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FINAL
PRELIMINARY ASSESSMENT
NAVAL WEAPONS STATION YORKTOWN – CHEATHAM ANNEX, VIRGINIA

JULY 2006

Prepared for:

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NAVAL WEAPONS STATION YORKTOWN – CHEATHAM ANNEX, VIRGINIA

DoD Contract Number: N62472-02-D-1300

Reviewed and Approved by:

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Malcolm Pirnie, Inc. prepared this report at the direction of Engineering Field Activity Northeast. This document should be used only with the approval of the Engineering Field Activity Northeast. This report is based, in part, on information provided in other documents, and is subject to the limitations and qualifications presented in the referenced documents.

July 2006

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ACRONYMS

ATV	All Terrain Vehicle
BRAC	Base Realignment and Closure
CAX	Cheatham Annex
CD	Compact Disc
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CNRMA	Commander Navy Region Mid-Atlantic
CSM	Conceptual Site Model
CWM	Chemical Warfare Materiel
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DV	Depleted Uranium
EFANE	Engineering Field Activity, Northeast
EOD	Explosive Ordnance Disposal
FUDS	Formerly Used Defense Site
FY	Fiscal Year
IRP	Installation Restoration Program
LANTDIV	Atlantic Division
MEC	Munitions and Explosives of Concern
MC	Munitions Constituents
MMRP	Military Munitions Response Program
MRP	Munitions Response Program
MSL	Mean Sea Level
NAVFAC	Naval Facilities Engineering Command
NCP	National Contingency Plan
NPS	National Park Service
OE	Ordnance and Explosives
PA	Preliminary Assessment
POC	Point of Contact

RG	Record Groups
RPM	Remedial Project Manager
SARA	Superfund Amendment and Reauthorization Act
TNT	Trinitrotoluene
U.S.	United States
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USEPA	U.S Environmental Protection Agency

GLOSSARY OF TERMS

Base Realignment and Closure (BRAC) – A Department of Defense (DoD) program that focuses on compliance and cleanup efforts at military installations undergoing closure or re-alignment, as authorized by Congress in four rounds of base closures for 1988, 1991, 1993, and 1995. (DERP Management Guidance, September, 2001)

Closed Range – A range that has been taken out of service as a range and that either has been put to new uses that are incompatible with range activities or is not considered by the military to be a potential range area. A closed range is still under the control of a DoD component. (DERP Management Guidance, September, 2001)

Defense Site – All locations that are or were owned by, leased to, or otherwise possessed or used by the DoD. The term does not include any operational range, operating storage or manufacturing facility, or facility that is used or was permitted for the treatment or disposal of military munitions. (10 U.S.C. 2710(e)(1))

Discarded Military Munitions – Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 U.S.C. 2710(e)(2))

Explosive Ordnance Disposal (EOD) – The detection, identification, field evaluation, rendering-safe, recovery, and final disposal of unexploded explosive ordnance (UXO). It may also include the rendering-safe and/or disposal of EO (explosive ordnance) which has become hazardous by damage or deterioration, when disposal of such EO requires techniques, procedures, or equipment which exceed the normal requirements for routine disposal. (OPNAVINST 8027.1G, 14 Feb 92)

Explosives Safety – A condition where operational capability and readiness, personnel, property, and the environment are protected from the unacceptable effects of an ammunition or explosives mishap. (DoD Directive 6055.9 July 1996)

Formerly Used Defense Site (FUDS) – Real property that was formerly owned by, leased by, possessed by, or otherwise under the jurisdiction of the Secretary of Defense or the Components (including governmental entities that are the legal predecessors of DoD or the Components) and those real properties where accountability rested with DoD but where activities at the property were conducted by contractors (i.e., government-owned, contractor-operated (GOCO) properties) that were transferred from DoD control prior to October 17, 1986. The status of a site as a FUDS is irrespective of current ownership or current responsibility within the federal government. (DERP Management Guidance, September, 2001)

Munitions Constituents (MC) – Any materials originating from unexploded ordnance, discarded military munitions or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 U.S.C. 2710 (e)(3))

Munitions and Explosives of Concern (MEC) – This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means: unexploded ordnance, discarded military munitions or munitions constituents (e.g., TNT, RDX) present in high enough concentrations to pose an explosive hazard. (OUSD(AT&L) 18 December 2003)

Operational Range – A range that is under the jurisdiction, custody, or control of the Secretary of Defense and that is used for range activities, or although not currently being used for range activities, that is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities. (10 U.S.C. 101 (e)(3))

Other than Operational Range – Encompasses closed, transferred and transferring ranges.

Range – A designated land or water area set aside, managed, and used for range activities of the DoD. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, electronic scoring sites, buffer zones with restricted access and exclusionary areas, and airspace areas designated for military use in accordance with regulations and procedures prescribed by the Administrator of the Federal Aviation Administration. (10 U.S.C. 101 (e)(3))

Transferred Range – A property formerly used as a military range that is no longer under military control and had been leased by the DoD, transferred, or returned from the DoD to another entity, including federal entities. This includes a range that is no longer under military control but was used under the terms of a withdrawal, executive order, special-use permit or authorization, right-of-way, public land order, or other instrument issued by the federal land manager. (DERP Management Guidance, September, 2001)

Transferring Range – A range that is proposed to be transferred or returned from the DoD to another entity, including federal entities. This includes a range that is used under the terms of a withdrawal, executive order, act of Congress, special-use permit or authorization, right-of-way, public land order, or other instrument issued by the federal land manager or property owner. An operational or closed range will not be considered a "transferring range" until the transfer is imminent. (DERP Management Guidance, September, 2001)

Unexploded Ordnance – Military munitions that have been primed, fused, armed, or otherwise prepared for action; have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and remain unexploded either by malfunction, design, or any other cause. (10 U.S.C. 101(e)(5))

EXECUTIVE SUMMARY

The Department of Defense (DoD) has established the Military Munitions Response Program under the Defense Environmental Restoration Program (DERP) to address munitions and explosives of concern (MEC) (including unexploded ordnance (UXO) and discarded military munitions (DMM)) and munitions constituents (MC) at other than operational military ranges and other sites. Closed, transferred, and transferring military ranges and sites not located on an operational range are considered other than operational. This report addresses other than operational ranges and sites at an active installation. It may include transferring and/or transferred ranges and munition disposal sites associated with an active installation if they are not included in Base Realignment and Closure (BRAC) or Formerly Used Defense Site (FUDS).

This report represents a Preliminary Assessment (PA) for the Naval Weapons Station Yorktown (WPNSTA Yorktown) – Cheatham Annex (CAX), Virginia. The DoD, Navy, and United States Environmental Protection Agency (USEPA) guidance for conducting and documenting PAs was followed and tailored, where appropriate, to address the unique aspects of MEC and MC.

CAX is a 1,579-acre facility located outside of Williamsburg, in York County, Virginia. CAX is currently managed by the administration of WPNSTA Yorktown, just south of the CAX facility along the York River. CAX is the Naval recreational facility for the Hampton Roads area and supports numerous outdoor activities. CAX is adjacent to the York River and positioned 15 miles upstream of the Chesapeake Bay. The region in which CAX is located has been in use since before the colonization of Jamestown and has been operated by the Navy since 1943.

There is only one other than operational range being addressed at CAX for the purposes of this PA: the Marine Pistol and Rifle Range. The Marine Pistol and Rifle Range, approximately 7 acres in area, is located in the northeast portion of CAX near Cheatham Pond. The range was used for a period of approximately 30 years between the dates of 1939 and 1970. The range was used exclusively for small caliber munitions (less than .50 caliber rounds). Little evidence of this usage is apparent apart from the old targets and backstop that remain at the site. Part of the southern portion of the site is currently located in an active storage yard where vehicles and boats are stored.

1. INTRODUCTION

The Department of Defense (DoD) has established the Military Munitions Response Program under the Defense Environmental Restoration Program (DERP) to address munitions and explosives of concern (MEC) (including unexploded ordnance (UXO) and discarded military munitions (DMM)) and munitions constituents (MC) at other than operational military ranges and other sites. Closed, transferred, and transferring military ranges and sites not located on an operational range are considered other than operational. This report addresses other than operational ranges and sites at an active installation. It may include transferring and/or transferred ranges and munition disposal sites associated with an active installation if they are not included in BRAC or FUDS.

The DoD and the United States Navy are currently establishing policy and guidance for munitions response actions under the Navy Munitions Response Program (MRP). However, key program drivers developed to date conclude that munitions response actions will be conducted under the process outlined in the National Contingency Plan (NCP) (40 CFR 300) as authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9605, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), Pub. L. 99-499 (hereinafter CERCLA). This report represents a Preliminary Assessment (PA) for the Naval Weapons Station Yorktown (WPNSTA Yorktown) – Cheatham Annex (CAX), Virginia in York County. DoD, Navy, and U.S. Environmental Protection Agency (USEPA) guidance for conducting and documenting PAs were followed and tailored, where appropriate, to address the unique aspects of MEC and MC.

This PA Report is organized into the following sections:

- Section 1 – Introduction
- Section 2 – Installation Background
- Section 3 – Physical and Environmental Characteristics
- Section 4 – Summary of Data Collection Effort
- Section 5 – Site Characteristics

The following supporting information is appended to this PA:

- References (Appendix A)
- Project Source Data – General (Appendix B)
- Project Source Data – Site Specific (Appendix C)
- Ordnance Technical Data Sheets (Appendix D)

An interactive compact disc (CD) will be included with this final version of this report. The CD will include electronic files of the report text, tables, and figures; appendices; project source data; additional site photographs; and interactive maps of the installation and site.

1.1. Purpose

This PA summarizes the history of munitions use for the following former range at the CAX: Marine Pistol and Rifle Range. The PA provides an assessment of the current conditions with respect to MEC and MC. The PA provides the necessary information for Navy and regulatory decision-makers to: 1) eliminate from further consideration those MEC sites that pose minimal or no threat to public health or the environment; 2) differentiate MEC sites that may not require further munitions response actions from those that will require further investigation or munitions response actions; 3) determine if an imminent explosives safety hazard from MEC is present that warrants an accelerated response action; and, 4) determine if an imminent hazard from MC to human health, and the environment warranting accelerated response action exists.

1.2. Programmatic Framework

The regulatory structure for managing Navy MRP sites is guided by a complex mixture of federal, state, and local laws, as well as DoD and Navy regulations and guidance, and provides the necessary information for Navy decision makers. The key legislation, policy, and guidance directing the program includes, but is not limited to, the following:

Defense Environmental Restoration Program (DERP) Management Guidance (September 2001)

The DERP Management Guidance establishes a MRP element for MEC and MC defense sites. The history of DERP dates back to the Superfund Amendments and Reauthorization Act (SARA)

of 1986[1]. The scope of the DERP is defined in 10 United States Code (U.S.C.) §2701(b), which states that the: Goals of the program shall include the following: … (1) The identification, investigation, research and development, and cleanup of contamination from hazardous substances, and pollutants and contaminants. (2) Correction of other environmental damage (such as detection and disposal of unexploded ordnance) which creates an imminent and substantial endangerment to the public health or welfare or to the environment …

Draft DoD Directive Military Munitions Response Policy on Other Than Operational Ranges

The Draft DoD Directive 4715.MRP (September 2003 version) states that munitions response will be conducted "in accordance with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP)".

National Defense Authorization Act (FY02) (Sections 311-312)

Sections 311-312 of the National Defense Authorization Act of FY02 reinforced the DoD's 2001 DERP Management Guidance by tasking the DoD to develop and maintain an inventory of defense sites that are known or suspected to contain MEC and MC. Section 311 requires the DoD to develop a protocol for prioritizing defense sites for response activities in consultation with the states and Tribes. Section 312 requires the DoD to create a separate program element to ensure that the DoD can identify and track munitions response funding.

The September 2001 Management Guidance for the DERP and the Defense Authorization Act 2002, described above, established the MRP. The DoD provides program guidance and methods for conducting a baseline inventory of defense sites containing, or potentially containing, MEC and/or MC. The Navy baseline inventory of sites was completed in FY 2002 and was used to establish the sites where PAs are needed to further evaluate the potential for MEC and MC.

1.3. Project Management

This PA is being coordinated and managed by the Navy Engineering Field Activity Northeast (EFANE), a component of the Naval Facilities Engineering Command (NAVFAC) Atlantic Division (LANTDIV). The EFANE performs engineering functions for Navy installations

[1] *SARA was signed into law on October 17, 1986, and amended the CERCLA of 1980, 42 U.S.C. §9601* et seq. *Related sections in Title 10 of the U.S.C. (10 U.S.C. §§2702-2710 and §§2810-2811) further define the program.*

throughout the northeast U.S. and is the Program Manager for this PA. Malcolm Pirnie, Inc. has been contracted to prepare this PA. The Navy Remedial Project Manager (RPM) and the installation points of contact (POC) for CAX provided valuable information and assistance throughout the PA data collection process.

1.4. Preliminary Assessment Approach

CERCLA implementing guidance, which was prepared for sites contaminated with hazardous substances, describes the PA as a limited-scope investigation based upon existing and available data. However, the guidance also states that the PA process developed under CERCLA is not equally applicable to all sites and all contaminants, and that variation from the guidance may be necessary. Sites containing MEC are prime examples of sites where the generic CERCLA process is incomplete. Unique explosives safety issues associated with MEC cannot be assessed solely with the parameters developed for chemical and hazardous waste contaminants. Therefore, while this PA generally follows CERCLA guidance, certain elements of the report have been tailored to address the unique explosives safety aspects of MEC.

The PA process for each of the sites involved collecting and reviewing existing and available information about the site; data collection activities included off-site and on-site research and interviews. It also included a visual survey to assess physical evidence that might indicate the presence of MEC (e.g., discarded munitions items, ordnance penetration holes, or scarred trees) and MC (e.g.; ground scarring, stressed vegetation, or chemical residue) at the site. The Malcolm Pirnie data collection team conducted the on-site portion of the data collection and visual survey on August 18, 19, 21, and 27, 2003.

This PA is inclusive and makes use of all available data relating to munitions use at the CAX, including historical records, field data, anecdotal evidence, interviews with site personnel, and professional knowledge and experience. It is based, in part, on information provided in documents referenced in Appendix A and is subject to the limitations and qualifications presented in the referenced documents.

