e.g. NONS)
Analysis_Group	A9*	R	The CH2M HILL code for the analysis performed on the sample.
Analytical_Method	A20*	R	Analytical Method used to analyze sample fraction. (e.g. 6010)
PRC_Code	A15*	R	NIRIS code for the analytical method category (e.g. LEACH)
Lab_Code	A10**	R	CH2M HILL Code assigned to the laboratory (e.g. SHEA)
Lab_Name	A50**	R	The name of the laboratory that conducted the analysis.
Leachate_Method	A16*	RA	Code for the leachate method used on sample. (e.g. SW1310)
Sample_Basis	A16*	RA	Sample basis of analysis; wet weight, dry weight etc. (e.g. DRY)
Extraction_Method	A16*	RA	Code for the extraction method used on sample. (e.g. FLTRES)
Result_Type	A16*	RA	Type of results; dilution, reanalysis etc. (e.g. 000)
Lab_QC_Type	A15*	RA	Code for Laboratory Sample (MS, MSD, LBLK, LCS)
Sample_Medium	A16*	R	Sample medium reported by the laboratory. (e.g. L)
QC_Level	A16*	R	QC Level of data package : EPA levels I to IV. (e.g. 3)
DateTime_Collected	MM/DD/YYYY 00:00	R	Date and time sample was collected. Use 24 hour clock. (e.g. 02/13/07 15:34)
Date_Received	MM/DD/YYYY	R	The date the sample was received in the lab. (e.g. 03/24/07)
Leachate_Date	YYYYMMDD	RA	Date the sample was leached. (e.g. March 12, 2007 = 20070312)
Leachate_Time	HH:MM:SS	RA	Time the sample was leached. Use 24 hour clock. (e.g. 14:30:05)
Extraction_Date	YYYYMMDD	RA	Date that the lab extracted the sample.
Extraction_Time	HH:MM:SS	RA	Time of day that the lab extracted the sample. Use 24 hour clock.
Analysis_Date	YYYYMMDD	R	Date that the lab performed the analysis.
Analysis_Time	HH:MM:SS	R	Time of day that the lab extracted the sample. Use 24 hour clock.
Lab_Sample_ID	A20	R	Unique ID assigned to the sample by the laboratory.
Dilution	N10,2	R	Dilution factor used. (e.g. 10)
Run_Number	N4	RA	Number distinguishing multiple or repeat analyses by the same method, on the same day. Must be equal to or greater than 1.
Percent_Moisture	N6,3	RA	Percent moisture of the sample. (e.g. 20)
Percent_Lipid	N6,3	RA	Percent lipid of the sample.
Chem_Name	A45*	R	The compound being analyzed.
Analyte_ID	A20*	R	Analyte ID (CAS Number) assigned to the analyte. (e.g. 7440-47-3)
Analyte_Value	N18,7	R	Leave Blank for Validator to enter the final analyte concentration.
Original_Analyte_Value	N18,7	R	Analyte concentration value originally generated by the Laboratory.
Result_Units	A16*	R	Unit of measure for the analyte value. (e.g. UG_L)
Lab_Qualifier	A16*	RA	Lab data qualifier. Values will not be rejected if not in domain table.
Validator_Qualifier	A16*	RA	Leave blank for Validator. Values will not be rejected if not in domain table.
GC_Column_Type	A16*	RA	Data code for the type of GC column used in an analysis.

CH2M HILL SNEDD Format			
Field Name	**Field Format**	**REQ**	**Field Description**
Analysis_Result_Type	A3*	R	Type of analysis performed (allowed: TIC or TRG).
Result_Narrative	A120	RA	Additional information or comments associated with the result.
QC_Control_Limit_Code	A16*	RA	Type of quality control limit. Req'd if QC criteria included. (e.g. CLPA)
QC_Accuracy_Upper	N6,3	RA	Accuracy Upper Limit. Upper QC limit of % recovery as measured for a known target analyte spiked into a QC sample. (e.g. 25.45)
QC_Accuracy_Lower	N6,3	RA	Accuracy Lower Limit. Lower QC limit of % recovery as measured for a known target analyte spiked into a QC sample. (e.g. 10.15)
Control_Limit_Date	YYYYMMDD	RA	Date a control limit is established.
QC_Narrative	A120	RA	Leave blank for Validator. Enter EnDat EDD's DV_Qual_Code.
MDL	N18,7	RA	Method Detection Limit
Detection_Limit	N18,7	RA	Reported Detection Limit
SDG	A50	R	Lab code for a group of samples in a data deliverable package.
Analysis_Batch	A20	R	Laboratory code for a batch of analyses analyzed together.
Validator_Name	A50**	R	Leave Blank. Name of Validator. (e.g. CONTRACTOR INC.)
Val_Date	YYYYMMDD	RA	Populated by Validator/Reviewer. Validation/Review QC date.

Notes:
* - See Valid Value List or Lookup Table
** - See Naval Master List. Please request from the EIS. If name is new, corresponding NEDD must be submitted by EIS.
R - Required Field
RA - Required as Appropriate
NR - Not Required
EDD to be submitted in Excel

QAPP Worksheet #15-1
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Volatile Organic Compounds

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
1,1,1-Trichloroethane	71-55-6	910	200	n/a	n/a	0.041	1
1,1,2,2-Tetrachloroethane	79-34-5	0.067	NC	n/a	n/a	0.047	1
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5900	NC	n/a	n/a	0.062	1
1,1,2-Trichloroethane	79-00-5	0.24	5	n/a	n/a	0.072	1
1,1-Dichloroethane	75-34-3	2.4	NC	n/a	n/a	0.041	1
1,1-Dichloroethene	75-35-4	34	7	n/a	n/a	0.077	1
1,2,3-Trichlorobenzene	87-61-6	NC	NC	n/a	n/a	0.092	1
1,2,4-Trichlorobenzene	120-82-1	19	70	n/a	n/a	0.093	1
1,2-Dibromo-3-chloropropane	96-12-8	0.00032	0.2	n/a	n/a	0.14	1
1,2-Dibromoethane	106-93-4	0.0065	0.05	n/a	n/a	0.066	1
1,2-Dichlorobenzene	95-50-1	37	600	n/a	n/a	0.070	1
1,2-Dichloroethane	107-06-2	0.15	5	n/a	n/a	0.020	1
1,2-Dichloropropane	78-87-5	0.39	5	n/a	n/a	0.50	1
1,3-Dichlorobenzene	541-73-1	NC	NC	n/a	n/a	0.054	1
1,4-Dichlorobenzene	106-46-7	0.43	75	n/a	n/a	0.079	1
2-Butanone	78-93-3	710	NC	n/a	n/a	0.78	5
2-Hexanone	591-78-6	200	NC	n/a	n/a	0.29	5
4-Methyl-2-pentanone	108-10-1	200	NC	n/a	n/a	0.29	5

Matrix: Groundwater
Analytical Group: Volatile Organic Compounds

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
Acetone	67-64-1	2200	NC	n/a	n/a	0.77	5
Benzene	71-43-2	0.41	5	n/a	n/a	0.059	1
Bromochloromethane	74-97-5	NC	NC	n/a	n/a	0.064	1
Bromodichloromethane	75-27-4	1.1	80	n/a	n/a	0.031	1
Bromoform	75-25-2	8.5	80	n/a	n/a	0.20	1
Bromomethane	74-83-9	0.87	NC	n/a	n/a	0.29	1
Carbon disulfide	75-15-0	100	NC	n/a	n/a	0.045	1
Carbon tetrachloride	56-23-5	0.2	5	n/a	n/a	0.031	1
Chlorobenzene	108-90-7	91	100	n/a	n/a	0.047	1
Chloroethane	75-00-3	2100	NC	n/a	n/a	0.15	1
Chloroform	67-66-3	0.19	80	n/a	n/a	0.041	1
Chloromethane	74-87-3	1.8	NC	n/a	n/a	0.11	1
Dibromochloromethane	124-48-1	0.8	80	n/a	n/a	0.035	1
Dichlorodifluoromethane (Freon-12)	75-71-8	39	NC	n/a	n/a	0.058	1
Ethylbenzene	100-41-4	1.5	700	n/a	n/a	0.038	1
Methyl-tert-butyl ether (MTBE)	1634-04-4	12	NC	n/a	n/a	0.036	1
Methylene chloride	75-09-2	4.8	5	n/a	n/a	0.12	1
Styrene	100-42-5	160	100	n/a	n/a	0.050	1
Tetrachloroethene	127-18-4	0.11	5	n/a	n/a	0.063	1
Toluene	108-88-3	230	1000	n/a	n/a	0.041	1
Trichloroethene	79-01-6	1.7	5	n/a	n/a	0.058	1
Trichlorofluoromethane(Freon-11)	75-69-4	130	NC	n/a	n/a	0.067	1
Vinyl chloride	75-01-4	0.016	2	n/a	n/a	0.062	1
o-Xylene	95-47-6	140	NC	n/a	n/a	0.060	1

Matrix: Groundwater
Analytical Group: Volatile Organic Compounds

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
m,p-Xylene	m&pXYLENE[3]	NC	NC	n/a	n/a	0.097	1
cis-1,2-Dichloroethene	156-59-2	37	70	n/a	n/a	0.065	1
cis-1,3-Dichloropropene	10061-01-5	0.43	NC	n/a	n/a	0.049	1
isopropylbenzene	98-82-8	68	NC	n/a	n/a	0.039	1
trans-1,2-Dichloroethene	156-60-5	11	100	n/a	n/a	0.059	1
trans-1,3-Dichloropropene	10061-02-6	0.43	NC	n/a	n/a	0.053	1

[1] Analytical QLs are those documented in promulgated CLP methods. There are no QLs or MDLs supplied by this method.
[2] Achievable MDLs and QLs are limits that an individual laboratory can achieve when performing a specific analytical method. These Limits were the most current available as of March, 2008. They are subject to change as new studies may be performed.

[3] CH2M HILL generated CAS number.

Sample results that are between the Laboratory MDL and QL will be "J" flagged as estimated. These results will still be considered to be usable.

NC = No Criteria
n/a= Not Applicable
MDL= Method Detection Limit
QL= Quantitation Limit

"RSLs – Tap for GW Adjusted" are from http://www.epa.gov/reg3hwmd/risk/human/index.htm and are current as of May 15, 2008. Regional Screening Levels (RSLs) are subject to change when RBCs are updated.

"MCLs" are from the U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs) for drinking water contaminants. These values were current as of February 2008.

Criteria shaded in grey are below the Laboratory QLs.

QAPP Worksheet #15-2
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Explosives

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
HMX	2691-41-0	180	NC	n/a	n/a	0.067	0.25
RDX	121-82-4	0.61	NC	n/a	n/a	0.053	0.25
1,3,5-Trinitrobenzene	99-35-4	110	NC	n/a	n/a	0.021	0.25
1,3-Dinitrobenzene	99-65-0	0.37	NC	n/a	n/a	0.021	0.25
Methyl-2,4,6-trinitrophenylnitramine	479-45-8	15	NC	n/a	n/a	0.025	0.25
Nitrobenzene	98-95-3	0.34	NC	n/a	n/a	0.021	0.25
2,4,6-Trinitrotoluene	118-96-7	1.8	NC	n/a	n/a	0.021	0.25
4-Amino-2,6-dinitrotoluene	1946-51-0	7.3	NC	n/a	n/a	0.022	0.25
2-Amino-4,6-dinitrotoluene	35572-78-2	7.3	NC	n/a	n/a	0.023	0.25
2,4-Dinitrotoluene	121-14-2	7.3	NC	n/a	n/a	0.028	0.25
2,6-Dinitrotoluene	606-20-2	3.7	NC	n/a	n/a	0.034	0.25
2-Nitrotoluene	88-72-2	37	NC	n/a	n/a	0.041	0.25
3-Nitrotoluene	99-08-1	NC	NC	n/a	n/a	0.063	0.25

Matrix: Groundwater
Analytical Group: Explosives

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
4-Nitrotoluene	99-99-0	4.2	NC	n/a	n/a	0.032	0.25

[1] Analytical method does not supply MDLs and QLs.
[2] Achievable MDLs and QLs are limits that an individual laboratory can achieve when performing a specific analytical method. These Limits were the most current available as of February 2008. They are subject to change as new studies may be performed.

Sample results that are between the Laboratory MDL and QL will be "J" flagged as estimated. These results will still be considered usable for the purposes of risk assessment.

NC = No Criteria

n/a= Not Applicable
MDL= Method Detection Limit
QL= Quantitation Limit

"RSLs – Tap for GW Adjusted" are from http://www.epa.gov/reg3hwmd/risk/human/index.htm and are current as of May 15, 2008. Regional Screening Levels (RSLs) are subject to change when RBCs are updated.
"MCLs" are from the U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs) for drinking water contaminants. These values were current as of February 2008.

Criteria shaded in grey are below the Laboratory QLs.

QAPP Worksheet #15-3
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: METAL and FMETAL (Metals/CN and Filtered Metals)

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
Aluminum	7429-90-5	3700	NC	n/a	n/a	4.9	80
Antimony	7440-36-0	1.5	6	n/a	n/a	0.25	20
Arsenic	7440-38-2	0.045	10	n/a	n/a	0.14	2
Barium	7440-39-3	730	2000	n/a	n/a	1.5	100
Beryllium	7440-41-7	7.3	4	n/a	n/a	0.044	2
Cadmium	7440-43-9	1.8	5	n/a	n/a	0.15	2
Calcium	7440-70-2	NC	NC	n/a	n/a	52.2	1000
Chromium	7440-47-3	11	100	n/a	n/a	0.19	4
Cobalt	7440-48-4	73	NC	n/a	n/a	0.20	10
Copper	7440-50-8	150	1300	n/a	n/a	0.38	20
Cyanide	57-12-5	73	200	n/a	n/a	3.2	10
Iron	7439-89-6	2600	NC	n/a	n/a	33.6	200
Lead	7439-92-1	NC	15	n/a	n/a	0.030	2
Magnesium	7439-95-4	NC	NC	n/a	n/a	59.2	1000
Manganese	7439-96-5	88	NC	n/a	n/a	0.20	4
Mercury	7439-97-6	1.1	2	n/a	n/a	0.059	0.2
Nickel	7440-02-0	73	NC	n/a	n/a	0.18	20
Potassium	7440-09-7	NC	NC	n/a	n/a	17	1000
Selenium	7782-49-2	18	50	n/a	n/a	0.30	2
Silver	7440-22-4	18	NC	n/a	n/a	0.035	2

Matrix: Groundwater
Analytical Group: METAL and FMETAL (Metals/CN and Filtered Metals)

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
Sodium	7440-23-5	NC	NC	n/a	n/a	9.9	1000
Thallium	7440-28-0	0.24	2	n/a	n/a	0.016	2
Vanadium	7440-62-2	26	NC	n/a	n/a	0.21	4
Zinc	7440-66-6	1100	NC	n/a	n/a	0.68	20

[1] Analytical QLs and MDLs are not provided in the analytical methods.
[2] Achievable MDLs and QLs are limits that an individual laboratory can achieve when performing a specific analytical method. These Limits were the most current available as of July, 2008. They are subject to change as new studies may be performed.

Sample results that are between the Laboratory MDL and QL will be "J" flagged as estimated. These results will still be considered usable for the purposes of risk assessment.

NC = No Criteria

n/a= Not Applicable
MDL= Method Detection Limit
QL= Quantitation Limit

"RSLs – Tap for GW Adjusted" are from http://www.epa.gov/reg3hwmd/risk/human/index.htm and are current as of May 15, 2008. Regional Screening Levels (RSLs) are subject to change when RBCs are updated.

"MCLs" are from the U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs) for drinking water contaminants. These values were current as of February 2008.

Criteria shaded in grey are below the Laboratory QLs.

QAPP Worksheet #15-4
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: PEST/PCBs

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs (µg/L)	QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
alpha-BHC	319-84-6	0.011	NC	n/a	n/a	0.0069	0.050
beta-BHC	319-85-7	0.037	NC	n/a	n/a	0.0060	0.050
delta-BHC	319-86-8	0.037	NC	n/a	n/a	0.0036	0.050
gamma-BHC (Lindane)	58-89-9	0.061	0.2	n/a	n/a	0.0030	0.050
Heptachlor	76-44-8	0.015	0.4	n/a	n/a	0.0035	0.050
Aldrin	309-00-2	0.004	NC	n/a	n/a	0.0040	0.050
Heptachlor epoxide	1024-57-3	0.0074	0.2	n/a	n/a	0.0047	0.050
Endosulfan I	959-98-8	22	NC	n/a	n/a	0.0050	0.050
Dieldrin	60-57-1	0.0042	NC	n/a	n/a	0.0095	0.10
4,4'-DDE	72-55-9	0.2	NC	n/a	n/a	0.0093	0.10
Endrin	72-20-8	1.1	2	n/a	n/a	0.010	0.10
Endosulfan II	33213-65-9	22	NC	n/a	n/a	0.011	0.10
4,4'-DDD	72-54-8	0.28	NC	n/a	n/a	0.011	0.10
Endosulfan sulfate	1031-07-8	22	NC	n/a	n/a	0.011	0.10
4,4'-DDT	50-29-3	0.2	NC	n/a	n/a	0.012	0.10
Methoxychlor	72-43-5	18	40	n/a	n/a	0.053	0.50
Endrin ketone	53494-70-5	1.1	2	n/a	n/a	0.011	0.10
Endrin aldehyde	7421-93-4	1.1	2	n/a	n/a	0.021	0.10
gamma-Chlordane	5103-74-2	0.19	NC	n/a	n/a	0.0043	0.050
alpha-Chlordane	5103-71-9	0.19	NC	n/a	n/a	0.0054	0.050
Chlordane	57-74-9	0.19	2	n/a	n/a	0.070	0.50

Matrix: Groundwater
Analytical Group: PEST/PCBs

Toxaphene	8001-35-2	0.061	3	n/a	n/a	0.46	5.0
Aroclor-1016	12674-11-2	0.26	0.5	n/a	n/a	0.13	0.50
Aroclor-1260	11096-82-5	0.034	0.5	n/a	n/a	0.14	0.50
Aroclor-1221	11104-28-2	0.0068	0.5	n/a	n/a	0.11	0.50
Aroclor-1254	11097-69-1	0.034	0.5	n/a	n/a	0.091	0.50
Aroclor-1242	53469-21-9	0.034	0.5	n/a	n/a	0.043	0.50
Aroclor-1248	12672-29-6	0.034	0.5	n/a	n/a	0.049	0.50
Aroclor-1262	37324-23-5	NC	NC	n/a	n/a	0.050	0.50
Aroclor-1232	11141-16-5	0.0068	0.5	n/a	n/a	0.023	0.50
Aroclor-1268	11100-14-4	NC	NC	n/a	n/a	0.13	0.50

[1] There are no QLs or MDLs supplied by this method.
[2] Achievable MDLs and CRQLs are limits that an individual laboratory can achieve when performing a specific analytical method. These Limits were the most current available as of May-June, 2008. They are subject to change as new studies may be performed.
Sample results that are between the Laboratory MDL and QL will be "J" flagged as estimated. These results will still be considered usable for the purposes of risk assessment.

NC = No Criteria

n/a= Not Applicable
MDL= Method Detection Limit
QL= Contract Required Quantitation Limit

"RSLs – Tap for GW Adjusted" are from http://www.epa.gov/reg3hwmd/risk/human/index.htm and are current as of May 15, 2008. Regional Screening Levels (RSLs) are subject to change when RBCs are updated.

"MCLs" are from the U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs) for drinking water contaminants. These values were current as of February 2008.

Criteria shaded in grey are below the Laboratory QLs.

QAPP Worksheet #15-5
Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: SVOC

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
Benzaldehyde	100-52-7	370	NC	n/a	n/a	0.86	25
Phenol	108-95-2	1100	NC	n/a	n/a	0.32	10
bis-(2-Chloroethyl) ether	111-44-4	0.012	NC	n/a	n/a	0.32	10
2-Chlorophenol	95-57-8	18	NC	n/a	n/a	0.34	10
2-Methylphenol	95-48-7	180	NC	n/a	n/a	0.32	10
2,2'-oxybis(1-Chloropropane)	108-60-1	0.32	NC	n/a	n/a	0.29	10
Acetophenone	98-86-2	370	NC	n/a	n/a	0.41	10
4-Methylphenol	106-44-5	18	NC	n/a	n/a	0.24	10
N-Nitroso-di-n propylamine	621-64-7	0.0096	NC	n/a	n/a	0.22	10
Hexachloroethane	67-72-1	3.7	NC	n/a	n/a	0.66	10
Nitrobenzene	98-95-3	0.34	NC	n/a	n/a	0.38	10
Isophorone	78-59-1	71	NC	n/a	n/a	0.27	10
2-Nitrophenol	88-75-5	18	NC	n/a	n/a	0.28	10
2,4-Dimethylphenol	105-67-9	73	NC	n/a	n/a	0.60	10
bis(2-Chloroethoxy) methane	111-91-1	11	NC	n/a	n/a	0.40	10
2,4-Dichlorophenol	120-83-2	11	NC	n/a	n/a	0.22	10
Naphthalene	91-20-3	0.62	NC	n/a	n/a	0.64	10
4-Chloroaniline	106-47-8	15	NC	n/a	n/a	0.26	10
Hexachlorobutadiene	87-68-3	0.86	NC	n/a	n/a	0.65	10
Caprolactam	105-60-2	1800	NC	n/a	n/a	0.50	10
4-Chloro-3-methylphenol	59-50-7	18	NC	n/a	n/a	0.55	10

Matrix: Groundwater

Analytical Group: SVOC

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
2-Methylnaphthalene	91-57-6	15	NC	n/a	n/a	0.68	10
Hexachlorocyclopentadiene	77-47-4	22	50	n/a	n/a	2.0	10
2,4,6-Trichlorophenol	88-06-2	3.7	NC	n/a	n/a	0.49	10
2,4,5-Trichlorophenol	95-95-4	370	NC	n/a	n/a	0.91	25
1,1'-Biphenyl	92-52-4	180	NC	n/a	n/a	0.53	10
2-Chloronaphthalene	91-58-7	290	NC	n/a	n/a	0.62	10
2-Nitroaniline	88-74-4	NC	NC	n/a	n/a	0.37	25
Dimethylphthalate	131-11-3	NC	NC	n/a	n/a	0.40	10
2,6-Dinitrotoluene	606-20-2	3.7	NC	n/a	n/a	0.57	10
Acenaphthylene	208-96-8	220	NC	n/a	n/a	0.54	10
3-Nitroaniline	99-09-2	NC	NC	n/a	n/a	0.22	25
Acenaphthene	83-32-9	220	NC	n/a	n/a	0.70	10
2,4-Dinitrophenol	51-28-5	7.3	NC	n/a	n/a	2.7	25
4-Nitrophenol	100-02-7	NC	NC	n/a	n/a	1.3	25
Dibenzofuran	132-64-9	3.7	NC	n/a	n/a	0.54	10
2,4-Dinitrotoluene	121-14-2	7.3	NC	n/a	n/a	0.51	10
Diethylphthalate	84-66-2	2900	NC	n/a	n/a	0.64	10
Fluorene	86-73-7	150	NC	n/a	n/a	0.47	10
4-Chlorophenyl-phenyl ether	7005-72-3	18	NC	n/a	n/a	0.58	10
4-Nitroaniline	100-01-6	NC	NC	n/a	n/a	0.50	25
4,6-Dinitro-2-methylphenol	534-52-1	NC	NC	n/a	n/a	0.67	25
N-Nitroso diphenylamine	86-30-6	14	NC	n/a	n/a	0.40	10
4-Bromophenyl-phenylether	101-55-3	NC	NC	n/a	n/a	0.33	10
Hexachlorobenzene	118-74-1	0.042	1	n/a	n/a	0.36	10
Atrazine	1912-24-9	0.29	3	n/a	n/a	0.55	10
Pentachlorophenol	87-86-5	0.56	1	n/a	n/a	0.50	25
Phenanthrene	85-01-8	1100	NC	n/a	n/a	0.42	10

Matrix: Groundwater

Analytical Group: SVOC

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
Anthracene	120-12-7	1100	NC	n/a	n/a	0.55	10
Carbazole	86-74-8	3.4	NC	n/a	n/a	0.58	10
Di-n-butylphthalate	84-74-2	370	NC	n/a	n/a	0.61	10
Fluoranthene	206-44-0	150	NC	n/a	n/a	0.68	10
Pyrene	129-00-0	110	NC	n/a	n/a	0.20	10
Butylbenzylphthalate	85-68-7	730	NC	n/a	n/a	0.40	10
3,3'-Dichlorobenzidine	91-94-1	0.15	NC	n/a	n/a	2.0	10
Benzo(a)anthracene	56-55-3	0.029	NC	n/a	n/a	0.32	10
Chrysene	218-01-9	2.9	NC	n/a	n/a	0.58	10
bis(2-Ethylhexyl) phthalate	117-81-7	4.8	6	n/a	n/a	0.64	10
Di-n-octylphthalate	117-84-0	NC	NC	n/a	n/a	0.37	10
Benzo(b)fluoranthene	205-99-2	0.029	NC	n/a	n/a	0.89	10
Benzo(k)fluoranthene	207-08-9	0.29	NC	n/a	n/a	1.5	10
Benzo(a)pyrene	50-32-8	0.0029	0.2	n/a	n/a	0.48	10
Indeno(1,2,3-cd)-pyrene	193-39-5	0.029	NC	n/a	n/a	0.52	10
Dibenzo(a,h)-anthracene	53-70-3	0.0029	NC	n/a	n/a	0.21	10
Benzo(g,h,i)perylene	191-24-2	110	NC	n/a	n/a	0.39	10

[1] There are no QLs or MDLs supplied by this method.

[2] Achievable MDLs and QLs are limits that an individual laboratory can achieve when performing a specific analytical method. These Limits were the most current available as of May, 2007. They are subject to change as new studies may be performed.

Sample results that are between the Laboratory MDL and QL will be "J" flagged as estimated. These results will still be considered usable for the purposes of risk assessment.

NC = No Criteria
n/a= Not Applicable
MDL= Method Detection Limit
QL= Quantitation Limit

Matrix: Groundwater

Analytical Group: SVOC

Analyte	CAS Number	RSLs – Tap for GW Adjusted (µg/L)	MCLs (µg/L)	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)

"RSLs – Tap for GW Adjusted" are from http://www.epa.gov/reg3hwmd/risk/human/index.htm and are current as of May 15, 2008. Regional Screening Levels (RSLs) are subject to change when RBCs are updated.

"MCLs" are from the U.S. Environmental Protection Agency's Maximum Contaminant Levels (MCLs) for drinking water contaminants. These values were current as of February 2008.

Criteria shaded in grey are below the Laboratory QLs.

QAPP Worksheet #16
Project Schedule/Timeline Table

WPNSTA Yorktown Background Study	
Key Project Milestones	**Days Duration (from last date shown)**
Navy Submit Final Background Investigation Work Plan	July 2009
Procure Subcontractors/Mobilize	30
Conduct Field Investigation (including utility clearance, vegetation clearance, IDW management, surveying as necessary)	60
Laboratory Analyses	30
Data Validation/Management	30
Data Evaluation/Prepare Draft Background Investigation Report	60
Navy, USEPA, VDEQ Review of Draft Background Investigation Report	90
Prepare Final Background Report	75

QAPP Worksheet #17
Sampling Design and Rationale

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach):

The sampling approach will be to collect groundwater samples from those areas believed to not be impacted by the IR sites or other potential point sources to assess natural and non-point source anthropogenic background conditions.

The criteria for the groundwater samples are provided as follows:

- **Spatial Extent.** Locations were chosen to provide data over the extent of the aquifer to assess potential spatial variability. The broad spatial extent of sample locations will also help evaluate the range of background concentrations (which may vary over the undeveloped and industrialized areas) and ensure concentration levels potentially attributable to point-sources are identified and eliminated from the background dataset.
- **IR Sites and Other Potential Point Sources of Contamination.** Locations were chosen outside areas potentially impacted by previous CERCLA releases. Specifically, the well locations were chosen in areas upgradient or side-gradient of these releases. In addition to avoiding locations potentially influenced by IR sites, any other known or suspected non-site-specific point source of contamination was avoided in selecting background sampling locations.

Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) (May refer to map or Worksheet #18 for details):

Groundwater samples will be collected during this field event. There will be one round of sampling that will occur over the course of two to three weeks. All samples will be analyzed at normal concentrations.

Twenty-eight groundwater samples will be analyzed for SVOCs, Low-Level VOCs, Explosives, Pesticides/PCBs, Total Metals/CN, and Filtered Metals.

See Figures 5-1 and 5-2 of the Work Plan for sampling locations and Worksheet 18 for more information on Sample IDs.

A full QA/QC suite will be collected for all analytical groups. See Worksheet 20 for more details on QA/QC requirements and sample numbers for this field event.

QAPP Worksheet #18
Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ID Number	Matrix	Depth (Units)	Analytical Group	Concentration Level	Number of Samples (Identify Field Duplicates)	Sampling SOP Reference[1]	Rationale for Sampling Location
Locations can be found in Figures 5-1 and 5-2 and Section 5 of the work plan. Information on sample IDs can be found below in Tables 2 and 3.	Groundwater	Samples will be collected from the middle of the screen.	SVOCs, VOCs, Explosives, Pesticides, Total and Dissolved Metals	Medium	See Worksheet #20	See Field SOPs in Attachment 1.	See Worksheet #17

[1]Specify the appropriate letter or number from the Project Sampling SOP References table (Worksheet #21).

SAMPLE IDS – CORNWALLIS CAVE WELLS

Aquifer	Well ID (listed basically left to right as they appear on Figures 5-1 or 5-2)	Corresponding Sample ID
Cornwallis Cave (Figure 5-1)	CXBG3-MW01[(1)]	BKG-CXBG3-MW01
	CXBG1-MW01[(1)]	BKG-CXBG1-MW01
	58G57 (N3)[(2)]	BKG-N3
	58G58 (N4)[(2)]	BKG-N4
	58F120 (I3)[(2)]	BKG-I3
	BGGW07A[(3)]	BKG-BGGW07A
	BGGW07[(3)]	BKG-BGGW07
	BGGW01[(3)]	BKG-BGGW01
	BGGW06A[(3)]	BKG-BGGW06A
	58F110 (G3)[(2)]	BKG-G3
	58F115 (H3)[(2)]	BKG-H3
	BGGW03A[(3)]	BKG-BGGW03A
	BGGW05A[(3)]	BKG-BGGW05A
	58F105 (E3)[(2)]	BKG-E3
	BGGW10[(4)]	BKG-BGGW10

(Footnotes are located after Yorktown-Eastover Table on next page)

SAMPLE IDS – YORKTOWN-EASTOVER WELLS

Yorktown-Eastover (Figure 5-2)	58G55 (N1)[2]	BKG-N1
	58G56 (N2)[2]	BKG-N2
	58F118 (I1)[2]	BKG-I1
	58F119 (I2)[2]	BKG-I2
	BGGW01A[3]	BKG-BGGW01A
	58F108 (G1)[2]	BKG-G1
	58F109 (G2)[2]	BKG-G2
	58F113 (H1)[2]	BKG-H1
	58F114 (H2)[2]	BKG-H2
	58F103 (E1)[2]	BKG-E1
	58F104 (E2)[2]	BKG-E2
	BGGW09A[4]	BKG-BGGW09A
	BGGW10A[4]	BKG-BGGW10A

[1]Installed as part of the CAX Background Study (Baker, 2003). This is the well identification assigned by Baker for the study.

[2]Installed as part of the USGS Shallow Aquifer Study of Naval Weapons Station Yorktown (Brockman et. al, 1997). The USGS installed seven four-well clusters (labeled B, E, F, G, H, I, and N) and gave each well within the cluster its own unique identifier (e.g., 58F105), along with a cluster designation (e.g., E3). The cluster designation has been used on Figures 5-1 and 5-2 for brevity and less "clutter."

[3]Installed as part of the Yorktown Background Study (Baker, 1995). This is the well identification assigned by Baker for the study.

[4]New well to be installed as part of 2009 Background Study. The well identification number follows Baker's nomenclature for the Yorktown Background Study and starts sequentially where that study ended (i.e., Baker's study ended at BGGW08A).

BKG = Background

QAPP Worksheet #19
Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference[1]	Sample Volume[1]	Containers (Number, Size, and Type)	Preservation Requirements (Chemical, Temperature, Light Protected)	Maximum Holding Time (Preparation/Analysis)
Groundwater	METAL	Low (ICP-MS and CVAA)	SW-846 6020, 7470A / BR-ME-003, BR-ME-015	500 mL	1 x 500 mL poly	HNO_3 to pH < 2; Cool to 4°C	6 months (Hg : 28 days)
Groundwater	METAL	Medium	SW-846 9012B / BR-WC-004	250 mL	1 x 250 mL poly	NaOH to pH > 14; Cool to 4°C	14 days
Groundwater	FMETAL	Low (ICP-MS and CVAA)	SW-846 6020, 7470A / BR-ME-003, BR-ME-015	500 mL	1 x 500 mL poly	HNO_3 to pH < 2; Cool to 4°C	6 months (Hg : 28 days)
Groundwater	PEST/PCBs	Medium	SW-846 8081A, 8082 / BR-GC-006, BR-GC-005	2 L	4 x 1 Liter amber glass	Cool to 4°C	7 days (extraction) 40 days (analysis)
Groundwater	SVOCs	Medium	SW-846 8270C / BR-MS-001	1 L	2 x 1 Liter amber glass	Cool to 4°C	7 days (extraction) 40 days (analysis)
Groundwater	VOCs	Low-Level	SW-846 8260B / BR-MV-006	40 mL	3 x 40 mL vials	HCl to pH < 2; Cool to 4°C	14 days
Groundwater	Explosives	Low	SW-846 8330 / BR-LC-003	1 L	2 x 1 L amber glass	Cool to 4°C	7 days (extraction) 40 days (analysis)

[1] assume triple volume for MS/MSD samples.

QAPP Worksheet #20
Field Quality Control Sample Summary Table

Matrix	Analytical Group	Method	Concentration Level	Analytical and Preparation SOP Reference[1]	No. of Sampling Locations	No. of Field Duplicate Pairs	No. of MS	No. of MSD	No. of Field Blanks[2]	No. of Equipment Blanks[2]	No. of Trip Blanks	Total No. of Samples to Lab
Groundwater	Total Metals/CN	SW-846 6020 SW-846 7470A SW-846 9012B	Low(ICP-MS and CVAA)	BR-ME-003, BR-ME-015, BR-WC-004	28	3	2	2	3	10	0	48
Groundwater	Filtered Metals	SW-846 6020 SW-846 7470A	Low(ICP-MS and CVAA)	BR-ME-003, BR-ME-015	28	3	2	2	3	10	0	48
Groundwater	PEST/PCBs	SW-846 8081A SW-846 8082	Medium	BR-GC-006, BR-GC-005	28	3	2	2	3	10	0	48
Groundwater	SVOCs	SW-846 8270C	Low	BR-MS-001	28	3	2	2	3	10	0	48
Groundwater	VOCs	SW-846 8260B	Low-Level	BR-MV-006	28	3	2	2	3	10	10	58
Groundwater	Explosives	SW-846 8330	Low	BR-LC-003	28	3	2	2	3	10	0	48

[1]See Worksheet #23 for more detailed information on Analytical SOPs.
[2]The actual number of field blanks and equipment blanks collected in the field may vary.
SOP=Standard Operating Procedure
VOC= Volatile Organic Compound
SVOC= Semivolatile Organic Compound
MS= Matrix Spike; MSD = Matrix Spike Duplicate

QC samples are based on the following:
Field Blanks- 1 per week
Field Duplicates- 1 per every 10 samples
MS/MSDs- 1 pair per every 20 samples
Equipment Blanks- 1 per sampling day, per piece of equipment
Trip Blanks (VOCs only)- 1 per cooler per shipment to the laboratory

QAPP Worksheet #21
Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
n/a	Equipment Blank and Field Blank Preparation, 5/20/03	CH2M HILL	Blanks	N	
n/a	Chain of Custody 5/20/03	CH2M HILL	Chain of Custody	N	
n/a	Field Measurement of pH, Specific Conductance, Turbidity, D.O., ORP, and Temperature Using the Horiba® U-22 with Flow-Through Cell 1/23/03	CH2M HILL	Horiba® U-22	N	
n/a	Preparing Field Log Books	CH2M HILL	Field Log Book	N	
n/a	Packaging and Shipping	CH2M HILL	Coolers, Packaging Supplies	N	
n/a	Preserving Non-VOC Aqueous Samples	CH2M HILL	Preservatives, Bottleware	N	
n/a	Low-Flow Groundwater Sampling from Monitoring Wells	CH2M HILL	Pump, Flow-Through Cell	N	
n/a	General Guidance for Monitoring Well Installation	CH2M HILL	Drill Rig	N	
n/a	Installation of Shallow Monitoring Wells	CH2M HILL	Drill Rig	N	
n/a	Installation of Surface-Cased Monitoring Wells	CH2M HILL	Drill Rig	N	
	Water Level Measurement	CH2M HILL	Water Level Indicator	N	
	Utility Location	CH2M HILL	n/a	N	
n/a	Decontamination of Drilling Rigs and Equipment	CH2M HILL	Decontamination chemicals, equipment, water	N	
n/a	Decontamination of Personnel and Equipment	CH2M HILL	Decontamination chemicals, buckets, water	N	

QAPP Worksheet #22
Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
Horiba® U-22 pH Probe	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution				Daily, before use	pH reads 4.0 +/- 3%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	Field Measurement of pH, Specific Conductance, Turbidity, D.O., ORP, and Temperature Using the Horiba® U-22 with Flow-Through Cell 1/23/03
Horiba® U-22 Specific conductance Probe	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution				Daily, before use	conductivity reads 4.49 +/- 3%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	
Horiba® U-22 Turbidity Probe	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution				Daily, before use	turbidity reads 0 +/- 3%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	
Horiba® U-22 Dissolved oxygen and Temperature Probes			During calibration of other probes, check these readings against the day's atmospheric pressure and ambient temperature		Daily, before use	Consistent with the current atmospheric pressure and ambient temperature	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	
Horiba® U-22		Check mechanical and electronic parts, verify system continuity, check battery, and clean probes. Calibration check.	Visual inspection		Daily before use, at the end of the day, and when unstable readings occur.	Stable readings after 3 minutes pH reads 4.0 +/- 3% conductivity reads 4.49 +/- 3% turbidity reads 0 +/- 3%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	
Groundwater sampling pumps and tubing				Inspect pumps, tubing and air/ sample line quick-connects	Regularly	Maintained in good working order per manufacturer's recommendations	Replace items	Field Team Lead	Low-Flow Groundwater Sampling from Monitoring Wells

[1] SOP reference numbers refer to Attachment 1 of this QAPP. See Project Sampling SOP References Table, Worksheet 21.

QAPP Worksheet #23
Analytical SOP References Table

Reference Number	Title	Revision Date	Revision No.	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work (Y/N)
BR-EX-005	Separatory Funnel Extraction (SW-846 3510C)	4/22/08	6	Definitive	SVOC, PEST/PCB	n/a	TAL Burlington	No
BR-GC-005	Polychlorinated Biphenyls (PCB's) by Gas Chromatography (SW-846 Method 8082)	1/1/08	8		PEST/PCB	GC		
BR-GC-006	Organochlorine Pesticides by Gas Chromatography (SW-846 Method 8081A)	1/1/08	8		PEST/PCB	GC		
BR-ME-003	Determination of Trace Elements by ICP-MS (SW-846 6020)	1/1/08	5		METAL, FMETAL	ICP-MS		
BR-LC-003	Nitroaromatics and Nitramines by HPLC SW-846 Method 8330	01/01/08	14		Nitroaromatics	HPLC		
BR-ME-005	Inductively Coupled Plasma-Atomic Emission Spectrometry (SW-846 Method 6010B)	1/1/08	10		METAL, FMETAL	ICP-AES		
BR-ME-009	Acid Digestion of Waters for Total Metals (SW-846 3010A)	1/1/08	13	Definitive	METAL, FMETAL	n/a	TAL Burlington	No

Reference Number	Title	Revision Date	Revision No.	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work (Y/N)
BR-ME-015	Mercury by Cold Vapor Analysis (Aqueous) SW-846 7470A	1/1/08	12		METAL, FMETAL	CVAA		
BR-MS-001	Semivolatile Organic Compounds by GC/MS SW-846 8270C	1/1/08	5		SVOC	GC-MS		
BR-MV-006	Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (SW-846 8260B)	1/1/08	5		VOC	GC-MS		
BR-WC-004	Total and Amenable Cyanide (EPA 9012A/9012B)	1/1/08	13		METAL	Colorimeter		
LM-MV-5030B	Standard Operating Procedure for the Purge and Trap of Aqueous Samples	11/25/03	3		VOC	n/a		
BR-SM-001	Sample Management	01/01/08	7		n/a			
BR-QAM	Quality Assurance Manual	02/01/08	0					

QAPP Worksheet #24
Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Hydra AA	Linear Regression	Daily	R < or = 0.995	Perform Maintenance and re-calibrate	Analyst	BR-ME-015
ICP AES	Establish the upper limit of the Linear Dynamic Range (LDR) for each wavelength used by determining the signal responses from a minimum of 2 different concentration standards across the range.	Daily	+ or – 10% of expected value % RSD between replicate integrations < 5%	Perform maintenance and re-calibrate	Analyst	BR-ME-005
ICP-MS	Linear Regression	Daily	R < or = 0.995	Perform Maintenance and re-calibrate	Analyst	BR-ME-003
GCMS	Relative Response Factor	Initially prior to sample analysis, when calibration verification standards indicate calibration relationship is no	% RSD ≤ 15%	Perform Maintenance and re-calibrate	Analyst	BR-MV-006 BR-MS-001

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
		longer valid, whenever significant instrument maintenance is performed.				
GC	Relative Response Factor	Initially prior to sample analysis, when calibration verification standards indicate calibration relationship is no longer valid, whenever significant instrument maintenance is performed.	% RSD $\leq$ 20%	Perform Maintenance and re-calibrate	Analyst	BR-GC-006 BR-GC-005
HPLC	As per SW-846 Method	as needed	Per SOP	verify problem, re-calibrate	Analyst	BR-LC-003

[1] SOP Reference from Worksheet 23

QAPP Worksheet #25
Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
Hydra AA	Check tubing connections, fill stannous chloride reductant reservoir	Recalibrate and/or acquire acceptable CCV standard.	Failing CCV standards.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-ME-015
ICP AES	Adjust Spectral Shifter, clean/replace torch, replace nebulizer, replace peristaltic pump tubing.	Arsenic Profile (for sensitivity) on older instruments, check internal standard sensitivity on new instrument.	Measure responses of arsenic and/or internal standard.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-ME-005
ICP MS	Clean/replace torch, replace nebulizer, replace peristaltic pump tubing.	Perform stability report.	As specified in method 6020.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-ME-003

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
ICP MS	Adjust detector voltage/ replace detector	Perform stability report.	As specified in method 6020.	As needed	Minimum of 25,000 counts for In 115	Increase voltage to achieve response. Replace when detector no longer provides adequate counts.	Analyst	BR-ME-003
GCMS	Replace Septa, Replace injection port liner, trim/replace guard column, replace column	Recalibrate and/or acquire acceptable CCV standard.	Observance of poor peak shape, CCV failure, high breakdown check standard.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-MV-006 BR-MS-001
GC	Replace Septa, Replace injection port liner, trim/replace guard column, replace column	Recalibrate and/or acquire acceptable CCV standard.	Observance of poor peak shape, CCV failure, high breakdown check standard.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-GC-006 BR-GC-005

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
GC	Refurbish Detectors	Recalibrate.	Observance of poor peak shape and poor linearity.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-GC-006 BR-GC-005
HPLC	Check valves and change seals	Acquire check standard, observe retention time stability, check for air in system expressed by cavitation of baseline.	Passing calibration and check standard.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-LC-003
HPLC	Replace Guard Column and in-line filter	Acquire check standard, observe chromatography and peak shape.	Passing calibration and check standard.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-LC-003
HPLC	Back-flush column and/or replace column	Acquire check standard, observe chromatography and peak shape.	Passing calibration and check standard.	As needed	Acceptable calibration and stable calibration check standards	Perform instrument maintenance	Analyst	BR-LC-003

[1] SOP Reference from Worksheet 23

QAPP Worksheet #26
Sample Handling System

Sample Collection, Packaging, and Shipment

Sample Collection (Personnel/Organization):

- Project Field Team. Field SOPs are found in Attachment 1 of this QAPP.

Sample Packaging (Personnel/Organization):

- Project Field Team. Field SOPs are found in Attachment 1 of this QAPP.

Coordination of Shipment (Personnel/Organization):

- Field Team Leader. David Livingston/CH2M HILL.

Type of Shipment/Carrier:

- Overnight/Fed Ex.

Sample Receipt and Analysis (Analytical SOPs are found in Attachment 1 of this QAPP)

Sample Receipt (Personnel/Organization):

- Test America Laboratories-Burlington

Sample Custody and Storage (Personnel/Organization):

- Test America Laboratories-Burlington

Sample Preparation (Personnel/Organization):

- Test America Laboratories-Burlington

Sample Determinative Analysis (Personnel/Organization):

- Test America Laboratories-Burlington

Sample Archiving

Field Sample Storage (No. of days from sample collection): See Worksheet 19.

Sample Extract/Digestate Storage (No. of days from extraction/digestion): See Worksheet 19.

Biological Sample Storage (No. of days from sample collection): See Worksheet 19.

Sample Disposal

Personnel/Organization:

- Test America Laboratories-Burlington

Number of Days from Analysis: After submission, the laboratory will keep samples 90 days and the sample extracts for a minimum of 60 days.

QAPP Worksheet #27-1
Sample Custody Requirements

Field Sample Custody Procedures:

Samples will be collected by field team members under the supervision of the field team leader. As samples are collected, they will be placed into containers and labeled, as outlined below. Labels will be taped to the jar to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples below 4 degrees Celsius (°C) until they are received by the laboratory. The chain of custody (COC) will be placed into the cooler as well. Coolers will be shipped to the laboratory via FedEx, with the air bill number indicated on the COC (to relinquish custody). Upon delivery, the laboratory will log in each cooler and report the status of the samples.

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):

Found in Attachment 1 of this QAPP. See the laboratory Sample Control SOPs: BR-SM-001 (Sample Management) and Lab Laboratory Quality Manual (BR-QAM).

Sample Identification Procedures:

Sample labels will include, at a minimum, client name, site, sample ID, preservative, date/time collected, analysis group or method, and sampler's initials. The field logbook will identify the sample ID with the location and time collected and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the chain of custody. The laboratory will send sample log-in forms to Environmental Information Specialist (EIS) to check sample IDs and parameters are correct.

Chain-of-Custody Procedures:

Chains of custody will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID, date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain of custody will also have the sampler's name and signature. The chain of custody will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the LIMS database for each sample.

QAPP Worksheet #27-2
Sample Custody Requirements

(Chain of Custody)

Project Site		**Background Study**			Number of Containers	Analysis Requested													Project No.
Project Manager		Marlene Ivester				Pesticides	Total Metals	Diss. Metals	Semivolatiles	VOCs	Explosives								
Contact Tel No.		(757) 873-1442 x34																	Lab Batch/SDG ID
Contact Address		11818 Rock Landing Drive Suite 200 Newport News, VA 23606																	
Lab Name		TAL-Burlington																	Lab Tel No./Fax No.
Lab Contact		Jim Madison																	
Lab Address		30 Community Drive South Burlington, VT 05403 PH: 802-923-1028																	
Item	Sample ID	Station ID	Matrix	Date & Time Collected															Comments
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			

Sampled By:	Date/Time:	Custody Seal: Y / N Relinquished By:	Date/Time:
Shipped Via: UPS FedEx Hand Other (Please specify):			
Samples Temperature and Condition Upon Receipt (for lab's use):			
Received By:	Date/Time:	Custody Seal: Y / N Relinquished By:	Date/Time:
Received By:	Date/Time:	Custody Seal: Y / N Relinquished By:	Date/Time:
Remarks:			

QAPP Worksheet #28-1
QC Samples Table

Matrix	Groundwater
Analytical Group	VOCs
Analytical Method/SOP Reference[2]	SW-846 8260B/ BR-MV-006

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch of 20 or fewer samples	Should meet all internal standard and DMC criteria; all target compounds < ½ QL except methylene chloride, acetone, and 2-butanone which should be < QL	confirm issue, re-analyze associated samples as necessary and appropriate	analyst	Accuracy/ Bias	Should meet all internal standard and DMC criteria; all target compounds < ½ QL except methylene chloride, acetone, and 2-butanone which should be < QL
Storage Blank	1 per SDG	Same as method blank	Same as method blank	analyst	Accuracy/ Bias	Same as method blank
Instrument Blank	as necessary, after high concentration sample	Same as method blank	Same as method blank	analyst	Accuracy/ Bias	Same as method blank
BFB Tune	1x per 12 hour window	BFB abundance should meet criteria in BR-MV-006 Table 2	confirm issue, re-analyze associated samples as necessary and appropriate	analyst	Sensitivity	BFB abundance should meet criteria in BR-MV-006 Table 2
MS/MSD	1 per batch of 20 or fewer samples	Should meet % recovery and RPD criteria in BR-MV-006 Table 4	confirm issue, re-analyze associated samples as necessary and appropriate	analyst	Precision	Should meet % recovery criteria in BR-MV-006 Table 4
LCS	1 per batch of 20 or fewer samples	Should meet % recovery criteria in BR-MV-006 Table 4	confirm issue, re-analyze associated samples as necessary and appropriate	analyst	Accuracy/ Bias	Should meet % recovery criteria in BR-MV-006 Table 4

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23.
SDG = Sample Delivery Group
QL = Quantitation Limit
RPD = Relative Percent Difference

QAPP Worksheet #28-2
QC Samples Table

Matrix	Groundwater
Analytical Group	METAL and FMETAL
Analytical Method/SOP Reference[2]	SW-846 6020, 7470A, 9012 / BR-ME-003, BR-ME-007, BR-ME-015, BR-WC-004

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
METAL and FMETAL (SW-846 6020 and SW-846 7470A						
ICAL	Daily	N/A	N/A	Analyst	Accuracy/Bias	N/A
ICV	After each calibration, prior to sample analysis	±10% of expected value; %RSD between replicate integrations < 5%	Stop analysis; correct problem; recalibrate	Analyst	Accuracy/Bias	±10% of expected value; %RSD between replicate integrations < 5%
ICB	Beginning of analytical sequence after ICV	No analytes > QL	Correct problem and reanalyze	Analyst	Accuracy/Bias	No analytes > QL
CCB	Beginning of sample run, after every 10 samples, and at end of the sequence (after each CCV)	No analytes > QL	Correct problem and reanalyze the calibration blank and previous 10 samples	Analyst	Accuracy/Bias	No analytes > QL
CCV	At beginning of analytical sequence, after every 10 samples, and at the end of the analytical sequence	±10% of expected value; %RSD between replicate integrations < 5%	Correct problem, reanalyze CCV. If that fails, repeat calibration and reanalyze all samples since last successful calibration	Analyst	Accuracy/Bias	±10% of expected value; %RSD between replicate integrations < 5%
Interference Check Solutions	At the beginning of the analytical run	±20% of expected value	Stop analysis, locate and correct problem, reanalyze ICS and all associated QC and samples	Analyst	Accuracy/ Bias	±20% of expected value
Low Level Standard (CRI)	Daily, after ICSA and ICSAB	±20%	Examine project DQOs. If necessary, reanalyze.	Analyst	Precision	±20%
Method blank	One per digestion batch	No analytes > QL	Correct problem, redigest and reanalyze MB and associated samples.	Analyst	Accuracy/ Bias	No analytes > QL
Laboratory Control Sample (LCS)	One per digestion batch	%R 80-120%	Correct problem, redigest and reanalyze LCS, MB, and associated samples for failed analytes if sufficient sample volume is available	Analyst	Accuracy/ Bias	%R 80-120%
Matrix Spike	One per batch of twenty samples or less	%R 80-120%	Examine project DQOs with project manager. Evaluate data to determine if outage is related to analytical error or matrix effect	Analyst	Precision	%R 80-120%
Laboratory Duplicate	One per batch of 20 samples or less	RPD ≤20%	Examine project DQOs with project manager. Evaluate data to determine source of difference between results	Analyst	Precision	RPD ≤20%

Matrix	Groundwater
Analytical Group	METAL and FMETAL
Analytical Method/SOP Reference[2]	SW-846 6020, 7470A, 9012 / BR-ME-003, BR-ME-007, BR-ME-015, BR-WC-004

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Linear Range Verification	Once per analytical batch	%R 90-110%	Stop analysis, correct problem, and reanalyze all samples with concentrations that exceed respective calibration standard level	Analyst	Accuracy	%R 90-110%
Serial Dilution	Each digestion batch	5X dilution within ±10% of original sample result	Perform post-digestion spike. Flag data	Analyst	Accuracy/ Bias	5X dilution within ±10% of original sample result
Post-Digestion Spike	Each digestion batch	%R 75-125%	Flag data	Analyst	Accuracy/Bias	%R 75-125%
CYANIDE (SW-846 9012B)						
ICAL	Beginning of analytical sequence	r < 0.995	Standards check, re-calibration	Analyst	Accuracy/ Bias	r < 0.995
ICV / Water LCS	After ICAL and with each preparation batch of 20 samples or less	85-115% R	Check formulation of standards and ICV, re-prepare and recalibrate	Analyst	Accuracy/Bias	85-115% R
ICB	After ICV	±10 ug/L	Re-analyze once, if still outside limits, bracketed samples are rerun with new ICAL	Analyst	Accuracy/Bias	±10 ug/L
Distilled Standards (50 & 200 ppb)	Every batch of 20 samples or less	90-110% R	Check formulation of standards, re-prepare, and re-calibrate	Analyst	Accuracy	90-110% R
CCV	At the beginning of the run, every 10 samples, and at the end of the run.	85-115% R	Re-analyze once, if still outside limits, bracketed samples are rerun with new ICAL	Analyst	Accuracy/Bias	85-115% R
CCB	Every 10 samples and at the end of the analytical run	±10 ug/L	Re-analyze once, if still outside limits, bracketed samples are rerun with new ICAL	Analyst	Accuracy/Bias	±10 ug/L
Method blank	Each distillation batch of 20 samples or less	< ½ QL	Re-analyze, if still above, re-prepare and recalibrate	Analyst	Accuracy/ Bias	< ½ QL
Matrix Spike	Every 20 samples	85-115% R	The MS is used to assess the effect of the sample matrix on the accuracy of the method. Evaluate any MS outside limits and note as a non-conformance if a matrix effect is indicated.	Analyst	Accuracy/Bias	85-115% R
Laboratory Duplicate	Every 20 samples	RPD ≤20%	The laboratory duplicate is used to assess the effect of the sample matrix on the precision of the method. Evaluate any DP outside limits and note as a non-conformance if a matrix effect is indicated	Analyst	Precision	RPD ≤20%

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23.
SDG = Sample Delivery Group
QL = Quantitation Limit
LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-3
QC Samples Table

Matrix	Groundwater
Analytical Group	Explosives
Analytical Method/SOP Reference[2]	SW-846 8330/ BR-LC-003

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per 12 hour window	Target analyte < QL; surrogate recovery within 39-132%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	Analyst	Accuracy/ Bias	Target analyte < QL; surrogate recovery within 39-132%
LCS	1 per extraction batch of 20 or less	See Table 1 of BR-LC-003	confirm issue, re-extract / re-analyze associated samples as necessary and appropriate	Analyst	Accuracy/ Bias	See Table 1 of BR-LC-003
MS/MSD	1 pair per extraction batch of 20 or less	See Table 1 of BR-LC-003; RPD ≤ 30%	confirm issue, re-extract / re-analyze associated samples as necessary and appropriate	Analyst	Precision	See Table 1 of BR-LC-003; RPD ≤ 30%
ICV	After each calibration	% Difference +/- 15%	confirm issue, re-extract / re-analyze associated samples as necessary and appropriate	Analyst	Accuracy/ Bias	% Difference +/- 15%
CCV	Daily before sample analysis, every 10 samples or 12 hours, at the end of an analytical sequence	% Difference or Drift +/- 15%	confirm issue, re-extract / re-analyze associated samples as necessary and appropriate	Analyst	Accuracy/ Bias	% Difference or Drift +/- 15%

[1]Reference number from QAPP Worksheet #21.

[2]Reference number from QAPP Worksheet #23.

LCS = Laboratory Control Sample
MS/MSD = Matrix Spike/ Matrix Spike Duplicate
RPD = Relative Percent Difference
LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-4
QC Samples Table

Matrix	Groundwater
Analytical Group	PEST/PCBs
Analytical Method/SOP Reference[2]	SW-846 8081A and 8082 / BR-GC-006 and BR-GC-005

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Breakdown Check Standard	Before initial calibration and each CCV	Degradation ≤ 15% for Endrin and DDT each	Correct problem, reanalyze, repeat calibration	Analyst	Accuracy	Degradation ≤ 15% for Endrin and DDT each
ICAL	Before sample analysis, when calibration verification standards indicate calibration relationship is no longer valid, and after major instrument maintenance	CF: RSD ≤ 20% Linear Regression: r ≥ 0.995	Correct problem and repeat initial calibration	Analyst	Accuracy/Bias	CF: RSD ≤ 20% Linear Regression: r ≥ 0.995
ICV	After each ICAL	%D ±20% from expected value for each analyte	Correct problem and verify second source standard. If that fails, repeat ICAL	Analyst	Accuracy/Bias	%D ±20% from expected value for each analyte
CCV	Daily before sample analysis, every 10 samples, and at the end of the analytical sequence	%D ±15%	Re-analyze once. If still outside criteria, perform corrective action. Sequence can be restarted if two successive CCVs pass. Otherwise, repeat ICAL and all associated samples since last successful CCV, unless CCV is high and bracketed samples are non-detects.	Analyst	Accuracy/Bias	%D ±15%
Method Blank	1 per extraction batch of 20 or less	≤ ½ QL	Correct problem, re-extract and reanalyze. Examine project DQOs with PM. If there are no detects in the associated samples, re-prep and reanalysis may not be required	Analyst	Accuracy/Bias	≤ ½ QL
LCS	One per extraction batch	%R within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005	Correct problem, re=extract, reanalyze along with associated samples. Examine project DQOs. Flag data if corrective action fails	Analyst	Accuracy/Bias	%R within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005
MS/MSD	One pair per extraction batch	%R and RPD within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005	Evaluate data and determine if a matrix effect or analytical error is indicated. If analytical error, reanalyze or re-extract. If matrix effect, report data with qualifier	Analyst	Precision	%R and RPD within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005
Laboratory Duplicate	Per client request	RPD within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005	Same as MS/MSD	Analyst	Precision	RPD within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005

Matrix	Groundwater
Analytical Group	PEST/PCBs
Analytical Method/SOP Reference[2]	SW-846 8081A and 8082 / BR-GC-006 and BR-GC-005

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Surrogate Spike	All field and QC samples	%R within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005	Evaluate data and determine if a matrix effect or analytical error is indicated. If analytical error, re-analyze or re-extract. If matrix effect, review project DQOs to determine if a matrix effect must be confirmed by re-analysis. Flag all reported values outside of control limits.	Analyst	Accuracy	%R within control limits as per Table 2 of BR-GC-006 and Table 1A of BR-GC-005

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23.
SDG = Sample Delivery Group
LCS = Laboratory Control Sample
MS/MSD = Matrix Spike/ Matrix Spike Duplicate
LQAO = Laboratory Quality Assurance Officer
RPD = Relative Percent Difference

QAPP Worksheet #28-5
QC Samples Table

Matrix	Groundwater
Analytical Group	SVOC
Analytical Method/SOP Reference[2]	SW-846 8270C / BR-MS-001

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Tune Standard	Prior to initial calibration and every 12 hours	See Table 4 of BR-MS-001	Correct problem and repeat check; no samples may be analyzed until criteria are met.	Analyst	Sensitivity	See Table 4 of BR-MS-001
Breakdown Check	Daily prior to sample analysis	No peak tailing observed for benzidine and pentachlorophenol	Correct problem and repeat check; no samples may be analyzed until criteria are met.	Analyst	Accuracy	No peak tailing observed for benzidine and pentachlorophenol
ICAL	Before sample analysis, when CCVs indicate calibration is no longer valid; after major instrument maintenance	SPCCs: Mean RF $\geq$ 0.050. CCCs: %RSD $\leq$ 30% Target Analytes: %RSD $\leq$ to 15% in order to use RF for quantification. If criteria are not met, linear or weighted regression: Linear Regression: r $\geq$ 0.995	Correct problem then repeat calibration, no samples may be analyzed until criteria are met.	Analyst	Accuracy / Bias	SPCCs: Mean RF $\geq$ 0.050. CCCs: %RSD $\leq$ 30% Target Analytes: %RSD $\leq$ to 15% in order to use RF for quantification. If criteria are not met, linear or weighted regression: Linear Regression: r $\geq$ 0.995
ICV	Immediately after each initial calibration	% Recovery within ±25% of expected value	Correct problem and verify second source standard. Reanalyze. If that fails, repeat initial calibration; no samples should be analyzed without an acceptable ICV.	Analyst	Accuracy / Bias	% Recovery within ±25% of expected value
CCV	Beginning of each 12-hour window after the tune standard	SPCCs: Mean RF $\geq$ 0.050. CCCs: %D $\leq$ 20%	Re-analyze once, if still outside criteria perform corrective action, sequence can be re-started if two successive CCVs at different concentrations pass, otherwise repeat ICAL and all associated samples since last successful CCV, unless CCV is high and samples are non-detects.	Analyst	Accuracy / Bias	SPCCs: Mean RF $\geq$ 0.050. CCCs: %D $\leq$ 20%
MB	One per extraction batch of 20 or fewer samples	No analyte > ½ RL except common lab contaminants (< RL)	Examine project DQO's and take appropriate corrective action, which may include re-analysis of MB, re-extraction of batch, and/or non-conformance report (NCR). Corrective action must be documented on NCR. If there are no detects in samples, or if all detects are > 10 X MB level, re-prep and reanalysis may not be required.	Analyst	Bias / Contamination	No analyte > ½ RL except common lab contaminants (< RL)
LCS	One per extraction batch of 20 or fewer samples	See Table 5 of BR-MS-001	Examine project DQO's and take appropriate corrective action, which may include re-analysis of LCS, re-extraction of batch, and/or non-conformance report (NCR). Corrective action must be documented on NCR. Flag all reported values outside of control limits.	Analyst	Accuracy	See Table 5 of BR-MS-001
MS/MSD	One per extraction batch of 20 or less samples.	See Table 5 of BR-MS-001	Evaluate data and determine if a matrix effect or analytical error is indicated. If analytical error, re-analyze and/or re-extract. Flag all reported values outside of control limits.	Analyst	Accuracy	See Table 5 of BR-MS-001

Matrix	Groundwater
Analytical Group	SVOC
Analytical Method/SOP Reference[2]	SW-846 8270C / BR-MS-001

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Surrogate Standard	All field and QC samples	See Table 5 of BR-MS-001	Evaluate data and determine if a matrix effect or analytical error is indicated. If analytical error, re-analyze or re-extract. If matrix effect, review project DQOs to determine if a matrix effect must be confirmed by re-analysis. Flag all reported values outside of control limits.	Analyst	Accuracy / Bias	See Table 5 of BR-MS-001
Internal Standard	All field and QC samples	EICP area between – 50 to +100% of area of daily calibration internal standard area RT ± 30 seconds from RT of midpoint of ICAL	Same as surrogate standards	Analyst	Accuracy	EICP area between – 50 to +100% of area of daily calibration internal standard area RT ± 30 seconds from RT of midpoint of ICAL

[1]Reference number from QAPP Worksheet #21.
[2]Reference number from QAPP Worksheet #23.
SVOC = Semivolatile Organic Compound
SDG = Sample Delivery Group
LCS = Laboratory Control Sample
MS/MSD = Matrix Spike/ Matrix Spike Duplicate
LQAO = Laboratory Quality Assurance Officer
RPD = Relative Percent Difference

QAPP Worksheet #29
Project Documents and Records Table

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
Field Notebooks	No onsite analysis projected other than water quality parameters. These readings will be recorded in field logbooks as they are collected.	Sample Receipt, Chain of Custody, and Tracking Records	Fixed Laboratory Audit Checklists	
Chain-of-Custody Records		Standard Traceability Logs	Data Validation Reports	
Air Bills		Equipment Calibration Logs	Corrective Action Forms	
Custody Seals		Sample Prep Logs	Laboratory QA Plan	
Corrective Action Forms		Run Logs	MDL Study Information	
Electronic Data Deliverables		Equipment Maintenance, Testing, and Inspection Logs		
Identification of QC Samples		Corrective Action Forms		
Meteorological Data from Field		Reported Field Sample Results		

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
Sampling instrument decontamination records		Reported Results for Standards, QC Checks, and QC Samples		
Sampling instrument calibration logs		Instrument Printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples		
Sampling location and sampling plan		Data Package Completeness Checklists		
Sampling notes and drilling logs		Sample Disposal Records		
		Extraction/Clean-up Records		
		Raw Data (stored on disk or CD-R)		

QAPP Worksheet #30
Analytical Services

Matrix	Analytical Group	Sample Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/ Organization	Backup Laboratory/ Organization
Groundwater	VOCs	See Worksheet 18, Worksheet 20	BR-MV-006	28 calendar days	TAL Burlington 30 Community Drive South Burlington, VT 05403 Jim Madison PH: 802-660-1990	TBD[1]
Groundwater	METAL and FMETAL	See Worksheet 18, Worksheet 20	BR-ME-003 BR-ME-005[2] BR-ME-015 BR-WC-004	28 calendar days	TAL Burlington 30 Community Drive South Burlington, VT 05403 Jim Madison PH: 802-660-1991	TBD[1]
Groundwater	PEST/PCBs	See Worksheet 18, Worksheet 20	BR-GC-006 BR-GC-005	28 calendar days	TAL Burlington 30 Community Drive South Burlington, VT 05403 Jim Madison PH: 802-660-1992	TBD[1]
Groundwater	Explosives	See Worksheet 18, Worksheet 20	BR-LC-003	28 calendar days	TAL Burlington 30 Community Drive South Burlington, VT 05403 Jim Madison PH: 802-660-1993	TBD[1]

Matrix	Analytical Group	Sample Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/ Organization	Backup Laboratory/ Organization
Groundwater	SVOCs	See Worksheet 18, Worksheet 20	BR-MS-001	28 calendar days	TAL Burlington 30 Community Drive South Burlington, VT 05403 Jim Madison PH: 802-660-1994	TBD[1]

[1] The need for a backup laboratory is not anticipated. If a situation arises in which TAL-Burlington cannot perform the analytical services for this project, another laboratory within the TAL network will be utilized.
[2] The use of ICP-AES (SW-846 6010B) is not anticipated unless significant interferences exist.

QAPP Worksheet #31
Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for…			
				Performing Assessment	Responding to Assessment Findings	Identifying and Implementing Corrective Actions (CA)	Monitoring Effectiveness of CA
Offsite Laboratory Technical Systems Audit	Laboratory must have current NFESC evaluation letter which will identify the period of performance. The laboratory must be re-evaluated prior to expiration of period of performance	External	U.S. Navy	Project QA Officer – Pati Moreno/ NFESC, Port Hueneme, CA	Kirsten McCracken, TAL Burlington's QA Officer	Kirsten McCracken, TAL Burlington's QA Officer	Anita Dodson, Program Chemist CH2M HILL

QAPP Worksheet #31-2
Corrective Action Form

CORRECTIVE ACTION FORM

Person initiating corrective action _____ Date _____

Description of problem and when identified: _____

_____

_____

Cause of problem, if known or suspected: _____

_____

_____

_____

Sequence of Corrective Action (CA): (including date implemented, action planned and personnel/data affected) _____

_____

_____

_____

_____

_____

_____

_____

CA implemented by: _____ Date: _____

CA initially approved by: _____ Date: _____

Follow-up date: _____

Final CA approved by: _____ Date: _____

Information copies to:

_____

_____

QAPP Worksheet #32
Assessment Findings and Response Actions

Assessment Type	Nature of Deficiencies Documentation	Individual Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual Receiving Corrective Action Response	Timeframe for Response
Laboratory Performance and Systems Audits	Written Audit Report	Kirsten McCracken, TAL Burlington QA Officer	Within two months of the audit	Memorandum	NFESC Auditor	Within two months of receipt of response

QAPP Worksheet #32-2
Field Performance Audit Checklist

n/a. There will be no Field Performance Audits.

QAPP Worksheet #33
QA Management Reports Table

Type of Report	Frequency	Projected Delivery Date	Person(s) Responsible for Report Preparation	Report Recipient(s)
Data Usability Assessment Report	One after all data are generated and validated	Submitted with Final Reports	Marlene Ivester / Project Manager CH2M HILL Megan Hilton/ Project Chemist CH2M HILL	Included in the Background Report. See Worksheet #3 for distribution list.