2. INSTALLATION BACKGROUND

CAX is a 1,579-acre facility located outside of Williamsburg, York County, Virginia. In 1999, CAX was realigned under WPNSTA Yorktown, which is located just south of the CAX facility along the York River. CAX is adjacent to the York River and positioned 15 miles upstream of the Chesapeake Bay. CAX's current mission includes providing recreational opportunities to military and civilian personnel. For this purpose, CAX was designated the Hampton Roads Navy Recreational Complex. Recreational activities at the CAX facility include camping, hiking, hunting, fishing, golf, and other outdoor sports.

CAX is also the Naval Sea System Command's East Coast Consolidated Stock Point for major shipboard mechanical, electronic and navigational equipment. In addition to receiving, storing, issuing, packing, and shipping Navy stock material, particularly large bulky shipboard equipment (such as submarine periscopes, ship propellers, bull gears, antennae, sonar domes), CAX provides warehouse and distribution services for 39 Storage Authorization Programs and tenant organizations.

The following sections provide general information about CAX, including its location and setting; a brief history of the installation; its missions over time; and a history of munitions related training, storage, and usage.

2.1. Location and Setting

CAX lies on the York-James Peninsula in southeastern Virginia; the peninsula is an embayed portion of the Atlantic Coastal Plain. To the southwest, the peninsula is bound by the James River; to the northeast it is bound by the York River. At CAX, the peninsula is about six miles wide. The facility lies on the York River, just northwest of WPNSTA Yorktown. The location of CAX is illustrated in Figure 2.1-1. CAX currently consists of 1,578 acres, 55 percent of which is undeveloped. The area is split into two parcels, the larger of which contains almost all of the facility's activities and administration. The smaller portion is located adjacent to the main portion, but to the south of the Colonial National Historic Parkway (Colonial Parkway). The lands surrounding CAX are a mix of government, residential and undeveloped woodlands and wetlands, with the York River to the north. Williamsburg lies to the northwest, the Busch Gardens theme park lies to the southwest, and the City of Newport News lies farther south on the

peninsula. In the region of CAX, the peninsula is primarily wooded with a mix of hard woods and pine. It is rolling terrain ranging from sea level to 50 feet above mean sea level (MSL). Some portions of CAX are wetlands, and there are numerous small open bodies of water on the facility. The facility is served by Newport News Waterworks since 2002. Prior to 2002, Jones Pond was the primary source of water. Map 2.1-1 depicts the location of the one other than operational range identified during the Navy Range Inventory.

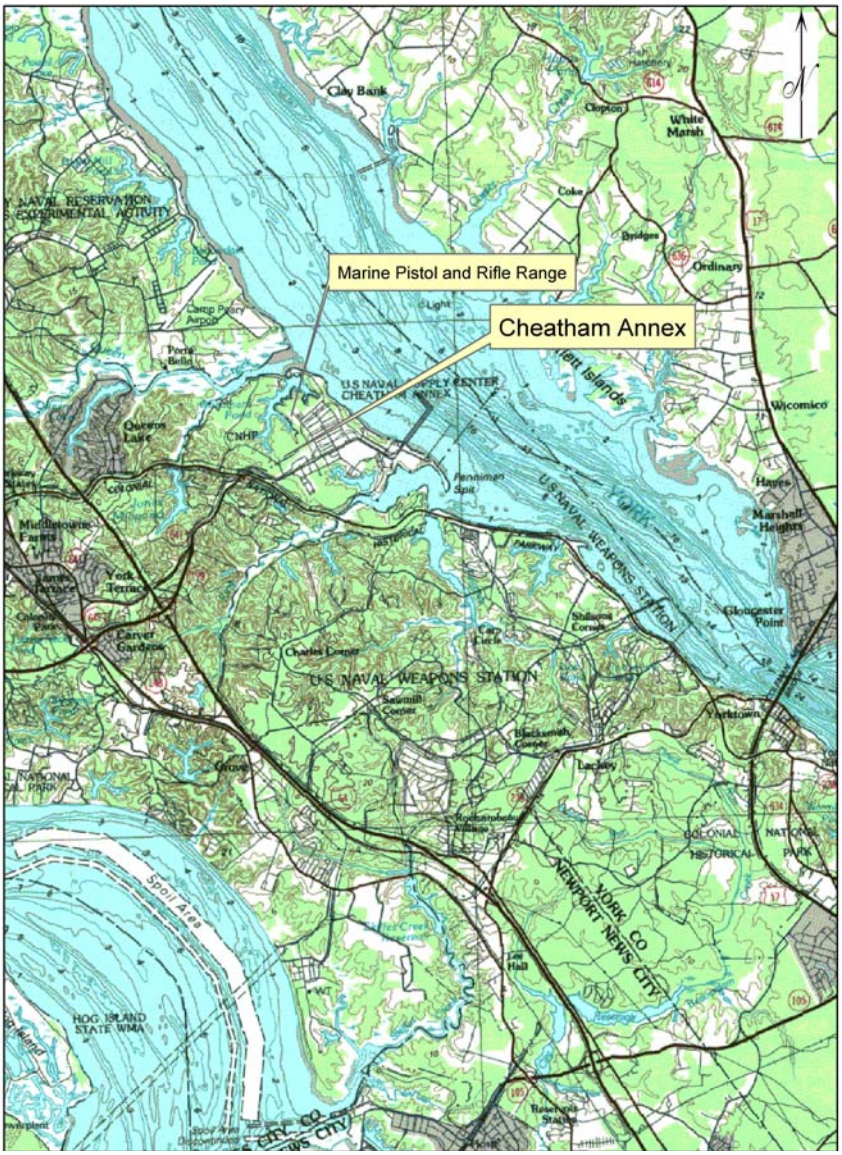


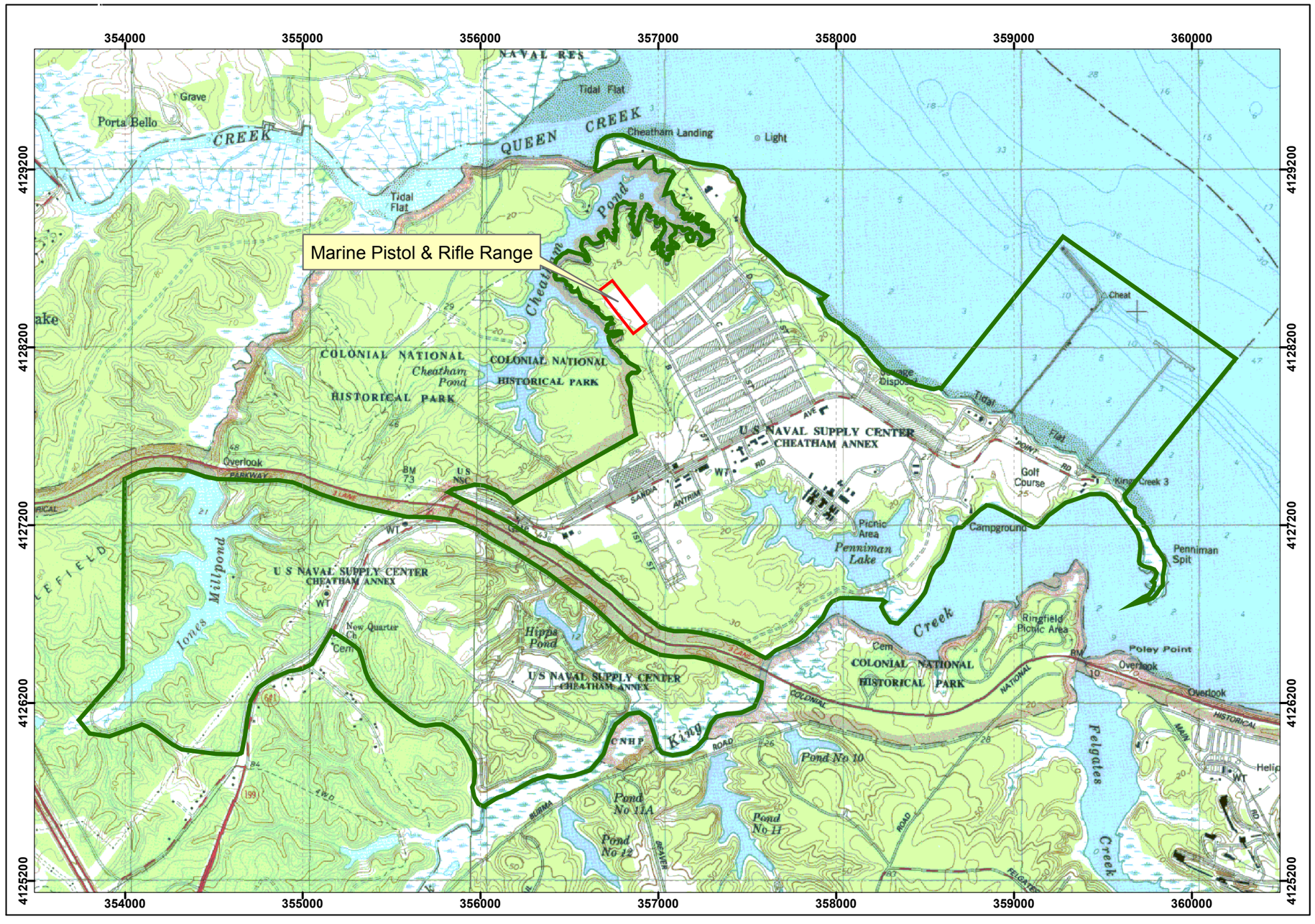
Figure 2.1-1: Location of Cheatham Annex, VA.

(Source: USGS 1984 7.5 Minute Topographic Series Map)

Preliminary Assessment
WPNSTA Yorktown, Cheatham Annex, Virginia

MALCOLM PIRNIE

Map 2.1-1
Area Location Map



Legend

- Installation Boundary
- Site Boundary

0 375 750 1,125 1,500
Meters

Coordinate System: UTM Zone 18
Datum: NAD 83
Units: meters

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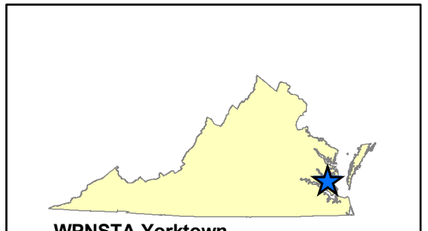
Source: USGS. 1984. 7.5 Minute Topographic Series Map.



WPNSTA Yorktown,
Cheatham Annex, Virginia

2.2. Installation History

Although CAX was not commissioned until 1943, the land has been in continuous use since the founding of the Jamestown colony. Archeological records indicate that it was inhabited prior to that time by Native Americans, possibly belonging to Chief Powhatan's people. In 1630, a 600-acre plot was awarded to Captain John Utie. The plantation was originally named Ultimaria. By 1710, the plantation was owned by James Burwell and named Kings Creek. The gravestone of James Burwell is still located near the 9th hole of the CAX golf course.

Until World War I, the land was primarily used for farming. At that point, the Dupont Company built a powder and shell loading plant. The plant was located in what was to become the town of Penniman, which had 15,000 residents at its peak. By 1920, the town had been abandoned, and the land reverted to farming. In June of 1943, a supply depot, the Fleet Industrial Supply Center (FISC), was commissioned for the Navy. Over the next five decades, the Navy sold or excessed 1,700 acres of land to other government agencies. In 1987, the mission of the CAX facility changed to become the recreational center for Naval personnel for the Hampton Roads region. In 1999, CAX was realigned under Commander Navy Region Mid-Atlantic (CNRMA) with WPNSTA Yorktown.

Table 2.2-1: Timeline of Significant Events

Time Period	Significant Events
Pre- 1918	• Dupont used location as a large powder and shell loading facility during World War I • Facility closed in 1918
1918-1943	• Portions of CAX location used for farming, remainder left idle
1943	• CAX commissioned as FISC
1943-1987	• CAX served as Naval Sea System Command's East Coast Consolidated Stock Point for major shipboard mechanical, electronic and navigational equipment. • Operated under FISC Norfolk • Sold or excessed over 1,700 acres to other government organizations, including National Park Service and Commonwealth of Virginia
1987	• Designated Hampton Roads Navy Recreational Facility
1987-Present	• USEPA and Virginia Department of Environmental Quality became actively involved in the Installation Restoration Program (IRP) • CAX realigned with WPNSTA Yorktown • Placed on the CERCLA National Priorities List in December 2000

2.3. Munitions Related Training / Storage / Usage

There is one other than operational range, and four other areas of interest identified at CAX. The one other than operational range is the focus of this PA report. The other areas of interest are not addressed further.

Other than Operational Ranges:

Marine Pistol and Rifle Range: The former Marine Pistol and Rifle Range (noted as Building 166 in archival maps), consisting of approximately seven acres. The range was located northwest of Building #14, on the southeast side of Cheatham Pond in the northwestern portion of CAX. Information regarding the specific timeframe for construction and utilization of this range was not available. However, based on interviews with CAX personnel during the site visit, operations had ceased at the range by the early 1970s. During the site reconnaissance, the location of a wooden barrier wall and the locations of the former target stands were observed. Part of the southern portion of the site is located in an active storage yard where vehicles and boats are stored. The Marine Pistol and Rifle Range was identified during the Navy range inventory as an other than operational range and is addressed in this PA report.

Other Areas of Interest:

Proposed Skeet Range: A 6 April 1972 drawing showing a proposed Skeet Range was reviewed during the data collection/evaluation process. The proposed Skeet Range was to be located to the northeast of the Marine Pistol and Rifle Range, with a firing zone that extended into the York River. Based on observations made during a site reconnaissance of this area, no remnants or indications of the proposed range were observed. No evidence of the proposed skeet range was noted on aerial photographs from the early 1970s reviewed for CAX. As such, it appears that the range was not actually constructed. In addition, access roads to the range do not appear to have been constructed.

Gun Emplacements: As noted in CAX archival maps dated back to 1943, gun emplacements were present on the supply pier that extended into the York River. Archival drawings dated 7 October 1942 depicted the construction design of these gun emplacements. They were placed at two locations: approximately half way out on the pier, and at the end of the L-shaped pier.

Information regarding the types of guns and munitions associated with the emplacements was not included in the material reviewed. A visual survey of these former emplacements was conducted via the water, and the former concrete platforms for these guns are still in-place. According to installation personnel, the gun emplacements were defensive in nature and not used for training, storage, or regular use.

Penniman: The Penniman Area was noted in the Draft WPNSTA Yorktown Site Management Plan, dated June 2003. The Penniman Area of Concern includes trinitrotoluene (TNT) graining house sump and TNT catch box ruins. The site is scheduled for further investigation under the IRP.