QAPP Worksheet #34
Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification
CoC and shipping forms	CoC forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the CoC will be initialed by the reviewer, a copy of the CoC retained in the site file, and the original and remaining copies taped inside the cooler for shipment. See CoC SOP for further details.	I	Patrick Murphy CH2M HILL Chelsea Bennet CH2M HILL
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and corrective action forms will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the site manager will be notified to ensure action is taken. Audit reports will be included in the QA Assessment section of the final RI report.	I	Anita Dodson CH2M HILL
Field Notebooks	Field notes will be reviewed internally and placed in the site file.	I	Marlene Ivester, CH2M HILL
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. All received data packages will be verified externally by the third party validator. Also, the data will be validated by an EIS specialist and a Chemist according to the data validation procedures specified in Worksheet #6.	I E, I	Laboratory QA Officers Environmental Data Services Chelsea Bennet (EIS) Megan Hilton (Chemist)

QAPP Worksheet #35
Validation (Steps IIa and IIb) Process Table

Step IIa/ IIb	Validation Input	Description	Responsible for Validation
IIa	SOPs	Ensure that all sampling and analytical SOPs were followed	Patrick Murphy, CH2M HILL
IIa	Documen-tation of Method QC Results	Establish that all required QC samples were run and met required limits.	Environmental Data Services
IIb	Documen-tation of QAPP QC Sample Results	Establish that all required QAPP QC samples were run and met required limits	Megan Hilton, CH2M HILL and Environmental Data Services
IIb	Project Quant-ification Limits	Ensure all sample results met the project quantification limit specified in the QAPP.	Megan Hilton, CH2M HILL
IIa	Raw Data	10 percent review of raw data to confirm laboratory calculations.	Environmental Data Services

QAPP Worksheet #36
Validation (Steps IIa and IIb) Summary Table

Step IIa/ IIb	Matrix	Analytical Group	Concen-tration Level	Validation Criteria	Data Validator
IIa	Groundwater	Total Metals/CN and Dissolved Metals	Low (ICP-MS, CVAA, and Colorimetry)	SW-846 methods 6020, 7470A, and 9012B will be reviewed for QC limits. EPA CLP Region III Modifications to National Functional Guidelines for Inorganic Data Review (April 1993) will be used for flagging conventions. The data validation subcontractor may also use laboratory SOPs if necessary.	Environmental Data Services
IIa	Groundwater	VOCs, SVOCs, PEST/PCBs	Low-Level to Medium	SW-846 methods 8260B, 8270C, 8081A, and 8082 will be reviewed for QC limits. EPA CLP Region III Modifications to National Functional Guidelines for Organic Data Review: Multi-Media, Multi-Concentration (Sept. 1994) will be used for flagging conventions and blank qualification scheme	Environmental Data Services

Step IIa/ IIb	Matrix	Analytical Group	Concen-tration Level	Validation Criteria	Data Validator
IIa	Groundwater	Explosives	Medium	SW846 method 8330 will be reviewed for QC Limits and the National Functional Guidelines should be used for flagging conventions. The data validation subcontractor may also use laboratory SOPs if necessary.	Environmental Data Services
IIb	Groundwater	Total Metals/CN and Dissolved Metals	Medium	Project Action Limits in Worksheet 15	Marlene Ivester, CH2M HILL
IIb	Groundwater	VOCs, SVOCs, PEST/PCBs	Medium	Project Action Limits in Worksheet 15	Marlene Ivester, CH2M HILL
IIb	Groundwater	Explosives	Medium	Project Action Limits in Worksheet 15	Marlene Ivester, CH2M HILL

QAPP Worksheet #37
Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

- Non-detected site contaminants will be evaluated to ensure that project QLs in Worksheet #15 were achieved. If project QLs were achieved and the verification and validation steps yielded acceptable data, then the data is considered usable.
- During verification and validation steps, data may be qualified as estimated with the following qualifiers: J, UJ, K, L, or UL. These qualifiers represent minor QC deficiencies which will not affect the usability of the data. When major QC deficiencies are encountered, data will be qualified with an R and in most cases is not considered usable for project decisions.
- For statistical comparisons non-detect values will be represented by a concentration equal to one-half the sample reporting limit. For duplicate sample results, the most conservative value will be used for project decisions.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. These checks include comparison of hardcopy data and qualifiers to the electronic data deliverable. Once the data has been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be compared as RPD between the two results.
- Deviations from the SAP will be reviewed to assess whether Corrective Action is warranted and to assess impacts to achievement of project objectives.

Describe the evaluative procedures used to assess overall measurement error associated with the project.

- To assess whether a sufficient quantity of acceptable data are available for decision making, the data will be reconciled with MPC following validation and review of Data Quality Indicator.
- A minimum of 8-10 samples should be obtained to calculate a defensible background value threshold values (BTVs) (USEPA, 2007).
- If significant biases are detected with laboratory QA/QC samples it will be evaluated to assess impact on decision making. Low biases will be described in greater detail as they represent a possible inability to detect compounds that may be present at the site.
- If significant deviations are noted between laboratory and field precision the cause will be further evaluated to assess impact on decision making.

Describe the documentation that will be generated during the usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

- Data tables will be produced to reflect detected and non-detected constituents. Data qualifiers will be reflected in the tables and discussed in the data quality evaluation.
- Graphical representations will be produced to reflect increasing and/or decreasing concentrations of constituents.

Identify the personnel responsible for performing the usability assessment.

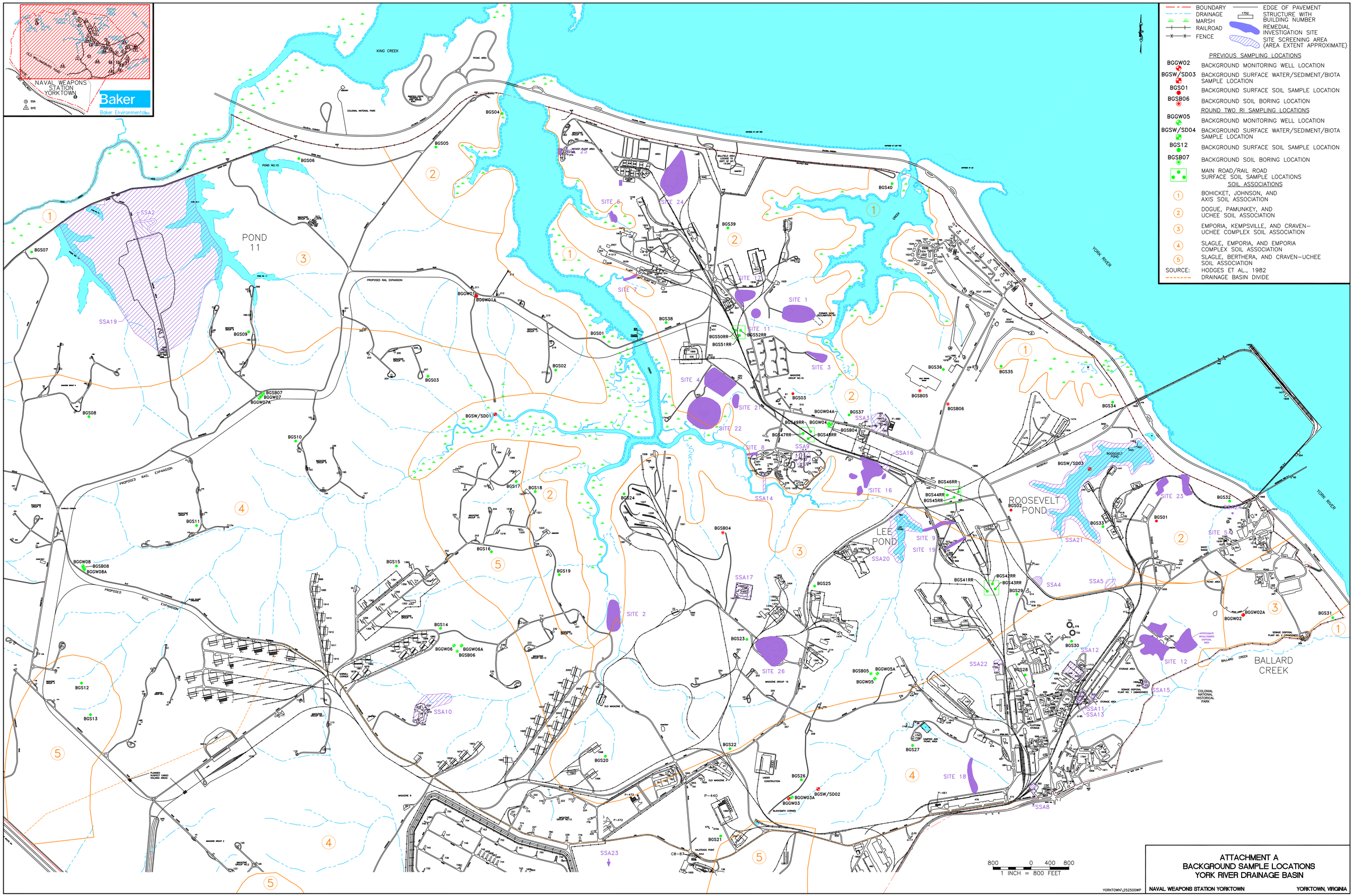
- The PM, Project Chemist, and other team members will be responsible for compiling the data. The data will then be presented to the Partnering Team who, as a whole, will evaluate the data usability according to project objectives.

Attachment 1
Laboratory Standard Operating Procedures, Field Standard Operating Procedures

Laboratory SOPs are proprietary and confidential.
They are provided upon request at the discretion of the Project Manager.

Appendix B
Previous Yorktown and CAX Background Investigation Sampling Location Figures

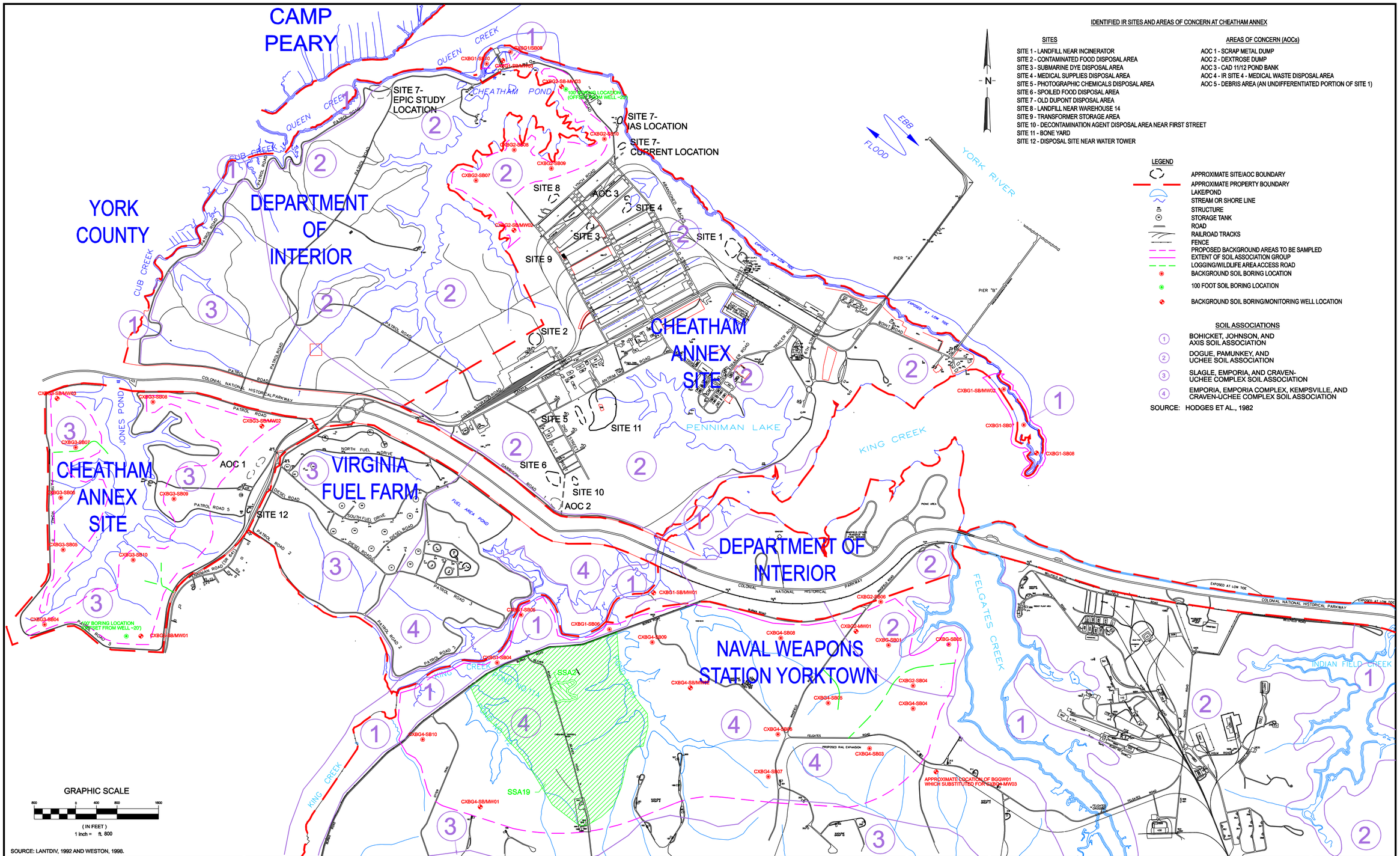
Appendix B
Previous Yorktown and CAX Background Investigation Sampling Location Figures



ATTACHMENT A
BACKGROUND SAMPLE LOCATIONS
YORK RIVER DRAINAGE BASIN

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA

YORKTOWN_252500WP



SOURCE: LANTDIV, 1992 AND WESTON, 1998.

IDENTIFIED IR SITES AND AREAS OF CONCERN AT CHEATHAM ANNEX

SITES

- SITE 1 - LANDFILL NEAR INCINERATOR
- SITE 2 - CONTAMINATED FOOD DISPOSAL AREA
- SITE 3 - SUBMARINE DYE DISPOSAL AREA
- SITE 4 - MEDICAL SUPPLIES DISPOSAL AREA
- SITE 5 - PHOTOGRAPHIC CHEMICALS DISPOSAL AREA
- SITE 6 - SPOILED FOOD DISPOSAL AREA
- SITE 7 - OLD DUPONT DISPOSAL AREA
- SITE 8 - LANDFILL NEAR WAREHOUSE 14
- SITE 9 - TRANSFORMER STORAGE AREA
- SITE 10 - DECONTAMINATION AGENT DISPOSAL AREA NEAR FIRST STREET
- SITE 11 - BONE YARD
- SITE 12 - DISPOSAL SITE NEAR WATER TOWER

AREAS OF CONCERN (AOCs)

- AOC 1 - SCRAP METAL DUMP
- AOC 2 - DEXTROSE DUMP
- AOC 3 - CAD 11/12 POND BANK
- AOC 4 - IR SITE 4 - MEDICAL WASTE DISPOSAL AREA
- AOC 5 - DEBRIS AREA (AN UNDIFFERENTIATED PORTION OF SITE 1)

LEGEND

- APPROXIMATE SITE/AOC BOUNDARY
- APPROXIMATE PROPERTY BOUNDARY
- LAKE/POND
- STREAM OR SHORE LINE
- STRUCTURE
- STORAGE TANK
- ROAD
- RAILROAD TRACKS
- FENCE
- PROPOSED BACKGROUND AREAS TO BE SAMPLED
- EXTENT OF SOIL ASSOCIATION GROUP
- LOGGING/WILDLIFE AREA ACCESS ROAD
- BACKGROUND SOIL BORING LOCATION
- 100 FOOT SOIL BORING LOCATION
- BACKGROUND SOIL BORING/MONITORING WELL LOCATION

SOIL ASSOCIATIONS

1. BOHICKET, JOHNSON, AND AXIS SOIL ASSOCIATION
2. DOGUE, PAMUNKEY, AND UCHEE SOIL ASSOCIATION
3. SLAGLE, EMPORIA, AND CRAVEN-UCHEE COMPLEX SOIL ASSOCIATION
4. EMPORIA, EMPORIA COMPLEX, KEMPSVILLE, AND CRAVEN-UCHEE COMPLEX SOIL ASSOCIATION

SOURCE: HODGES ET AL., 1982

REVISIONS	
1	
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DSN/DWN:	HGW/WJH
CHK:	HGW
S.O. NO.:	26007-196
FILE:	2196705W

NORTH

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA
CHEATHAM ANNEX SITE

Baker Environmental, Inc.
Coraopolis, Pennsylvania

Baker

SURFACE SOIL, SUBSURFACE SOIL, AND GROUNDWATER SAMPLE LOCATION MAP
CTO - 0196

SCALE: 1" = 800'

DATE: JULY 2002

FIGURE NO.

5-1

...\2196705W_Fig 5-1.dwg 3/3/2008 4:28:10 PM

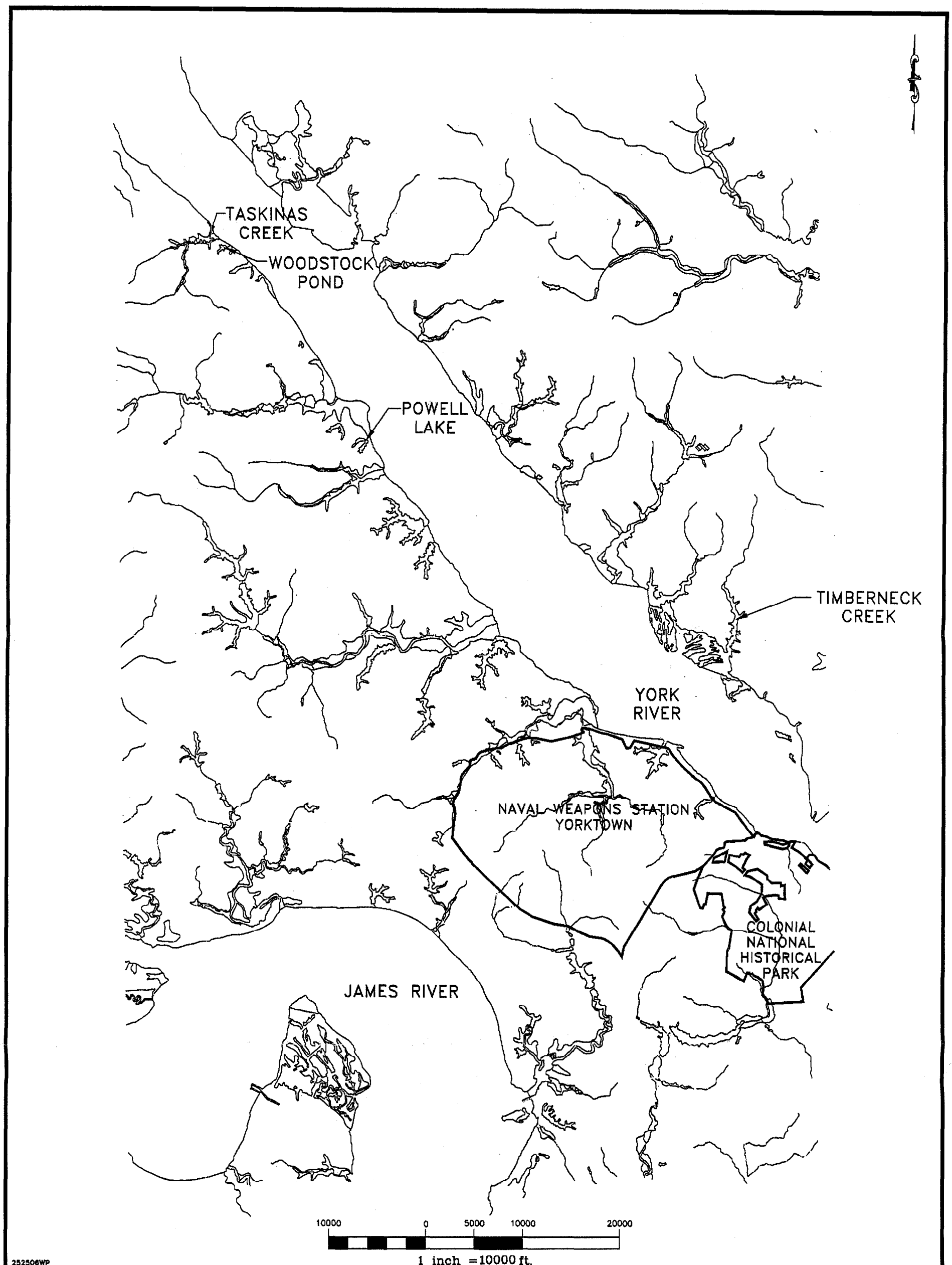
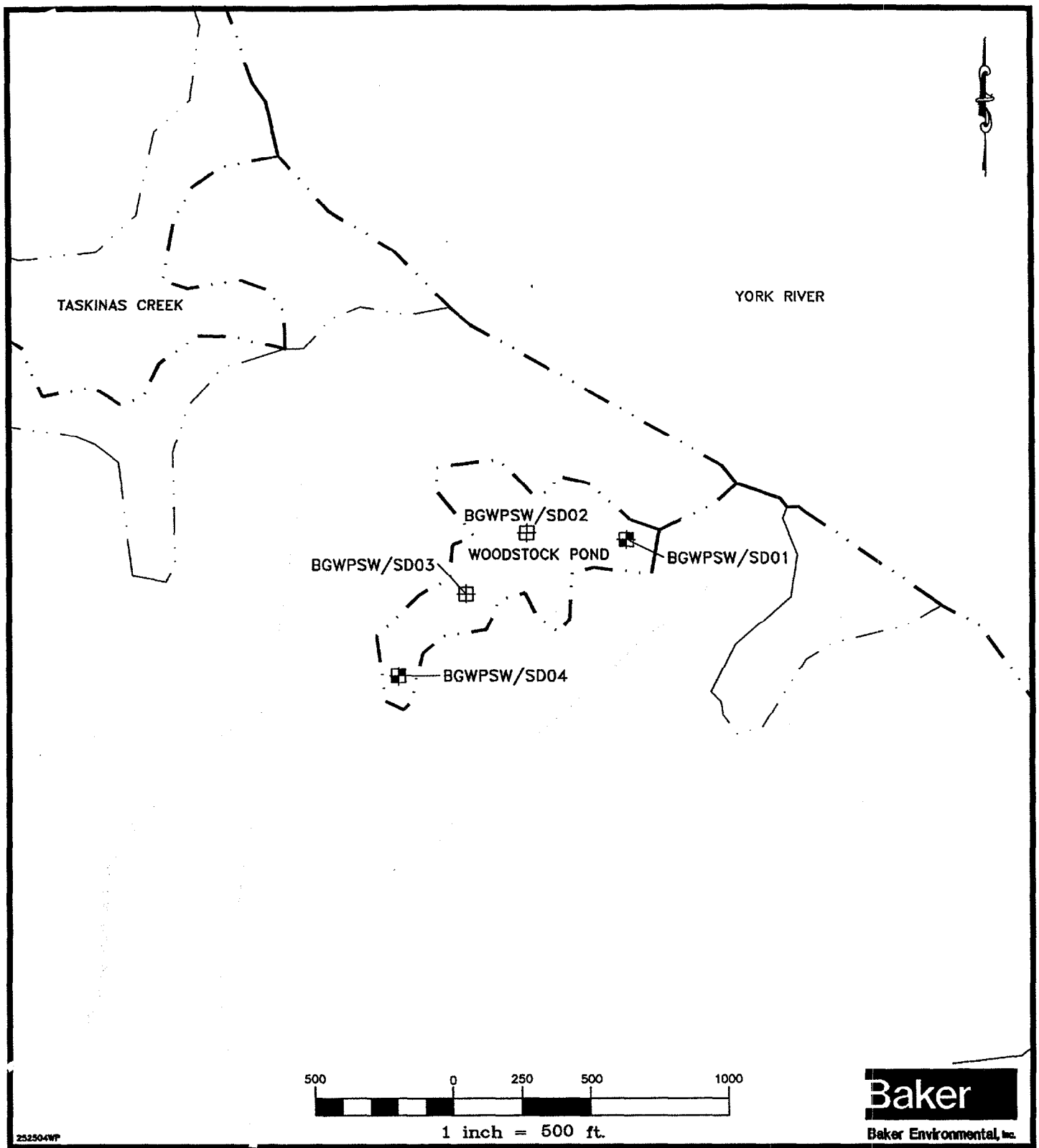


FIGURE 3-1
OFF-SITE SAMPLING LOCATION MAP
BACKGROUND INVESTIGATION

SOURCE: ADC MAPS, 1994 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

00636Y032



Baker
Baker Environmental, Inc.

LEGEND

BGWPSW/SD03 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE SAMPLE LOCATION

BGWPSW/SD01 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE/FISH SAMPLE LOCATION

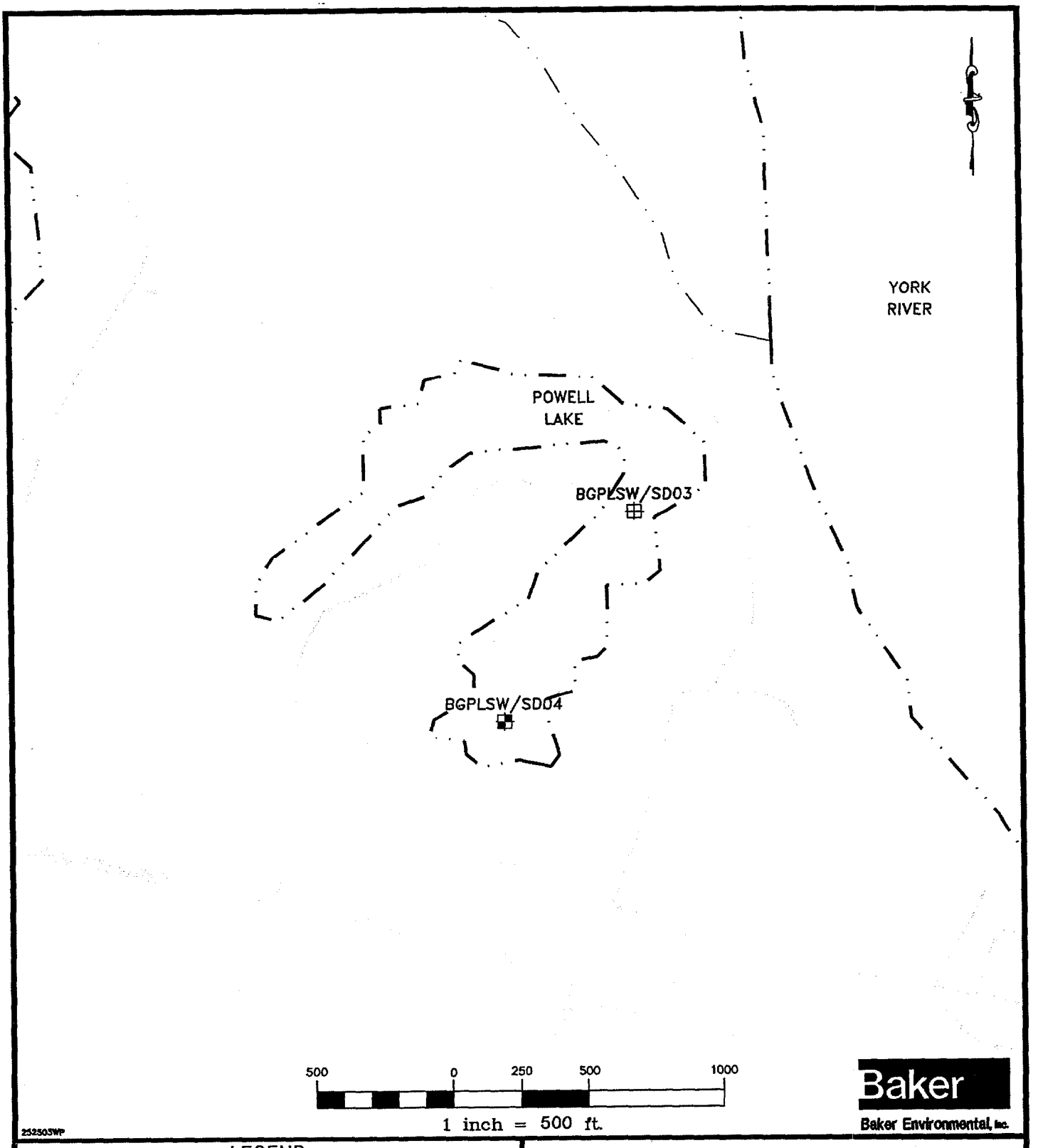
– · · – SURFACE WATER BOUNDARY

— · · — WETLAND BOUNDARY

SOURCE: ADC MAPS, 1994

FIGURE 3-2
FRESHWATER POND - WOODSTOCK POND
SAMPLE LOCATION MAP
BACKGROUND INVESTIGATION

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



LEGEND

BGPLSW/SD03 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE SAMPLE LOCATION

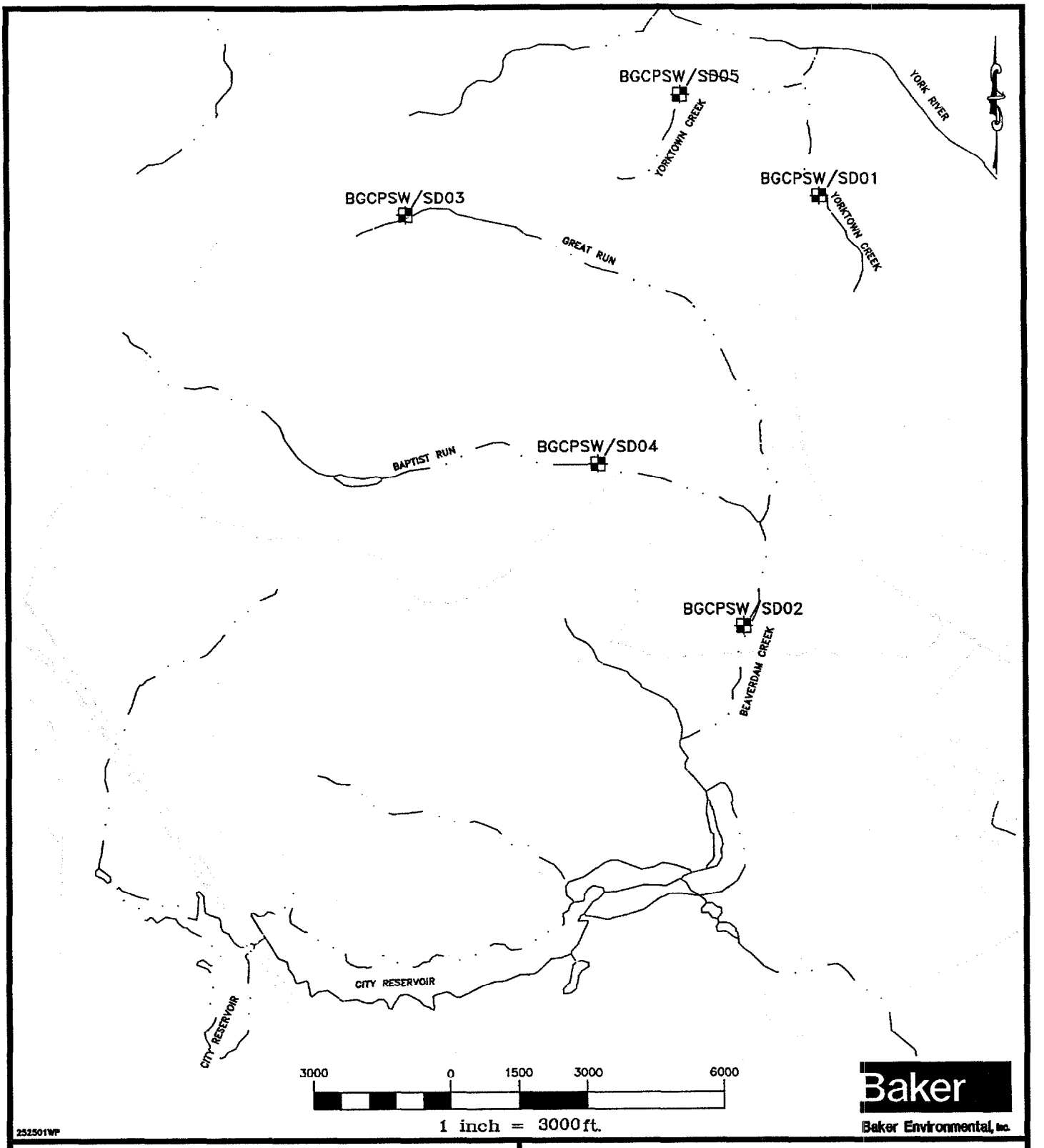
BGPLSW/SD04 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE/FISH SAMPLE LOCATION

– SURFACE WATER BOUNDARY

SOURCE: ADC MAPS, 1994

FIGURE 3-3
FRESHWATER POND - POWELL LAKE
SAMPLE LOCATION MAP
BACKGROUND INVESTIGATION

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



LEGEND

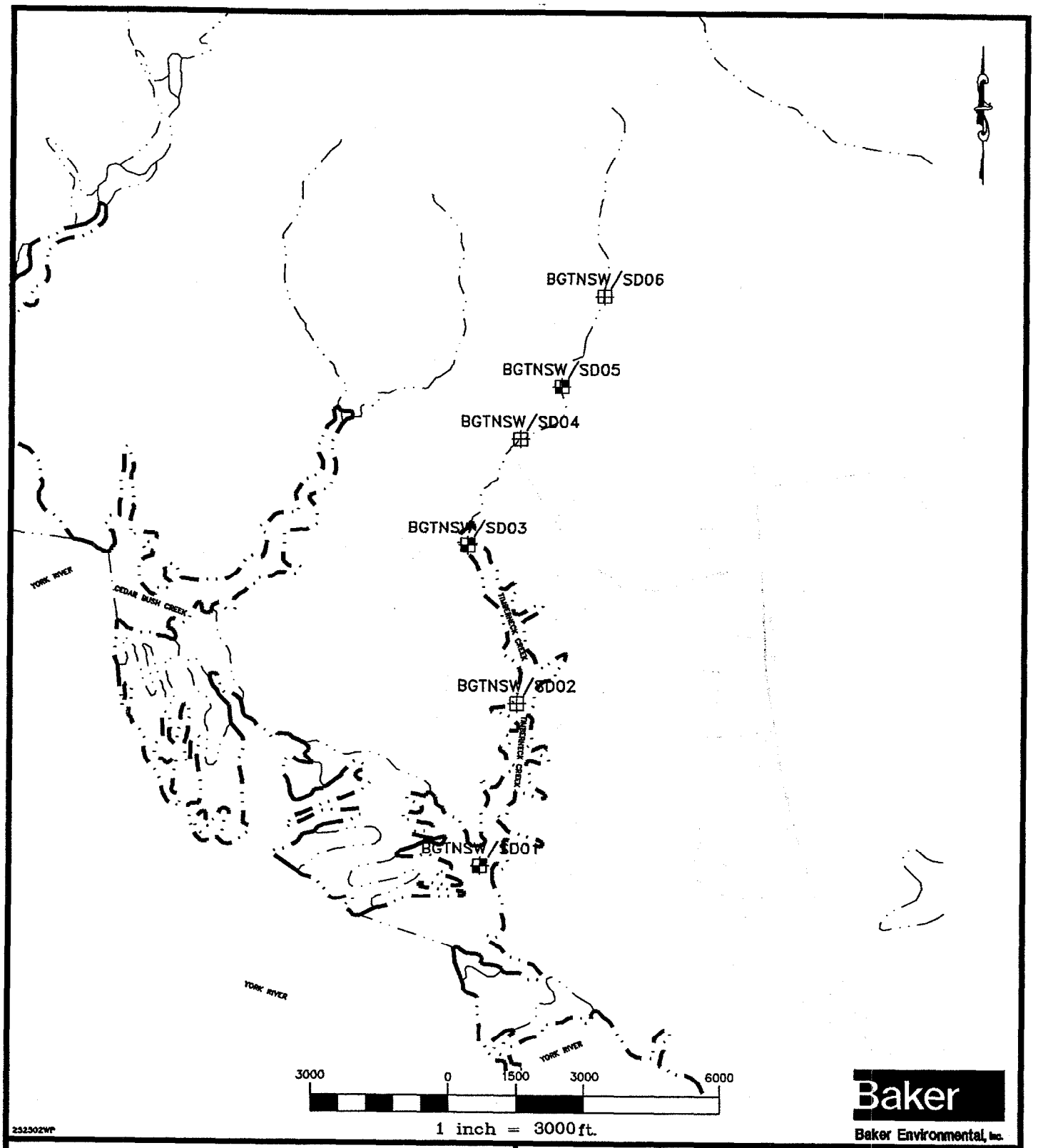
BGCPSW/SD02 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE/FISH SAMPLING LOCATION