Small Arms Range: Along the York River, approximately 1500 feet to the west of the Marine Pistol and Rifle Range, is an operational small arms range. The range is aligned along a north-south axis. Due to the distance and the direction of firing, the small arms range is not expected to have any impact on the Marine Pistol and Rifle Range.

3. PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS

The following sections provide general information for CAX, including its climate; topography; geology; soil and vegetation types; hydrology; hydrogeology; cultural and natural resources; and endangered species.

3.1 Climate

The CAX is located on the York-James Peninsula; thus, the weather is highly moderated by the Atlantic Ocean. January is the coldest month, with an average temperature of 38.8 degrees Fahrenheit (ºF); July is the warmest month, with a monthly average temperature of 77.4ºF. The average annual precipitation is 44.15 inches. The WPNSTA Yorktown-CAX area is subject to hurricanes and other easterly storms that can cause high winds, high precipitation, significant storm surges, and flooding. Frosting is expected in the early spring and late fall. Winter brings moderate snowfall, though accumulated snow normally lasts less than a week. Ground fog is common, especially in late summer. Winds come predominately from the south and southwest, though onshore winds can predominate during the spring and summer. The spring and summer winds predominately come from the north and northeast.

3.2. Topography

The topography at CAX is characterized by gently rolling terrain, interrupted by ravines and streams, which trend toward the northeast and the York River. Ground elevations vary from sea level at the York River to about 50 feet above mean sea level (MSL). The ravines, which range up to 50 feet deep, are found scattered throughout the facility along many of the creeks and can have slopes greater than 10:1. Many areas of CAX are poorly draining, and ponding can occur with little rainfall.

3.3. Geology

CAX lies within the Atlantic Coastal plain physiographic province, which runs from the foothills of the Appalachian Mountains to the Atlantic Ocean. The province is underlain by unconsolidated sediments of Quaternary, Tertiary, and Cretaceous ages that dip toward the southeast and have a combined thickness of approximately 1,900 feet in the vicinity of CAX.

Most of the unconsolidated sediment at CAX has been mapped as the Shirley Formation of the Pleistocene series. The formation is composed of gravel, sand, silt, clay, and peat that were deposited in river and estuarine environments. It is estimated to range in thickness from zero to 80 feet. Underlying the Shirley formation is the Chuckatuck Formation, which is described as sand, silt, and clay, with minor amounts of peat, deposited in a bay environment. The Chuckatuck Formation rests on top of the Windsor Formation. The Windsor Formation is composed of marine and lagoonal sand, silt, and clay, with some gravel. The Bacons Castle Formation underlies the Windsor Formation; the Bacons Castle Formation is described as clayey silt and silty fine-grained sand. Underlying the Bacons Castle Formation is the Yorktown Formation. Shells and shell fragments characterize the Yorktown Formation. The Yorktown Formation contains the Yorktown Confining Unit and the Yorktown Aquifer.

3.4. Soil and Vegetation Types

There are four soil associations that have been mapped at the CAX facility. The four associations found at CAX are described below.

The Bohicket, Johnston, and Axis Soil Association is found along very wet or flooded ground and is characterized by muck to sandy loams. Because this soil association is normally flooded with the tide, the vegetation is typically marsh grasses, reeds, or shrubs. This type of vegetation is salt tolerant.

The Dogue, Pammunkey, and Uchee Soil Association is found along the York River and King, Queen, and Cub Creeks. This association is located along level or nearly level terrain. The association ranges from poorly to moderately drained soil. Most of the developed areas of CAX are located on areas with this soil association.

The Emporia, Slagle, and Craven-Uchee Complex Soil Association contains well-to moderately well-drained soils. The soils are loamy and clayey and are found along the Coastal Plane Upland and along medium and narrow ridges with steep and sloping sides. Most of this association is wooded, though some CAX outbuildings and storage areas have been constructed in this association.

The fourth association is the Kempsville, Emporia, Emporia, Complex and Craven-Uchee Complex Soils Association. These soils are well-and moderately well drained. This association is formed in loamy and clayey Coastal Plain sediments. The water table for these soils lies from three to five feet below ground surface; the Craven soils have a high water table of 1.5 feet below ground surface.

Most of CAX is wooded, with a mix of pines and hardwoods. Salt tolerant species dominate within the tidal zones. Pine stands, which make up a significant portion of the wooded area, are primarily composed of loblolly and Virginia pines. Hardwood stands can be composed of cherry, cedar, red maple, sweet gum, white ash, and white oak. The understory is primarily seedlings and various vine species such as Virginia creeper, briars, and honeysuckle. Ferns are abundant in many areas.

In addition, there are four major wetland plant community types found along the York River and CAX creeks. They are:

- Salt-marsh cordgrass community (very environmentally productive)
- Big cordgrass community (moderately environmentally productive)
- Cattail community (moderately environmentally productive)
- Brackish water mixed community (very environmentally productive)

3.5. Hydrology

The York River runs along the northeastern boundary of CAX. Within CAX, there are three major creeks (King, Queen, and Cub Creeks), as well as many shallow open bodies of water (200 small ponds). Cheatham Pond and Jones Pond are the most significant. Most of the open bodies of water, including Cheatham, Jones, and Penniman Ponds, are artificial. Prior to 1999, Jones Pond was the drinking water source for CAX and is located south of the Colonial Parkway; currently, CAX is served by the Waterworks of the City of Newport News. Cheatham Pond is owned by the National Park Service (NPS). All surface water on CAX eventually drains to the York River.

3.6. Hydrogeology

The shallow aquifer system in York County and CAX is comprised of six units. Listed in order of increasing depth, these are: the Columbia aquifer, the Cornwallis Cave confining unit, the

Cornwallis Cave aquifer, the Yorktown confining unit, the Yorktown aquifer and the Eastover-Calvert confining unit. Water table depth ranges from 1.5 to 5 feet below ground surface at CAX.

Most drinking water in the region of CAX is received from surface water reservoirs or the Yorktown aquifer, which is approximately 50 feet below ground surface. The Columbia and Cornwallis Cave aquifers are too salty to be used as water sources. The groundwater in the region is affected by the salinity of the York River and the James River, as well as the Chesapeake Bay. Salt-water intrusion into the supply aquifer is a problem due to the demand from Virginia Peninsula communities. Groundwater flow is predominately east toward the Chesapeake Bay, although local groundwater flow may follow the topography.

3.7. Cultural and Natural Resources

In 1999, a complete survey of cultural resources of WPNSTA Yorktown and adjacent Cheatham Annex was completed by the CNRMA. The CNRMA operates 13 installations and annexes in the Hampton Roads Navy Concentration Area, including CAX. As part of the ongoing effort to identify areas of cultural and archaeological importance, the CNRMA is conducting investigations of all 13 installations to be completed during FY04 – FY06. This survey identified 385 sites and recommended 150 for evaluation at WPNSTA Yorktown and CAX. This includes ten Native American and four early European American sites. Eight of the sites may be eligible for the National Register. Prior to development by early settlers, the area of Penniman Spit at CAX was the location of a Native American village, possibly one of Chief Powhatan's villages. The first plantation on the land, established in 1630, was named Ultimaria and was centered on a house near King Creek. In 1780, both the British and the Continental Armies camped on sites that are located at CAX; in 1862, the local area, including CAX, was involved in the 30-day siege of Yorktown by the Union's Army. Some of these events have left evidence, such as the grave markers that date back to the plantation days. In alignment with CAX's current mission, much of the undeveloped land in CAX has been set aside for outdoor recreation, including fishing, hunting, camping, and hiking.

3.8. Endangered and Special Status Species

In 1998, the Virginia Department of Agriculture and Consumer Service, Division of Consumer Protection, Office of Plant and Pest Services reported in a letter that there were no endangered or threatened species found on CAX. Another report from the Virginia Department of Game and

Inland Fisheries indicates that a breeding Bald Eagle pair was discovered near Penniman Pond, no date for this sighting was given. By 1998, there were no known nesting pairs in residence at CAX.

In 1980, the Virginia Department of Conservation and Recreation, Division of Natural Heritage surveyed CAX for rare vertebrate and plant species. The survey found 23 species of rare amphibians, though none merited legal status. The marl ravines around Cheatham Lake were identified as prime habitat for certain rare plants: Loesels's twayblade (*Liparis loeselii*), sweet pinesap (*Monotropsis odorata*), shadow witch (*Ponthieva racemosa*), mountain camellis (*Stewaritia ovata*) and southern cattail (*Typha domingensis*). None of these plants have legal status. The same survey found two other plants that are on the Federal Threatened Species List: the sensitive joint vetch and small whorled pogonia.

A pair of peregrine falcons was sited in 1991, and a mating pair was spotted nesting on an abandoned pier in 1998. According to Navy personnel, no sightings have been reported since 1998. The peregrine falcon is on the State Threatened Species List.

Protected species that are known to or have the potential to inhabit CAX are listed in the following table:

Table 3.8-1: Summary of Known or Potential Protected Species

Ecological Receptors	Species
Federal Endangered	None
Federal Threatened	Small whorled pogonia, sensitive joint vetch, Bald Eagle
State Endangered	None
State Threatened	Peregrine falcon
Other Ecological Receptors	Common fauna/flora, large mammals (e.g., deer), small mammals, amphibians/reptiles and game birds, including the State Special Concern species Least Tern

4. SUMMARY OF DATA COLLECTION EFFORT

Five primary sources of information were researched as part of the data collection effort for the PA. The sources of data included:

1) Historical archives;
2) Personal interviews;
3) Installation data repositories;
4) Visual survey; and
5) Off-site data sources and repositories, such as local libraries and museums.

These five sources of data are discussed below, along with their relative application to this PA.

4.1. Historical Archive Repositories (off-site)

The data collection team reviewed archival records located at the National Archives in College Park, Maryland, and in Washington, D.C. The data collection team researched the following records and record groups (RG) for documents relating to munitions usage at CAX.
(* indicates boxes with copy.)

Textual Records:

RG 72, Bureau of Aeronautics:

- Entry 62-B, General Correspondence, 1943-1945, Box 2160*

RG 71, Bureau of Yards and Docks:

- Naval Property Case Files, Boxes 1274-1278, 1335, 1336*, 1337, 1359, 1360*, 1361*, 1362, 1363*, 1364

RG 74, Bureau of Ordnance:

- Entry 25-E, General Correspondence, Confidential, 1940-1943, Bulky, Box 33
- Entry 25-I, General Correspondence, 1942, Confidential, Box 217*
- Entry 25-J, General Correspondence, 1942, Restricted, Box 596, 597*, 598, 599, 602
- Entry 25-M, General Correspondence, 1943, Confidential, Box 409*, 410*

- Entry 25-O, General Correspondence, 1943, Restricted, Boxes 153*, 262*, 518*, 519*, 704*, 705*, 706-710, 713
- Entry 25-U, General Correspondence, 1944, Confidential, Boxes 597-600
- Entry 25-V, General Correspondence, 1944, Restricted, Box 916*, 1282-1285, 1286*, 1287-1289, 1290*, 1291, 1292, 1293*, 1294, 1298
- Entry1001, General Correspondence, 1948, Boxes 72*, 73
- Entry1001, General Correspondence, 1949, Boxes 665-668
- Entry 1003-A, General Correspondence, 1948, Boxes 230-233
- Entry 1003-B, General Correspondence, 1949, Boxes 665-668
- Construction and Procurement Subject Files
- 1945, Boxes 1284*, 1589, 1590*, 1591*, 1592*, 1593*, 1594*, 1595*, 1596-1600
- 1946, Boxes 415*, 416*, 417*, 418*, 420
- 1947, Boxes 313-315
- 1948, Boxes 60, 61
- 1949, Boxes 103, 105
- Entry 5704, Office of Administration, General Subject Files, 1942-1946, Box 21*

RG 334, Records of Inter-Service Agencies, Armed Forces Explosives Safety Board:

- Entry 15, Explosion Files, #328, 338-A

Cartographic Records:

RG 23, Coast and Geodetic Survey:

- T Charts: T-4712
- Folders for Nautical Charts 406*, 492*, 494*, 495

RG 71, Bureau of Yards and Docks:

- Maps for facilities 540, 560, 564, codes 1, 2, 3, 15, 16, 32, 33, 34, 42, 44-48
- Series II Microfilm, Reels 100, 467, 468, 476

RG 77, Department of Army:

- Army Mapping Service, AMS-V034-S

RG 385, Naval Facilities Engineering Command, 1917-1989:

- Architectural and Engineering Plans, Boxes 19, 101*, 102*, 103*, 104*, 105*, 106*, 107, 108*, 109*, 110*, 111*, 112*, 113*. 114*
- Restricted UIC Architectural and Engineering Plans, Boxes A1*, A2*, A3, A19, A32, A33*

Aerial Photos:

RG145, Department of Agriculture:

- DWI-4N-177

RG 373, Defense Intelligence Agency:

- Cans ON 3522, ON 3961, ON 4826, ON 4837, ON 4838, ON 4839, ON 4840, ON 7484
- Mosaics 755.461

Still Photos:

RG 80, Department of Navy:

- Series 80-G, Box 419*

NAVAL HISTORICAL CENTER, WASHINGTON, D.C.

Photo Archives, Aerials

Operational Archives

Command Histories, 1946 – 1989*

NATIONAL ARCHIVES, REGIONAL OFFICE, PHILADELPHIA:

RG 181, U.S. Naval Districts and Shore Establishments

Fifth Naval District, General Correspondence, 1926-1940, Boxes 93*, 65*, 114*, 115

Fifth Naval District, General Correspondence, 1961, Boxes 1-4

Fifth Naval District, General Correspondence, 1964, Box 3

Fifth Naval District, General Correspondence, 1965, Boxes 1-3

Fifth Naval District, General Correspondence, 1968, Boxes 9-10

The archive records search did not provide information specifically associated with the munitions related activities suspected at the Marine Pistol and Rifle Range. However, the archival data provided general information about the area of the installation where the site is located, including the layout of the area over time and the location and number of structures and improvements in the area.

4.2 Personal Interviews

During the site visit, the following personnel were interviewed:

- Ms. Valerie Walker (IRP, Regional Environmental Group, WPNSTA Yorktown)
- Ms. Carolyn Neill (Compliance Department, WPNSTA Yorktown)
- Mr. Charles Wilson (Natural Resources, WPNSTA Yorktown-CAX)
- Mr. David Shield (Natural Resources, WPNSTA Yorktown-CAX)
- Mr. Bryan Fulford (Regional Engineer, Facility Management, WPNSTA Yorktown)
- LT Sal Dentu (Explosives Ordnance Disposal Mobile Unit Two, Detachment Yorktown)
- Mr. Jeff Harlow (EFD POC, NAVFAC, Atlantic Division)
- Ms. Lora Fly (Installation POC, Hazardous Waste Program Manager, Regional Environmental Group, Navy Public Works Center, Naval Station Norfolk)
- Ms. Dawn Hayes (EFD POC, NAVFAC, Atlantic Division)
- Mr. Mike Forester (Facility Management, WPNSTA Yorktown)

4.3 On-Site Data Repositories

CAX indicated that they had no reports regarding the range. Reports collected from the environmental management office include the Background Investigation Naval Weapons Station Yorktown, Cheatham Annex (2002) and the Division of Natural Heritage Rare Species Inventory Report – Cheatham Annex (date unknown).

4.4. Visual Survey

The data collection team conducted a visual survey of the site as part of the data collection effort for the PA. The purpose of the visual survey was to identify any MEC ordnance related materials (e.g., expended rounds, fragmentation, range debris, or old targets), any evidence of MC (such as ground scarring, stressed vegetation, or chemical residue) or surface features that could provide

additional information to aid in the characterization of the site. The visual survey was also used to enhance, augment, or confirm the archival data and, in some cases, provide new data to the team. A description of the area surveyed and the results of the survey are provided in Section 5. A walk through survey by Malcolm Pirnie was conducted along with WPNSTA Yorktown personnel. WPNSTA Yorktown personnel took photos during the survey due to security concerns. During the survey, geographical information system data was recorded.

4.5. Off-Site Data Sources

The data collection team visited the York County Public Library to obtain additional historical information regarding the site. No useful information was found. The Microsoft Terraserver was also searched for the most recent aerial photos and United States Geological Survey Quads.

5. SITE CHARACTERISTICS

The following sections provide site-specific information about the Marine Pistol and Rifle Range located on CAX, including history and site description; land use; access controls and restrictions; visual survey observation and results; contaminant migration routes; and receptors.

5.1 Marine Pistol and Rifle Range

5.1.1. History and Site Description

The Marine Pistol and Rifle Range is located in the northwest portion of CAX, directly southeast of Cheatham Pond. On archival maps, the range is marked as Building 166 and is located at the end of B Street, just north of Building 14.

The dates for construction of the range are not available. Aerial photographs show that the range was in use by 1939. According to Navy personnel, the range was no longer is use by the 1970s, giving a total lifespan of approximately 30 years. Currently, the most southern portion of the range is used for vehicle storage.

The range is rectangular and approximately seven acres in area. Firing took place from the southern end of the range toward a wooden backstop and wooden targets in the north; the firing zone is about 750 feet long, stretching along the north-south axis. The range is located in a wooded portion of CAX; a creek is located to the west of the range and flows into Cheatham Pond. The open portion of the range is now lightly wooded due to planting of cedar trees about 15 years ago.

5.1.1.1. Topography

The topography around the Marine Pistol and Rifle Range is flat with an elevation of approximately 25 feet above mean sea level (MSL.) The land is slightly rolling and drains locally either north/northwest toward Cheatham Pond or northeast toward the York River. Saturated soil conditions are common in this area due to a shallow water table. Erosion due to run off is minimal, as steep flow channels are lacking and vegetation covers most of the ground surface.

5.1.1.2. Geology

Refer to Section 3.3 for information on regional geology. No site specific geological data is available for the range.

5.1.1.3. Soil and Vegetation Types

The range is primarily wooded along the west, north and east borders, with pines as the dominant tree type. Approximately 15 years ago, the range itself was replanted with cedar trees, which dominate the once open area of the range. Grasses and vines have taken over the remaining open areas of the range. To the west and northwest along the Cheatham Pond, wetland vegetation dominates. Many soils at CAX are poorly drained, and ponding is likely, especially as the range is slightly sloping toward Cheatham Pond. The heavy vegetation of the site is illustrated in Figure 5.1-1

Figure 5.1-1: Heavy vegetation on and around the Marine Pistol and Rifle Range

5.1.1.4. Hydrology

The range is located southeast of Cheatham Pond and southwest of the York River. Cheatham Pond is located approximately 300 feet from the range, while the York River is approximately 1,500 feet at its closest point. Cheatham Pond is owned by the NPS. A small, possibly intermittent, stream is located on the western edge of the range and drains to Cheatham Pond. All surface water on CAX eventually drains to the York River.

5.1.1.5. Hydrogeology

There are no pumping, monitoring or injection wells located at or near the range. Though no subsurface investigations have been performed at the range, it is assumed that the hydrogeological units discussed in Section 3.6 are present. However, the thicknesses of these units are unknown.

5.1.1.6. Cultural and Natural Resources

There are no known sites of cultural importance at the range. The range is currently used by the local wildlife as a grazing area. This has been encouraged by the planting of cedar trees about 15 years ago to allow for more cover for foraging game animals. Therefore, the range is used to support game and fowl hunting on the CAX property. The York River is used by the local communities, visitors, and Navy personnel for a number of activities. Nearby Cheatham Pond is used for fishing and boating by Navy personnel and guests only.

5.1.1.7. Endangered and Special Status Species

No rare, threatened, or endangered species have been identified at the range. Although no survey has been conducted to find special status species at the range in particular, it is unlikely that any special status species reside here due to the small size of the site.

5.1.2 Visual Survey Observations and Results

Malcolm Pirnie and Navy personnel conducted a site visit to CAX and a visual survey of the Marine Pistol and Rifle Range on August 18, 19, 21, and 27, 2003. Due to security concerns, Navy personnel took photos. The range was examined through a walk of the perimeter and several transects through the range. The team accessed the southeast section of the range through

a locked gate in the fence surrounding the storage yard. A visual depiction of the site reconnaissance is provided on Map 5.1-1, located at the end of Section 5.1. The area is overgrown with trees and brush that cover the wooden backstop located in the center of the range. The backstop is roughly 200 feet long surrounded by pushed up mounds of soil. On the south side of the backstop, a cleared area with several wooden targets was found. The berm in front of the backstop (Figure 5.1-2) is approximately 200 feet from the fence. The targets are spaced 15 feet apart along the entire length of the backstop. Bullet holes were found in several of the remaining targets. Firing occurred from the south side of the range towards the north. Directly south of the target line is a small grove of planted cedar trees. Several deer trails, a deer stand, and a small All Terrain Vehicle (ATV) bridge are located behind the backstop on the north and west sections of the range. One closed and rusted 55-gallon drum was found close to the fence in the southwest corner. The contents of this drum are unknown, and subsequently the drum has been removed. Additional range/site details are illustrated on Map 5.1-2, also located at the end of Section 5.1.

Figure 5.1-2: Looking southwest along the front of the wooden backstop on the range.

5.1.3 Munitions and Munitions Related Materials Associated with the Site

This section describes the munitions or munitions related materials known or suspected to be at the site. This includes both MEC and non-hazardous munitions related scrap (e.g., fragmentation, base plates, inert mortar fins).

The Marine Pistol and Rifle Range was a training ground for small arms of various calibers. From historical reports, the munitions used at the range were all small caliber ammunitions (i.e., less than .50-caliber). As only small arms were used on site, there is no MEC associated with the Marine Pistol and Rifle Range.

Based on the information obtained during the data collection process, the Marine Pistol and Rifle Range is not suspected to contain chemical warefare materiel (CWM) filled munitions, electrically fuzed muntions, or depleted uranium (DU) associated munitions.

5.1.4 MEC Presence

The entire site has been subdivided and categorized into one of three levels of MEC presence including: Known MEC Areas, Suspect MEC Areas, and Areas where No Evidence exists to indicate that MEC is known or is suspected to be at the site. The MEC presence is discussed below.

As indicated on Map 5.1-3, provided at the end of Section 5-1, no areas are known or suspected to have MEC at the Marine Pistol and Rifle Range. There is no evidence of MEC as only small arms were used at the range.

5.1.4.1. Known MEC Areas

There are no known MEC areas as only small caliber ammunition was used at this range.

5.1.4.2. Suspected MEC Areas

There are no known MEC areas as only small caliber ammunition was used at this range.

5.1.4.3. Areas Not Suspected to Contain MEC

The entire Marine Pistol and Rifle Range is not expected to contain any MEC as only small caliber ammunition was used at the range.

5.1.5 Ordnance Penetration Estimates

The depth to which munitions penetrate below the ground surface depends on many factors, including the type of soil, the angle of impact, the size of the munition, the velocity at impact, and site-specific environmental conditions. Over the years, the DoD has studied and modeled munitions penetration depths and has issued various guidance and technical documents on the subject. For the purposes of the PA, maximum probable penetration depths are estimated following guidance listed in the latest draft (July 2002) of the DoD Directive on Explosives Safety issued by the DoD Explosives Safety Board [*DoD Directive 6055.9* (*DoD Ammunition and Explosives Safety Standards*)]. The Directive refers to *TM 5.855.1* and *NAVFAC P-1080*.

For small arms ranges, the Interstate Technology and Regulatory Council (ITRC) has prepared a document titled, "Characterization and Remediation of Soils at Closed Small Arms Firing Ranges", dated January 2003, to provide information on the general layout of small arms ranges, as well as information on areas that may be impacted with MC and/or MEC as a result of range use and the characteristics of the munitions used. According to the ITRC guidance, the penetration depth of small arms on the range floor is one foot or less. The document states that rounds that impact the range floor are typically a flat trajectory that fell short of or missed the target, or those resulting from ricochet, and these fragments are usually found within the top six inches of soil.

5.1.6 Munitions Constituents

No evidence of MC was found during the site survey. Indications of expended small caliber ammunition existed in the old timber targets near the wooden backstop. It is expected that most visual indications of MC have been covered or obliterated during the years since the range was taken out of use. Potential MC may include elevated metals such as lead, antimony, copper, zinc and arsenic from bullets, fragments and bullet jackets.

5.1.7 Contaminant Migration Routes

Contaminants from the Marine Pistol and Rifle Range may migrate from surface soil through erosion and surface water runoff. Sandy soils, such as those found along the York River in the region of CAX, can allow for significant migration. Groundwater at the site is expected to follow the surface topography and flow to the west and north, toward Cheatham Pond. Cheatham Pond is linked to the York River. There is no surface water at the site, nor is there any well or direct groundwater surface water interaction. Weather-related flooding could dramatically increase MC migration, which can occur in the spring rains or during the fall hurricanes and other large over-ocean generated cyclonic storms. Flooding can quickly transport MC from the local area into the local surface water.

Leaching to groundwater is considered a potential migration route; however, there are no potential receptors of contaminated groundwater. There are no groundwater wells on CAX. The Yorktown aquifer, which is used for drinking water supply by some outside communities, is positioned below two other isolated aquifers, which are not used due to high salinity. Migration of contaminants into the lower Yorktown aquifer is not anticipated. Drinking water to CAX is supplied through surface water reservoirs.

5.1.8 Receptors

Potential human receptors include authorized Navy personnel (military and civilian), visitors, contractors, maintenance workers and trespassers. Plant and animal biota are also potential receptors. Examples of ecological receptors include the white tailed deer and turkey, both of which are common animals to this region.

5.1.8.1. Nearby Populations

The range is most likely to be used as an access path to Cheatham Pond for hunting, fishing or hiking. The southern portion of the range is accessed regularly for storage and retrieval of vehicles and boats. Data on how often these vehicles are accessed or rotated out of storage was unavailable.

CAX's population is a mix of commuters and boarders. There are multiple housing complexes for both married couples and unmarried individuals. Navy personnel that come to CAX to utilize the recreational facilities make up a large portion of the CAX community. This portion is likely

to have a great deal of contact with the undeveloped areas of CAX, but only for the time of their stay. The commuting population of CAX is mainly from the Williamsburg-Yorktown area.

Williamsburg, with a population of 11,998 as of 2000, is the nearest city. CAX sits on the border between James City County and York County with populations of 51,800 and 58,800, respectively.

5.1.8.2. Buildings Near/Within Site

The Marine Pistol and Rifle Range is indicated as Building 166 on archival maps; however, there are no structures other than the wooden backstop remaining at the site. Currently, Building 14 to the southeast is the nearest structure to the range. Building 14 is used for industrial/storage purposes. The rest of the block along B Street is also used for various storage purposes. There are locations to store vehicles and boats around the B Street storage buildings.

5.1.8.3. Utilities On/Near Site

There are no known utilities on the range. Building 14 and other nearby storage buildings have all major utilities including water, sewage, and electricity.

5.1.9 Land Use

Before the establishment of the Marine Pistol and Rifle Range, the land was undeveloped. Currently, the majority of the range is unused, although trees were planted to encourage foraging by game animals. There is no site maintenance or upkeep of the northern portion of the range. The southern portion has been partially graveled and is accessed for vehicle storage. Maintenance of this portion, such as mowing, laying gravel or duration of vehicle storage is unknown.

There is no expected change in the use of the range area. The unmaintained portion of the site is expected to remain fallow and be used for foraging by the local animal populations.

5.1.10 Access Controls / Restrictions

Fencing surrounds CAX, and all gates are manned. At the range, the fence near the southern end of the firing zone has one access point. There is no indication as to when the fence was built.

5.1.11 Conceptual Site Model

This Conceptual Site Model (CSM) was developed following guidance documents issued by the USEPA for hazardous waste sites and the U.S. Army Corps of Engineers (USACE) for ordnance and explosives (OE) sites. Guidance documents included the USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA/540/G-89/004) and the USACE CSM Guidance Development of Integrated Conceptual Site Models for Environmental Ordnance and Explosives (OE) Sites, which was final as of February 2003.

The CSM describes the site and its environmental setting. The CSM presents information regarding: 1) MEC or MC known or suspected to be at the site; 2) current and future reasonably anticipated or proposed uses of the real property; and 3) actual, potentially complete, or incomplete exposure pathways that link them.

The CSM is presented in a series of information profiles that present information about the site. The information profiles are included in Table 5.1-1 below.

Table 5.1-1: Conceptual Site Model Information Profiles – Marine Pistol and Rifle Range

Profile Type	Information Needs	Preliminary Information
Range/Site Profile:	Installation Name	WPNSTA Yorktown – Cheatham Annex
	Installation Location	York County, Virginia
	Range/Site Name	Marine Pistol and Rifle Range
	Range/Site Location	The range is located about 1000 feet northwest of Building 14 along B Street and accessed by a dirt road in the north end of CAX. The range is indicated as Building 166 on archive maps. The range is about 300 feet from Cheatham Pond.
	Range/Site History	The dates for construction and use of the range are not available, although by the early 1970s the range was no longer in use. Aerial photos show that the range has been in existence from at least 1939. The southern portion of the range is currently in use for storage of vehicles and boats.