– SURFACE WATER BOUNDARY

SOURCE: ADC MAPS, 1994

FIGURE 3-4
FRESHWATER STREAMS -
COLONIAL NATIONAL HISTORICAL PARK
SAMPLE LOCATION MAP
BACKGROUND INVESTIGATION

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



LEGEND

BGTNSW/SD02 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE SAMPLE LOCATION

BGTNSW/SD01 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE/FISH SAMPLE LOCATION

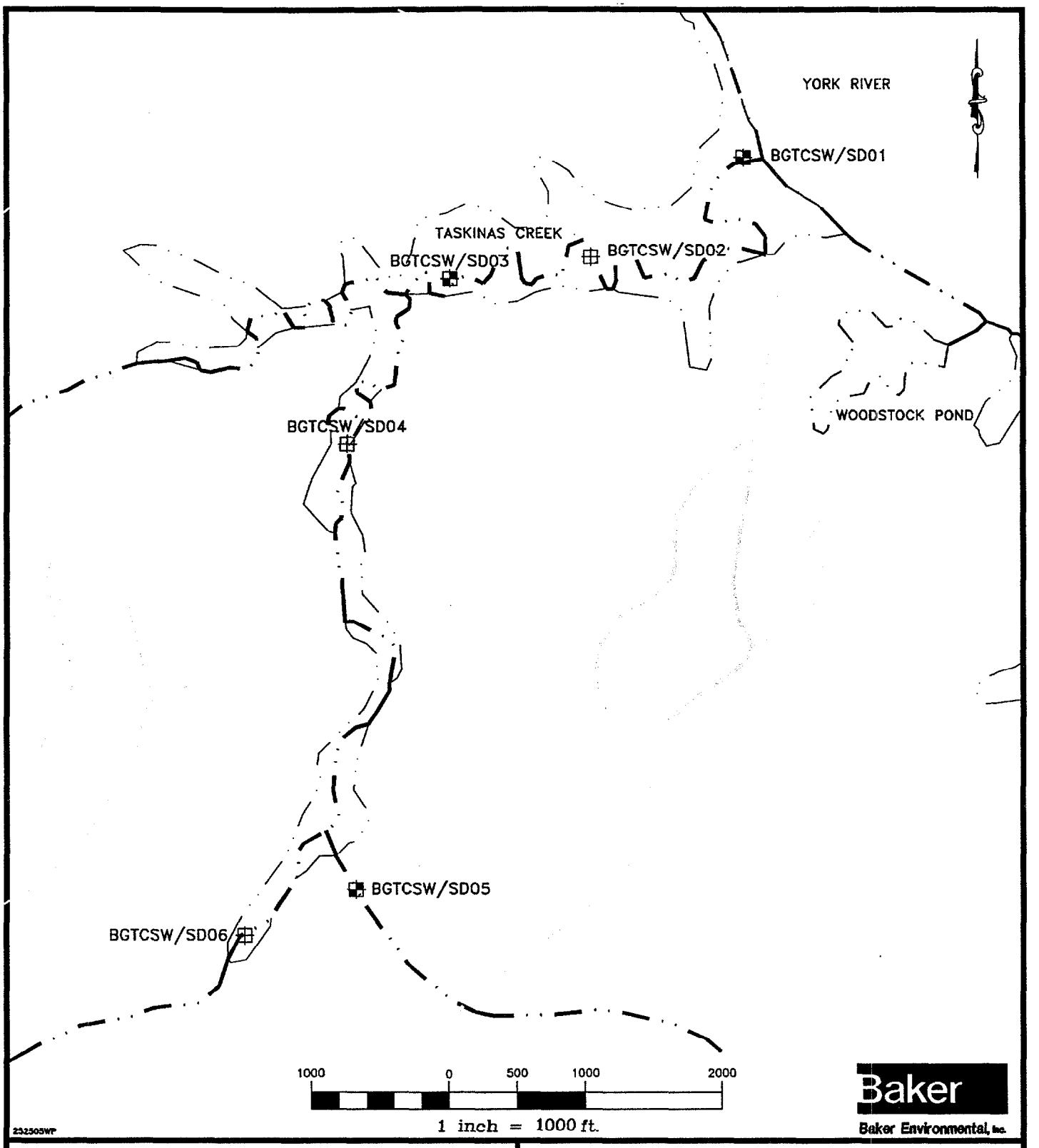
– SURFACE WATER BOUNDARY

– WETLAND BOUNDARY

SOURCE: ADC MAPS, 1994

FIGURE 3-5
TIDAL FRESHWATER STREAM - TIMBERNECK CREEK
SAMPLE LOCATION MAP
BACKGROUND INVESTIGATION

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



LEGEND

BGTCSW/SD02 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE SAMPLE LOCATION

BGTCSW/SD03 – SURFACE WATER/SEDIMENT/BENTHIC MACROINVERTEBRATE/FISH SAMPLE LOCATION

– SURFACE WATER BOUNDARY

– WETLAND BOUNDARY

SOURCE: ADC MAPS, 1994

FIGURE 3-6
TIDAL FRESHWATER STREAM - TASKINAS CREEK
SAMPLE LOCATION MAP
BACKGROUND INVESTIGATION

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Appendix C
Soil Data and Statistical Analysis

Table C-1
Surface Soil Samples
Inorganics
Background Investigation
Naval Weapons Station Yorktown

Sample ID	BGS01	BGS02	BGS03	BGS04	BGS05	BGS06	BGS07	BGS08	BGS09	BGS10	BGS11	BGS12	BGS13	BGS14	BGS15
Date sampled	07/08/94	07/08/94	07/08/94	07/08/94	07/08/94	07/08/94	07/08/94	07/08/94	07/08/94	07/19/94	07/19/94	07/20/94	07/20/94	07/19/94	07/20/94
Depth	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"
Metals (mg/kg)															
Aluminum	1960.0	4590	6320	8550	4530	3210	6030	6530	4960	4980	4370	3940	2540	4530	6180
Antimony	8.4 UL	8.3 UL	8.8 UL	8.9 UL	8.7 UL	9.2 L	8.5 UL	9.4 UL	8.4 UL	8.6 UL	9.5 UL	8.6 UL	8.5 UL	9.2 UL	9.3 UL
Arsenic	1.9 J	1.2 J	1.5 J	3.4	3.6	2 J	5.8	1.4 J	1.5 J	1.2 J	2.9	0.46 L	0.65 L	0.84 J	0.75 L
Barium	12.7 J	22 J	53.1	62	24.8 J	19.1 J	17.8 J	20 J	20.4 J	31.5 J	35 J	5.1 J	4.2 J	24.4 J	20.2 J
Beryllium	0.2 U	0.23 J	0.51 J	0.52 J	0.28 J	0.23 J	0.4 J	0.25 U	0.31 J	0.42 J	0.32 J	0.23 U	0.23 U	0.25 U	0.42 J
Cadmium	1.1 U	1.1 U	1.2 U	1.2 U	1.2 U	1.1 U	1.1 U	1.3 U	1.1 U	1.2 U	1.3 U	1.2 U	1.1 U	1.2 J	1.3 U
Calcium	268.0 J	215 J	937 J	7820	1420	388 J	259 J	269 J	110 J	204 J	1610 J	39.4 J	67.3 J	696 J	229 J
Chromium	4.3	5.5	5.4	13.6	9.4	5.3	11.8	6.9	5.1	6.8	9.8	4.3	3.2	5.4	5.7
Cobalt	0.9 U	1.6 J	1.5 J	4.2 J	1.2 J	2.3 J	2.2 J	1.1 J	1.6 J	6 J	2.5 J	1.1 J	0.91 U	2 J	3.6 J
Copper	1.1 U	1.7 J	1.5 J	24.4	2 J	1.1 U	2.4 J	2 J	1.1 U	1.2 UL	3.7 J	1.2 U	1.1 U	2.5 J	1.6 J
Iron	3310.0	4160	4670	12400	7090	4910	11100	5670	3690	3580	7010	3150	1440	4400	5260
Lead	6.9	6.4	15.3	22.7	9.9	9.8	43.1	14.7	12	14.3 J	14.2 J	7.6	8.4	14.2 J	11.3
Magnesium	175.0 J	236 J	290 J	1060 J	475 J	262 J	489 J	329 J	319 J	297 J	487 J	159 J	61.5 J	233 J	229 J
Manganese	8.3	65.8	491	298	73.4	85.9	29.9	40	26.5	169 J	191 J	7.6 L	10.3 L	118 J	45.2 L
Mercury	0.1 U	0.05 U	0.06 U	0.06 U	0.06 U	0.05 U	0.05 U	0.06 U	0.05 U	0.06 U	0.06 U	0.06 UL	0.06 UL	0.06 U	0.06 UL
Nickel	3.6 U	4.5 J	4.9 J	9 J	4.8 J	5.6 J	6.2 J	7 J	4.2 J	6.6 J	4.1 U	3.7 U	3.7 U	6 J	4 U
Potassium	355.0 U	353 U	372 U	828 J	531 J	354 U	360 U	398 U	355 U	367 U	515 J	367 U	359 U	390 U	396 U
Selenium	0.4 J	0.32 J	0.46 J	0.27 J	0.24 U	0.32 J	0.32 J	0.55 L	0.38 L	0.23 U	0.27 J	0.23 U	0.23 U	0.25 U	0.25 U
Silver	0.9 U	0.9 U	0.95 U	0.96 U	0.94 U	0.9 U	0.92 U	1 U	0.9 U	1 J	1 U	0.93 U	0.91 U	0.99 U	1 U
Sodium	43.2 J	32.3 J	40.1 J	115 J	40.6 J	22.7 J	37.8 J	45.4 J	34 J	46.7 J	34.7 J	13.9 J	40.1 J	31.9 J	24 J
Thallium	0.2 U	0.22 U	0.24 U	0.24 U	0.24 U	0.23 U	0.23 U	0.25 U	0.23 U	0.23 U	0.26 U	0.23 U	0.23 U	0.25 U	0.25 U
Vanadium	7.4 J	10.8 J	10.7 J	19.3	15.3	10.1 J	20.4	14.8	10.1 J	11.2 J	15	11 J	7.6 J	11 J	12.7
Zinc	5.7	8.6	13	37.5	14.9	9.8	18	13.4	10.9	17.2	18.6	5.1 Z	3.2 KJ	11.3	11.7
Cyanide	0.6 U	0.56 U	0.59 U	0.6 U	0.59 U	0.55 U	0.57 U	0.63 U	0.56 U	0.58 U	0.64 U	0.58 U	0.57 U	0.61 U	0.63 U

Table C-1
Surface Soil Samples
Inorganics
Background Investigation
Naval Weapons Station Yorktown

Sample ID	BGS16	BGS17	BGS18	BGS18D	BGS19	BGS20	BGS20D	BGS21	BGS22	BGS23	BGS24	BGS24D	BGS25	BGS26	BGS27	BGS28	BGS29
Date sampled	07/19/94	07/20/94	07/20/94	07/20/94	07/20/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94	07/21/94
Depth	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"
Metals (mg/kg)																	
Aluminum	4630	7500	5630	5780	5760	13000	12900	15600	10600	3110	4380	4440	5010	5810	12000	19200	4410
Antimony	8.7 UL	9.4 UL	9.3 UL	9.4 UL	9 UL	10.3 UL	10.4 UL	8.9 UL	9.3 UL	8.5 UL	8.9 UL	8.9 UL	8.3 UL	8.7 UL	10.6 UL	9.2 UL	8.5 UL
Arsenic	0.53 L	2.5 L	1.6 L	2.5 L	4.2	2.9	2.6 J	63.9	1.8 J	1.1 J	1.3 J	1.5 J	1.4 J	1.1 J	2.7 J	2.9	1.2 J
Barium	15.1 J	28.1 J	34.3 J	35.1 J	17.4 J	76.6	75.7	19.5 J	57.0	10.8 J	20.9 J	22.9 J	32.4 J	19 J	23.5 J	80.2	15.5 J
Beryllium	0.23 U	0.6 J	0.51 J	0.59 J	0.42 J	0.64 J	0.63 J	0.24 U	0.57 J	0.23 U	0.28 J	0.33 J	0.38 J	0.24 U	0.32 J	0.63 J	0.23 U
Cadmium	1.2 U	1.3 U	1.3 U	1.3 U	1.2 U	1.4 U	1.4 U	1.2 U	1.3 U	1.1 U	1.2 U	1.2 U	1.1 U	1.2 U	1.4 U	1.2 U	1.1 U
Calcium	346 J	447 J	727 J	670 J	908 J	2730	2940	97.0 J	1330	133 J	469 J	575 J	148 J	105 J	346 J	854 J	168 J
Chromium	5.1	9.7	8.7	8.3	13.4	14.3	13.7	13.1	9.7	3.4	4.3	5.4	6.1	5.3	14.1	17.5	4.5
Cobalt	1.6 J	4.6 J	6.2 J	6.7 J	4.9 J	4.1 J	4.0 J	1.6 J	3.0 J	1.0 J	1.2 J	2.7 J	3.5 J	1.0 J	1.9 J	3.5 J	1.4 J
Copper	1.7 J	1.9 J	1.9 J	2 J	2.3 J	3.9 J	3.9 J	2.7 J	3.4 J	1.1 U	1.5 J	1.4 J	1.3 J	1.9 J	3.7 J	5.3 J	1.1 U
Iron	3550	9210	7960	7510	17200	11200	10600	6820	6780	2160	3270	3940	6490	3820	19900	13000	3400
Lead	8.7	14.3	12.7	13.3	12.9	16.7 L	14.8 L	13.9 L	25.3 L	10 L	12.6 L	11.3 L	11.8 L	10.4 L	14.5 L	38.7 L	8.8 L
Magnesium	245 J	416 J	372 J	385 J	492 J	803 J	818 J	456 J	586 J	181 J	287 J	303 J	290 J	320 J	401 J	1070 J	257 J
Manganese	39.2 L	92.3 L	254 L	273 L	97.7 L	332	340	9.5	157	19.0	84.7	87.6	72.9	15.5	28.7	126	28.6
Mercury	0.06 UL	0.06 UL	0.06 UL	0.06 UL	0.06 UL	0.06 UL	0.07 UL	0.06 UL	0.06 UL	0.05 UL	0.06 UL	0.06 UL	0.05 UL	0.06 UL	0.07 UL	0.06 UL	0.06 UL
Nickel	3.8 U	7.7 K	4 U	4.8 K	6.2 K	6.4 J	11.9	7.2 J	6.5 J	5.7 J	5.1 J	5.4 J	5.7 J	5.4 J	4.6 J	10.7	5.1 J
Potassium	368 U	399 U	535 J	400 U	429 J	725 J	442 U	377 U	519 J	359 U	377 U	377 U	353 U	370 U	449 U	457 J	360 U
Selenium	0.24 U	0.26 U	0.25 U	0.25 U	0.24 U	0.43 J	0.43 J	0.44 J	0.39 J	0.23 U	0.3 J	0.3 J	0.22 U	0.30 J	0.36 J	0.31 J	0.23 U
Silver	0.94 U	1 U	1 U	1 U	0.98 U	1.1 U	1.1 U	2.1 J	1.0 U	0.91 U	0.96 U	0.96 U	0.90 U	0.94 U	1.1 U	1.00 U	0.92 U
Sodium	32.1 J	25 J	26.1 J	24.4 J	17.4 J	21.2 J	26.4 J	51.0 J	32.2 J	22.7 J	15.8 J	18.6 J	29.6 J	43.0 J	33.0 J	37.3 J	18.7 J
Thallium	0.24 U	0.26 U	0.25 U	0.25 U	0.24 U	0.28 U	0.28 U	0.24 U	0.25 U	0.23 U	0.24 U	0.24 U	0.22 U	0.24 U	0.29 U	0.25 U	0.23 U
Vanadium	10.8 J	20.2	17.3	16.4	20.8	27.8	26.9	25.4	20.4	8.7 J	9.8 J	10.0 J	10.7 J	12.5	29.8	34.7	9.8 J
Zinc	8.4	17.2	15.6	16.3	17.9	25.5	25.2	8.5	22.7	5.7	11.0	12.1	11.0	8.2	15.5	48.4	16
Cyanide	0.6 U	0.64 U	0.63 U	0.64 U	0.61 U	0.70 U	0.70 U	0.58 U	0.62 U	0.57 U	0.6 U	0.59 U	0.56 U	0.59 U	0.71 U	0.61 U	0.57 U

Table C-1
Surface Soil Samples
Inorganics
Background Investigation
Naval Weapons Station Yorktown

Sample ID	BGS30	BGS31	BGS33	BGS34	BGS34D	BGS35	BGS36	BGS37	BGS38	BGS39	BGS39D	BGS40
Date sampled	07/21/94	07/21/94	07/22/94	07/23/94	07/23/94	07/23/94	07/22/94	07/23/94	07/23/94	07/23/94	07/23/94	07/23/94
Depth	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"	0-6"
Metals (mg/kg)												
Aluminum	9210	4500	8440	4790	8330	12000	2850	6250	6880	4660	4130	3640
Antimony	8.6 UL	8.7 UL	8.3 R	8.7 UL	8.8 UL	11 L	8.1 R	8.4 UL	8.6 UL	8 UL	8.3 UL	8.1 UL
Arsenic	2.4	1.1 J	1.4 J	3.7	4.1	2.1 K	0.68 J	1.6 K	1.7 K	0.83 K	0.81 J	1.2 K
Barium	15.8 J	23.7 J	30.2 J	25 J	30 J	47.9 J	11.8 J	34 J	76.3	18.4 J	17 J	18.5 J
Beryllium	0.23 U	0.30 J	0.37 J	0.42 J	0.49 J	0.55 J	0.22 U	0.56 J	0.93 J	0.3 J	0.27 J	0.22 U
Cadmium	1.5	1.2 U	1.1 U	1.2 UL	1.2 UL	1.2 UL	1.3 K	1.1 UL	1.2 UL	1.1 UL	1.1 UL	1.1 UL
Calcium	347 J	1120 J	596 J	1720	1740	800 J	135 J	432 J	1430	285 J	233 J	467 J
Chromium	9.6	4.7	8.8	10	18.3	10.9	2.6	7.9	7	5.1	5.4	5.2
Cobalt	1.7 J	1.8 J	2.5 J	2.6 J	3.4 J	3.6 J	1.1 J	2.3 J	4 J	2.7 J	1.8 J	1 J
Copper	2.0 J	1.2 J	2.4 J	2.6 J	4.2 J	3.7 J	1.1 U	3.3 J	5 J	1.6 J	1.5 J	1.7 J
Iron	7830	3150	7410	7060	12500	6310	1910	5190	6300	2700	2660	3510
Lead	13 L	7.3 L	9.3	7.3 L	7.4 L	16.5 L	16.5	8.7 L	9.9 L	6.8 L	8.6	7.7 L
Magnesium	394 J	324 J	493 J	840 J	1610	914 J	161 J	482 J	594 J	307 J	280 J	347 J
Manganese	13.0	72.8	89.3	105	70.6	206	20.3	252	413	54.9	36.1	48
Mercury	0.06 UL	0.06 UL	0.05 U	0.06 UL	0.05 UL	0.06 UL	0.05 U	0.05 UL	0.06 UL	0.05 UL	0.05 UL	0.06 UL
Nickel	5.5 J	5.1 J	8.8 K	3.7 U	8.6 J	6.9 J	5.5 K	7.5 J	5.9 J	5.2 J	3.8 J	4.3 J
Potassium	416 J	371 U	350 U	738 J	1640 J	724 J	345 U	358 U	593 J	338 U	611 J	398 J
Selenium	0.36 J	0.24 U	0.22 UL	0.23 UL	0.24 UL	0.4 L	0.22 UL	0.27 L	0.23 UL	0.26 L	0.27 L	0.22 UL
Silver	0.92 U	0.94 U	0.89 U	0.94 U	0.95 U	0.96 U	0.88 U	0.91 U	0.93 U	0.86 U	0.9 U	0.88 U
Sodium	35.7 J	32.7 J	36.2 J	46.7 J	63.4 J	84.3 J	50 J	37.6 J	52 J	69.3 J	35 J	68.7 J
Thallium	0.23 U	0.24 U	0.22 U	0.23 U	0.24 U	0.25 U	0.22 U	0.23 U	0.23 U	0.22 U	0.22 U	0.22 U
Vanadium	21.2	8.9 J	17.1	12.2	18.9	21.2	6.1 J	14.4	12	8.7 J	9.4 J	8.8 J
Zinc	12.9	9.7	12.8 J	18.2	24.1	21.3	5.9 J	15.5	23.8	12.1	11.5	9.8
Cyanide	0.58 U	0.59 U	0.55 U	0.59 U	0.59 U	0.62 U	0.55 U	0.56 U	0.58 U	0.54 U	0.56 U	0.55 U

Table C-2
Subsurface Soil Samples
Inorganics
Background Investigation
Naval Weapons Station Yorktown

Sample ID	BGSB04-01		BGSB04-01D		BGSB05-01	
Date sampled	08/08/94		08/08/94		07/19/94	
Depth	1-3 '		1-3 '		1-3 '	
Metals (mg/kg)						
Aluminum	6270	J	6560	J	6840	
Antimony	8.1	R	8.1	R	8.9	UL
Arsenic	1.1	L	0.7	L	1.2	L
Barium	39.4	J	42.1	J	47.8	J
Beryllium	0.57	J	0.49	J	0.52	J
Cadmium	1.1	U	1.1	U	1.2	U
Calcium	363	J	353	J	378	J
Chromium	5.4		6		7.5	
Cobalt	2.9	J	3.1	J	2.2	J
Copper	2	J	2.2	J	2.4	J
Iron	3810	J	4030	J	6130	
Lead	5.6	L	3.6	L	13.7	J
Magnesium	466	J	512	J	462	J
Manganese	284	J	254	J	85.6	J
Mercury	0.05	UL	0.05	UL	0.06	U
Nickel	6.2	K	6.7	K	3.8	U
Potassium	344	U	399	J	392	J
Selenium	0.26	L	0.22	UL	0.38	J
Silver	0.88	U	0.87	U	1.1	J
Sodium	101	J	117	J	58.5	J
Thallium	0.22	U	0.22	U	0.24	U
Vanadium	7.8	J	8.6	J	12.9	
Zinc	14.3		12.6		11.1	
Cyanide	0.54	U	0.54	U	0.59	U

Table C-3
Surface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG1-SS01-00	BG1-SS02-00	BG1-SS03-00	BG1-SS04-00	BG1-SS05-00	BG1-SS05-00D	BG1-SS06-00	BG1-SS07-00	BG1-SS08-00	BG1-SS09-00	BG1-SS10-00
SAMPLE DATE	08-06-2001	07-25-2001	07-25-2001	08-06-2001	08-06-2001	08-06-2001	08-06-2001	07-25-2001	07-25-2001	07-25-2001	07-25-2001
SAMPLE DEPTH (inches)	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6" - 6"	0 - 6"
Inorganics (mg/kg)											
Aluminum	3700	265	16500	5640	3120	2800	3570	235	476	12400	2320
Antimony	0.42 UL	0.36 UL	1.4 UL	0.58 UL	0.66 UL	1 L	0.93 UL	0.33 UL	0.36 UL	1.2 UL	0.54 UL
Arsenic	2.6 B	0.25 U	9.9	4.7	3.1 B	2.6 B	8.3	0.23 U	0.25 U	6 J	4.2
Barium	21 J	0.75 J	31.6 J	9.1 J	13.4 J	11.5 J	25.8 J	5.1 J	2.2 J	21.5 J	7.1 J
Beryllium	0.38 J	0.085 U	1.1 J	0.39 J	0.41 J	0.31 J	0.34 J	0.082 B	0.11 B	0.72 J	0.22 B
Calcium	867 J	1380	2300 J	2950	4220	3500	33500	149 J	1640	2280 J	470 J
Chromium	8	1.8 J	43.2	13.5	9.4	8.2	9.9	7.7	3.7	26.8	8.9
Cobalt	1.6 J	0.15 U	3.8 J	1.4 J	1.6 J	1.5 J	2.2 J	0.13 U	0.2 J	2.4 J	0.35 J
Copper	1.7 J	0.41 J	22.1	4 J	2.6 J	2.7 J	8.8 J	0.43 J	1.5 J	9.8 J	4.2 J
Iron	12300	1520	18300	13500	8280	8680	17400	1470	3220	16500	6410
Lead	6.2 J	1.1	136	12.2 J	7.2 J	8.9 J	15.6 J	14.4	3.2	34.7	7.5
Magnesium	396 J	160 J	6770	2050	1190 J	1200 J	1160 J	92.1 B	195 J	5290	1130 J
Manganese	26 J	6.9	108	47.6 J	43.2 J	46.3 J	90.3 J	10.3	15.8	62.7	15.5
Mercury	0.052 J	0.04 U	0.24 J	0.14 J	0.11 J	0.1 J	0.15 J	0.046 U	0.05 U	0.16 U	0.06 U
Nickel	2.4 J	0.37 J	14.2 J	4.1 J	3.5 J	3 J	5.6 J	0.4 J	1.1 J	8.7 J	2.1 J
Potassium	359 J	170 B	4560	1420 J	1020 J	909 J	911 J	97.6 B	220 B	3510	754 J
Selenium	0.7 UL	0.59 UL	2.2 UL	1.5 J	1.1 UL	1.2 J	2.7 J	0.54 UL	0.59 UL	1.9 UL	0.89 UL
Silver	0.12 U	0.11 U	0.4 U	0.17 U	0.19 U	0.18 U	0.27 U	0.096 U	0.11 U	0.34 U	0.16 U
Sodium	437 B	568 B	21300	2610	1400 B	1960	2970	187 B	408 B	20500	4140
Thallium	1 UL	0.87 UL	3.3 UL	1.4 UL	1.6 UL	1.5 UL	2.2 UL	0.79 UL	0.87 UL	2.8 UL	1.3 UL
Vanadium	13.5	2.4 J	50.3	20.5	11.7 J	10.8 J	19.5 J	4.3 J	3.2 J	41.2	21.2
Zinc	7.9 L	4.2 J	113	18.1	11.9 L	13.3 L	30	16.1	41.2	47.8	12.2

Table C-3
Surface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG2-SS01-00	BG2-SS01-00D	BG2-SS02-00	BG2-SS03-00	BG2-SS04-00	BG2-SS05-00	BG2-SS06-00	BG2-SS07-00	BG2-SS08-00	BG2-SS09-00	BG2-SS10-00	BG3-SS01-00
SAMPLE DATE	07-27-2001	07-27-2001	07-24-2001	07-25-2001	07-26-2001	07-26-2001	07-27-2001	07-24-2001	07-24-2001	07-24-2001	07-25-2001	07-23-2001
SAMPLE DEPTH (inches)	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Inorganics (mg/kg)												
Aluminum	2230	2330	2930	3640	2370	2830	4420	3820	4570	2660	4290	4710
Antimony	0.41 B	0.37 U	0.35 UL	0.37 UL	0.35 U	0.37 U	0.4 U	0.36 UL	0.36 U	0.36 U	0.37 U	0.38 UL
Arsenic	0.28 U	0.56 B	0.63 J	0.8 J	0.61 B	1.2 B	4.1	1.5 J	1.6 J	0.66 B	1.2 B	0.75 J
Barium	28.3 J	27.9 J	24.6 J	28.5 J	12.2 J	25 J	27.4 J	26.9 J	29.4 J	22.3 J	32.7 B	18.2 J
Beryllium	0.42 B	0.33 B	0.38 B	0.4 B	0.13 B	0.31 B	0.42 B	0.42 B	0.52 B	0.37 B	0.36 B	0.16 B
Calcium	830 J	746 B	598 J	321 J	112 J	1210	3320	373 J	345 J	536 J	319 B	49.5 J
Chromium	2.9	3 B	5.5	3.6	2.9	4.5	12.4	6.1	5.5	3.4	3.8	5.4
Cobalt	1.3 J	1.2 B	1.2 J	2.3 J	1 J	5.3 J	1.8 J	3.1 J	2.7 J	1.8 B	2.3 B	0.43 B
Copper	1.6 B	1.5 B	1.4 J	1.5 J	0.83 B	2 B	4 J	1.5 J	0.99 B	1.2 B	1.5 B	1.6 J
Iron	2560	2660	5320	3540	2650	4420	12600	6740	5480	3420	3770	5850
Lead	9.1	8.1	8.2	10.1	8.1	6.4	11	8.9	6.8	6.6	9.8	12
Magnesium	242 J	248 J	463 J	262 J	157 J	412 J	1020 J	510 J	401 J	271 BE	292 BE	137 J
Manganese	257	255	81.4	134	68	197	100	169	112	62.7	101	48.1
Mercury	0.059 U	0.041 U	0.048 U	0.042 U	0.052 U	0.053 U	0.058 U	0.054 U	0.048 U	0.05 U	0.05 U	0.048 U
Nickel	2 B	1.9 B	2.4 J	2.9 J	1.4 J	3.9 J	3.8 J	3.4 J	2.9 J	2 J	2.8 J	1.4 B
Potassium	166 B	167 B	360 J	188 B	93.5 B	245 J	1210 L	356 J	231 B	200 B	161 B	139 B
Selenium	0.66 UL	0.6 UL	0.69 J	0.61 UL	0.58 UL	0.61 UL	0.65 UL	0.59 UL	0.59 UL	0.59 UL	0.6 UL	0.62 UL
Silver	0.16 J	0.11 U	0.1 U	0.11 U	0.1 U	0.11 U	0.12 U	0.1 U	0.1 U	0.1 U	0.11 U	0.11 U
Sodium	356 B	320 B	154 B	171 B	305 B	264 B	321 B	194 B	293 B	308 B	250 B	172 B
Thallium	0.96 UL	0.88 UL	0.85 UL	0.89 UL	0.85 UL	0.9 UL	0.95 UL	0.86 UL	0.86 UL	0.86 UL	0.88 UL	0.91 UL
Vanadium	5.7 J	5.7 J	8 J	7.8 J	6 J	7.5 J	15.2	11.6	9.4 J	6.1 J	7.6 J	13.6
Zinc	14.5 J	9.6 J	12.2	9.9	4.9 J	10.8 J	17.9 J	11.3	8.2 J	5.4 J	8.5 J	5.5

Table C-3
Surface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG3-SS01-00D	BG3-SS02-00	BG3-SS03-00	BG3-SS04-00	BG3-SS05-00	BG3-SS06-00	BG3-SS07-00	BG3-SS08-00	BG3-SS09-00	BG3-SS10-00	BG4-SS01-00	BG4-SS01-00D
SAMPLE DATE	07-23-2001	07-24-2001	07-24-2001	07-23-2001	07-24-2001	07-24-2001	07-24-2001	07-24-2001	07-23-2001	07-23-2001	07-26-2001	07-26-2001
SAMPLE DEPTH (inches)	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Inorganics (mg/kg)												
Aluminum	5160	4460	3850	3110	5230	3880	3220	4040	4110	6160	5130	4970
Antimony	0.38 UL	0.4 UL	0.36 UL	0.37 UL	0.38 UL	0.35 UL	0.37 UL	0.36 UL	0.36 UL	0.36 UL	0.6 B	0.41
Arsenic	0.7 J	0.5 J	0.094 J	1.7 J	0.82 J	1.3 J	0.9 J	1.2 J	1.1 J	0.72 J	12.6	11.7
Barium	16.7 J	22.7 J	46.4	16.3 J	6 J	34.9 J	38.3 J	21.7 J	33.1 J	30.6 J	19.6 J	18.7
Beryllium	0.21 B	0.24 B	0.34 B	0.28 B	0.088 U	0.53 B	0.31 B	0.32 B	0.63 B	0.36 B	0.74 B	0.67
Calcium	45.8 J	47.4 J	406 J	365 J	316 J	367 J	925 J	157 J	208 J	76.8 J	2860	2680
Chromium	6.4	2.7	4.9	6.2	9	2.7	3.1	3.6	3.5	3.6	16.9	17.3
Cobalt	0.4 B	0.56 J	4.3 J	2.4 J	0.15 U	3.2 J	1.8 J	1.2 J	5.3 J	0.94 B	3.2 J	3.2
Copper	1.6 J	1.2 J	1.7 J	1.6 J	1.2 J	1.6 J	1.3 J	1 J	1.4 J	0.9 J	2.7 B	2.7
Iron	6850	2420	3480	4970	8240	2150	2910	3340	3660	3560	20700	20300
Lead	10.9	10.9	7.8	7.2	7	10	7.1	12.2	6.7	9.8	14.6	13.4
Magnesium	143 J	166 J	218 J	237 J	154 J	164 J	197 B	184 J	212 J	228 J	782 J	762
Manganese	36.3	44.3	138	30.4	19.2	234	111	94.8	278	129	85.7	80.7
Mercury	0.055 U	0.049 U	0.051 U	0.053 U	0.051 U	0.097 J	0.041 U	0.052 U	0.048 U	0.05 U	0.062 UL	0.059
Nickel	1.4 B	1.7 J	3.1 J	2.8 J	1 B	3.3 J	2 J	1.9 J	4.4 J	3.1 J	5.8 J	5.9
Potassium	156 B	86.8 B	160 B	207 B	307 J	118 B	114 B	137 B	136 B	133 B	841 J	827
Selenium	0.65 J	0.65 UL	0.59 UL	0.6 UL	0.62 UL	0.57 UL	0.62 UL	0.6 UL	0.6 UL	0.59 UL	0.7 UL	1.4
Silver	0.11 U	0.12 U	0.1 U	0.11 U	0.11 U	0.1 U	0.11 U	0.11 U	0.11 U	0.1 U	0.12 U	0.12
Sodium	171 B	142 B	152 B	172 B	197 B	134 B	150 B	163 B	114 B	143 B	374 B	362
Thallium	0.91 UL	0.96 UL	0.87 UL	0.88 UL	0.91 UL	0.84 UL	0.9 UL	0.87 UL	0.88 UL	0.86 UL	1 UL	0.99
Vanadium	15.5	6.1 J	6.5 J	10.9	22.1	5 J	5.4 J	7.3 J	6 J	7.3 J	26.1	25.2
Zinc	5.6	6.4	10.9	7.4	3.6 J	8.8	7.6	7.5	12.2	5.9	26.7	26.6

Table C-3
Surface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID		BG4-SS02-00	BG4-SS03-00	BG4-SS04-00	BG4-SS05-00	BG4-SS06-00	BG4-SS07-00	BG4-SS08-00	BG4-SS09-00	BG4-SS10-00
SAMPLE DATE		07-27-2001	07-26-2001	07-26-2001	07-26-2001	07-26-2001	07-27-2001	07-27-2001	07-27-2001	07-26-2001
SAMPLE DEPTH (inches)		0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Inorganics (mg/kg)										
Aluminum		2560	3330	2410	1760	3930	2150	3090	3300	5100
Antimony	UL	0.35 U	0.37 U	0.35 U	0.34 U	0.35 U	0.36 U	0.36 U	0.37 U	0.38 U
Arsenic		0.7 B	0.83 B	0.61 B	0.47 B	0.66 B	0.26 U	1.5 J	1.4 B	5.2
Barium	J	20 J	18.6 J	16.1 B	9.6 J	19.7 B	18.8 J	13.4 J	36.6 J	41.5 J
Beryllium	B	0.21 B	0.089 B	0.083 U	0.079 U	0.082 U	0.086 U	0.084 U	0.32 B	0.79 J
Calcium		244 J	175 J	84.4 J	95.7 J	251 J	308 J	258 B	762 J	619 J
Chromium		2.8 B	3.1	2.4	2.2	3.8	2.3	5.5	4	12.4
Cobalt	J	1 J	1.2 B	1 J	0.84 J	0.96 J	0.68 J	1.2 J	3.4 J	6.7 J
Copper	B	1.4 B	2 B	2.9 B	2.5 B	3 B	2.6 B	3.5 B	4 J	2.2 J
Iron		2510	2810	2490	1950	3540	1720	5800	3770	10400
Lead		6.2	16	5.8	6.1	9.1	8.1	7.2	11.2	11.5
Magnesium	J	169 J	179 J	164 J	112 J	194 J	132 J	241 J	245 J	329 J
Manganese		150	43.7	60.4	81.9	61	60.2	40.1	304	435
Mercury	UL	0.046 U	0.045 U	0.037 U	0.047 U	0.046 U	0.051 J	0.042 U	0.042 U	0.051 U
Nickel	J	1.4 B	1.7 J	1.4 B	1.1 J	1.4 J	1 B	1.8 B	2.2 B	4.1 J
Potassium	J	143 B	105 B	97.1 B	87 B	112 B	92.6 B	207 B	159 B	274 B
Selenium	L	0.58 UL	0.61 UL	0.58 UL	0.55 UL	0.57 UL	0.6 UL	0.59 U	0.62 UL	1.2 K
Silver	U	0.1 U	0.11 U	0.1 U	0.1 U	0.1 U	0.11 U	0.11 U	0.11 U	0.11 U
Sodium	B	239 B	294 B	255 B	240 B	242 B	309 B	265 B	246 B	73.6 U
Thallium	UL	0.85 UL	0.89 UL	0.85 UN	0.81 UL	0.84 UL	0.88 UL	0.87 UL	0.9 UL	0.9 UL
Vanadium		5.1 J	7.1 J	4.7 J	4 J	8.1 J	4.6 J	11.1	7.7 J	14
Zinc		5.9 J	4.7 J	8.7 J	6.4 J	6.5 J	6.7 J	7 J	14.6 J	22.5 J

Table C-4
Surface Soil Samples
Organics
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SAMPLE ID	BG1-SS01-00	BG1-SS02-00	BG1-SS03-00	BG1-SS04-00	BG1-SS05-00	BG1-SS05-00D	BG1-SS06-00	BG1-SS07-00	BG1-SS08-00	BG1-SS09-00	BG1-SS10-00
SAMPLE DATE	08-06-2001	07-25-2001	07-25-2001	08-06-2001	08-06-2001	08-06-2001	08-06-2001	07-25-2001	07-25-2001	07-25-2001	07-25-2001
SAMPLE DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Semivolatiles (ug/kg)											
Acetophenone	410 U	350 U	1600 U	570 U	630 U	610 U	95 J	340 U	350 U	1300 U	450 U
Benzaldehyde	410 U	350 U	1600 U	100 J	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Benzo(a)anthracene	410 U	350 U	220 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Benzo(a)pyrene	410 U	350 U	340 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Benzo(b)fluoranthene	410 U	350 U	650 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Benzo(g,h,i)perylene	410 U	350 U	350 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Benzo(k)fluoranthene	410 U	350 U	260 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Chrysene	410 U	350 U	480 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Di-n-octylphthalate	410 U	350 U	1600 U	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Fluoranthene	410 U	350 U	270 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Indeno(1,2,3-cd)pyrene	410 U	350 U	340 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
Pyrene	410 U	350 U	330 J	570 U	630 U	610 U	920 U	340 U	350 U	1300 U	450 U
bis(2-Ethylhexyl)phthalate	410 U	59 J	280 J	68 B	630 U	610 U	120 B	120 J	38 J	380 J	66 J
4,4'-DDD	4.1 U	3.5 U	11 J	5.3 J	6.3 U	6.1 U	12	3.4 U	3.5 U	13 U	4.5 U
4,4'-DDE	4.1 U	3.5 U	23	5.7 U	6.3 U	6.1 U	4.9 J	3.4 U	3.5 U	4.6 J	4.5 U
4,4'-DDT	4.1 U	3.5 U	10 J	5.7 U	6.3 U	6.1 U	9.2 U	3.4 U	3.5 U	13 U	4.5 U
Dieldrin	3.7 J	3.5 U	16 U	5.7 U	6.3 U	6.1 U	9.2 U	3.4 U	3.5 U	13 U	4.5 U
Endosulfan I	2.1 U	1.8 U	8.1 U	1.1 J	3.3 U	2.1 J	2.1 J	1.8 U	1.8 U	6.5 U	2.3 U
Endosulfan II	4.1 U	3.5 U	16 U	5.7 U	6.3 U	2.1 J	9.2 U	3.4 U	3.5 U	13 U	4.5 U
Endosulfan sulfate	4.1 U	3.5 U	16 U	2.1 J	6.3 U	2.9 J	3.7 J	3.4 U	3.5 U	13 U	4.5 U
Endrin	3.5 J	3.5 U	16 U	5.7 U	6.3 U	6.1 U	9.2 U	3.4 U	3.5 U	13 U	4.5 U
Endrin aldehyde	4.1 U	3.5 U	16 U	1.8 J	3.1 J	12	8.9 J	3.4 U	3.5 U	13 U	4.5 U
Endrin ketone	4.1 U	3.5 U	16 U	5.7 U	1.9 J	4.5 J	3.4 J	3.4 U	3.5 U	13 U	4.5 U
Heptachlor epoxide	2.1 U	1.8 U	8.1 U	2.9 U	3.3 U	3.1 U	4.7 U	1.8 U	1.8 U	6.5 U	2.3 U
alpha-BHC	1.6 J	1.8 U	8.1 U	1.1 J	3.3 U	0.72 J	1.2 J	1.8 U	1.8 U	6.5 U	2.3 U
alpha-Chlordane	2.1 U	1.8 U	4.7 J	1.1 B	3.3 U	3.4 B	4.7 U	1.8 U	1.8 U	6.5 U	2.3 U
beta-BHC	14 J	1.8 U	8.1 U	2.9 U	5.3 J	3.1 U	4.7 U	1.8 U	1.8 U	6.5 U	2.3 U
delta-BHC	2.1 U	1.8 U	8.1 U	5 P	3.3 U	3.1 U	4.7 U	1.8 U	1.8 U	6.5 U	2.3 U
gamma-BHC (Lindane)	3.3	1.8 U	8.1 U	1.4 J	3.3 U	3.1 U	4.7 U	1.8 U	1.8 U	6.5 U	2.3 U
gamma-Chlordane	2.1 U	1.8 U	7 J	2.9 U	0.92 J	0.74 J	1.9 J	1.8 U	1.8 U	6.5 U	2.3 U

Table C-4
Surface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG2-SS01-00	BG2-SS01-00D	BG2-SS02-00	BG2-SS03-00	BG2-SS04-00	BG2-SS05-00	BG2-SS06-00	BG2-SS07-00	BG2-SS08-00	BG2-SS09-00	BG2-SS10-00
SAMPLE DATE	07-27-2001	07-27-2001	07-24-2001	07-25-2001	07-26-2001	07-26-2001	07-27-2001	07-24-2001	07-24-2001	07-24-2001	07-25-2001
SAMPLE DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Semivolatiles (ug/kg)											
Acetophenone	390 U	380 U	350 U	350 U	360 U	380 U	41 J	360 U	360 U	350 U	1100 U
Benzaldehyde	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Benzo(a)anthracene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Benzo(a)pyrene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Benzo(b)fluoranthene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Benzo(g,h,i)perylene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Benzo(k)fluoranthene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Chrysene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Di-n-octylphthalate	390 U	380 U	350 U	350 U	360 U	380 U	66 J	360 U	360 U	350 U	1100 U
Fluoranthene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Indeno(1,2,3-cd)pyrene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
Pyrene	390 U	380 U	350 U	350 U	360 U	380 U	400 U	360 U	360 U	350 U	1100 U
bis(2-Ethylhexyl)phthalate	140 B	110 B	240 J	46 J	250 B	2000	2100	140 J	670 B	200 B	5000
4,4'-DDD	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
4,4'-DDE	3.9 U	3.8 U	1.1 J	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
4,4'-DDT	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Dieldrin	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Endosulfan I	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	1.8 U	1.8 U	1.8 U	1.8 U
Endosulfan II	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Endosulfan sulfate	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Endrin	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Endrin aldehyde	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Endrin ketone	3.9 U	3.8 U	3.5 U	3.6 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.5 U	3.6 U
Heptachlor epoxide	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	1.8 U	1.8 U	1.8 U	1.8 U
alpha-BHC	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	1.8 U	1.8 U	1.8 U	1.8 U
alpha-Chlordane	2 U	2 U	1.1 J	1.8 U	1.8 U	2 U	2.1 U	1.1 J	0.83 B	0.59 B	2.5
beta-BHC	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	1.8 U	1.8 U	1.8 U	1.8 U
delta-BHC	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	0.65 J	1.8 U	1.8 U	1.8 U
gamma-BHC (Lindane)	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	1.8 U	1.8 U	1.8 U	1.8 U
gamma-Chlordane	2 U	2 U	1.8 U	1.8 U	1.8 U	2 U	2.1 U	0.55 J	1.9 U	1.8 U	1.8 U

Table C-4
Surface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG3-SS01-00	BG3-SS01-00D	BG3-SS02-00	BG3-SS03-00	BG3-SS04-00	BG3-SS05-00	BG3-SS06-00	BG3-SS07-00	BG3-SS08-00	BG3-SS09-00	BG3-SS10-00
SAMPLE DATE	07-23-2001	07-23-2001	07-24-2001	07-24-2001	07-23-2001	07-24-2001	07-24-2001	07-24-2001	07-24-2001	07-23-2001	07-23-2001
SAMPLE DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Semivolatiles (ug/kg)											
Acetophenone	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	110 J	370 U	360 U
Benzaldehyde	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Benzo(a)anthracene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Benzo(a)pyrene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Benzo(b)fluoranthene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Benzo(g,h,i)perylene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Benzo(k)fluoranthene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Chrysene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Di-n-octylphthalate	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Fluoranthene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Indeno(1,2,3-cd)pyrene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
Pyrene	370 U	370 U	390 U	370 U	370 U	410 U	360 U	370 U	360 U	370 U	360 U
bis(2-Ethylhexyl)phthalate	370 U	190 J	600	450	290 J	340 J	140 J	370 U	130 J	370 U	360 U
4,4'-DDD	3.6 U	3.7 U	3.9 U	3.7 U	3.7 U	4.1 U	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
4,4'-DDE	1.3 J	3.7 U	3.9 U	3.7 U	3.7 U	4.1 U	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
4,4'-DDT	3.6 U	3.7 U	3.9 U	3.7 U	3.7 U	4.1 U	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
Dieldrin	3.3 J	3.7 U	4.4 J	3.7 U	3.7 U	4.1 U	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
Endosulfan I	1.9 U	1.9 U	2 U	1.9 U	1.9 U	2.1 U	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U
Endosulfan II	3.6 U	3.7 U	3.9 U	3.7 U	3.7 U	4.1 U	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
Endosulfan sulfate	3.6 U	3.7 U	3.9 U	3.7 U	2.3 J	2.4 J	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
Endrin	3.6 U	3.7 U	3.9 U	3.7 U	3.7 U	4.1 U	3.6 U	3.7 U	3.6 U	3.7 U	3.6 U
Endrin aldehyde	3.6 U	3.7 U	3.9 U	3.7 U	3.7 U	2.7 J	3.6 U	3.7 U	1.2 J	3.7 U	3.6 U
Endrin ketone	1.8 J	3.7 U	3.9 U	3.7 U	3.7 U	2.1 J	3.6 U	3.7 U	1.2 J	3.7 U	3.6 U
Heptachlor epoxide	1.9 U	1.9 U	2 U	1.9 U	1.9 U	1.8 J	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U
alpha-BHC	1.9 U	1.9 U	2 U	1.9 U	1.9 U	2.1 U	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U
alpha-Chlordane	1.9 U	1 J	2 U	0.94 J	0.89 J	1.4 J	0.65 J	1.9 U	1.7 J	0.83 J	1.8 U
beta-BHC	1.9 U	1.9 U	2 U	1.9 U	1.9 U	2.1 U	1.8 U	1.9 U	0.94 J	1.9 U	1.8 U
delta-BHC	1.9 U	1.9 U	2 U	1.9 U	1.9 U	2.1 U	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U
gamma-BHC (Lindane)	1.9 U	1.9 U	2 U	1.9 U	1.9 U	2.1 U	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U
gamma-Chlordane	1.9 U	1.9 U	2 U	1.9 U	1.9 U	0.65 J	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U

Table C-4
Surface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG4-SS01-00	BG4-SS01-00D	BG4-SS02-00	BG4-SS03-00	BG4-SS04-00	BG4-SS05-00	BG4-SS06-00	BG4-SS07-00	BG4-SS08-00	BG4-SS09-00	BG4-SS10-00
SAMPLE DATE	07-26-2001	07-26-2001	07-27-2001	07-26-2001	07-26-2001	07-26-2001	07-26-2001	07-27-2001	07-27-2001	07-27-2001	07-26-2001
SAMPLE DEPTH	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"
Semivolatiles (ug/kg)											
Acetophenone	400 U	420 U	360 U	360 U	350 U	61 L	350 U	360 U	360 U	380 U	390 U
Benzaldehyde	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Benzo(a)anthracene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Benzo(a)pyrene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Benzo(b)fluoranthene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Benzo(g,h,i)perylene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Benzo(k)fluoranthene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Chrysene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Di-n-octylphthalate	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Fluoranthene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Indeno(1,2,3-cd)pyrene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
Pyrene	400 U	420 U	360 U	360 U	350 U		350 U	360 U	360 U	380 U	390 U
bis(2-Ethylhexyl)phthalate	170 J	200 J	240 B	230 B	54 B	340 B	200 B	750 B	2300	71 B	95 B
4,4'-DDD	1.3 J	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
4,4'-DDE	1.3 J	2.5 J	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
4,4'-DDT	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
Dieldrin	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	2.6 J	2.4 J
Endosulfan I	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.9 U	2 U
Endosulfan II	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
Endosulfan sulfate	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	1.6 J	3.6 U	3.6 U	3.8 U	3.9 U
Endrin	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
Endrin aldehyde	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
Endrin ketone	4 U	4.2 U	3.6 U	3.6 U	3.5 U	3.4 U	3.5 U	3.6 U	3.6 U	3.8 U	3.9 U
Heptachlor epoxide	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.9 U	2 U
alpha-BHC	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.9 U	2 U
alpha-Chlordane	1.7 J	0.75 J	1.8 U	1.3 B	1.5 J	1.8 U	2.2	0.65 B	0.84 B	1.9 U	2.3 J
beta-BHC	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.9 U	2 U
delta-BHC	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.9 U	2 U
gamma-BHC (Lindane)	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.9 U	2 U
gamma-Chlordane	2.1 U	2.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.65 J	2 U

Table C-5
Subsurface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG1-SB01-01	BG1-SB02-01	BG1-SB03-01	BG1-SB04-01	BG1-SB05-01	BG1-SB05-01D	BG1-SB06-01	BG1-SB07-01	BG1-SB08-01	BG1-SB09-01	BG1-SB10-01	BG2-SB01-01
SAMPLE DATE	08-06-2001	07-23-2001	07-23-2001	08-06-2001	08-06-2001	08-06-2001	08-06-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-27-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Inorganics (mg/kg)												
Aluminum	3640	238	18400	5190	3670	3620	4570	307	1510	11600	2700	1710
Arsenic	4.5	0.29 U	10.4	5.5	3 J	3.4	3.2	0.28 U	1.7 B	12.5	2.5 B	0.26 U
Barium	21.7 J	0.9 J	28.5 J	6.6 J	11.8 J	12 J	14.2 J	3.8 J	3.5 J	19.8 J	5.1 J	21.4 J
Calcium	1120 J	307 J	1420 J	1590	3390	1770	32200	145 J	880 J	1310 J	351 J	136 J
Chromium	8.2	2.4	37.5	17.1	12.1	11.1	15.3	4.5	5.7	25	7.5	2.5
Cobalt	1.3 B	0.17 U	3.7 J	1.4 B	2 J	1.8 J	1.6 J	0.2 J	0.57 J	2.7 J	1.1 J	1.7 J
Copper	1.4 J	0.86 J	9.6 J	2.9 J	2.6 J	1.7 J	3 J	0.79 J	2.3 J	9 J	2.9 B	0.71 B
Cyanide	0.05 U	0.046 U	2.7	0.058 U	0.061 U	0.051 U	0.06 U	0.045 U	0.055 U	0.096 U	0.056 U	0.12 B
Iron	7610	1280	22400	14000	9910	9510	9780	1820	4510	19300	5360	1870
Lead	6.4	2.6	23.3	4.8	5.7	4.5	5.8	6	83.7	35.3	5.4	2
Magnesium	318 J	214 J	4630	1810	1040 J	928 J	1350 J	213 J	710 J	3340	862 J	176 J
Manganese	16	2.9 J	86.2	14.6	15.2	11	17.2	6.7	13.4	53.8	14	131
Mercury	0.054 U	0.052 UL	0.11 UL	0.07 U	0.077 U	0.067 J	0.068 U	0.054 UL	0.059 UL	0.083 UL	0.05 UL	0.053 U
Nickel	2 J	0.51 J	11 J	3.2 J	3.1 J	3.1 J	3.6 J	0.57 J	2 J	7.8 J	2.8 J	1.5 B
Potassium	281 J	147 B	4240	2370 J	1210 J	1190 J	1970 J	182 B	542 J	2790	611 J	100 J
Selenium	1.6 B	0.68 UL	1.5 UL	1.8 B	1.9 L	0.75 B	1.3 B	0.65 UL	0.77 UL	1.3 UL	0.78 UL	0.6 UL
Sodium	467 B	1280	9810	1560	629 B	492 B	2560	973 B	1700	10400	2360	285 B
Vanadium	12.2 J	2.1 J	53.8	19.4	12.9 J	12.2 J	17.7	3.1 J	7.8 J	37.8	14.1	2.2 J
Zinc	6.7 J	20.9	52.9	14.2 J	12.4 J	11.3 J	14.7 J	7.1 L	17.3	34.3	15.2	3 B

Table C-5
Subsurface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG2-SB01-01D	BG2-SB02-01	BG2-SB03-01	BG2-SB04-01	BG2-SB05-01	BG2-SB06-01	BG2-SB07-01	BG2-SB08-01	BG2-SB09-01	BG2-SB10-01	BG3-SB01-01	BG3-SB01-01D
SAMPLE DATE	07-27-2001	07-23-2001	07-23-2001	07-26-2001	07-26-2001	07-27-2001	07-23-2001	07-24-2001	07-24-2001	07-25-2001	07-23-2001	07-23-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Inorganics (mg/kg)												
Aluminum	6960	11400	4590	12600	4820	8350	9770	8040	6310	9990	6830	6320
Arsenic	15.9	3.8	1.3 B	4.2	1.6 B	6.8	5	3	2.4	4.2	0.86 B	0.65 B
Barium	14.2 J	38.7 J	36.2 J	32.4 J	32.2 J	48.5	37.1 J	35.2 J	33.7 J	42 J	18.3 J	17.4 J
Calcium	1810	1060	412 J	479 J	231 J	162000	474 J	363 J	546 J	819 J	76.8 J	42.3 B
Chromium	25.3	26.4	5.3	15.2	7.2	24.5	15.2	11.4	9.8	15.1	7.8	7.3
Cobalt	4.4 J	2.4 J	4.2 J	3.1 J	7.3 J	4 J	2.1 J	2.4 J	1.7 J	2.2 J	0.39 B	0.4 B
Copper	2.2 B	2.5 B	1 B	3.9 B	0.61 B	5 J	2.4 B	0.92 B	0.75 B	1.4 B	1.2 J	1.1 J
Cyanide	0.05 U	0.043 U	0.043 U	0.057 B	0.044 U	0.11 B	0.1 B	0.044 U	0.042 U	0.056 U	0.043 U	0.1 B
Iron	30000	21700	5140	18300	7320	20900	18200	12800	11200	19500	8390	7680
Lead	7.1	7.7	7.7	8.1	4.1	6.9 L	6.1	6	6.6	8.3	5.5	5.6
Magnesium	765 J	1420	357 J	667 J	563 J	3340	819 J	649 J	455 J	550 J	175 J	172 J
Manganese	34.6	44.2	82.5	101	135	104	60.8	31.8	26.1	37.6	8.4	13.5
Mercury	0.11 B	0.045 UL	0.043 UL	0.11 B	0.082 B	0.12 B	0.046 UL	0.082 B	0.076 B	0.1 B	0.049 UL	0.056 UL
Nickel	8.2 J	5.5 J	3.4 J	6.8 J	5.3 J	9.1 J	5 J	4 J	2.9 J	3.5 J	1.1 B	1.1 B
Potassium	889 J	1140	210 B	459 J	373 J	2100	563 J	409 J	298 J	389 J	179 B	167 B
Selenium	1.2 J	0.59 UL	0.57 UL	0.64 UL	0.57 UL	0.65 UL	0.61 UL	0.87 J	0.61 UL	0.77 UL	0.6 UL	0.62 UL
Sodium	321 B	206 B	175 B	305 B	268 B	815 B	152 B	297 B	299 B	371 B	191 B	205 B
Vanadium	33.2	32	9.1 J	28.5	10.7	20.6	26	19.8	16.5	28	17.6	16.3
Zinc	29.5	19.9	7.4 L	18.4	10.6	30.8	16	9.8	7.5 L	10.2	5 L	5 L

Table C-5
Subsurface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG3-SB02-01	BG3-SB03-01	BG3-SB04-01	BG3-SB05-01	BG3-SB06-01	BG3-SB07-01	BG3-SB08-01	BG3-SB09-01	BG3-SB10-01	BG4-SB01-01	BG4-SB01-01D	BG4-SB02-01
SAMPLE DATE	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-26-2001	07-26-2001	07-27-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Inorganics (mg/kg)												
Aluminum	4970	3620	3290	9110	1920	3610	5800	6280	10900	7380	2120	5540
Arsenic	0.87 B	1.1 B	2.1	1.2 B	0.4 B	1.2 B	1.2 B	1.3 B	1.5 B	18.6	0.24 U	1.1 B
Barium	38.3 J	28 J	21.7 J	8.2 J	19.4 J	28.7 J	18.8 J	47.8	26.1 J	15.3 J	27.4 J	41 J
Calcium	112 J	234 J	102 J	304 J	96.4 J	242 J	56.4 J	151 J	111 J	2080	203 J	261 J
Chromium	4.7	5.1	7.6	15.6	2.9	5.3	7.2	4.6	11.9	25.6	2.6	6.1
Cobalt	1.3 J	2.8 J	4 J	0.16 U	2.4 J	1.5 J	0.84 J	8.1 J	0.92 B	4.4 J	1.9 J	2.6 J
Copper	0.71 J	0.93 J	0.59 B	2.2 J	0.95 J	1.5 J	1.1 J	1.3 J	2.4 J	3.2 J	1.5 B	1.2 B
Cyanide	0.066 B	0.063 B	0.041 U	0.047 U	0.04 B	0.21 B	0.045 U	0.44 B	0.045 U	0.042 U	0.041 U	0.044 U
Iron	4790	3940	4790	12500	1740	5520	6780	5070	12500	31700	2080	6700
Lead	6.1	3.6	5	6.7	3.2	4.5	5.3	5.5	6.6	7.8	2.8	6.8
Magnesium	206 J	241 J	251 J	218 J	115 J	300 J	202 J	324 J	392 J	754 J	203 J	371 J
Manganese	30.4	51.1	40	5.4	49.3	38.3	14.4	208	16.4	42	195	86.1
Mercury	0.056 UL	0.044 UL	0.054 UL	0.044 UL	0.036 UL	0.038 UL	0.048 UL	0.048 UL	0.039 UL	0.053 UL	0.042 UL	0.084 B
Nickel	1.8 J	2.4 J	3.8 J	0.99 B	2 J	2 J	1.9 J	6.4 J	2.6 J	8.5	1.8 J	4.9 J
Potassium	131 B	167 B	177 B	278 J	78.8 B	193 B	173 B	168 B	253 B	764 J	109 B	259 B
Selenium	0.61 UL	0.61 UL	0.58 UL	0.63 UL	0.58 UL	0.59 UL	0.61 UL	0.58 UL	0.62 UL	0.59 UL	0.55 UL	0.62 UL
Sodium	214 B	170 B	162 B	210 B	177 B	217 B	208 B	135 B	199 B	299 B	314 B	303 B
Vanadium	10 J	7.9 J	7.5 J	36	3.4 J	9.6 J	12.7	7.2 J	22.3	35.1	2.5 J	11.9
Zinc	5.2 L	5.7 L	6.6 L	5 L	4 B	5.8 L	6.9 L	13.8	12.3	32	3.8 B	7.1 L

Table C-5
Subsurface Soil Samples
Inorganics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG4-SB03-01	BG4-SB04-01	BG4-SB05-01	BG4-SB06-01	BG4-SB07-01	BG4-SB08-01	BG4-SB09-01	BG4-SB10-01
SAMPLE DATE	07-26-2001	07-26-2001	07-26-2001	07-26-2001	07-27-2001	07-27-2001	07-27-2001	07-26-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Inorganics (mg/kg)								
Aluminum	10700	8460	2310	11000	6870	6680	4740	7900
Arsenic	2 J	3	0.46 B	1.4 B	1.3 B	2.4	1.2 B	13.8
Barium	33.5 J	58	20.4 J	10.8 J	19.4 J	21.1 J	48.2	46
Calcium	345 J	362 J	87.2 J	300 J	138 J	481 J	123 J	493 J
Chromium	12	10.2	2.8	10.8	7.8	8.3	3.5 B	18.4
Cobalt	1.1 J	2.3 J	1.2 J	0.5 J	1.1 J	2 J	7 J	6 J
Copper	1.8 B	2.8 B	0.43 B	1.5 B	1.7 B	3.1 J	0.68 B	2.9 J
Cyanide	0.045 U	0.11 B	0.043 U	0.045 U	0.041 U	0.075 B	0.1 B	0.046 B
Iron	12800	12400	2310	10200	7560	11000	3870	23600
Lead	5.8	5.5	3.8	6.2	5.1	5.4	6.1	8.1
Magnesium	414 J	471 J	193 J	273 J	318 J	322 J	178 J	447 J
Manganese	27.7	67.8	39	7.4	21.6	62.2	154	137
Mercury	0.14	0.12 B	0.075 B	0.093 B	0.1 B	0.11 B	0.066 B	0.092 B
Nickel	3 J	4.9 J	1.5 J	1.8 J	2.4 J	3.3 J	2.5 J	6.3 J
Potassium	276 J	367 J	102 B	191 B	197 B	287 J	117 B	471 J
Selenium	0.62 UL	0.58 UL	0.6 UL	0.61 UL	0.6 UL	0.63 UL	0.59 UL	0.64 J
Sodium	337 B	294 B	300 B	332 B	373 B	332 B	222 B	292 B
Vanadium	22	18.9	4.7 J	30	14.6	17.8	5.8 J	30.8
Zinc	10.1	10.3	2.5 B	3.8 B	6.3 L	8.2 L	4.5 L	19.9

Table C-6
Subsurface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG1-SB01-01	BG1-SB02-01	BG1-SB03-01	BG1-SB04-01	BG1-SB05-01	BG1-SB05-01D	3G1-SB06-01	BG1-SB07-01	BG1-SB08-01	BG1-SB09-01	BG1-SB10-01	BG2-SB01-01
SAMPLE DATE	08-06-2001	07-23-2001	07-23-2001	08-06-2001	08-06-2001	08-06-2001	08-06-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-27-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Volatiles (ug/kg)												
1,1,2,2-Tetrachloroethane	2 J	13 U	29 U	4 J	15 U	13 U	15 U	12 U	3 J	12 U	15 U	11 U
2-Butanone	13 U	13 U	29 U	5 J	15 U	13 U	4 J	12 U	14 U	12 U	15 U	11 U
Acetone	12 B	5 J	42	14 B	16 B	9 B	15 B	12 U	14 U	9 J	15 U	11 U
Carbon Disulfide	13 U	13 U	14 J	15 U	15 U	13 U	15 U	12 U	14 U	2 J	15 U	11 U
Isopropylbenzene	13 U	13 U	29 U	15 U	15 U	13 U	15 U	12 U	14 U	12 U	15 U	11 U
Methylene Chloride	8 B	13 U	29 U	26 B	13 B	3 B	4 B	12 U	14 U	12 U	15 U	11 U
Styrene	13 U	13 U	29 U	15 U	15 U	13 U	15 U	12 U	14 U	12 U	15 U	11 U
Toluene	8 B	13 U	29 U	11 B	16 B	7 B	2 B	12 U	3 B	3 J	2 B	1 B
Benzaldehyde	430 U	410 UL	940 U	100 J	510 U	440 U	53 J	380 U	450 U	970 U	490 U	350 U
Phenol	430 U	410 UL	940 U	510 U	510 U	440 U	490 U	380 U	450 U	970 U	490 U	350 U
bis(2-Ethylhexyl)phthalate	120 B	180 B	350 B	160 B	120 B	54 B	160 B	57 B	72 B	970 U	75 B	670
4,4'-DDD	4.3 U	4.1 U	9.4 U	5.1 U	5.1 U	4.4 U	4.9 U	3.8 U	4.5 U	9.7 U	4.8 U	3.5 U
4,4'-DDE	4.3 U	4.1 U	3.9 J	1.7 J	5.1 U	4.4 U	4.9 U	3.8 U	4.5 U	2.7 J	4.8 U	3.5 U
Dieldrin	4.3 U	4.1 U	9.4 U	5.1 U	5.1 U	2.5 J	4.9 U	3.8 U	4.5 U	9.7 U	4.8 U	3.5 U
Endosulfan I	2.2 U	2.1 U	2.3 J	2.6 U	1.2 J	1.2 J	0.96 J	2 U	2.3 U	5 U	2.5 U	1.8 U
Endosulfan sulfate	4.3 U	4.1 U	3.4 J	5.1 U	2.7 J	4.4 U	4.9 U	3.8 U	4.5 U	9.7 U	4.8 U	3.5 U
Endrin aldehyde	4.3 U	4.1 U	9.4 U	5.1 U	5.1 U	4.4 U	4.9 U	3.8 U	4.5 U	9.7 U	4.8 U	3.5 U
Endrin ketone	4.3 U	4.1 U	9.4 U	5.1 U	2.5 J	4.4 U	4.9 U	3.8 U	4.5 U	9.7 U	4.8 U	3.5 U
alpha-BHC	1.3 J	2.1 U	4.8 U	2.6 U	0.81 J	0.6 J	2.5 U	2 U	2.3 U	5 U	2.5 U	1.8 U
alpha-Chlordane	2.2 U	2.1 U	4.8 U	2.6 U	1.5 J	0.98 J	1.4 J	2 U	2.3 U	5 U	2.5 U	1.8 U
beta-BHC	2.2 U	2.1 U	4.8 U	2.6 U	2.6 U	2.3 U	2.5 U	2 U	2.3 U	5 U	2.5 U	1.8 U
delta-BHC	0.8 J	2.1 U	4.8 U	2.6 U	2.6 U	2.3 U	2.5 U	2 U	2.3 U	5 U	2.5 U	1.8 U
Total Organic Carbon	28660	2310	133000	34600	40740		52360	3030	10100	55100	10600	4338