Table 5.1-1: Conceptual Site Model Information Profiles – Marine Pistol and Rifle Range		
Profile Type	**Information Needs**	**Preliminary Information**
	Range/Site Area and Layout	The range is approximately seven acres in area. Firing took place from the southern end of the range toward a wooden backstop and targets at the northern end of the range. The range is about 750 feet long. There is a fence at the south end of the range. A swale is located less than 100 feet to the west of the range that flows towards Cheatham Pond.
	Range/Site Structures	There are no structures on the range; vehicles and boats are stored on site at the south end. Some timbers used as targets are present toward the northern end of the range.
	Range/Site Boundaries	N: Tree line, pines. S: Open field, graveled and paved lot and storage for vehicles and boats, Building 14 lot. W: Tree line consisting of mostly pines with some mixed hardwoods, Cheatham Pond within 300 feet of west boundary. E: Tree line, mixed pines.
	Range/Site Security	Fencing bounds the CAX property. All gates are manned. There is no security fencing bordering the range.
Munitions/ Release Profile	Munitions Types	Small caliber ammunition of varied calibers. Primarily rifle and pistol ammunition (less then .50 caliber).
	Maximum Probability Penetration Depth	Surface (0-12 inches). Only small arms were used on site.
	MEC Density	Small arms ammunition is not explosive; therefore, there is no MEC density.
	Munitions Debris	No munitions debris were identified during the site visit.
	Associated Munitions Constituents	MC may include lead, antimony, copper, zinc, and arsenic from bullets and fragments and bullet jackets.
	Migration Routes/Mechanisms	Possible routes of exposure from the range include surface water runoff, leaching from soil and groundwater release into surface water or uptake wells.

Table 5.1-1: Conceptual Site Model Information Profiles – Marine Pistol and Rifle Range		
Profile Type	**Information Needs**	**Preliminary Information**
	Climate	The CAX is located on the Virginia Peninsula. Thus, the weather is highly moderated by the Atlantic Ocean. January is the coldest month, with an average temperature of 38.8ºF; July is the warmest with a monthly average of 77.4ºF. The average annual precipitation is 44.15 inches. The WPNSTA Yorktown-CAX area is subject to hurricanes and other easterly storms that can cause high winds, high precipitation and flooding.
Physical Profile	Topography	The topography of the Virginia Peninsula around WPNSTA Yorktown-CAX is gently rolling and dissected by ravines and streams flowing predominately northeast toward the York River. The local maximum elevation is 90 feet above MSL with some ravines 40 to 60 feet deep with slopes exceeding a 10:1 gradient. The range is 25-30 feet above MSL. The topography of the former range is relatively flat.
	Geology	CAX is located within the Atlantic Coastal Plain that is underlain with unconsolidated sediments of Cretaceous, Tertiary and Quaternary ages. These have a combined depth of about 1900 feet in the vicinity of CAX. These are overlain with sandy or silty clays.
	Soil	The range has clayey sand soil near the surface. No soil cores have been taken to date.
	Hydrogeology	The Columbia and Cornwallis Cave aquifer systems make up the shallow aquifer system in the CAX region. The Cornwallis Cave confining unit, a clay-silt layer, confines the Cornwallis Cave aquifer. The shallow aquifer system ranges in thickness between 20 and 150 feet, with an easterly trend of flow. These units are sand and gravel/shell. The Columbia aquifer is not saturated in all locations. The Columbia and Cornwallis Cave aquifers are too salty to be used as water resources. Most of the drinking water is received from surface water reservoirs or the Yorktown Aquifer, which is approximately 50 feet below ground surface.
	Hydrology	The nearest pond is Cheatham Pond, 300 feet from the west side of the range. The York River is 1,500 feet to the northeast. Cheatham Pond belongs to the NPS.

Table 5.1-1: Conceptual Site Model Information Profiles – Marine Pistol and Rifle Range		
Profile Type	**Information Needs**	**Preliminary Information**
	Vegetation	The site is a mix of young trees, grasses and shrub vegetation surrounded by mature forest on three sides. A section of the range has been recently (approximately 15 years ago) replanted with cedars.
	Current Land Use	The former range area is currently not in use, except for the fenced southern portion that is used for storage of vehicles and boats and a deer stand.
Land Use and Exposure Profile	Current Human Receptors	Authorized Navy personnel, Navy-escorted visitors, contractors, and trespassers.
	Current Activities (frequency, nature of activity)	The range is currently not slated for development. As part of the recreational area of CAX, it will remain undeveloped for the foreseeable future.
	Potential Future Land Use	The Navy's goal is that all environmental sites and their activities including the Marine Pistol and Rifle Range, be restored to residential standards with no land use controls when technically and economically feasible.
	Potential Future Human Receptors	Authorized Navy personnel, Navy-escorted visitors, contractors and trespassers.
	Potential Future Land Use-Related Activities	Minimal activity, since there is no known future change in land use. Remediation goals are residential standards.
	Zoning/Land Use Restrictions	The range is part of the recreational area of CAX. Future development for other use is possible.
	Demographics/Zoning	CAX is zoned for Military Use. Demographic data include the following: • City of Williamsburg: o Population (2000): 11,998 • James City County: o Population (2002): 51,800 • York County: o Population (2002): 58,800

Table 5.1-1: Conceptual Site Model Information Profiles – Marine Pistol and Rifle Range		
Profile Type	**Information Needs**	**Preliminary Information**
	Beneficial Resources	The surface water reservoirs and Yorktown aquifer systems are used by the local municipalities and residents along the Virginia Peninsula. The York River is used for a number of industrial and recreational purposes. The Navy uses the Cheatham Pond and environs as an outdoor recreational site. Undeveloped land is used for hiking, hunting and fishing.
	Habitat Type	Flat and forested (pine and hardwood), borders river and tidal areas.
Ecological Profile	Ecological Receptors	
	Federal Endangered Species:	None
	Federal Threatened Species:	Small whorled pogonia, sensitive joint vetch, Bald Eagle
	State Endangered Species:	None
	State Threatened Species:	Peregrine falcon
	Other Ecological Receptors:	Common fauna/ flora such as large mammals (e.g., deer), small mammals, reptiles/amphibians, and grassland birds. Game birds include quail, turkey and pheasant.
	Relationship of MEC/MC Sources to Habitat and Potential Receptors	Most likely vectors to ecological receptors are MC leaching into the subsurface or surface runoff into local water bodies. There is potential for leaching into the groundwater aquifers. Bioaccumulation in biota, including game species, is possible.

A key element of the CSM is the exposure pathway analysis. For MEC, a complete or potentially complete exposure pathway must include the following components: 1) a source (e.g., locations where MEC are expected to be found); 2) access (e.g., controlled or uncontrolled access, items on the surface or within the subsurface); 3) an activity (e.g., non-intrusive grounds maintenance or intrusive construction); and 4) receptors (e.g., Navy personnel, construction workers, recreational users or authorized visitors). It is important to recognize that environmental mechanisms (e.g., erosion) and/or human intervention may result in the repositioning of MEC.

For MC, a complete or potentially complete exposure pathway must include the following components: 1) a source (e.g., locations where MC are expected to be found); 2) an exposure

medium (e.g., surface soil); 3) an exposure route (e.g., dermal contact); and 4) receptors (e.g., Navy personnel, construction workers, recreational users or authorized visitors). If the point of exposure is not at the same location as the source, the pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air).

The potential interactions between the source and receptors are assessed differently between MEC and MC. For MC, interaction between the source and receptors involves a release mechanism for the MC, an exposure medium that contains the MC, and an exposure route that places the receptor into contact with the contaminated medium. For MEC, interaction between the potential receptors and an MEC source has two components. The receptor must have access to the source and must engage in some activity that results in contact with individual MEC items within the source area.

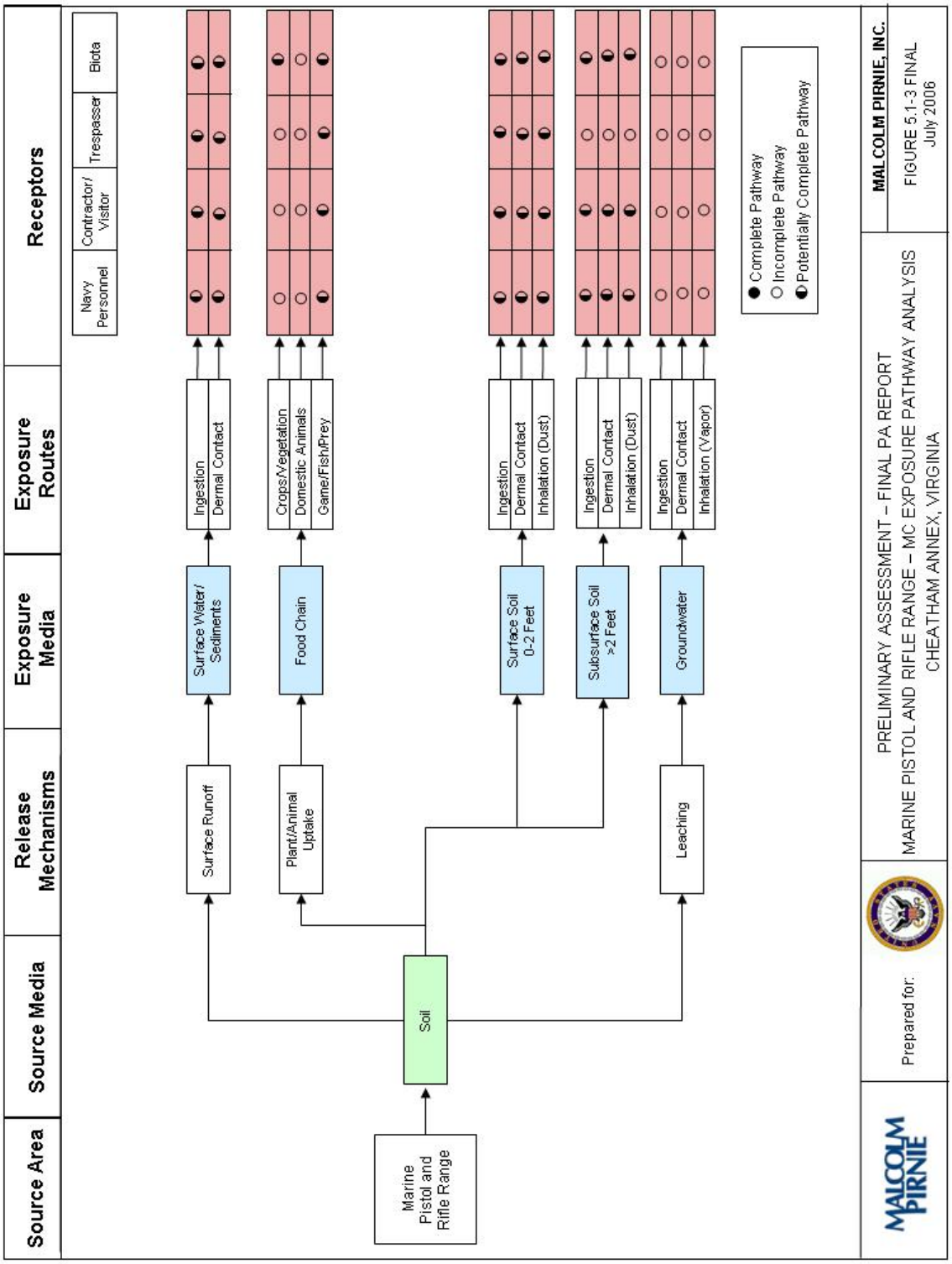
As indicated earlier, there is no potential for MEC to be located on the range. As such, an MEC Exposure Pathways Analysis figure was not created. As seen in the MC Exposure Pathway Analysis Figure 5.1-3, the potential for MC exists on the site. Given this potential, the figure identifies the exposure pathways through which receptors could come in contact with or be impacted by the MC.

Soil and surface water/sediments impacted by MC represent possible source media. A potentially complete pathway exists for surface and subsurface soil through ingestion, inhalation and dermal contact for human receptors (Naval personnel, contractors, visitors, and trespassers) and ecological (biota) receptors. Navy personnel, visitors, and trespassers could come into contact with contaminated soil through outdoor recreational activities. Contractors and Navy personnel may be exposed during site investigations or from potential future land use changes that may require construction. Trespassers are not anticipated to disturb subsurface soil. Biota on the site may disturb soil through nesting or feeding. Such activities by humans and biota can create dust, which that can come in direct contact or inhaled. Ingestion of contaminated subsurface soil is a potentially complete pathway for those invertebrates that are known to burrow to depths greater than 2 feet.

MC that enters into surface waters/sediments through runoff or groundwater discharge could become available for dermal contact and/or ingestion by human and ecological receptors on or near the range. Biota could directly contact or ingest contaminated surface water. Potential

accumulation in game animals can pose a threat to human receptors. Although leaching to groundwater is a potential release mechanism, groundwater is not considered a potential exposure medium as drinking water on CAX is supplied from surface water reservoirs. The Yorktown aquifer, which is used for drinking water supply by some outside communities, is positioned below two other isolated aquifers, which are not used due to high salinity. Migration of contaminants into the lower Yorktown aquifer is not anticipated. CAX is used for sport hunting and fishing by Navy personnel; therefore, exposure via bioaccumulation in the food chain is possible for human receptors. The food chain is also a potential pathway for biota on or near the range. Currently, there are no known complete pathways present for MC exposure.

Figure 5.1-3: MC Exposure Pathway Analysis



5.1.12 Summary

The Marine Pistol and Rifle Range is located in the northeast portion of CAX near Cheatham Pond. The range was used for a period of approximately 30 years between the dates of 1939 and 1970. The range was used exclusively for small caliber firearms. Old targets and a wooden backstop are still present on the range. As only small arms were used at this site, there is no potential for MEC at the range. The extent of MC at the site is unknown but potential MC includes lead, copper, arsenic, and other black powder byproducts. There are currently no known complete pathways for MC exposure to humans or biota. Several potentially complete pathways exist for human and ecological receptors.