Table C-6
Subsurface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG2-SB01-01D	BG2-SB02-01	BG2-SB03-01	BG2-SB04-01	BG2-SB05-01	BG2-SB06-01	BG2-SB07-01	BG2-SB08-01	BG2-SB09-01	BG2-SB10-01	BG3-SB01-01	BG3-SB01-01D
SAMPLE DATE	07-27-2001	07-23-2001	07-23-2001	07-26-2001	07-26-2001	07-27-2001	07-23-2001	07-24-2001	07-24-2001	07-25-2001	07-23-2001	07-23-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Volatiles (ug/kg)												
1,1,2,2-Tetrachloroethane	13 U	11 U	11 U	12 U	11 U	13 U	11 U	11 U	11 U	14 U	11 U	11 U
2-Butanone	13 U	11 U	11 U	12 U	11 U	13 U	11 U	11 U	11 U	14 U	11 U	11 U
Acetone	6 J	11 U	11 U	12 U	11 U	4 J	11 U	11 U	11 U	14 U	9 B	5 B
Carbon Disulfide	13 U	11 U	11 U	12 U	11 U	13 U	11 U	11 U	11 U	14 U	11 U	11 U
Isopropylbenzene	13 U	11 U	1 J	12 U	11 U	13 U	11 U	11 U	11 U	14 U	11 U	11 U
Methylene Chloride	13 U	11 U	11 U	12 U	11 U	13 U	11 U	11 U	11 U	14 U	11 U	11 U
Styrene	13 U	11 U	11 U	12 U	11 U	13 U	11 U	11 U	11 U	14 U	4 J	4 J
Toluene	13 U	11 U	2 B	12 U	1 B	1 B	11 U	1 B	11 U	14 U	11 U	11 U
Benzaldehyde	420 U	380 U	350 U	390 U	360 U	420 U	370 U	370 U	360 U	460 U	380 U	370 U
Phenol	420 U	380 U	350 U	390 U	360 U	420 U	370 U	370 U	360 U	460 U	380 U	370 U
bis(2-Ethylhexyl)phthalate	70 J	380 U	610	160 B	67 B	120 J	180 J	58 J	73 J	660	380 U	370 U
4,4'-DDD	4.2 U	3.8 U	3.5 U	3.9 U	3.6 U	4.2 U	30 U	3.7 U	3.6 U	4.6 U	3.8 U	3.7 U
4,4'-DDE	4.2 U	3.8 U	3.5 U	3.9 U	3.6 U	4.2 U	30 U	3.7 U	3.6 U	4.6 U	3.8 U	3.7 U
Dieldrin	4.2 U	3.8 U	1.9 J	3.9 U	3.6 U	4.2 U	30 U	3.7 U	3.6 U	4.6 U	3.8 U	3.7 U
Endosulfan I	2.2 U	2 U	1.8 U	2 U	1.8 U	2.2 U	15 U	1.9 U	1.9 U	2.4 U	1.9 U	1.9 U
Endosulfan sulfate	4.2 U	3.8 U	3.5 U	3.9 U	3.6 U	4.2 U	30 U	3.7 U	3.6 U	4.6 U	3.8 U	3.7 U
Endrin aldehyde	4.2 U	3.8 U	2.7 J	3.9 U	3.6 U	4.2 U	30 U	3.7 U	3.6 U	4.6 U	3.8 U	3.7 U
Endrin ketone	4.2 U	3.8 U	3.5 U	3.9 U	3.6 U	4.2 U	30 U	3.7 U	3.6 U	4.6 U	3.8 U	3.7 U
alpha-BHC	2.2 U	2 U	1.8 U	2 U	1.8 U	2.2 U	15 U	1.9 U	1.9 U	2.4 U	1.9 U	1.9 U
alpha-Chlordane	2.2 U	2 U	1.8 U	2 U	1.8 U	2.2 U	15 U	1.9 U	1.9	2.4 U	1.9 U	1.9 U
beta-BHC	2.2 U	2 U	1.8 U	0.74 J	1.8 U	0.79 J	15 U	1.9 U	0.99 J	2.4 U	1.9 U	1.9 U
delta-BHC	2.2 U	2 U	1.8 U	2 U	1.8 U	2.2 U	15 U	1.9 U	1.9 U	2.4 U	1.9 U	1.9 U
Total Organic Carbon		5010	6030	5971	6795	9307	5530	4584	6682	8982	7050	

Table C-6
Subsurface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	BG3-SB02-01	BG3-SB03-01	BG3-SB04-01	BG3-SB05-01	BG3-SB06-01	BG3-SB07-01	BG3-SB08-01	BG3-SB09-01	BG3-SB10-01	BG4-SB01-01	BG4-SB01-01D	BG4-SB02-01
SAMPLE DATE	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-23-2001	07-26-2001	07-26-2001	07-27-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Volatiles (ug/kg)												
1,1,2,2-Tetrachloroethane	11 U	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	13 U	11 U	11 U
2-Butanone	11 U	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	13 U	11 U	11 U
Acetone	11 U	11 U	11 U	12 U	11 U	11 U	7 B	11 U	11 U	9 B	6 B	11 U
Carbon Disulfide	11 U	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	13 U	11 U	11 U
Isopropylbenzene	11 U	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	13 U	11 U	11 U
Methylene Chloride	1 J	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	2 B	11 U	11 U
Styrene	11 U	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	13 U	11 U	11 U
Toluene	11 U	11 U	11 U	12 U	11 U	11 U	11 U	11 U	11 U	13 U	11 U	11 U
Benzaldehyde	370 U	360 U	350 U	390 U	350 U	350 U	370 U	370 U	370 U	420 U	350 U	370 U
Phenol	370 U	360 U	350 U	390 U	350 U	350 U	370 U	370 U	370 U	420 U	350 U	370 U
bis(2-Ethylhexyl)phthalate	370 U	360 U	37 B	58 J	350 U	140 J	41 J	370 U	160 B	470	350 U	130 J
4,4'-DDD	3.1 J	3.6 U	3.6 U	3.9 U	3.5 U	3.6 U	3.7 U	3.6 U	3.7 U	4.2 U	3.5 U	3.7 U
4,4'-DDE	3.7 U	3.6 U	3.6 U	3.9 U	3.5 U	3.6 U	3.7 U	3.6 U	3.7 U	4.2 U	3.5 U	3.7 U
Dieldrin	2.3 J	3.6 U	3.6 U	3.9 U	3.5 U	3.6 U	3.7 U	3.6 U	3.7 U	4.2 U	3.5 U	3.7 U
Endosulfan I	1.9 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	2.2 U	1.8 U	1.9 U
Endosulfan sulfate	3.7 U	3.6 U	3.6 U	3.9 U	3.5 U	3.6 U	3.7 U	3.6 U	3.7 U	4.2 U	3.5 U	3.7 U
Endrin aldehyde	3.7 U	3.6 U	3.6 U	3.9 U	3.5 U	3.6 U	3.7 U	3.6 U	3.7 U	4.2 U	3.5 U	3.7 U
Endrin ketone	3.7 U	3.6 U	3.6 U	3.9 U	3.5 U	3.6 U	3.7 U	3.6 U	3.7 U	4.2 U	3.5 U	3.7 U
alpha-BHC	1.9 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	2.2 U	1.8 U	1.9 U
alpha-Chlordane	1.9 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	2.4 J	1.9 U	4.7	2.2 U	1.8 U	1.9 U
beta-BHC	1.9 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	2.2 U	1.8 U	1.9 U
delta-BHC	1.9 U	1.8 U	1.8 U	2 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U	2.2 U	1.8 U	1.9 U
Total Organic Carbon	3760	4680	3360	4490	6200	4730	6680	5200	8060	7332		3019

Table C-6
Subsurface Soil Samples
Organics
Background Investigation
Cheatham Annex Site

SAMPLE ID	3G4-SB03-01	BG4-SB04-01	BG4-SB05-01	BG4-SB06-01	BG4-SB07-01	BG4-SB08-01	BG4-SB09-01	BG4-SB10-01
SAMPLE DATE	07-26-2001	07-26-2001	07-26-2001	07-26-2001	07-27-2001	07-27-2001	07-27-2001	07-26-2001
SAMPLE DEPTH (inches)	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"	6 - 24"
Volatiles (ug/kg)								
1,1,2,2-Tetrachloroethane	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
2-Butanone	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Acetone	11 U	11 U	11 U	3 B	3 B	11 U	11 U	11 U
Carbon Disulfide	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Isopropylbenzene	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Methylene Chloride	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Styrene	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Toluene	11 U	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Benzaldehyde	380 U	370 U	350 U	380 U	360 U	370 U	51 J	360 U
Phenol	380 U	370 U	340 J	53 J	360 U	370 U	360 U	360 U
bis(2-Ethylhexyl)phthalate	380 U	410	100 B	55 B	130 J	580	57 J	85 B
4,4'-DDD	3.8 U	3.6 U	3.5 U	3.8 U	3.6 U	3.7 U	3.6 U	3.6 U
4,4'-DDE	3.8 U	3.6 U	3.5 U	3.8 U	3.6 U	3.7 U	3.6 U	3.6 U
Dieldrin	3.8 U	3.6 U	3.5 U	3.8 U	3.6 U	3.7 U	3.6 U	3.6 U
Endosulfan I	2 U	1.9 U	1.8 U	1.9 U	1.8 U	1.9 U	1.8 U	1.8 U
Endosulfan sulfate	3.8 U	3.6 U	3.5 U	3.8 U	3.6 U	3.7 U	3.6 U	3.6 U
Endrin aldehyde	3.8 U	3.6 U	3.5 U	3.8 U	3.6 U	3.7 U	3.6 U	3.6 U
Endrin ketone	3.8 U	3.6 U	3.5 U	3.8 U	3.6 U	3.7 U	3.6 U	3.6 U
alpha-BHC	2 U	1.9 U	1.8 U	1.9 U	1.8 U	1.9 U	1.8 U	1.8 U
alpha-Chlordane	2 U	0.86 B	1.8 U	1.9 U	1.9 U	1.9 U	1.8 U	1.5 J
beta-BHC	2 U	1.9 U	1.8 U	1.9 U	1.8 U	1.9 U	1.8 U	1.8 U
delta-BHC	2 U	1.9 U	1.8 U	1.9 U	1.8 U	1.9 U	1.8 U	1.8 U
Total Organic Carbon	3537	4282	3013	2967	2324	2665	4088	4010

Tables C-7 and C-8
ANOVA Comparison of the Soil Associations
Background Investigation Work Plan

Table C-7
ANOVA Including Soil Associations 2, 3, and 4

Parameter	Percent Detects	Soil Association Probability	Soil Association Decision (using 0.05 significance level)	Depth Probability	Depth Decision (using 0.05 significance level)
Aluminum	100	0.446		0.059	
Arsenic	69	0.093		0.775	
Barium	98	0.006	Yes	0.810	
Beryllium	32	0.470		0.902	
Calcium	98	0.000	Yes	0.118	
Chromium	98	0.287		0.006	Yes
Cobalt	83	0.859		0.781	
Copper	75	0.085		0.931	
Iron	100	0.699		0.002	Yes
Lead	100	0.982		0.000	Yes
Magnesium	98	0.000	Yes	0.063	
Manganese	100	0.047	Yes	0.008	Yes
Nickel	83	0.591		0.929	
Potassium	40	0.000	Yes	0.093	
Selenium	32	0.001	Yes	0.486	
Sodium	50	0.000	Yes	0.000	Yes
Vanadium	99	0.771		0.087	
Zinc	96	0.003	Yes	0.277	

Table C-8
ANOVA Including Soil Associations 3 and 4

Parameter	Percent Detects	Soil Association Probability	Soil Association Decision (using 0.05 significance level)	Depth Probability	Depth Decision (using 0.05 significance level)
Aluminum	100	0.484		0.028	Yes
Arsenic	67	0.476		0.664	
Barium	97	0.553		0.354	
Beryllium	29	0.561		0.614	
Calcium	97	0.111		0.062	
Chromium	97	0.812		0.009	Yes
Cobalt	86	0.912		0.908	
Copper	68	0.868		0.581	
Iron	100	0.834		0.001	Yes
Lead	100	0.921		0.000	Yes
Magnesium	99	0.275		0.152	
Manganese	100	0.089		0.010	Yes
Nickel	81	0.365		0.719	
Potassium	28	0.685		0.292	
Selenium	33	0.568		0.872	
Sodium	38	0.000	Yes	0.000	Yes
Vanadium	99	0.521		0.083	
Zinc	94	0.789		0.072	

Table C-9
Summary Statistics of Background Soil Data
Background Investigation Work Plan

Chemical Group	SoilGroup	Depth	ParamName	Mean	Median	Standard Deviation	Minimum DL	Maximum DL	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples	Percent Detects
Metals (mg/kg)	Soil Association 1	Combined SS-SB	Aluminum	5150	3640	5030	NA	NA	235	18400	26	26	100
	Soil Association 2	SB	Aluminum	7620	7500	3090	NA	NA	1710	12600	12	12	100
	Soil Association 2	SS	Aluminum	4570	4290	1890	NA	NA	2330	8440	19	19	100
	Soil Association 3/4	Combined SS-SB	Aluminum	5820	4980	3320	NA	NA	1760	19200	64	64	100
	Soil Association 1	Combined SS-SB	Antimony	1.35	0.265	2.45	0.33	8.9	1	11	2	26	8
	Soil Association 3/4	Combined SS-SB	Antimony	1.71	0.19	2.23	0.34	10.6	9.2	9.2	1	63	2
	Soil Association 1	Combined SS-SB	Arsenic	3.5	2.55	3.46	0.23	3.1	1.1	12.5	17	26	65
	Soil Association 2	Combined SS-SB	Arsenic	2.56	1.6	3.02	0.26	1.6	0.63	15.9	23	31	74
	Soil Association 3/4	SB	Arsenic	2.2	0.6	4.54	0.24	1.5	0.7	18.6	7	23	30
	Soil Association 3/4	SS	Arsenic	1.69	1.2	2.02	0.26	1.4	0.094	11.7	33	40	83
	Soil Association 1	Combined SS-SB	Barium	16.5	12.4	14.5	NA	NA	0.75	62	26	26	100
	Soil Association 2	SB	Barium	35	35.7	9.76	NA	NA	14.2	48.5	12	12	100
	Soil Association 2	SS	Barium	27.2	26.9	13.7	32.7	32.7	11.8	76.3	18	19	95
	Soil Association 3/4	Combined SS-SB	Barium	27.4	21.7	15.4	16.1	19.7	6	80.2	62	64	97
	Soil Association 1	Combined SS-SB	Beryllium	0.298	0.241	0.245	0.082	1.2	0.3	1.1	9	26	35
	Soil Association 2	Combined SS-SB	Beryllium	0.33	0.28	0.172	0.13	0.95	0.27	0.93	9	31	29
	Soil Association 3/4	Combined SS-SB	Beryllium	0.217	0.158	0.17	0.079	0.89	0.23	0.79	16	64	25
	Soil Association 2	Combined SS-SB	Cadmium	0.243	0.0455	0.318	0.081	1.3	1.3	1.3	1	31	3
	Soil Association 3/4	Combined SS-SB	Cadmium	0.258	0.044	0.328	0.079	1.4	1.2	1.5	2	64	3
	Soil Association 1	Combined SS-SB	Calcium	4000	1350	8640	NA	NA	145	33500	26	26	100
	Soil Association 2	Combined SS-SB	Calcium	5940	536	29000	319	319	112	162000	30	31	97
	Soil Association 3/4	Combined SS-SB	Calcium	421	243	570	42.3	258	45.8	2940	62	64	97
	Soil Association 1	Combined SS-SB	Chromium	12.2	8.55	10.3	NA	NA	1.8	43.2	26	26	100
	Soil Association 2	SB	Chromium	13.8	13.3	8.07	NA	NA	2.5	26.4	12	12	100
	Soil Association 2	SS	Chromium	6.93	5.5	4.16	NA	NA	2.6	18.3	19	19	100
	Soil Association 3/4	Combined SS-SB	Chromium	7.23	5.6	4.75	2.8	3.5	2.2	25.6	62	64	97
	Soil Association 1	Combined SS-SB	Cobalt	1.53	1.45	1.26	0.13	1.4	0.2	4.2	20	26	77
	Soil Association 2	Combined SS-SB	Cobalt	2.79	2.3	1.64	1.8	2.3	1	7.3	29	31	94
	Soil Association 3/4	Combined SS-SB	Cobalt	2.25	1.75	1.79	0.15	1.2	0.5	8.1	56	64	88
	Soil Association 1	Combined SS-SB	Copper	4.72	2.45	6.17	1.1	2.9	0.41	24.4	24	26	92
	Soil Association 2	Combined SS-SB	Copper	1.66	1.25	1.36	0.61	3.9	1.4	5	14	31	45
	Soil Association 3/4	SB	Copper	1.34	1.1	0.892	0.43	2.8	0.71	3.2	14	23	61
	Soil Association 3/4	SS	Copper	1.8	1.5	1.08	1.1	3.5	0.9	5.3	28	41	68
	Soil Association 1	Combined SS-SB	Cyanide	0.191	0.0306	0.522	0.04	0.62	2.7	2.7	1	26	4
	Soil Association 1	Combined SS-SB	Iron	8980	8150	6230	NA	NA	1280	22400	26	26	100
	Soil Association 2	SB	Iron	14400	15500	8360	NA	NA	1870	30000	12	12	100
	Soil Association 2	SS	Iron	6230	5320	4000	NA	NA	1910	17200	19	19	100
	Soil Association 3/4	SB	Iron	8780	6780	7020	NA	NA	1740	31700	23	23	100
	Soil Association 3/4	SS	Iron	5760	4160	4230	NA	NA	1720	20300	41	41	100
	Soil Association 1	Combined SS-SB	Lead	18.6	7.4	29.3	NA	NA	1.1	136	26	26	100
	Soil Association 2	SB	Lead	7.03	7	2.77	NA	NA	2	13.7	12	12	100
	Soil Association 2	SS	Lead	9.5	8.9	2.53	NA	NA	6.4	16.5	19	19	100
	Soil Association 3/4	SB	Lead	5.42	5.5	1.38	NA	NA	2.8	8.1	23	23	100
	Soil Association 3/4	SS	Lead	12.5	11.2	7.51	NA	NA	5.8	43.1	41	41	100
	Soil Association 1	Combined SS-SB	Magnesium	1410	921	1720	92.1	92.1	160	6770	25	26	96
	Soil Association 2	SB	Magnesium	852	606	841	NA	NA	176	3340	12	12	100
	Soil Association 2	SS	Magnesium	459	412	347	271	292	157	1610	17	19	89
	Soil Association 3/4	Combined SS-SB	Magnesium	307	248	181	197	197	112	1070	63	64	98
	Soil Association 1	SB	Manganese	22.8	14.6	24.8	NA	NA	2.9	86.2	11	11	100

Table C-9
Summary Statistics of Background Soil Data
Background Investigation Work Plan

Chemical Group	SoilGroup	Depth	ParamName	Mean	Median	Standard Deviation	Minimum DL	Maximum DL	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples	Percent Detects
Metals (mg/kg)	Soil Association 1	SS	Manganese	70.8	47.6	81.6	NA	NA	6.9	298	15	15	100
	Soil Association 2	Combined SS-SB	Manganese	112	89.3	86.9	NA	NA	20.3	413	31	31	100
	Soil Association 3/4	Combined SS-SB	Manganese	96.3	60.3	102	NA	NA	5.4	491	64	64	100
	Soil Association 1	Combined SS-SB	Mercury	0.0544	0.03	0.0512	0.04	0.16	0.052	0.24	6	26	23
	Soil Association 3/4	Combined SS-SB	Mercury	0.0316	0.0263	0.0184	0.036	0.12	0.051	0.14	3	64	5
	Soil Association 1	Combined SS-SB	Nickel	4.18	3.1	3.51	3.6	3.6	0.37	14.2	25	26	96
	Soil Association 2	Combined SS-SB	Nickel	4.48	3.9	2.32	1.5	3.8	1.4	9.1	28	31	90
	Soil Association 3/4	Combined SS-SB	Nickel	3.69	3.1	2.53	0.99	4.1	1.1	11.9	52	64	81
	Soil Association 1	Combined SS-SB	Potassium	1170	739	1300	97.6	371	281	4560	19	26	73
	Soil Association 2	Combined SS-SB	Potassium	477	373	476	93.5	358	100	2100	21	31	68
	Soil Association 3/4	Combined SS-SB	Potassium	190	128	179	78.8	449	276	827	14	64	22
	Soil Association 1	Combined SS-SB	Selenium	0.701	0.423	0.595	0.22	2.2	0.27	2.7	7	26	27
	Soil Association 2	SB	Selenium	0.438	0.313	0.289	0.57	0.77	0.38	1.2	3	12	25
	Soil Association 2	SS	Selenium	0.252	0.29	0.139	0.22	0.66	0.27	0.69	3	19	16
	Soil Association 3/4	Combined SS-SB	Selenium	0.34	0.3	0.2	0.22	0.65	0.26	1.4	20	64	31
	Soil Association 2	Combined SS-SB	Silver	0.21	0.055	0.249	0.1	1	0.16	1.1	2	31	6
	Soil Association 3/4	Combined SS-SB	Silver	0.233	0.055	0.325	0.099	1.1	1	2.1	2	64	3
	Soil Association 1	Combined SS-SB	Sodium	3290	883	5840	187	973	32.7	21300	18	26	69
	Soil Association 2	Combined SS-SB	Sodium	112	103	74.9	152	815	17.4	63.4	10	31	32
	Soil Association 3/4	Combined SS-SB	Sodium	87.4	85.5	48.9	73.6	374	18.6	117	22	64	34
	Soil Association 1	Combined SS-SB	Vanadium	17.1	13.2	14.1	NA	NA	2.1	53.8	26	26	100
	Soil Association 2	SB	Vanadium	20	20.2	9.89	NA	NA	2.2	33.2	12	12	100
	Soil Association 2	SS	Vanadium	11.3	9.4	4.84	NA	NA	5.7	20.8	19	19	100
	Soil Association 3/4	Combined SS-SB	Vanadium	13.7	10.9	8.56	NA	NA	2.5	36	64	64	100
	Soil Association 1	Combined SS-SB	Zinc	22.9	15	22.7	NA	NA	4.2	113	26	26	100
	Soil Association 2	Combined SS-SB	Zinc	13.4	11.3	6.95	3	3	4.9	30.8	30	31	97
	Soil Association 3/4	SB	Zinc	8.23	6.3	6.81	2.5	4	4.5	32	19	23	83
	Soil Association 3/4	SS	Zinc	12.3	10.9	8.11	NA	NA	3.6	48.4	41	41	100

Table C-9
Summary Statistics of Background Soil Data
Background Investigation Work Plan

Chemical Group	SoilGroup	Depth	ParamName	Mean	Median	Standard Deviation	Minimum DL	Maximum DL	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples	Percent Detects
Metals with All Nondetects (mg/kg)	Soil Association 2	Combined SS-SB	Antimony	1.37	0.235	1.88	0.35	9.3	NA	NA	0	29	0
	Soil Association 1	Combined SS-SB	Cadmium	0.169	0.0632	0.207	0.077	1.2	NA	NA	0	26	0
	Soil Association 2	Combined SS-SB	Cyanide	0.113	0.0285	0.125	0.04	0.63	NA	NA	0	31	0
	Soil Association 3/4	Combined SS-SB	Cyanide	0.133	0.0353	0.13	0.04	0.71	NA	NA	0	64	0
	Soil Association 2	Combined SS-SB	Mercury	0.0313	0.027	0.0105	0.042	0.12	NA	NA	0	31	0
	Soil Association 1	Combined SS-SB	Silver	0.161	0.0784	0.155	0.096	0.96	NA	NA	0	26	0
	Soil Association 1	Combined SS-SB	Thallium	0.604	0.55	0.384	0.22	3.3	NA	NA	0	26	0
	Soil Association 2	Combined SS-SB	Thallium	0.343	0.43	0.162	0.22	1.1	NA	NA	0	31	0
	Soil Association 3/4	Combined SS-SB	Thallium	0.331	0.425	0.154	0.22	1	NA	NA	0	64	0
Organics (ug/kg)	Soil Association 1	Combined SS-SB	4,4'-DDD	3.69	2.4	2.92	3.4	13	5.3	12	3	21	14
	Soil Association 3/4	Combined SS-SB	4,4'-DDD	1.85	1.8	0.227	3.4	4.2	1.3	3.1	2	42	5
	Soil Association 1	Combined SS-SB	4,4'-DDE	3.54	2.25	4.55	3.4	6.3	1.7	23	6	21	29
	Soil Association 2	Combined SS-SB	4,4'-DDE	2.48	1.8	2.88	3.5	30	1.1	1.1	1	21	5
	Soil Association 3/4	Combined SS-SB	4,4'-DDE	1.84	1.8	0.154	3.4	4.2	1.3	2.5	2	42	5
	Soil Association 1	Combined SS-SB	4,4'-DDT	3.17	2.4	2.01	3.4	13	10	10	1	21	5
	Soil Association 1	Combined SS-SB	Acetophenone	291	225	172	340	1600	95	95	1	21	5
	Soil Association 2	Combined SS-SB	Acetophenone	198	180	87.9	350	1100	41	41	1	21	5
	Soil Association 3/4	Combined SS-SB	Acetophenone	180	185	23.5	350	420	61	110	2	42	5
	Soil Association 1	Combined SS-SB	alpha-BHC	1.45	1.15	0.879	1.8	8.1	0.6	1.6	7	21	33
	Soil Association 1	Combined SS-SB	alpha-Chlordane	1.57	1.15	0.979	1.1	6.5	0.98	4.7	4	21	19
	Soil Association 2	Combined SS-SB	alpha-Chlordane	1.37	1	1.47	0.59	15	1.1	2.5	4	21	19
	Soil Association 3/4	Combined SS-SB	alpha-Chlordane	1.12	0.95	0.714	0.65	2.2	0.65	4.7	14	42	33
	Soil Association 1	Combined SS-SB	Benzaldehyde	283	220	188	340	1600	53	100	3	21	14
	Soil Association 3/4	Combined SS-SB	Benzaldehyde	181	185	22.4	350	420	51	51	1	41	2
	Soil Association 1	Combined SS-SB	Benzo(a)anthracene	280	225	127	340	1300	220	220	1	21	5
	Soil Association 1	Combined SS-SB	Benzo(a)pyrene	286	245	127	340	1300	340	340	1	21	5
	Soil Association 1	Combined SS-SB	Benzo(b)fluoranthene	301	245	150	340	1300	650	650	1	21	5
	Soil Association 1	Combined SS-SB	Benzo(g,h,i)perylene	287	245	127	340	1300	350	350	1	21	5
	Soil Association 1	Combined SS-SB	Benzo(k)fluoranthene	282	245	126	340	1300	260	260	1	21	5
	Soil Association 1	Combined SS-SB	beta-BHC	2.37	1.25	2.91	1.8	8.1	5.3	14	2	21	10
	Soil Association 2	Combined SS-SB	beta-BHC	1.25	0.9	1.43	1.8	15	0.74	0.99	3	21	14
	Soil Association 3/4	Combined SS-SB	beta-BHC	0.941	0.95	0.048	1.8	2.2	0.94	0.94	1	42	2
	Soil Association 1	Combined SS-SB	bis(2-Ethylhexyl)phthalate	129	66	130	54	970	38	380	6	21	29
	Soil Association 2	Combined SS-SB	bis(2-Ethylhexyl)phthalate	614	140	1160	67	670	46	5000	14	21	67
	Soil Association 3/4	Combined SS-SB	bis(2-Ethylhexyl)phthalate	235	175	357	37	750	41	2300	18	42	43
	Soil Association 1	Combined SS-SB	Chrysene	293	245	133	340	1300	480	480	1	21	5
	Soil Association 1	Combined SS-SB	delta-BHC	1.73	1.25	1.14	1.8	8.1	0.8	5	2	21	10
	Soil Association 2	Combined SS-SB	delta-BHC	1.27	0.95	1.43	1.8	15	0.65	0.65	1	21	5
	Soil Association 1	Combined SS-SB	Dieldrin	3.17	2.5	1.68	3.4	16	2.5	3.7	2	21	10

Table C-9
Summary Statistics of Background Soil Data
Background Investigation Work Plan

Chemical Group	SoilGroup	Depth	ParamName	Mean	Median	Standard Deviation	Minimum DL	Maximum DL	Minimum Detect	Maximum Detect	Number of Detects	Number of Samples	Percent Detects
Organics (ug/kg)	Soil Association 2	Combined SS-SB	Dieldrin	2.51	1.85	2.86	3.5	30	1.9	1.9	1	21	5
	Soil Association 3/4	Combined SS-SB	Dieldrin	1.97	1.83	0.476	3.4	4.2	2.3	4.4	5	42	12
	Soil Association 2	Combined SS-SB	Di-n-octylphthalate	199	180	85.8	350	1100	66	66	1	21	5
	Soil Association 1	Combined SS-SB	Endosulfan I	1.55	1.15	0.859	1.8	8.1	0.96	2.3	7	21	33
	Soil Association 1	Combined SS-SB	Endosulfan II	3.03	2.25	1.71	3.4	16	2.1	2.1	1	21	5
	Soil Association 1	Combined SS-SB	Endosulfan sulfate	2.93	2.25	1.63	3.4	16	2.1	3.7	5	21	24
	Soil Association 3/4	Combined SS-SB	Endosulfan sulfate	1.86	1.8	0.139	3.4	4.2	1.6	2.4	3	42	7
	Soil Association 1	Combined SS-SB	Endrin	3.15	2.45	1.68	3.4	16	3.5	3.5	1	21	5
	Soil Association 1	Combined SS-SB	Endrin aldehyde	3.65	2.25	2.86	3.4	16	1.8	12	3	21	14
	Soil Association 2	Combined SS-SB	Endrin aldehyde	2.55	1.85	2.86	3.5	30	2.7	2.7	1	21	5
	Soil Association 3/4	Combined SS-SB	Endrin aldehyde	1.84	1.8	0.183	3.4	4.2	1.2	2.7	2	42	5
	Soil Association 1	Combined SS-SB	Endrin ketone	3.08	2.4	1.69	3.4	16	2.5	4.5	3	21	14
	Soil Association 3/4	Combined SS-SB	Endrin ketone	1.83	1.8	0.131	3.4	4.2	1.2	2.1	3	42	7
	Soil Association 1	Combined SS-SB	Fluoranthene	283	245	126	340	1300	270	270	1	21	5
	Soil Association 1	Combined SS-SB	gamma-BHC (Lindane)	1.68	1.25	0.921	1.8	8.1	1.4	3.3	2	21	10
	Soil Association 1	Combined SS-SB	gamma-Chlordane	1.65	1.15	1.38	1.8	6.5	0.74	7	3	21	14
	Soil Association 2	Combined SS-SB	gamma-Chlordane	1.26	0.95	1.43	1.8	15	0.55	0.55	1	21	5
	Soil Association 3/4	Combined SS-SB	gamma-Chlordane	0.926	0.95	0.0767	1.8	2.2	0.65	0.65	2	42	5
	Soil Association 3/4	Combined SS-SB	Heptachlor epoxide	0.96	0.95	0.14	1.8	2.2	1.8	1.8	1	42	2
	Soil Association 1	Combined SS-SB	Indeno(1,2,3-cd)pyrene	286	245	127	340	1300	340	340	1	21	5
	Soil Association 3/4	Combined SS-SB	Phenol	185	185	32.8	340	420	53	340	2	42	5
	Soil Association 1	Combined SS-SB	Pyrene	286	245	127	340	1300	330	330	1	21	5