Preliminary Assessment
WPNSTA Yorktown, Cheatham Annex, Virginia

MALCOLM PIRNIE

Map 5.1-1
Visual Survey
Marine Pistol & Rifle Range

Legend

- Installation Boundary
- Site Boundary
- Site Features
- Site Reconnaissance

0 25 50 75 100
Meters

Coordinate System: UTM Zone 18
Datum: NAD 83
Units: meters

Contract: N62472-02-D-1300
Edition: Final Preliminary Assessment
Date: July 2006

Source: USGS. 1999. DOQQ CIR Series Map.

Preliminary Assessment
WPNSTA Yorktown, Cheatham Annex, Virginia

MALCOLM PIRNIE

Map 5.1-2
Range/Site Details
Marine Pistol & Rifle Range

Legend

- Installation Boundary
- Site Boundary
- Site Features
- Contours
- Streams
- Wetlands
- Waterbodies

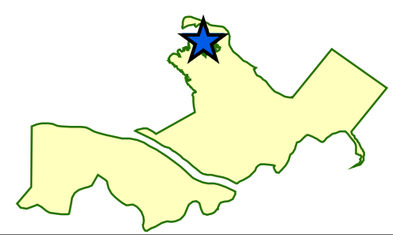
0 25 50 75 100
Meters

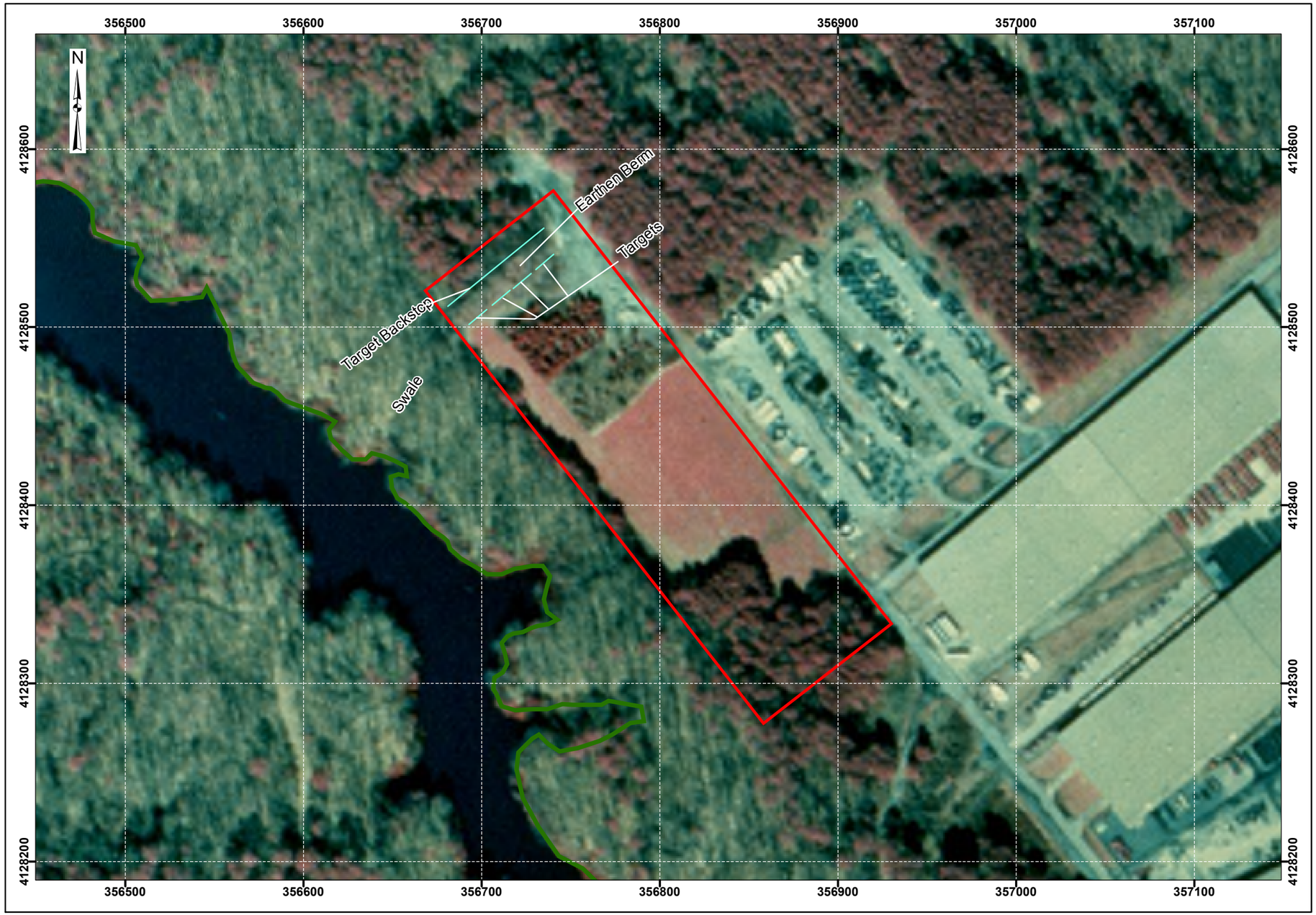
Coordinate System: UTM Zone 18
Datum: NAD 83
Units: meters

Contract: N62472-02-D-1300
Edition: Final Preliminary Assessment
Date: July 2006

Source: USGS. 1999. DOQQ CIR Imagery.

Marine Pistol & Rifle Range





Preliminary Assessment
WPNSTA Yorktown, Cheatham Annex, Virginia

MALCOLM PIRNIE

Map 5.1-3
Munitions Characterization
Marine Pistol & Rifle Range

Legend

- Installation Boundary
- Site Boundary
- Site Features

MEC Characterization

- Munition Scrap
- MEC Sightings

MEC Presence*

- Known
- Suspect

* There is no evidence of MEC presence as determined through historical documentation, interviews, and visual survey.

0 25 50 75 100
Meters

Coordinate System: UTM Zone 18
Datum: NAD 83
Units: meters

Contract: N62472-02-D-1300
Edition: Final Preliminary Assessment
Date: July 2006

Source: USGS. 1999. DOQQ CIR Imagery.

Appendix A: References

REFERENCES

Reports

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General Soil Associations and Map – Cheatham Annex, Date unknown.

Final Round Two Remedial Investigation Report Site 12 Naval Weapons Station Yorktown – Yorktown, VA, June 1996, Prepared by: Baker Environmental, Inc., Prepared for: Department of the Navy Atlantic Division Naval Facilities Engineering Command.

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Websites

http://terraserver.microsoft.com, accessed November 2003.

http://www.nor.fisc.navy.mil/home/CAX.html, accessed November 2003.

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Maps

Proposed Skeet Range, 6 April 1972 Drawing, Scale 3" = 100'

Rifle Range General Development Map- Cheatham Annex Prepared by Defense Mapping Agency January 1975 1"=300'

Cheatham Annex Map, Site Map, date unknown, source: Map Vault, Cheatham Annex, Virginia.

Aerial Photographs

Rifle Range, Cheatham Annex, Aerial Photograph, DMA Jan 1975,1"=600'

Appendix B: Project Source Data – General

Draft

Background Investigation
Naval Weapons Station Yorktown
Yorktown, Virginia
Cheatham Annex Site
Williamsburg, Virginia

Prepared For

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Contract No. N62470-95-D-6007
CTO-0196

July 2002

Prepared by

CH2M HILL
Federal Group, Ltd.

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

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LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
Baker	Baker Environmental, Inc.
bgs	Below Ground Surface
CAX	Cheatham Annex Site
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action – Navy
CLP	Contract Laboratory Program
CTO	Contract Task Order
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DERP	Defense Environmental Restoration Program
DOI	Department of Interior
DON	Department of the Navy
EPIC	Aerial Photographic Analysis
eV	Electron Volt
°F	Degree Fahrenheit
FISC	Fleet and Industrial Supply Center
FS	Feasibility Study
FSP	Final Site Screening Process
FSAP	Field Sampling and Analysis Plan
FY	Fiscal Year
GIS	Geographic Information System
GPS	Global Positioning System
HASP	Health and Safety Plan
HRS	Hazard Ranking System
IAS	Initial Assessment Study
IDW	Investigation Derived Waste
IR	Installation Restoration
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSL	Mean Sea Level
NEESA	Naval Energy and Environmental Support Activity
NFESC	Naval Facilities Engineering Service Center
NFRAP	No Further Response Action Planned
NPL	National Priorities List
NPS	National Park Service
NTU	Nephelometric Turbidity Unit
PAH	Polycyclic Aromatic Hydrocarbon

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
PPE	Personal Protective Equipment
ppt	parts per thousand
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RI	Remedial Investigation
RPD	Relative Percent Difference
RV	Recreational Vehicle
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SMP	Site Management Plan
SOP	Standard Operating Procedures
SVOC	Semivolatile Organic Compounds
TAL	Target Analyte List
TCL	Target Compound List
TCRA	Time Critical Removal Action
TNT	Trinitrotoluene
TOC	Total Organic Carbon
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VADES	Virginia Department of Emergency Services
VDCR-DNH	Virginia Department of Conservation and Recreation - Division of Natural Heritage
VDEQ	Virginia Department of Environmental Quality
VOC	Volatile Organic Compound
WPNSTA	Naval Weapons Station Yorktown

EXECUTIVE SUMMARY

This document presents the results of the Background Investigation for soil and groundwater at the Naval Weapons Station Yorktown (WPNSTA) Cheatham Annex Site (CAX), Williamsburg, Virginia and the northern portions of WPNSTA. This investigation was conducted by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division Naval Facilities Engineering Command (LANTDIV), under Comprehensive Long-term Environmental Action Navy (CLEAN II) Contract N62470-95-D-6007, Contract Task Order (CTO) 196.

The Background Investigation was conducted for the purposes of establishing data representative of naturally occurring or anthropogenic chemical concentrations at CAX. These data, when compared to site-specific data, can aide in the determination of whether or not contamination at a given site can be contributed to site activities. The data may also be appropriate for the establishment of clean-up levels should remedial action at a given site be warranted.

Surface soil (0 to 6 inches below ground surface [bgs]), subsurface soil (6 to 12 inches bgs), and groundwater data were collected in each of the four soil associations at CAX and northern portions of WPNSTA. The data for each media were divided into five data sets, one for each soil association group and a combined data set inclusive of all soil associations. The statistical distribution of each data set (normal or lognormal) was determined and parameters including means, standard deviations, and 95 percent upper confidence limits were calculated.

In addition to presenting the statistical evaluation of background data, general lithological and hydrogeological information regarding CAX and northern WPNSTA are presented based upon surface soil and monitoring well installation boring logs and on two 100-foot exploratory soil borings advanced during the Background Investigation.

1.0 INTRODUCTION

This document presents the results of the Background Investigation for soil and groundwater at the Naval Weapons Station Yorktown (WPNSTA) Cheatham Annex Site (CAX) and the northern portions of WPNSTA. This investigation was conducted by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division Naval Facilities Engineering Command (LANTDIV), under Comprehensive Long-term Environmental Action Navy (CLEAN II) Contract N62470-95-D-6007, Contract Task Order (CTO) 196.

The field activities conducted as part of this investigation were performed in accordance with the Work Plans prepared by Baker for this investigation (Baker, 2001d). The samples collected as part of this study are intended to provide the basis for a compilation of data representative of the natural concentration of metals and anthropogenic compounds in soils and groundwater within the boundaries of CAX and the northern portions of WPNSTA. The Work Plan detailed the number and types of samples to be collected, the analytical methods to be used for those samples, specific sample locations, and the rationale for selecting locations and analyses. Detailed descriptions of the field procedures, sample analysis, and any deviations from planned procedures are outlined in Section 5.0 of this report.

1.1 Background Investigation Objectives

The objectives of the Background Investigation are summarized as follows:

- Determine background concentrations of inorganic, organic, and cyanide constituents in surface soil, subsurface soil, and groundwater at CAX and the northern portion of WPNSTA.
- Establish statistical distributions of the data and identify spatial trends.
- Determine subsurface lithology conditions present within the four soil association groups.
- Determine deep lithology (100 feet below groundwater surface [bgs]) within soil association Group 2 and Group 3.
- Determine hydrogeological conditions present within the four soil association groups.

- Present results, findings, and conclusions of the Background Investigation in a manner that enables them to be used as comparison criteria within current or future CAX investigations.

The background levels of inorganic and anthropogenic chemicals in soils and groundwater presented herein will establish a frame of reference or baseline of data to which these chemicals at specific sites may be compared. The need to establish background levels of inorganics in soil and groundwater is driven by the ubiquitous presence of inorganics in nature. Because these analytes occur naturally, it is necessary (during subsequent investigations) to determine if the presence of inorganics at a site are due to site activities (i.e., disposal, spills, etc.) or to natural occurrences. Anthropogenic chemicals are defined by the United States Environmental Protection Agency (USEPA) as chemicals that are present in the environment because of manmade, not site-related sources (e.g., industry, automobiles, etc.). Chemicals of anthropogenic origin may include compounds such as lead, arsenic, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and polycyclic aromatic hydrocarbons (PAHs). Comparing concentrations of inorganics and anthropogenic chemicals on site to background concentrations assists in the determination of what chemicals can be attributed to the site.

1.2 Report Organization

This document is comprised of text, tables and figures, and the supporting appendices. In addition to Section 1.0, the report is organized into the following sections:

- Section 2.0 – Cheatham Annex Site History
- Section 3.0 - Environmental Setting
- Section 4.0 - Background Investigation Design
- Section 5.0 - Background Field Investigation
- Section 6.0 – Physical Results of Field Investigation
- Section 7.0 – Analytical Results
- Section 8.0 – Statistical Evaluation of Background Data
- Section 9.0 - Conclusions and Recommendations
- Section 10.0 - References
- Appendix A – Chain of Custody Records

- Appendix B – Test Boring and Well Construction Records
- Appendix C – Surface Soil Data
- Appendix D – Subsurface Soil Data
- Appendix E – Groundwater Data
- Appendix F – Quality Assurance/Quality Control Data

2.0 CHEATHAM ANNEX SITE HISTORY

This section presents the history and mission of CAX. Information presented in this section was obtained from reports of previous investigations conducted at the sites and Areas of Concern (AOCs). WPNSTA history and physical characteristics have been omitted from this section, but are provided within the WPNSTA Master Plans (Baker, 1994b).

2.1 Cheatham Annex

CAX is located in Williamsburg, Virginia, on the York-James Peninsula, which is an embayed portion of the Atlantic Coastal Plain physiographic province (Teifke, 1973). This elongated peninsula trends northwest southeast and occupies an area of approximately 1,752 square miles. The peninsula is bordered to the southwest by the James River, to the northeast by the York River, and to the southeast by the confluence of the James River and the Chesapeake Bay. At CAX, the peninsula is approximately six miles wide.