Figure C-1: Box and Whisker Plots for Inorganic Background Concentrations

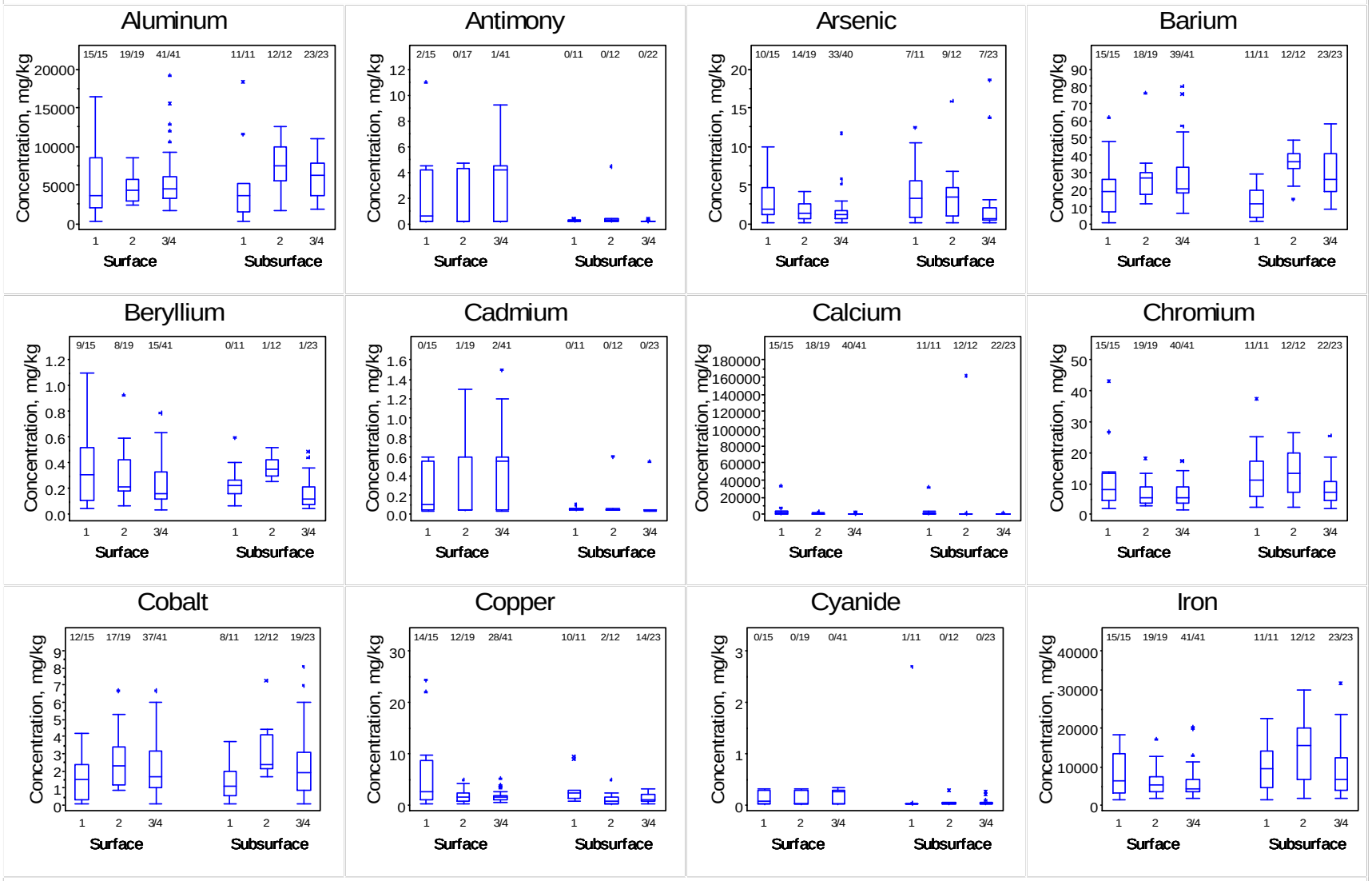


Figure C-1: Box and Whisker Plots for Inorganic Background Concentrations

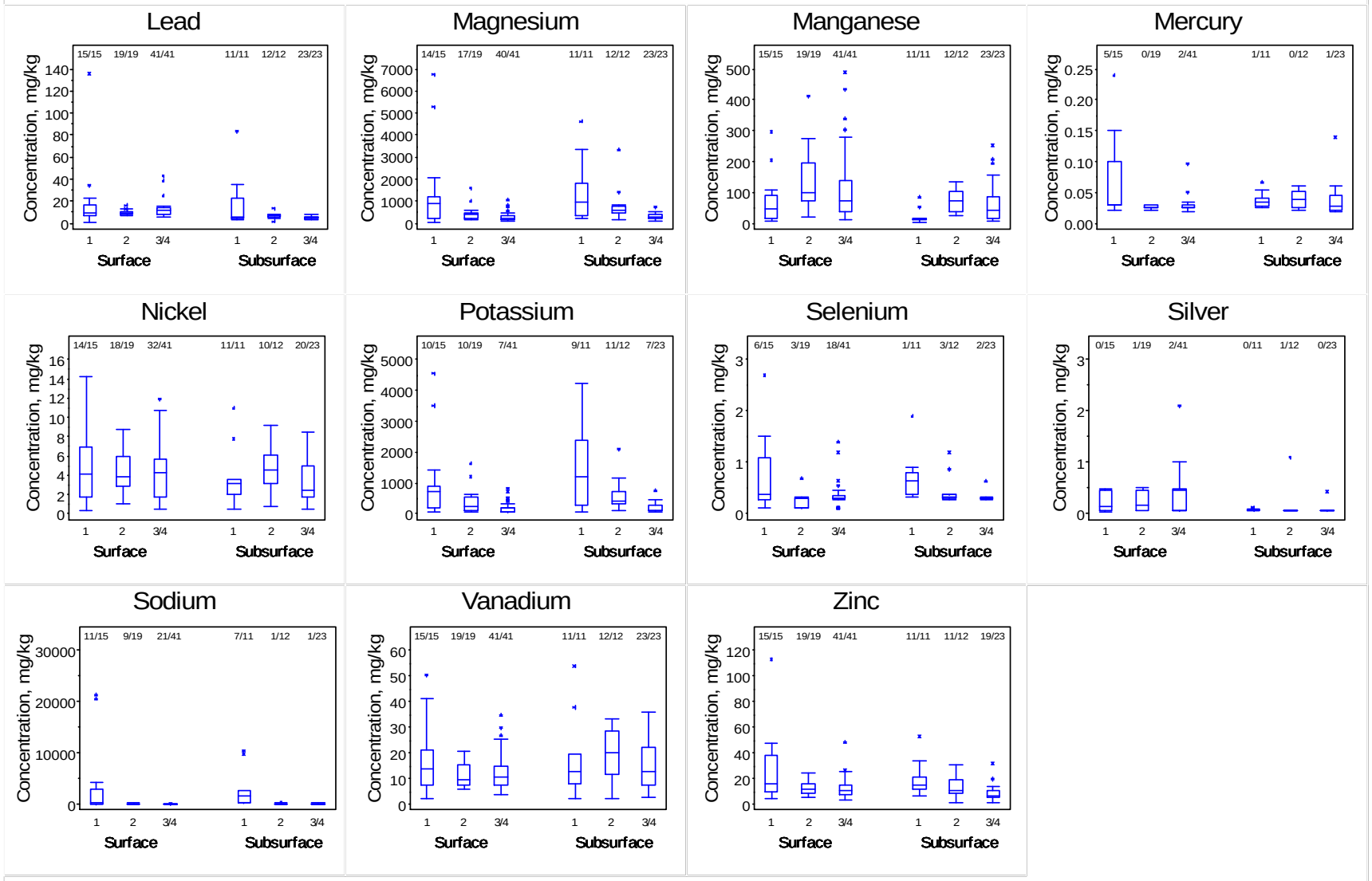


Figure C-2: Box and Whisker Plots for Organic Background Concentrations

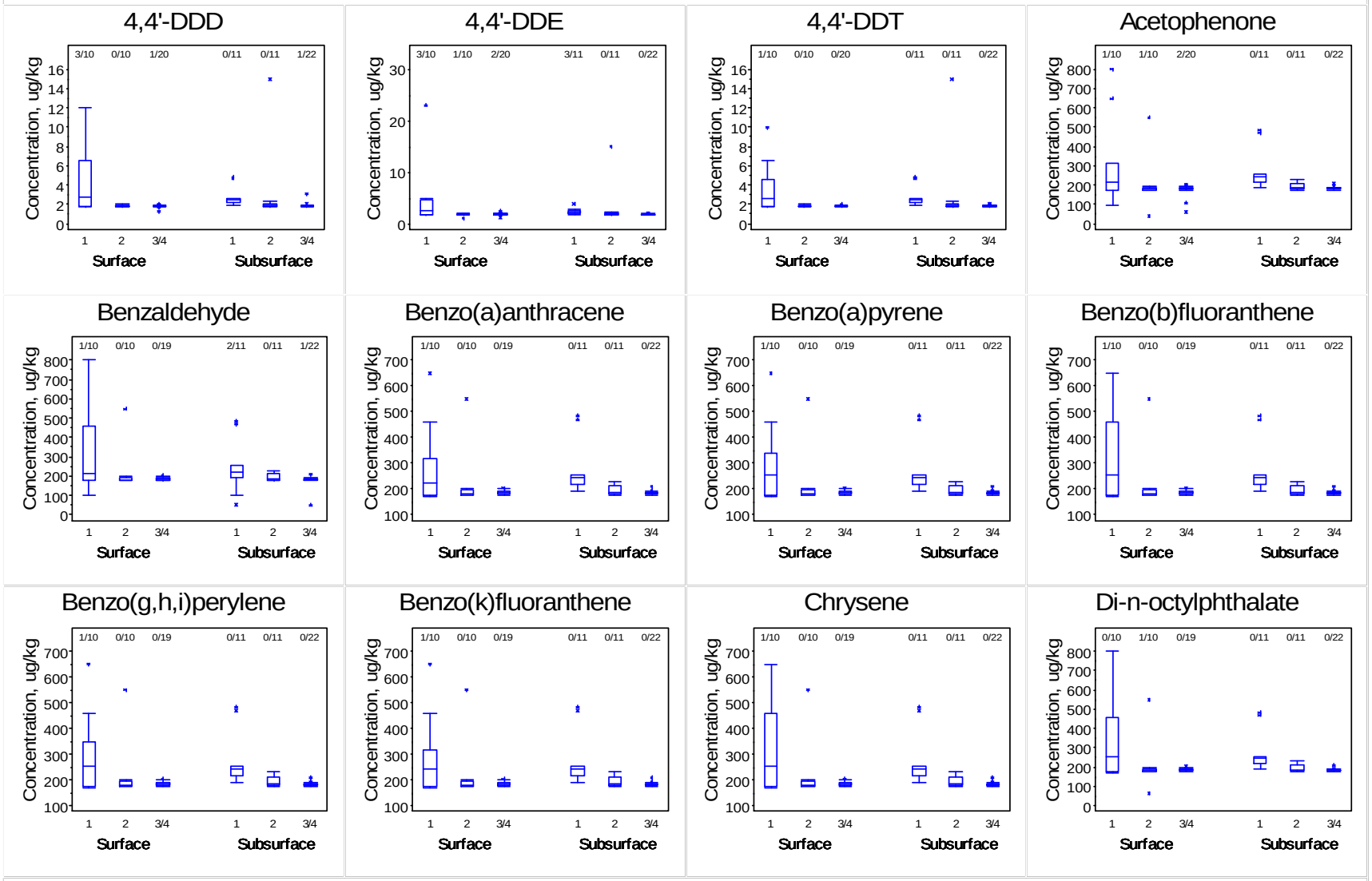


Figure C-2: Box and Whisker Plots for Organic Background Concentrations

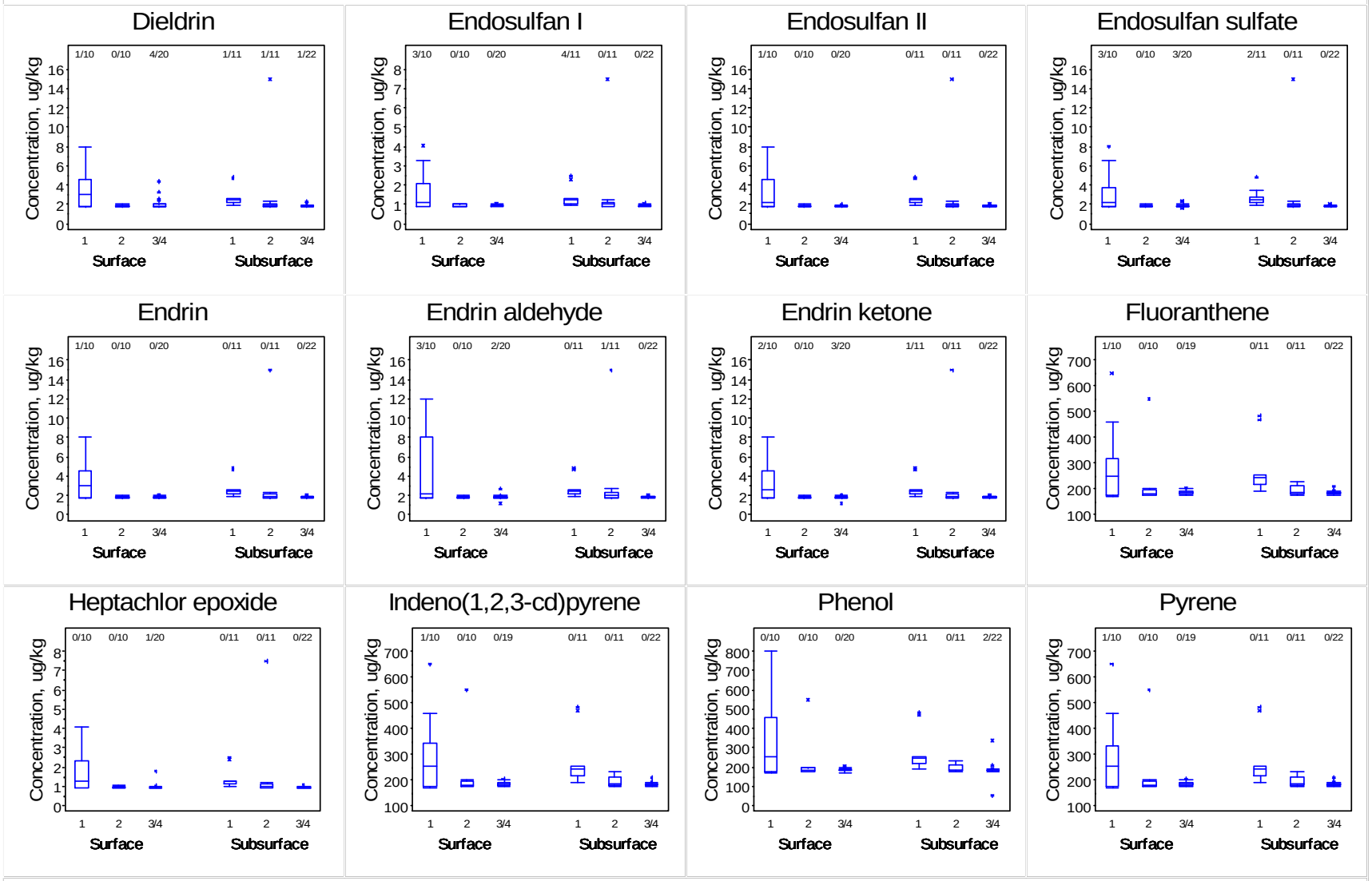
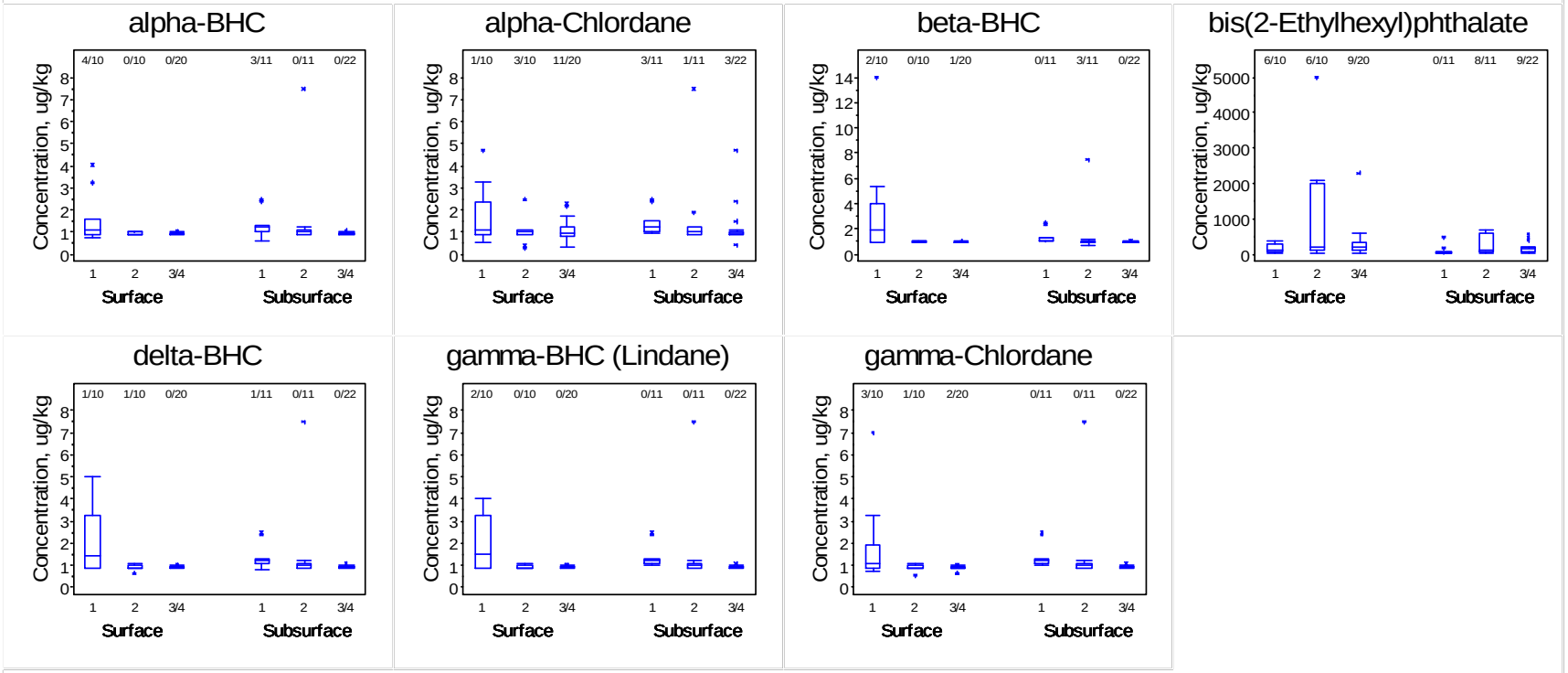


Figure C-2: Box and Whisker Plots for Organic Background Concentrations



Responses to Comments

Ivester, Marlene/HRO

From: Smith,Wade [Wade.Smith@deq.virginia.gov]
Sent: Wednesday, June 03, 2009 12:00 PM
To: Ivester, Marlene/HRO
Subject: RE: EPA Comment #7 on the Yorktown/CAX BG Study WP

Yes, please finalize.
Thanks,
wade

From: Marlene.Ivester@CH2M.com [mailto:Marlene.Ivester@CH2M.com]
Sent: Monday, June 01, 2009 4:38 PM
To: Thomson.Bob@epamail.epa.gov
Cc: William.Friedmann@CH2M.com; tom.kowalski@navy.mil; christopher.r.murray@navy.mil; Smith,Wade
Subject: RE: EPA Comment #7 on the Yorktown/CAX BG Study WP

Rob,

Thank you for your quick response.

Yes, the language from the response to Comment #7 will be added to the final WP to make it clear how the soil associations will be grouped.

The Navy, as well as HILL, is aware that the actual statistical approach will be dependent on the results and distribution of data. I will make sure that it is clear in the WP that the proposed approach may not be the actual approach and that all parties will agree on the approach once we have the results.

Do we have the go ahead for a final WP? Does everyone agree?

Thanks,

Marlene

From: Thomson.Bob@epamail.epa.gov [mailto:Thomson.Bob@epamail.epa.gov]
Sent: Monday, June 01, 2009 4:18 PM
To: Ivester, Marlene/HRO
Cc: Friedmann, William/VBO; tom.kowalski@navy.mil; christopher.r.murray@navy.mil; wmsmith@deq.virginia.gov
Subject: Re: EPA Comment #7 on the Yorktown/CAX BG Study WP

Marlene:

The response for Comment # 7 contained in the May 39, 2009 email satisfactorily addresses EPA concern, however, the Region would like to see the text of the response worked into the final Work Plan, as it helps to explain (especially to the public) how the soil associations will be grouped. Please include this text in the final Work Plan

For comments 1, 2, 9, and 10, as discussed in the Partnering meeting, it is difficult to speculate what stastical approach to use without seeing the actual data. As long as the Navy is aware that the statistical approaches can change based upon the distribution of the data, EPA is agreeable to keep our options open and flexible until we can see that data.

Robert Thomson, PE, REM

Office of Federal Facility Remediation
US EPA - Region 3
215-814-3357

-----<Marlene.Ivester@CH2M.com> wrote: -----

To: Bob Thomson/R3/USEPA/US@EPA
From: <Marlene.Ivester@CH2M.com>
Date: 05/29/2009 11:30AM
cc: <William.Friedmann@CH2M.com>, <tom.kowalski@navy.mil>, <christopher.r.murray@navy.mil>, <wmsmith@deq.virginia.gov>
Subject: EPA Comment #7 on the Yorktown/CAX BG Study WP

Rob,
Per the April 30 Yorktown Partnering meeting discussion, you said we should be able to wrap up through email the EPA's original Comment #7 on the BG Study WP . Therefore, below, I offer a revised response (below in blue, following the comment's sequence of events).
EPA's original comment was:
7. Section 3.2.1: The factors used to determine how soil associations will be grouped are not clearly defined in the draft Work Plan. Please define these factors in the revised Work Plan.

Our RTC letter asked for clarity and EPA then commented:
The Navy's response did not fully address the concerns EPA outlined in Specific Comment #7. The Navy's response is not clear about the
factors influencing the grouping of soil associations. The response indicates that the clarification requested was already presented in the draft Work Plan, in several different paragraphs. However, the text referenced did not address or answer the concern, which is whether the grouping of soil associations will be based on similarities in soil characteristics or in contaminant concentrations? Usually for background studies, samples are segregated based on soil characteristics. If that is not what is proposed in the draft Work Plan, then an explanation needs to be provided for review.

Our revised response is:
Yes, the samples will be segregated based on soil characteristics. There are four soil associations located at both WPNSTA Yorktown and CAX - 1 (Bohicket, Johnston, Axis), 2 (Dogue, Pamunkey, Uchee), 3 (Emporia, Slagle, Craven-Uchee Complex), and 4 (Slagle, Emporia, Emporia Complex. WPNSTA Yorktown has a fifth soil association (5 - Slagle, Bethera, Craven-Uchee); however, data from Soil Association 5 at WPNSTA Yorktown was excluded from the BG data set because this soil association comprises a relatively small portion of the Facility and there are no known CERCLA sites located with the areas of this soil association.
When determining the suitability to combine soil types and soil depths, the largest determining factor is the soil composition (i.e. grain size, organic content). The soil grain size distribution and organic content can impact a contaminant's transport properties as well as alter the contaminant's properties. Soil types are closely associated to the geographic features which represent varying deposition environments (i.e. wetlands are associated with low, quie t waters producing predominantly silt to mud deposits). The highest variability in a contaminant's characteristics within a soil occur between soils composed of sands to those composed of silts and muds. Soils with higher organic contents generally have the capacity to accumulate inorganic compounds and as such would produce higher concentrations of naturally occurring metals. For this reason, high organic soils (Bohicket, Johnston, Axis) are not combined with sandier, low-organic content soils (Slagle, Emporia).
Soils which are considered similar in their physical composition are then compared statistically. This process is repeated to determine if soil depths may also be considered for combination based on their physical composition. The purpose of conducting this process is to increase the statistical pool of data leading to a higher confidence in the statistics.
Does this response sufficiently address Comment #7. If not, please explain what other information you are seeking. Thanks.

If you agree with the above response, a paragraph using the language above will be added after the two bullets on Page 3-1 to clarify how the so il associations will be grouped. Do you concur?
Lastly, with respect to the remaining comments that required resolution (Comments 1, 2, 9, and 10 - all stats related), as we discussed during the April 30 meeting, we (CH) would make it clear in the WP that the statistical model we proposed and the one that we'll actually use could change, based on the analytical results, and that the once the results are available, there will be a Team meeting (including statistical experts) to agree upon the approach to use. Therefore, can we consider Comments 1, 2, 9, and 10 resolved as well?
If you agree that we have resolved the remaining five comments, then we can go final w/ the WP and schedule the fieldwork.
If you have any questions, please contact me or Bill.
Thanks so much,
Marlene

Ivester, Marlene/HRO

From: Thomson.Bob@epamail.epa.gov
Sent: Tuesday, June 02, 2009 3:09 PM
To: Ivester, Marlene/HRO
Cc: Friedmann, William/VBO; tom.kowalski@navy.mil; christopher.r.murray@navy.mil; wmsmith@deq.virginia.gov
Subject: RE: EPA Comment #7 on the Yorktown/CAX BG Study WP

Please finalize the Work Plan. The ticks are waiting and hungry.....

Robert Thomson, PE, REM
Office of Federal Facility Remediation
US EPA - Region 3
215-814-3357

-----<Marlene.Ivester@CH2M.com> wrote: -----

To: Bob Thomson/R3/USEPA/US@EPA
From: <Marlene.Ivester@CH2M.com>
Date: 06/01/2009 04:37PM
cc: <William.Friedmann@CH2M.com>, <tom.kowalski@navy.mil>, <christopher.r.murray@navy.mil>, <wmsmith@deq.virginia.gov>
Subject: RE: EPA Comment #7 on the Yorktown/CAX BG Study WP

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Sent: Monday, June 01, 2009 4:18 PM
To: Ivester, Marlene/HRO
Cc: Friedmann, William/VBO; tom.kowalski@navy.mil; christopher.r.murray@navy.mil; wmsmith@deq.virginia.gov
Subject: Re: EPA Comment #7 on the Yorktown/CAX BG Study WP

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To: Bob Thomson/R3/USEPA/US@EPA
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Date: 05/29/2009 11:30AM
cc: <William.Friedmann@CH2M.com>, <tom.kowalski@navy.mil>, <christopher.r.murray@navy.mil>, <wmsmith@deq.virginia.gov>
Subject: EPA Comment #7 on the Yorktown/CAX BG Study WP

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If you agree that we have resolved the remaining five comments, then we can go final w/ the WP and schedule the fieldwork.
If you have any questions, please contact me or Bill.
Thanks so much,
Marlene

CH2M HILL
Pennisula Professional Building
11818 Rock Landing Drive
Suite 200
Newport News, VA 23606-4320
Tel 757.873.1511
Fax 757.873.7657

June 2, 2009

357098.SI.BK

Mr. Rob Thomson
Remedial Project Manager
U.S. EPA Region III
1650 Arch Street
Philadelphia, PA 19103

Subject: Additional Responses to USEPA Comments on the *Draft Background Study Work Plan* for Naval Weapons Station, Yorktown, Yorktown, VA and Cheatham Annex, Williamsburg, VA

Dear Mr. Thompson,

On behalf of the U.S. Department of the Navy's Naval Facilities Engineering Command (NAVFAC), this letter is in response to your letter dated March 26, 2009, which provided comments on the Navy's responses to USEPA's original comments on the subject document. It is understood that out of the twelve original comments, the USEPA feels seven (Comments 3, 4, 5, 6, 8, 11, and 12) have been adequately addressed and that five (Comments 1, 2, 7, 9 and 10) need further clarification. Presented below is the resolution of these five comments.

GENERAL COMMENTS:

1. The Navy's response did not fully address the concerns EPA outlined in General Comment #1. Please address each bulleted concern separately, and provide revised text/inserts as needed for review.

2. The Navy's response did not fully address the concerns EPA expressed in General Comment # 2. Please give a detailed response to the specific concern outlined in the review comment, along with text modification.

9. The Navy's response did not fully address the concerns EPA outlined in specific comment #9. Please provide a more detailed response and include text modification to insure that the Work Plan is specific and clear.

10. The Navy' s response did not fully address the concerns EPA outlined in General Comment #10. Please provide text modifications to insure that the Work Plan is specific and clear. Also, please address the issue of dealing with symmetrical background distribution if it is encountered.

Navy Response:

These comments were discussed at the April 30, 2009 Yorktown Partnering meeting, as the Navy believed that between its responses to the original comments and the work plan itself, these comments had been adequately addressed. However, the EPA felt, while they understand what the Navy is proposing, the language should be geared toward normal vocabulary for the reader - that the work plan needs to define the ways the data will be used and provide more clarity for the audience reading the work plan who might not understand the statistics. Overall, the EPA said no additional RTC letter was necessary, but wanted language added to the work plan that stated the statistical model actually used could vary from what was proposed, as it is dependent on the how the data is distributed. Additionally, the EPA and Navy would agree on the model to use once the data was available.

The Navy agrees that the model to use is dependent on the data distribution. The Navy and EPA will discuss and agree upon the model to use for calculating the new soil and groundwater background values.

Regarding changes to the work plan, work plans are not geared toward the average person and are intended for technical reviewers who understand the science and the proposed course of action for a project/site. This project is further complicated by the fact that it is statistical in nature and has a more narrow audience. Adding more detail to the work plan about the statistics likely would be more confusing rather than providing more clarity. The Navy feels the background study report is a more appropriate place to present the details on how the data will be used and will include them there instead of in the work plan. The following changes to the work plan have occurred based on the discussion of these four comments:

Section 3.2, first paragraph

> "Overall, statistical approaches are dependent upon the distribution of the data and could vary from what is proposed in this work plan. The subsections below present the intended approach for calculating the soil UTLs. However, the Navy and EPA have agreed to review the data and decide together on the best statistical approach."

Section 5.2, first paragraph:

> "Overall, statistical approaches are dependent upon the distribution of the data and could vary from what is proposed in this work plan. The subsections below present the intended approach for calculating the groundwater UTLs. However, the Navy and EPA have agreed to review the data and decide together on the best statistical approach."

7. The Navy's response did not fully address the concerns EPA outlined in Specific Comment # 7. The Navy 's response is not clear about the factors influencing the grouping of soil associations. The response indicates that the clarification requested was already presented in the draft Work Plan, in several different paragraphs. However, the text referenced did not address or answer the concern, which is whether the grouping of soil associations will be based on similarities in soil characteristics or in contaminant concentrations? Usually for background studies, samples are segregated based on soil characteristics. If that is not what is proposed in the draft Work Plan, then an explanation needs to be provided for review.

Navy Response:

Following the April 30, 2009 Yorktown Partnering meeting, CH2M HILL provided the EPA with this response:

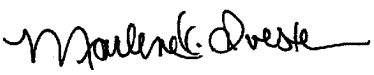
> "Yes, the samples will be segregated based on soil characteristics. There are four soil associations located at both WPNSTA Yorktown and CAX - 1 (Bohicket, Johnston, Axis), 2 (Dogue, Pamunkey, Uchee), 3 (Emporia, Slagle, Craven-Uchee Complex), and 4 (Slagle, Emporia, Emporia Complex. WPNSTA Yorktown has a fifth soil association (5 - Slagle, Bethera, Craven-Uchee); however, data from Soil Association 5 at WPNSTA Yorktown was excluded from the BG data set because this soil association comprises a relatively small portion of the Facility and there are no known CERCLA sites located with the areas of this soil association.
>
> When determining the suitability to combine soil types and soil depths, the largest determining factor is the soil composition (i.e., grain size, organic content). The soil grain size distribution and organic content can impact a contaminant's transport properties as well as alter the contaminant's properties. Soil types are closely associated to the geographic features which represent varying deposition environments (i.e. wetlands are associated with low, quiet waters producing predominantly silt to mud deposits). The highest variability in a contaminant's characteristics within a soil occurs between soils composed of sands to those composed of silts and muds. Soils with higher organic contents generally have the capacity to accumulate inorganic compounds and as such would produce higher concentrations of naturally occurring metals. For this reason, high organic soils (Bohicket, Johnston, Axis) are not combined with sandier, low-organic content soils (Slagle, Emporia).
>
> Soils which are considered similar in their physical composition are then compared statistically. This process is repeated to determine if soil depths may also be considered for combination based on their physical composition. The purpose of conducting this process is to increase the statistical pool of data leading to a higher confidence in the statistics."

The EPA concurred with response. The above response has been incorporated into the work plan, Section 3.2.1, first three paragraphs.

All EPA comments on the draft work plan are now resolved and the final work plan will be prepared. Any questions regarding these responses or the background study work plan should be directed to me at (757) 873-1442, x 34 or Mr. Bill Friedmann at (757) 671-6223.

Sincerely,

CH2M HILL



Marlene Ivester
Project Manager

cc: Mr. Thomas Kowalski/NAVFAC MIDLANT
Mr. Christopher Murray/NAVFAC MIDLANT
Ms. Susanne Haug/USEPA
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February 19, 2009

357098.SI.BK

Mr. Rob Thomson
Remedial Project Manager
U.S. EPA Region III
1650 Arch Street
Philadelphia, PA 19103

Subject: Response to USEPA Comments on the *Draft Background Study Work Plan* for Naval Weapons Station, Yorktown, Yorktown, VA and Cheatham Annex, Williamsburg, VA

Dear Mr. Thompson,

On behalf of the U.S. Department of the Navy's Naval Facilities Engineering Command (NAVFAC), this letter is in response to your letter dated December 17, 2008 that provided comments regarding the subject document. Your comments are presented in italics, followed by the Navy's response (in blue).

GENERAL COMMENTS:

1. *Section 3.2, Statistical Analysis, of the Work Plan does not provide sufficient information regarding how soil data populations with detections of less than 50 percent were statistically evaluated. It is unclear how uses of surrogate values are representative or justifiable; whether outliers were assessed; and how the distribution assumptions and statistical values for these background data sets are adequately comparable to site data. Accordingly, the following concerns should be addressed:*

   - *The text in Section 3.2 states on page 3-4 that "non-detects will be handled via substitution of a proxy of half the detection limit . . ." EPA guidance (referenced as USEPA 2007 in the Work Plan), pages 28-29 and 89-92, explicitly discourages the use of one-half the detection limit in calculating summary statistics for populations containing non-detects values since more representative and defensible methods currently exist. EPA's Guidance for Comparing Background and Chemical Concentrations in Soil at CERCLA Sites (referenced as USEPA 2002b in the Work Plan); ProUCL Version 4.0 Technical Guide; and Data Quality Assessment: Statistical Methods for Practitioners (EPA/240/B-06/003) suggest that other methods may be used to extrapolate surrogate values, or that alternative statistical methods may be used to calculate summary statistics without use of surrogate values. As an example, one method for calculating summary statistics without the use of a surrogate value includes computing an upper percentile value for the distribution of the detections in the background data for comparison with the comparable upper percentile distribution of the site data. A response and/or revision to the Work Plan should be provided which states why use of one-half the detection limit as a surrogate value for calculating summary statistics for the background data set is defensible, and whether alternative data analysis methods were*

evaluated to ensure that the most representative background data sets and best statistical methods for calculating mean values for comparison to site data were used.

- *Additional detail should be provided as to the defensibility of combining soil groups that is based on the lack of variation in analytical results between the soil groups.*

- *Additional detail should be provided on the ANOVA measurements that will be examined. A comparison of groups' means is specified in the text, which is essentially a t-test. ANOVA is commonly used when additional variation measures are desired.*

- *The non-detect surrogate value (one-half the detection limit) is inconsistently referenced as 'sample reporting limit' or 'detection limit' in the text of Section 3.2 and the Quality Assurance Project Plan (QAPP). For clarity, a definition of the term 'detection limit' should be provided in the Work Plan. It is also recommended that the detection limit be referenced as the sample Quantitation limit (QL) to provide consistency with the use of this term in QAPP worksheet #37 and in accordance with EPA National Functional Guidelines terminology, which is considered industry standard.*

- *The text of Section 3.2 does not state whether data sets with a detection percentage less than 50 percent were evaluated for statistical outliers. So that the adequacy and representativeness of the proposed background data sets can be evaluated, this information should be provided.*

- *The text states that data sets with a detect percentage of less than 50 percent were not subject to ANOVA testing, and as stated on page 3-4, distributional assumptions were not tested. Without testing the background data sets for distribution characteristics, it is unclear how it can be demonstrated that the mean and median of the background data populations were sufficiently comparable to the site data. According to pages 4-6, and 5-6 through 5-11 of EPA guidance document, Guidance for Comparing Background and Chemical Concentrations in Soil at CERCLA Sites (USEPA 2002b in the Work Plan); Data Quality Assessment: Statistical Methods for Practitioners (EPA/240/B-06/003), and ProUCL Version 4.0 Technical Guide (USEPA 2007 in the Work Plan) page 28, and 89-90; it is recommended that for data sets with less than 50 percent detections but greater than 4 to 5 percent, either non-parametric methods be used to compute the summary statistics, or a probability plot or goodness-of-fit test be performed to verify the distribution. Therefore, for data sets (populations) with fewer than 50 percent, but greater than 4 to 5 percent detections, it appears the ProUCL technical guide does not recommend ignoring distributional assumptions, but rather offers methods for alternative ways to evaluate the population distribution and to calculate summary statistics. Section 3.2 of the Work Plan should be revised to provide further justification for the method used to calculate summary statistics for the data sets with less than 50 percent detections. This justification should demonstrate that the method will provide meaningful comparisons between the background data set and the site data.*

- *Given that the data under examination originates from a variety of time periods and sources, particular attention should be paid to consistency of notation. Specifically, non-detect results must be clearly different from no results or missing data and it should be ensured that quantitation limits (QLs) and method detection limits (MDLs) were equivalent between data sets. If QLs and/or MDLs differed between data sets, the Work Plan should state how this*

was handled in the statistical analyses. The Work Plan should detail a data assessment plan that addresses such issues.

Please provide a response and/or revise the Work Plan to address these concerns.

Navy Response:

It is important to understand the various contexts of this overall data evaluation. The end goal of this background study is to present a background data set that can be approved as appropriate for comparison to investigative data. That comparison may be in the form of individual site values to background threshold values (which are calculated in this study), or two-sample hypothesis tests which would be handled outside this report as the site data becomes available. These two comparison types are the ones which carry inferential confidence in relation to site versus background comparisons.

EPA comments have stressed the use of approaches presented in various EPA guidance and technical documents that have been referenced in the work plan, in particular USEPA 2007. Concern has been raised that the proposed handling of non-detects may not follow the recommendations in that technical document and instead involve a simple proxy substitution of one-half the detection limit (a traditional method of handling non-detects). Please note that the work plan discusses using such a simple substitution for other summary statistics (other than the background threshold value), to present useful descriptive information for parameters which do not carry inferential connotation. In other words, additional information that might be of interest to a reviewer is included, but the background threshold values are to be calculated using the approaches described in USEPA 2007.

Thus, the approach in the work plan is not in disagreement with EPA's comments nor with USEPA 2007 (on the contrary, it follows them), but the presentation of additional statistics will be included per the work plan to increase the information available to reviewers of the background study.