At inception, CAX occupied approximately 3,349 acres. Several portions of the original base have since been declared surplus and transferred to other government jurisdictions, including the National Park Service, the Commonwealth of Virginia, and York County. CAX is currently comprised of 1,578 acres. The Activity is divided into two separate parcels, with the larger parcel situated along the banks of the York River. Almost all of the activities at CAX (administration, training, maintenance, support, and housing) take place in this portion of the Activity. The smaller parcel is located south of the Colonial National Historic Parkway (Colonial Parkway). This area contains the Activity's water supply (Jones Pond) and is used mainly as a watershed protection area. CAX and the northern portion of WPNSTA are shown on Figure 2-1.

2.2 History and Mission of Cheatham Annex

CAX was established in June 1943 as a satellite unit of the Naval Supply Depot to provide bulk storage facilities. Prior to 1943, CAX had been the location of a large powder and shell loading facility operated by Dupont during World War I, which subsequently closed in 1918. Between 1918 and 1943, the property was used for farming or left idle until CAX was commissioned in 1943. Since 1943, CAX has been used for receiving, storing, packaging, and shipping materials to federal facilities on the East Coast and to major distribution centers in Europe.

Previously operated as an annex to Fleet and Industrial Supply Center (FISC), Norfolk, which is the world's largest navy supply center, CAX provided logistic and supply support to naval shore installations. CAX is the Navy Sea System Command's East Coast consolidated stock point for major shipboard mechanical, electronic, and some navigational equipment. In addition to receiving, storing, issuing, packing and shipping navy stock material, particularly large, bulky (often unique) shipboard equipment (e.g., submarine periscopes, ship propellers, bull gears, antennae, and sonar domes), CAX provides warehouse and distribution services for 39 Storage Authorization Programs and tenant organizations.

In July 1987, CAX was designated the Hampton Roads Navy Recreational Complex. Today the mission of CAX includes supplying Atlantic Fleet ships and providing recreational opportunities to military and civilian personnel; 55 percent of CAX is undeveloped and rich in natural resources. Outdoor recreational facilities and activities available include: 13 cabins, 19 recreational vehicle (RV) sites, camp sites, an 18-hole golf course, swimming pool, ball fields, freshwater and saltwater fishing, boating, wildlife watching and hunting (Department of the Navy [DON], 1998). CAX currently operates under WPNSTA Yorktown. The transition of CAX control from FISC to WPNSTA occurred in October 1998.

2.3 Land Use and Demographics

Figure 2-2 presents a 1999 land use map of York County. As indicated on the figure, CAX and WPNSTA Yorktown are categorized as Military Use. Uses of surrounding areas include conservation/recreation, commercial, residential, industrial, public, and agricultural.

2.4 Regulatory History

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) established programs for the cleanup of hazardous waste disposal and spill sites. The Installation Restoration (IR) Program is a component of the Defense Environmental Restoration Program (DERP), which is one of the programs established under CERCLA/SARA by DON. CAX was placed on the CERCLA National Priorities List (NPL) effective December 1, 2000, primarily due to the facility's proximity to wetlands and the potential impact on the surrounding environment. Prior to being listed on the NPL, the CAX IR Program voluntarily followed CERCLA guidance consistent with other DON installations. The USEPA and Virginia Department of Environmental

Quality (VDEQ) have been actively involved in the IR Program at CAX since 1997. Currently, these agencies are invited to provide comments and feedback on all documents that are prepared under the IR Program. Prior to 1997, these agencies had minimal involvement with the IR Program at CAX.

2.5 Previous Investigations

The following environmental investigations/studies have been conducted to date at CAX:

- Soil Survey Report, Weapons Station Yorktown, Research Division, Agronomy Department, Virginia Polytechnic Institute and State University, 1982.
- Initial Assessment Study (IAS) of Naval Supply Center, Cheatham Annex and Yorktown Fuels Division. February 1984. Naval Energy and Environmental Support Activity (NEESA).
- Soil Survey Report, Cheatham Annex, Research Division, Agronomy Department, Virginia Polytechnic Institute and State University, 1985.
- Soil Survey of James City and York Counties and the City of Williamsburg, Virginia, United States Department of Agriculture, Soil Conservation Service, 1985.
- Confirmation Study, Step 1A (Verification), Round One, June 1986. Dames and Moore.
- Confirmation Study, Step 1A (Verification), Round Two. June 1988. Dames and Moore.
- Draft Remedial Investigation (RI) Interim Report. March 1989. Dames and Moore.
- Final Remedial Investigation (RI) Interim Report. February 1991. Dames and Moore.
- Final Site Investigation for Sites 1, 10, and 11. November 1994. Roy F. Weston.
- Final Site Screening Process Report, Sites 1, 10, and 11. September 1997. Baker.

- Aerial Photographic Analysis (EPIC). United States Naval Supply Center - Cheatham Annex, Williamsburg, Virginia. United States Environmental Protection Agency Region III. May 1998.

- Shoreline Assessment Letter Report (Site 1). August 1998. Baker

- Recommendations for Erosion Mitigation Measures Letter Report (Site 1). May 1999. Baker.

- Final Field Investigation Report Site 1 and AOC 2. September 1999. Baker.

- Final Action Memorandum - Time Critical Removal Action (TCRA) – Site 1. August 1999. Baker.

- Final Site Inspection Narrative Report, Penniman Shell Loading Plant. August 1999. Weston

- Final Data Acquisition/Summary Report, Penniman Shell Loading Plant. October 1999. Weston

- Draft Final No Further Remedial Action Planned (NFRAP) Decision Document for Site 9 - Transformer Storage Area. December 1999. Baker

- Hazard Ranking System (HRS) Documentation Record, Naval Weapons Station Yorktown (Cheatham Annex). Last revision January 12, 2000. USEPA

- Draft Removal Closeout Report, Site 11 – Bone Yard. April 2000. Baker

- Final Construction Closeout Report – Site 1 Time Critical Removal Action. June 2000. Baker

- Draft Final Remedial Investigation Report, Site 1. August 2000. Baker

- Geographic Information System (GIS) Needs Assessment and Implementation Plan. September 2000. Baker

- Final Compact Disc of Administrative Record. November 2000. Baker

- Draft Final Focused Feasibility Study (FS), Site 1. November 2000. Baker

- Final Field Investigation Report, Site 7 and AOC 2. March 2001. Baker

- Final Site Management Plan – Fiscal Year (FY) 2001. March 2001. Baker

- Final Site Inspection Report, Site 4 and Area of Concern 1. May 2001. Baker

- Final Pond Study Report. August 2001. Baker

2.5.1 Sites and Areas of Concern

The investigations and studies that have been conducted at CAX have lead to the identification of several sites and AOCs throughout CAX. These sites and AOCs are listed below and indicated on Figure 2-3. Not all of the sites or AOCs warrant investigation or actions.

- 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 Building CAD 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
- AOC 1 – Scrap Metal Dump

- AOC 2 – Dextrose Dump
- AOC 3 – CAD 11/12 Pond Bank
- AOC 4 – Installation Restoration (IR) Site 4 – Medical Supplies Disposal Area
- AOC 5 – Debris Area (An Unidentified Portion of Site 1)

The areas that incorporate these sites and AOCs were not considered as potential sampling areas for the Background Investigation.

The following subsections present a brief overview of the past and current operations/activities that have taken place at CAX. More detailed information with regards to the previous investigations and studies and site histories can be found within the CAX Site Management Plan (SMP) (Baker, 2002).

2.5.2 Penniman Shell Loading Plant

Existing information indicates that the Penniman Shell Loading Plant began manufacturing trinitrotoluene (TNT) in 1916 and began loading artillery shells for the war effort 1918. From 1918 through 1925, following the end of World War I, this facility was demolished and reverted to farmland (Weston 1999a). The former Penniman Plant encompassed a large portion of the existing CAX facility and property that is currently owned by the Department of the Interior (DOI). The only exception (based on current information) is that the former Penniman Plant did not encompass the area surrounding Jones Pond.

2.5.3 Fuel Farm Area

The Fuel Farm Area is located south of Colonial National Historical Parkway and directly east of Jones Pond. The United States Navy operated this facility from 1942 until the mid-1980s. The Fuel Farm was then purchased by the Virginia Department of Emergency Services (VADES) in the mid 1980s and is currently operated by VADES (Weston, 1999a). Because this area is not located on CAX or WPNSTA property it is not being considered as a potential sampling area for the Background Investigation.

2.5.4 Department of the Interior Property

DOI property is located to the north and west of the main portion of CAX. The eastern edge of Cheatham Pond serves as the property boundary between DOI and CAX. Additionally, DOI has property that lies south of King Creek and north of WPNSTA Yorktown. Because these areas are not located on CAX/WPNSTA property, they are not being considered as potential sampling areas for the Background Investigation.

2.5.5 Limitations of the Existing Database

Currently, information on soil and groundwater background at CAX does not exist. Additionally, hydrogeologic and lithology information from a base-wide perspective does not exist.

3.0 ENVIRONMENTAL SETTING

This section presents a discussion of the physical characteristics of CAX. The discussion details the topography and surface features, hydrology, geology, hydrogeology, land usage, climatology, water supply, ecology, wetlands, and threatened and endangered species. This information was obtained from the available literature about CAX.

3.1 Climatology

The climate of the Virginia Peninsula is influenced by the moderating effects of the Atlantic Ocean. This results in mild winters and long, warm summers. High humidity frequently occurs along the coast and less frequently inland. Ground fog is frequent in the late summer, especially during the early morning hours. Freezing temperatures occur intermittently from October through March. Average monthly temperatures in the area range from approximately 38.8 degrees Fahrenheit (°F) in January to 77.4°F in July.

Because of its location near the coastline, York County is subject to easterly storms throughout late summer and early fall, causing high tides and flooding. Intense hurricanes occasionally sweep the coast. Winter is characterized by storms that move along the eastern seaboard. The storms from the north are associated with high winds and precipitation occasionally in the form of snow, ice pellets, or rain; however, the snow is seldom prolonged or heavy. The average annual precipitation is 44 inches, with the summer months being the wettest and the winter months being the driest.

Spring is a period of contrasting weather, particularly during March. Spring and autumn are periods of frost. Summer is warm and humid with occasional showers and afternoon thunderstorms. Autumn is a season of comfortable temperatures (average temperature 60°F to 81°F) and generally pleasant weather.

Winds are highly variable in the area of CAX. Prevailing winds are usually from the south-southwest, but north-northeasterly winds are common in some months. Onshore winds predominate during the spring and summer.

3.2 Topography and Surface Features

The topography at CAX is characterized by gently rolling terrain dissected by ravines and stream valleys trending predominantly northeastward toward the York River. Ground elevations at CAX vary from sea level along the eastern boundary, which borders the York River, to a maximum elevation of approximately 50 feet above mean sea level (MSL) on a few scattered hills in the western portion of the Activity. Valleys consisting of 40- to 60-foot ravines with steep slopes (slopes exceeding 1:1) occur along the major creeks draining CAX. Figure 2-1 presents topographic features of the region.

3.3 Surface Soil Associations

The soil survey report for CAX was prepared by the Soil Conservation Service (SCS) in 1985. Information provided in this section was obtained from this report.

Figure 3-1 shows the soil associations of CAX and the northern portion of WPNSTA. A soil association is a landscape that exhibits a distinctive pattern based on soils, drainage and relief. These associations consist of one or more major soil types and at least one minor soil type. The association is then named for the major soil(s). A soil type from one association can exist in other associations, but commonly in a different pattern or percentage.

The two terms, loam and muck, are specifically used to describe soils. A loam is a soil that contains less than 52 percent sand, 28 to 50 percent silt, and 7 to 27 percent clay. A muck is a dark, finely layered, well decomposed, and contains organic soil material.

Four soil association groups occur at CAX. These groups are defined as follows:

1. Soil Association Group 1 – Bohicket, Johnston, and Axis Soil Association

   The soils of this association formed on marshes and floodplains in water-deposited material that range from muck to sandy clay loams. They are mainly along King, Queen and Cub Creeks and along the York River. The soils are commonly nearly level, are waterlogged and flooded by salt tides daily or during high water. They receive seepage and runoff from higher lying areas. In the upper parts of the tributaries the marshes are brackish or fresh water.

Bohicket and Axis soils are along the tidal part of the creeks and river. Johnston soils are in the upper tributaries. Bohicket soils are mucky and have mucky silt loam mucky silty clay subsoils. Axis soils have mucky surface layers but generally have sandy loam or sandy clay loam subsoils. The Johnston complex soils are mucky in the surface layers but have stratified sand, silt and silty substrata or weakly developed subsoils.

Among the soils of minor extent are beaches and made land areas. Most of the marshes are in native vegetation of salt tolerant species and grasses, reeds and shrubs. This association is best suited to wildlife habitat and recreation.

2. Soil Association Group 2 – Dogue, Pamunkey, and Uchee Soil Association

These soils formed on river terraces and are deep, moderately well and well, and poorly drained soils that have clayey and loamy subsoils. This association is along the York River, and King, Queen, and Cub Creeks. It is mainly on broad to medium ridges that are not flooded and slightly concave areas that are ponded for brief periods. These soils are mostly gently sloping or nearly level. Short, steep, side slopes and escarpments are common along drainageways, small streams, and terrace breaks.

Dogue and Pamunkey soils are nearly level and gently sloping; they occur mainly on ridge points and on medium to broad ridges about a mile wide, with the back escarpment being approximately parallel with the York River. Drainageways cutting into this terrace formed dendritic drainage patterns. The slopes along these drainageways are short, steep, and very steep. The Dogue soils are moderately well drained and have clayey subsoils. The Pamunkey soils are well drained and have loamy subsoils. Chickahominy soils are poorly drained and have clayey subsoils and are on nearly level slopes and depressions.

Among minor soils and miscellaneous areas are urban soils, or Udorthents – loamy, Emporia complex soils, Uchee soils, Bojac, Munden, Slagle and Newflat soils. These soils are on broad to narrow gently sloping ridges, and Emporia complex soils are on steep to very steep side slopes. This association is used for most of the developed area of Cheatham Annex.