Another concern of the comments revolves around decisions of whether to merge soil association groups and soil depths (surface versus subsurface). There are a variety of ways to evaluate whether various partitions in the data should be combined or kept separate. These include visual inspection of graphical presentations of the data. This work plan proposed to go beyond visual inspection only with ANOVA, when applicable (greater than 50% detected results as described in the work plan).

The ANOVA approach is described in Section 3.2.1 of the work plan. It is stated that a nonparametric ANOVA (based on ranks) will be used to avert complicated (and often unsuccessful) efforts to transform the data. This is similar to EPA guidance and technical document's recommendations to employ nonparametric two-sample tests (e.g. Wilcoxon Rank Sum test) for site to background comparisons. If appropriate transformations for these comparisons were the preferable way to approach these evaluations, the EPA guidance and technical documents would not propose the use of nonparametric two-sample comparisons.

EPA's comments, however, suggest that the work plan's approach with ANOVA then is in conflict with the EPA guidance on the appropriate approach used for calculating background threshold values (where distributional investigations are applicable and

recommended). Again, in the calculation of background threshold values, our approach did follow the recommendations in EPA guidance and technical documents. These recommendations (concerning calculation of background threshold values), however, do not apply to the ANOVA performed to help determine whether various soil association groups and soil depths should be combined.

Similar to the ANOVA, outlier testing was only performed when 50% detects were available. EPA's comments correctly noted this information was not included in the soil section (Section 3) of the work plan; however, it is the groundwater section (Section 5). The work plan will be revised to include a new Section 3.2 which will contain the language from Section 5.2. The current Section 3.2 will be renumbered to Section 3.3, and its subsections will likewise be renumbered accordingly. A new subsection will be added to the new Section 3.3 and labeled 3.3.2; it will contain the language from Section 5.3.2 that describes the evaluation of outliers. These items will be the only revisions to the work plan related to this comment.

2. *The Work Plan does not provide sufficient information in Section 5.3, Statistical Analysis, with respect to how groundwater constituent data populations with non-detect values will be statistically evaluated. Text in Section 5.3.3., Establishing Statistical Distributions, states "These recent recommendations (USEPA, 2007) also suggest that the distributional assumptions be tested on detected data only. . . All data, both detected and non-detected will be used in the calculation of the summary statistics." Please provide further explanation as to how non-detect values will be handled in the statistical evaluation of groundwater data, and what statistical methods will be used to compute summary statistics for the groundwater background data.*

   Navy Response: Please refer back to the response to Comment 1.

3. *The information provided in Section 5.1, Sampling Rationale, regarding the proposed new well locations for collection of additional groundwater background data is insufficient, as follows:*

   - *The text states on page 5-2 that two new background wells are proposed for the Yorktown aquifer and one new well in the Cornwallis Cave aquifer, which according to the text, are depicted in Figures 5-2 (Cornwallis Cave aquifer) and Figure 5-3 (Yorktown aquifer)." However, Figure 5-3 has not been included in the Work Plan, and further, Figure 5-2 is labeled as, and depicts the Yorktown aquifer wells, not the Cornwallis Cave aquifer as the text suggests. Figure 5-3 should be added to the Work Plan and the text should be revised to match the figures.*

   Navy Response: The reference to a "Figure 5-3" is a carryover from an earlier working version of the document. A figure was removed from this section and the figures were renumbered as "Figure 5-1" and "Figure 5-2" for the Cornwallis Cave and Yorktown aquifer well locations, respectively; however, the revision was not corrected in the text. The text (Section 5.1, third paragraph, second to last sentence) will be revised as follows (new text is underlined):

   "The location of CERCLA sites and the existing and proposed new background monitoring wells are shown on Figures <u>5-1</u> (Cornwallis Cave aquifer) and <u>5-2</u> (Yorktown aquifer). "

   - *The list of existing wells which will be sampled for collection of groundwater background data has not been provided in the text, and well locations depicted on Figure 5-2 are*

referenced as 'E', 'G', 'H', and 'N' wells. It is unclear if these references are the full name of the wells or just abbreviations. For clarity and completeness, please revise the Work Plan to include a listing of all the wells to be sampled.

Navy Response: The references to "E, G, H, etc." are the designations assigned by the USGS for their shallow aquifer system study at Naval Weapons Station Yorktown (Brockman et al, 1997). The Navy agrees that this reference is not clear in the text. The text (Section 5.1, third paragraph) will be revised as follows (new text is underlined):

> "To ensure a minimum of ten representative background samples are available for each aquifer, <u>a total of</u> 15 samples will be collected in the Cornwallis Cave aquifer and <u>a total of</u> 13 samples will be collected in the Yorktown-Eastover aquifer. <u>The samples will be collected from the existing background and USGS wells except for three</u>. Two new background wells are proposed for the Yorktown-Eastover aquifer (BGGW09A and BGGW10A), and one new well in the Cornwallis Cave aquifer (BGGW10) to ensure adequate sample size for statistical analyses. Additionally, the new wells will provide groundwater quality data on Croaker Flat, to supplement the existing wells installed on the Lackey Plain. The location of CERCLA sites and the existing and proposed new background monitoring wells are shown on Figures 5-1 (Cornwallis Cave aquifer) and 5-2 (Yorktown-Eastover aquifer). <u>Table 5-1 provides a listing of all wells to be sampled, including aquifer and well designations</u>."

A copy of Table 5-1 is provided as an attachment to this letter.

- *The second bulleted item on page 5-2 states that monitoring wells were selected at varying depths in the Cornwallis Cave and Yorktown aquifers to assess depth variability. However, the depths of the existing and newly proposed well locations have not been provided to support this assertion. Please revise the Work Plan to include monitoring well selection criteria and specific well depth information.*

Navy Response: There is no significant vertical variability in the Cornwallis Cave and Yorktown aquifers at Yorktown; therefore, depth variability is not relevant to this study. Therefore, the wells were selected not based on well depth, but on the previous background investigations that have established that exiting background wells are installed in locations appropriate to characterize background conditions, as stated in Section 5.1, paragraph two. The new well locations were chosen based on spatial extent and that they are located up- or side-gradient of areas potentially impacted by potential CERCLA releases (refer to bullets one and three on page 5-2). The work plan will be revised to remove the second bulleted item on page 5-2. No further revisions to the work plan based on this comment are necessary.

- *The third bullet states that locations for the new wells were chosen up-gradient or side-gradient of areas potentially impacted by CERCLA releases; however, groundwater elevation data and existing/potential CERCLA sites have not been adequately depicted on a figure to justify this assertion. While Figure 2-4, Geohydrologic Section of the Shallow Aquifer System, shows the direction of groundwater flow in the Cornwallis Cave aquifer and Yorktown-Eastover aquifer in the area of the Camp Peary Scarp, neither this figure nor the figures in Section 5 provide a conceptual area-wide depiction of groundwater contours and directional flow near the proposed new wells. It is recommended that a figure be provided in*

Section 5 which more clearly shows groundwater gradient and flow paths and existing/potential CERCLA sites for the entire area surrounding the newly proposed groundwater wells in order to demonstrate that the newly proposed wells are up-gradient or side-gradient of potential source areas. This information is needed to demonstrate that applicability and defensibility of the resulting background groundwater data set.

Navy Response: Figures 5-1 and 5-2 have been revised with call-out boxes that show groundwater contours and groundwater flow around the newly proposed wells and nearby CERCLA sites. The revised figures are included as attachments to this letter.

SPECIFIC COMMENTS:

4. ***Section 2.2.1, WPNSTA Yorktown, Page 2-3:*** *This section references two surface water features that are located within the site boundaries but which are not labeled on Figure 2-1, Site Map. These include Pond 10 and Lee Pond. So that a complete understanding of the site hydrologic features can be obtained from the text and figure, it is recommended that these two ponds be labeled on the Site Map.*

   Navy Response: Agreed. Figure 2-1 has been revised to included labels for the Pond 10 and Lee Pond surface water features. A copy of the revised figure is included as an attachment to this letter.

5. ***Section 2.2.2, CAX, Page 2-3:*** *Two man-made ponds, referred to in the text as Youth Pond and Catfish Pond have not been depicted on Figure 2-1, Site Map. Although it is understood that these ponds are one to two acres in size, it is recommended that these ponds be depicted on the Site map so that a complete understanding of the site hydrologic features can be obtained.*

   Navy Response: Agreed. Figure 2-1 has been revised to included labels for the Youth Pond and Rodgers Pond surface water features. In addition, the upstream pond (upstream of Youth Pond) has been noted and a reference to it added to the text, as shown below. (Note: The reference to "Catfish Pond" was in error. There is no Catfish Pond at CAX; it is instead known as Rodgers Pond.)

   The text (Section 2.2.2, second to last sentence), has been revised as follows (new text is underlined):

   > "<u>Three</u> small man-made ponds (Youth Pond [2 acres], <u>Rodgers</u> Pond [1 acre], <u>and Upstream Pond [upstream of Youth Pond and < 1 acre in size]</u>) are also present at the facility."

   A copy of the revised figure 2-1 is included as an attachment to this letter.

6. ***Section 3.1, Summary of Existing Soil Data, Page 3-1:*** *The text states that because subsurface soils were collected at varying depths at WPNSTA Yorktown and the CAX background subsurface sample collection depths ranged from 6 to 24 inches below ground surface (bgs), only the two subsurface samples collected at 1-3 feet bgs at WPNSTA were retained for inclusion in the combined background data set. While the rationale for only including WPNSTA background subsurface data collected from the 1 to 3 feet bgs interval in the combined background subsurface data set is appropriate, it is unclear whether the data excluded from the combined data set will be retained for further evaluation of site investigation subsurface soil samples collected at depths below 3 feet bgs. Additionally, Section 3.1 states samples collected along the former*

railroad tracks were excluded from the combined data set since they are considered overly biased. This too appears to be justifiable and appropriate, however it has not been stated whether site contamination exists or is thought to exist at other on-site locations near railroad tracks such that use of this background data would be deemed necessary. Please revise the Work Plan to address these concerns.

Navy Response: Regarding the existing subsurface soil sample data that are below three feet bgs, there is not enough data to allow statistical comparison. Subsurface soil samples below three feet generally are not collected. However, the data will be maintained in the Yorktown/CAX database if future site investigations evaluate soils below the three-foot depth and a non-statistical comparison of the site data could be made if the soil is from the same soil type. This sentence will be added to Section 3.1, paragraph two, (following the sentence that begins "Because subsurface soils were collected at varying depths . . ."):

> "There is not enough data below the three-foot depth to allow for statistical comparison, and subsurface soil samples below three feet generally are not collected. However, the data will be maintained in the Yorktown/CAX database if future site investigations evaluate soils below the three-foot depth and a non-statistical comparison of the site data could be made if the soil is from the same soil type."

Regarding the samples collected along the former railroad tracks that were excluded from the combined data set, use of this background data will not be necessary, as the group of compounds that would be detected (e.g., PAHs, creosote, etc.) would not be part of this report. Should site conditions indicate contamination may/does exist near railroad tracks and is related to the former railroad tracks, the evaluation will end there as railroad activities are not considered a CERCLA release. The following text will be added to work plan (Section 3.1, first paragraph, last sentence):

> "No further use of the railroad sample data set will be deemed necessary as any site contamination near and related to railroad tracks will not be evaluated because no CERCLA release has occurred."

7. ***Section 3.2.1:*** *The factors used to determine how soil associations will be grouped are not clearly defined in the draft Work Plan. Please define these factors in the revised Work Plan.*

   Navy Response: The first paragraph (last sentence) of Section 3.2.1 states that analysis of variance (ANOVA) and box and whisker plots were used to establish whether significant differences exist among soil associations and soil depths and thus, would determine how soil groups and depths would be combined. The third and fourth paragraphs of Section 3.2.1 give a detailed explanation of how ANOVA was applied. The fifth through seventh paragraphs provide the details for how box and whisker plots were evaluated. In addition, the reader is referred to Appendix C, which contains figures with the visual comparison of the soil associations and tables with summary statistics. Therefore, the Navy does not understand what further explanation is needed to explain the factors used to determine how the soil associations would be grouped. Please clarify.

8. *Section 5.1, Sampling Rationale, Page 5-2: The second paragraph states "To ensure a minimum of ten representative background samples are available for each aquifer, 15 samples will be*

collected in the Cornwallis Cave aquifer and 13 samples collected in the Yorktown aquifer." The Work Plan has not provided the basis for stating a minimum of 10 representative samples are required. If 10 samples are needed to meet the requirements of a statistical evaluation, the Work Plan should include this information. Please revise the Work Plan to include an explanation for requiring the collection of a minimum of 10 background samples.

Navy Response: USEPA 2007 recommends a sample size of at least 8-10 samples for calculation of background threshold values. This suggestion will be included in the report.

9. *Section 5.3.1, Aquifer-Specific Data Sets, Page 5-3: The text states "[F]or constituents with a detect percentage of less than 50 percent, professional judgment will be used to decide how their aquifer assignment (pooled or separate) will be assigned." In accordance with EPA' ProUCL Technical Guide, it is unclear why statistics will not be used to evaluate data sets with a detect percentage of less than 50 percent but greater than 4 to 5 percent. Additionally, it is unclear why the statistical protocols presented in Section 3 of the Work Plan for soil data sets with less than a 50 percent detection frequency are not planned for groundwater data sets such that background data for all matrices are evaluated in a consistent and defensible manner. Please revise the Work Plan to address these concerns.*

   Navy Response: The approaches for soil and groundwater matrices are consistent, aside from the different physical features involved (soil associations and depths as opposed to groundwater aquifer assignments). As discussed in the response to Comment 1, the pursuit of ANOVA to compare data from different partitions is additional evaluation beyond mere visual inspection of the data. The distributional approaches provided in ProUCL for calculations of UTLs, UCLs of the mean, etc. do not apply to nonparametric ANOVA, just as they do not apply to nonparametric two-sample hypothesis testing (e.g. the nonparametric Wilcoxon Rank Sum test).

10. ***Section 5.3.2, Evaluation of Outliers, Page 5-3 and 5-4:*** *This section states that a mathematical outlier test will be applied to the data and further states that "Most such tests, including Dixon's, assume that the remaining concentrations represent a normal distribution (after the potential outlier is excluded). This assumption is often not true in application, based on the Shapiro-Wilk test using a significance level of 0.05. An effort will be made to transform the data (USEPA, 2000) to obtain an improved adherence to normality." Accoring to EPA's ProUCL Technical Guide, Section 4.2.4.1 on page 91, use of transformations is discouraged. Further, Section 4.2.4.1 of the ProUCL Technical Guide cautions that statistics and results obtained from transformed data should be back-transformed to the original scale before using the results for comparison with site data. In accordance with EPA guidance, please revise the Work Plan to provide additional discussion of why transforming the data is deemed the best method to evaluate the data, and to document the requirement to back-transform the data before comparing the results to site data sets. This is particularly important to track if each outlier could be transformed using a different method.*

    Navy Response: Back-transformation is not required for the outlier evaluation. We are not calculating a statistic in transformed values that will need to be compared to untransformed values; there is a simple decision of whether the elevated value appears inconsistent with the other values.

The use of transformations in outlier evaluation is mentioned in USEPA 2006 (an updated version of the USEPA 2000 which also mentioned it). Transformations for outlier evaluation deal with the tendency of data in a skewed tail to appear more unlike the other data if that skewed data is evaluated using an assumption of normality (which is a symmetric distribution such that skewed data will tend to appear unlike the rest of the distribution if one is anticipating symmetry on both sides of the mean). Symmetric background data might be expected by some, for instance, with a pristine background data set. With the Yorktown background with its potential anthropogenic sources, however, we do not typically expect a symmetrical background distribution.

11. *Appendix A Quality Assurance Project Plan, QAPP Worksheet #37, Page 121: The Usability Assessment states that the evaluative procedures are used to assess overall measurement error associated with the project, but does not indicate what the completeness criteria is in terms of the total number of acceptable data required for statistical evaluation. Please revise the Work Plan QAPP Worksheet #37, Usability Assessment to provide the data completeness objective. This objective should ensure that sufficient data will be available to complete the statistical analyses for the background groundwater evaluation as stated in Section 5.3 of the Work Plan.*

    Navy Response: This bullet will be added to QAPP Worksheet #37:

    - A minimum of 8-10 samples should be obtained to calculate a defensible background value threshold values (BTVs) (USEPA, 2007).

12. *Appendix B, Figure Background Sample Locations York River Drainage Basin: The figure entitled "Background Sample Locations York River Drainage Basin" includes a legend that indicates proposed background surface water/sediment/biota and surface soil sample locations have been selected in addition to the proposed background monitoring well locations. However, the Work Plan and Background Study QAPP only address collection of additional groundwater samples for the background study. Please revise the figure label to provide the date and/or name of the Work Plan associated with the sample locations identified on the map in order to clearly indicate that is map does not correspond to proposed sampled locations in the October 2008 Work Plan. Additionally, the depiction of groundwater wells on the map is blurry and unusable as presented. The map should be revised so that the features and well names on the map are legible.*

    Navy Response: Appendix B contains the "Previous Background Investigation Sampling Location Figures," as stated in the Table of Contents. There should have been flysheet at the beginning of the Appendix that stated its contents as well, but it was mistakenly omitted. A flysheet with the appendix title will be added.

    The figure "Background Sample Locations York River Drainage Basin is a historic figure from the previous Yorktown Background Study (Baker, 2005). We will attempt to locate a copy of the original native file to make the suggested revisions to the legend, and print a more legible copy.

Sincerely,

CH2M HILL

Marlene Ivester
Project Manager

cc: Mr. Thomas Kowalski/NAVFAC MIDLANT
Mr. Christopher Murray/NAVFAC MIDLANT
Ms. Susanne Haug/USEPA
Mr. Wade Smith/VDEQ
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Ms. Stephanie Sawyer/CH2M HILL

References cited in responses:

Baker Engineering (Baker). 1995. *Final Summary of Background Constituent Concentrations and Characterization of Biotic Community from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown Virginia.* July.

Brockman et al. 1997. *Geohydrology of the Shallow Aquifer System, Naval Weapons Station Yorktown, Yorktown, Virginia.* U.S. Geological Survey Water-Resources Investigations Report 97-4188.

U.S. Environmental Protection Agency (USEPA). 2007. *ProUCL Version 4.0 Technical Guide*. Office of Research and Development, EPA/600/R-07/041. April

USEPA. 2006. *Data Quality Assessment: Statistical Methods for Practitioners*. Office of Environmental Information, Washington, D.C.

Table 5-1
Summary of Background Study
Wells to be Sampled

Aquifer	Well ID (listed basically left to right as they appear on Figures 5-1 or 5-2)	Existing Well? Yes	Existing Well? No
Cornwallis Cave (Figure 5-1)	CXBG3-MW01[1]	X	
	CXBG1-MW01[1]	X	
	58G57 (N3)[2]	X	
	58G58 (N4)[2]	X	
	58F120 (I3)[2]	X	
	BGGW07A[3]	X	
	BGGW07[3]	X	
	BGGW01[3]	X	
	BGGW06A[3]	X	
	58F110 (G3)[2]	X	
	58F115 (H3)[2]	X	
	BGGW03A[3]	X	
	BGGW05A[3]	X	
	58F105 (E3)[2]	X	
	BGGW10[4]		X
Yorktown-Eastover (Figure 5-2)	58G55 (N1)[2]	X	
	58G56 (N2)[2]	X	
	58F118 (I1)[2]	X	
	58F119 (I2)[2]	X	
	BGGW01A[3]	X	
	58F108 (G1)[2]	X	
	58F109 (G2)[2]	X	
	58F113 (H1)[2]	X	
	58F114 (H2)[2]	X	
	58F103 (E1)[2]	X	
	58F104 (E2)[2]	X	
	BGGW09A[4]		X
	BGGW10A[4]		X

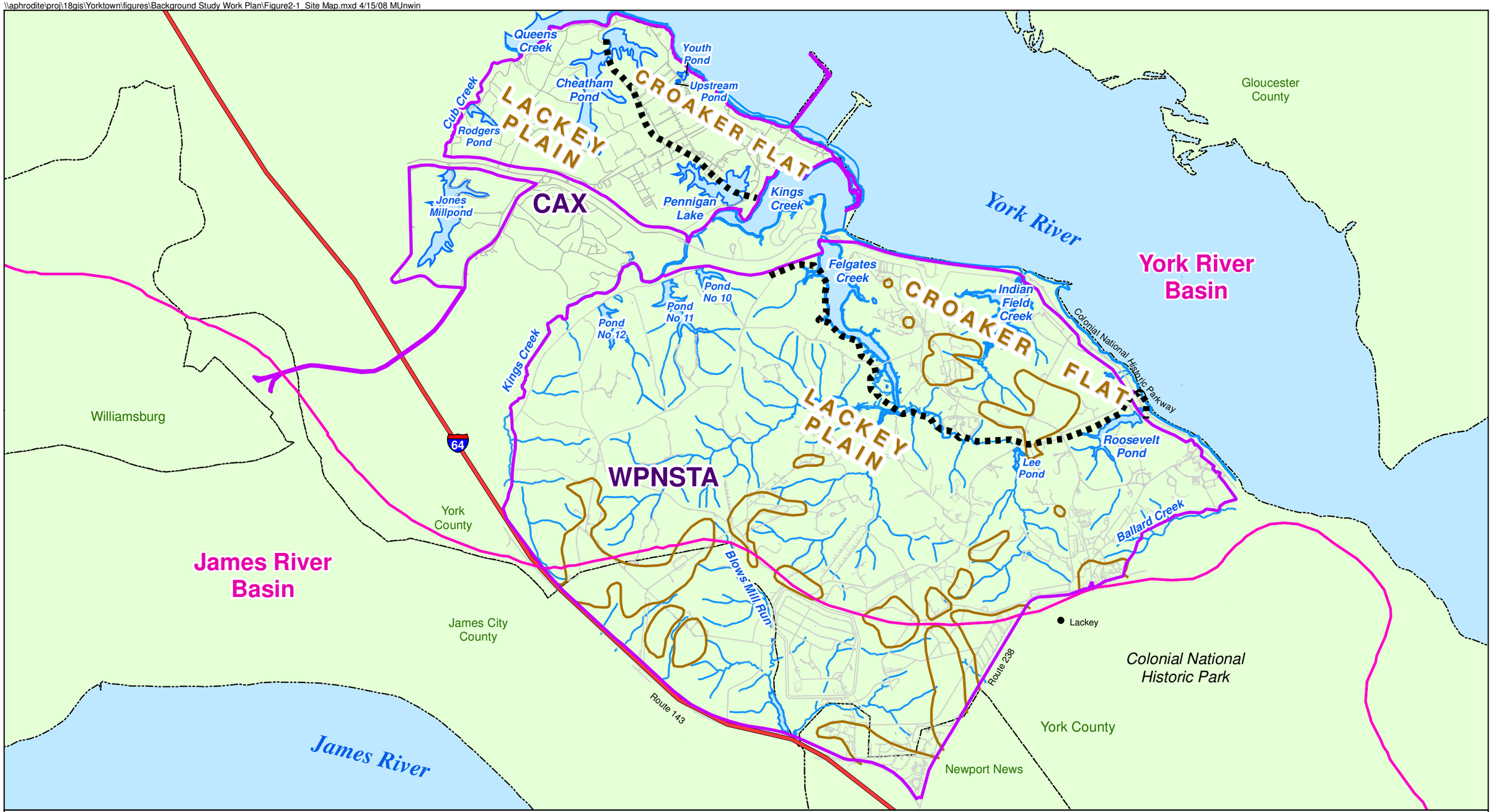
[1]Installed as part of the CAX Background Study (Baker, 2003). This is the well identification assigned by Baker for the study.

[2]Installed as part of the USGS Shallow Aquifer Study of Naval Weapons Station Yorktown (Brockman et. al, 1997). The USGS installed seven four-well clusters (labeled B, E, F, G, H, I, and N) and gave each well within the cluster its own unique identifier (e.g., 58F105), along with a cluster designation (e.g., E3). The cluster designation has been used on Figures 5-1 and 5-2 for brevity and less "clutter."

[3]Installed as part of the Yorktown Background Study (Baker, 1995). This is the well identification assigned by Baker for the study.

[4]New well to be installed as part of 2009 Background Study. The well identification number follows Baker's nomenclature for the Yorktown Background Study and starts sequentially where that study ended (i.e., Baker's study ended at BGGW08A).

\\aphrodite\proj\18gis\Yorktown\figures\Background Study Work Plan\Figure2-1_Site Map.mxd 4/15/08 MUnwin



Legend

- Activity Boundaries
- Camp Peary Scarp
- Watershed Boundaries
- Interstate 64
- Approximate Boundary of Columbia Aquifer, February 3, 1997
- Roads
- Shoreline and Water Bodies
- City / County Boundaries

N

0 4,000 8,000 Feet

Figure 2-1
Site Map
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

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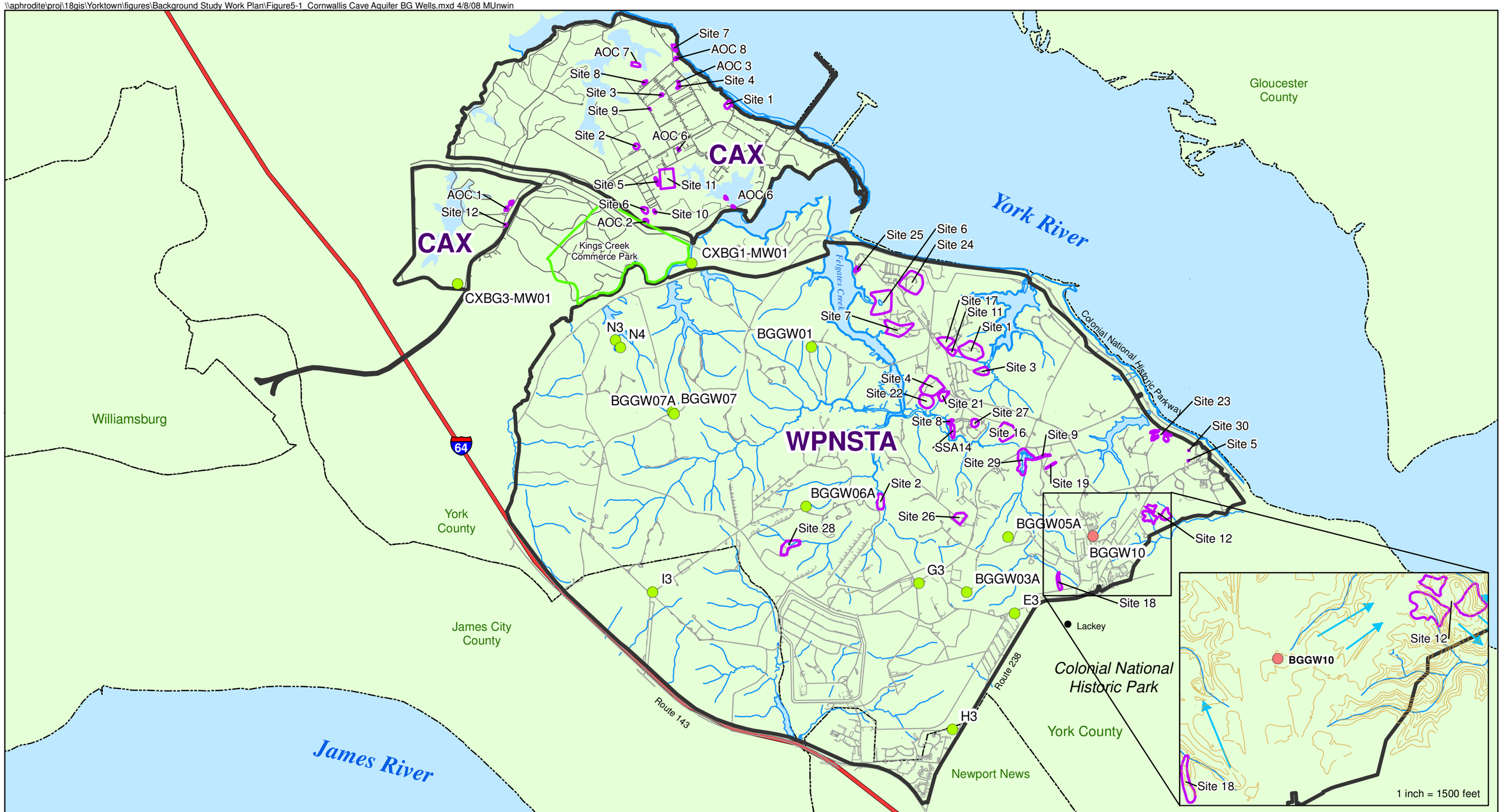
\\aphrodite\proj\18gis\Yorktown\figures\Background Study Work Plan\Figure5-1_Cornwallis Cave Aquifer BG Wells.mxd 4/8/08 MUnwin



Legend

- Proposed New Well for Background
- Proposed Existing Well for Background
- Roads
- Shoreline and Water Bodies
- Contours
- Interstate 64
- City / County Boundaries
- Groundwater Flow Arrow (the surface water body to which flow was going)
- Site Boundaries
- Activity Boundaries
- Kings Creek Commerce Park

N

0 4,000 8,000 Feet

Figure 5-1
Cornwallis Cave Aquifer Background Wells
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

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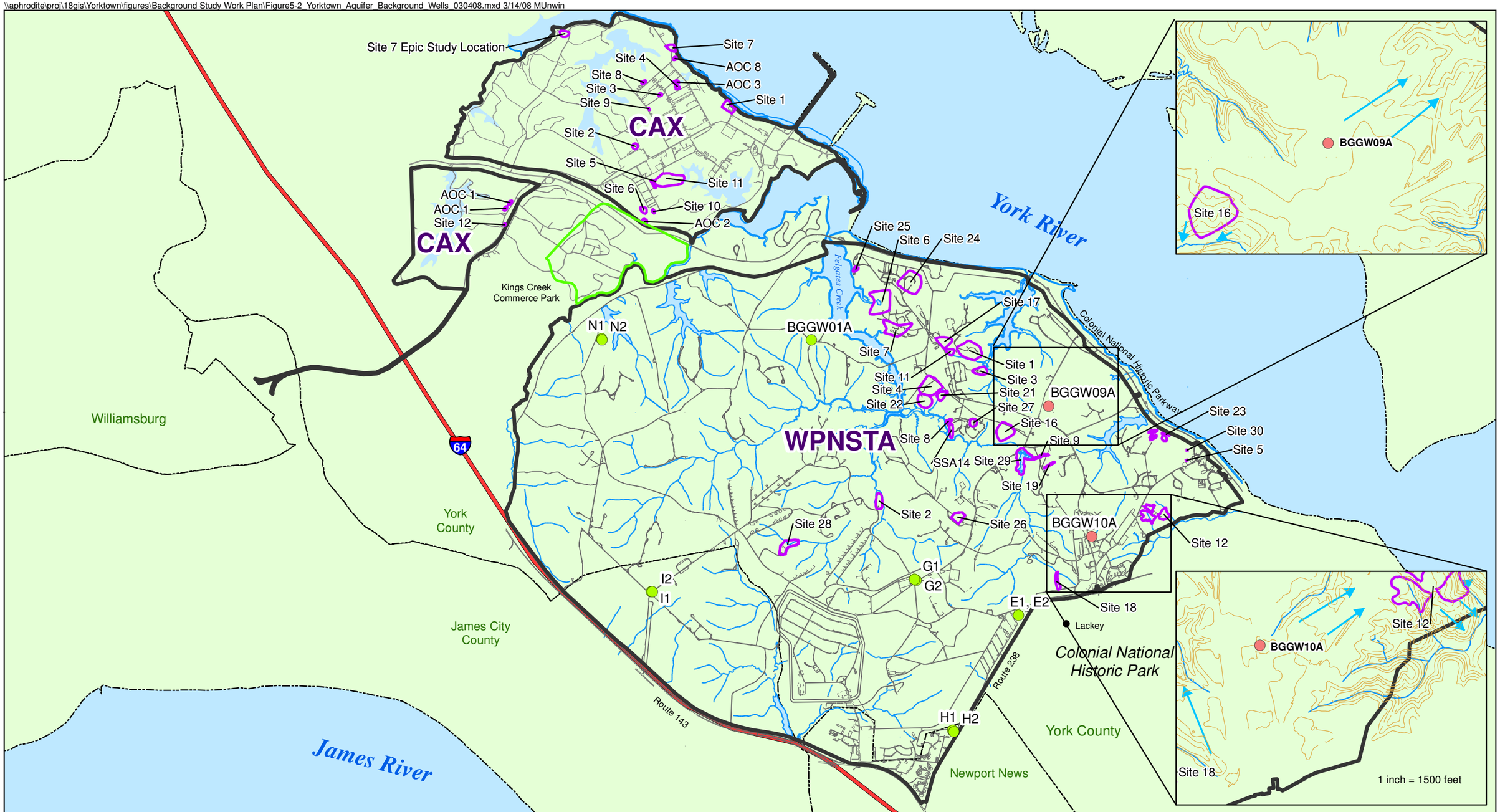

Legend

- Proposed New Well for Background
- Proposed Existing Well for Background
- Roads
- Shoreline and Water Bodies
- Interstate 64
- Contours
- City / County Boundaries
- Groundwater Flow Arrow (the surface water body to which flow was going)
- Site Boundaries
- Activity Boundaries
- Kings Creek Commerce Park

Figure 5-2
Yorktown Aquifer Background Wells
Background Study Work Plan
Naval Weapons Station Yorktown
Yorktown, Virginia

CH2MHILL

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February 19, 2009

357098.SI.BK

Mr. Wade Smith
Remedial Project Manager
Virginia Department of Environmental Quality
P.O. Box 1105
Richmond, VA 23218

Subject: Response to VDEQ Comments on the *Draft Background Study Work Plan* for Naval Weapons Station, Yorktown, Yorktown, VA and Cheatham Annex, Williamsburg, VA

Dear Mr. Smith,

On behalf of the U.S. Department of the Navy's Naval Facilities Engineering Command (NAVFAC), this letter is in response to your letter dated January 9, 2009 that provided comments regarding the subject document. Your comment is presented below, followed by the Navy's response.

1. *Subsequent to review of the Work Plan, this office requests that Appendix A (Quality Assurance Project Plan) be revised to indicate that Thomas Kowalski is the Yorktown RPM and Donna Caldwell is no longer CH2M HILL's Activity Manager. This office has no additional comments.*

   Navy Response: Agree, and thank you for your comment. The revisions will be made to reflect that Mr. Thomas Kowalski is now the Yorktown RPM and that Mr. William Friedmann is CH2M HILL's Activity Manager.

Sincerely,

CH2M HILL

Marlene Ivester
Project Manager

cc: Mr. Thomas Kowalski/NAVFAC MIDLANT
Mr. Christopher Murray/NAVFAC MIDLANT
Ms. Susanne Haug/USEPA
Mr. Robert Thomson/USEPA
Mr. William Friedmann/CH2M HILL
Ms. Rebekah Klyukin/CH2M HILL
Ms. Stephanie Sawyer/CH2M HILL