3. Soil Association Group 3 – Emporia, Slagle, and Craven-Uchee Complex Soils Association

These are deep, well, and moderately well-drained soils that have loamy and clayey subsoils, formed on the Coastal Plan Upland with medium to narrow ridges and sloping to very steep side slopes. This association formed in loamy and clayey Coastal Plain sediments. Emporia and Slagle soils are on medium width ridges. Emporia soils commonly occupy the higher landscape position while slagle soils occupy the lower landscape position. Craven and Uchee soils are on the narrower ridge points and the sloping area between the ridges and the steep and very steep side slopes. Emporia Complex soils are on the steep and very steep side slopes. The Emporia soils are well-drained and moderately to slowly permeable. They have a clay loam or sandy clay loam subsoil, and a seasonal water table at 3 to 5 feet. The Slagle soils are moderately well-drained with moderately slow or slow permeability and have a seasonal water table of 1.5 feet. The Craven soils are moderately well-drained and have a clay silty clay subsoil, a slow permeability, and a seasonal high water table at 1.5 feet. The Uchee soils are well-drained, have a moderately slow permeability, a subsoil of sandy clay loam, clay loam and sandy clay, and a seasonal high water table at 3.5 to 5 feet.

Among the soils of minor extent are Caroline, Kempsville, and Udorthents loamy. Most of this association is wooded but some areas are located around small buildings and within the fuel storage area.

4. Soil Association Group 4 – Kempsville, Emporia, Emporia Complex, and Craven-Uchee Complex Soils Association

As with Group 3, these are deep, well, and moderately well-drained soils that have loamy and clayey subsoils, formed on Coastal Plan uplands with medium to narrow ridges and sloping to very steep side slopes. This association formed in loamy and clayey Coastal Plain sediments. Kempsville and Emporia soils are on medium ridges. Kempsville and Emporia soils occur on the landscape. Emporia Complex soils are on the steep and very steep side slopes. Craven and Uchee soils are on narrow ridge points, and on the sloping area between the ridges and the steep and very steep side slopes.

The Kempsville soils are well-drained moderately permeable. They have sandy clay loam and clay loam subsoils, and have a water table at 5 feet or greater. The Emporia soils are well-drained and slowly permeable. They have a clay loam or sandy clay loam subsoil, and a seasonal water table of 3 to 5 feet. The Craven soils are moderately well-

drained with a clayey subsoil, slow permeability and seasonal high water table at 1.5 feet. The Uchee soils are well-drained and have a moderately slow permeability, a sandy clay loam, and sandy clay subsoil, and a seasonal high water table of 3.5 to 5 feet.

Among the soils of minor extent are Caroline, Slagle, Dogue, Johnston Complex, and Udorthents-loamy. Most of this area is wooded but some areas are located within the fuel storage area.

3.4 Subsurface Geology

The Atlantic Coastal Plain physiographic province is underlain by unconsolidated sediments of Quaternary, Tertiary, and Cretaceous ages that dip gently to the southeast and have a combined thickness of approximately 1,900 feet in the vicinity of CAX (Teifke, 1973).

Most of the surficial unconsolidated sediment at CAX has been mapped as the Shirley Formation of the Pleistocene series (Mixon et. al., 1989). This formation is composed of gravel, sand, silt, clay, and peat deposited in river and estuarine environments. Its thickness is estimated to vary from 0- to 80-feet. The Chuckatuck Formation of Pleistocene age underlies the Shirley Formation and is described as sand, silt, and clay with minor amounts of peat deposited in bay environments. The Chuckatuck Formation rests on the top of the Windsor Formation, also of Pleistocene age. The Windsor Formation is comprised of marine and lagoonal sand, silt, and clay, with gravel in areas.

The Bacons Castle Formation of Pliocene age underlies the Windsor Formation and is described as a clayey silt and silty fine-grained sand. The Bacons Castle Formation rests unconformably on the weathered top of the Upper Yorktown Formation, also of Pliocene age. The presence of calcite-cemented shells and shell fragments is characteristic of the upper portion of the Yorktown Formation.

The stratigraphy encountered during the background investigation is discussed in Section 6.0 of this report.

3.5 Hydrogeology

The Atlantic Coastal Plain sediments are the most important source of potable water in the region. Recharge to the groundwater system is derived from precipitation. Approximately 50 percent of the precipitation is lost to evapotranspiration. The remaining 50 percent either results in surface runoff, or infiltrates and is introduced into the groundwater regime. Recharge of aquifers may occur at the surface near outcrop zones, or from downward migration from overlying strata (Baker 1994).

The shallow aquifer system in York County is comprised of the following six units: (1) the Columbia aquifer, (2) the Cornwallis Cave confining unit, (3) the Cornwallis Cave aquifer, (4) the Yorktown confining unit, (5) the Yorktown-Eastover aquifer, and (6) the Eastover-Calvert confining unit (Brockman and Richardson 1992, Brockman et. al., 1997). Hydrogeologic units are recognized only where they are saturated (for aquifers) or confining (for confining units). For example, although the strata that typically comprise a given aquifer (when saturated) are present, the hydrogeologic unit does not exist in areas where the unit is not saturated. Vertical migration of groundwater is impeded in areas where the confining units are continuous, relatively thick, and comprised primarily of low-permeability strata such as clay or silt.

3.6 Surface Water Hydrology

CAX is bound on the west by Cheatham Pond, on the north by the mouth of Queen Creek, on the east by the York River, and on the south by King Creek. In 1943, dams were constructed to create the 108-acre Cheatham Pond from the tidal Queen Creek, as well as the 43-acre Penniman Lake from King Creek tidal influence. Jones Pond, a 69-acre freshwater nontidal pond, was formed by damming a portion of the Cub Creek watershed. It is located in the northwestern section of CAX and is enclosed by several wooded ravines. Numerous small creeks flow through wooded ravines throughout CAX, and drain into tidal creeks that join the York River. In most areas, forests extend to the marsh and lake margins. The tributaries of CAX all drain into the York River. The Walt Feurer Youth Pond (2 acres) and the Cat Fish Pond (1 acre) are shallow, warm water, man-made ponds (DON, 1998).

3.7 Ecological Characteristics

Characterization of the terrestrial and wetland/aquatic biology of CAX has been adapted from the IAS (NEESA, 1984) and from the Environmental Assessment for Recreational Cabins at CAX (DON, 1998).

3.7.1 Terrestrial Ecology

Terrestrial flora of CAX are predominantly woodland species. Three types of forest are present: pine stands composed primarily of loblolly and Virginia pines, mixed pine and hardwood stands, and hardwood stands. Elevated level areas are the predominant locations of pine stands, while hardwood stands are found on slopes and ravines. These wooded areas are important in reducing soil erosion and providing wildlife habitat. Native tree species found at CAX include beech, black cherry, red maple, sweet gum, various pines, white ash, and white oak.

The woodland's understory is composed of various seedling trees and vine species, such as Virginia creeper, briars, and honeysuckle. Ferns are found in many moist, shaded areas. Ornamental trees and shrubs have been planted in the improved areas and along major roadways. None of the plant species that thrive at CAX are listed on the federal or Commonwealth endangered lists.

3.7.2 Wildlife

Nearly 300 bird species, including more than 100 breeding species, have been observed on the installation. Migratory and resident Canadian geese and mute swans occur in nuisance population numbers and breed on CAX.

Forty-four mammal species have been found on or near CAX. State hunting and trapping regulations apply to 12 species on CAX. All other species are considered non-game species. There are 29 amphibian species and 43 reptile species that could occur at CAX. The most common mammals include:

- White-tailed deer (*Odocoileus virginiana*)
- Gray squirrel (*Sciurus carolinensis*)
- Eastern cottontail rabbit (*Sylvilagus floridana*)

- Beaver (*Castor canadensis*)
- Muskrat (*Ondatra zibethica*)
- Red fox (*Vulpes vulpes*)
- Gray fox (*Urocyon cinereoargenteus*)
- Raccoon (*Procyon lotor*)
- Mink (*Mustela vinson*)
- Nutria (*Myocastor coypus*)

King and Queen creeks provide important nursery grounds for many estuarine fishes. Freshwater species include largemouth bass, bluegill, redear sunfish, crappie, and channel catfish. Forage species include gizzard shad, threadfin shad, and Tidewater silversides.

Cheatham Pond is owned by the National Park Service (NPS). However, through a cooperative agreement with the NPS, CAX is permitted to use the pond for recreational fishing. Furthermore, the agreement requires that the Navy manage Cheatham Pond in accordance with NPS natural resource management practices. Game fish species found in Cheatham Pond include largemouth bass, bluegill, redear sunfish, and black crappie (DON, 1998).

3.8 Wetlands

At CAX, wetlands are mainly found along principal tributaries to the York River and along the York River shoreline. Four major marsh types exist in the vicinity:

- Type I: Salt-marsh cordgrass community.
- Type V: Big cordgrass community.
- Type VI: Cattail community.
- Type XII: Brackish water mixed community.

The wetlands are grouped into classifications based on their estimated environmental value per acre. Group One marshes, of which Type I and Type XII are a part, have the highest productivity and use by wildfowl and wildlife, as well as a close association with fish spawning and nursery areas. They are also important to the shellfish industry and as shoreline erosion inhibitors. These wetlands merit the highest order of protection. The majority of wetlands on CAX are of this type. Type V and Type VI marshes are in Group Two and are only slightly less important than the

Group One marshes. Because these marshes are found at higher elevations, there is less opportunity for detritus (loose soil or organic particles) to be washed into nearby waterways by the tides. This group of marshes is also valuable as flood buffers and should be preserved. CAX wetlands and adjacent creeks provide nursery areas for striped bass, white perch, and other species. These wetlands are also prime habitats for migrating waterfowl.

The habitat of aquatic floral species is generally determined by water salinity and bottom types. In this area of the York River, the following species are associated with certain salinity ranges:

- Hornwort: Freshwater only.
- Water-celery: Freshwater only.
- Pondweed: Fresh to 5 parts per thousand (ppt).
- Horned pondweed: Fresh to 5 ppt.
- Water milfoil: Fresh to 10 ppt.
- Eelgrass: 10 to 35 ppt.
- Widgeon grass: 5 to 40 ppt.

These species are commonly found growing at depths of three to nine feet in soft bottom muds. Due to increased nutrient loading, waterweed and water milfoil have been plant pests at times. Eelgrass is most often found growing in soft mud. Widgeon grass is sensitive to both increased water temperature and turbidity. (NEESA, 1984)

3.9 Threatened and Endangered Species

The Virginia Department of Agriculture and Consumer Service, Division of Consumer Protection, Office of Plant and Pest Services (in a letter dated November 20, 1998) reported that there are no endangered or threatened insect species found on CAX.

The Virginia Department of Game and Inland Fisheries discovered a breeding bald eagle (*Haliaetus leucocephalus*) near Penniman Lake. The bald eagle is a federally threatened species. No bald eagles nested at CAX in 1998. (DON, 1998)

In 1989, the Virginia Department of Conservation and Recreation – Division of Natural Heritage (VDCR-DNH) surveyed CAX for rare vertebrate and plant species. The survey discovered 23 species of rare amphibians, though none merited legal status. The marl ravines around Cheatham

Lake were identified by VDCR-DNH as prime-habitat for certain rare plants: Loesel's twayblade (*Liparis loeselii*), sweet pinesap (*Monotropsis odorata*), shadow witch (*Ponthieva racemosa*), mountain camellia (*Stewartia ovata*), and southern cattail (*Typha domingensis*). In the 1989 survey, Loesel's twayblade, an orchid, was found in three marl ravines around Cheatham Pond. None of these plants, however, have legal status.

The United States Fish and Wildlife Service (USFWS) (November 1998) has indicated that seven plant species of concern might be found in appropriate habitats in York County: large-leaf peatmoss (*Sphagnum macrophyllum*, variety *macrophyllum*), Cuthbert turtlehead (*Chelone cuthbertii*), Harper's fimbristylis (Fimbristylis perpusilla), New Jersey rush (*Juncus caesariensis*), pondspice (*Litsea aestivalis*), sweet pine sap (*Monotropsis odorata*), and Virginia least trillium (*Trillium pusillum*, variety *virginianum*). The tidewater interstitial amphipod (*Stygobromus araeus*), an invertebrate, is also listed as a species of concern in York County.

A pair of peregrine falcons (*Falco peregrinus anatum*), an endangered species, nested on a crane on the abandoned pier at CAX in 1998. The preferred habitat of peregrines is cliff ledges, but some peregrines accept man-made structures such as skyscraper ledges, tall towers, and bridges as breeding habitat. (DON, 1998)

4.0 BACKGROUND INVESTIGATION DESIGN

This study was designed to establish background concentrations of inorganic and organic chemicals in surface soils, subsurface soils, and groundwater throughout the Activity. This section explains the rationale for selecting the number of background surface and subsurface soil and groundwater samples and discusses any deviations from the approved scope of work as a result of field conditions. Specific locations of background samples will be provided in Section 5.0 of this report.

4.1 Overall Investigation Design

Because CAX is represented by four separate and distinct soil association groups, (see Section 3.3), these groups defined the boundaries of the Background Investigation. The spatial boundaries of the investigation were located throughout CAX and the northern portion of WPNSTA. The boundaries were in areas that have not been impacted from past or current base operations. As discussed in Section 2.5, several investigations and studies have been conducted at CAX since 1984. The areas that incorporate identified sites and AOCs were not considered as potential sampling areas for the Background Investigation. The sample locations presented herein were chosen based upon knowledge of previous investigations, site conditions, and professional judgment.

Elements such as metals and metaloids occur naturally in soils and groundwater, and distinguishing background levels from site-activity related concentrations often requires statistical analysis. Therefore, the number of background samples obtained to determine naturally occurring concentrations of inorganics was selected to support the performance of various statistical tests. As dictated in the Field Sampling and Analysis Plan (FSAP) for the Background Investigation (Baker, 2001d), each of the four soil association groups were investigated with 10 soil borings and three groundwater monitoring wells. Section 5.0 provides details of the sampling procedures employed for this investigation.

Surface and subsurface soil samples were collected at each of the soil sampling locations. It was anticipated during the design of the sampling program that each of the four soil groups discussed in Section 3.3 would be sampled and represented in the database. Therefore, the database could be segregated by depth (surface versus subsurface), lithologies, and location. Groundwater was collected from each monitoring well. The following paragraphs provide a discussion of the sampling rationale for the background sampling effort.

4.2 Surface Soil Investigation

There are four major soil association within the boundaries of CAX. Forty soil borings were advanced throughout the Base and were distributed among the four soil associations as follows:

- Soil Association 1 – Bohicket, Johnston, and Axis Soil Association 10 borings
- Soil Association 2 – Dogue, Pamunkey, and Uchee Soil Association 10 borings
- Soil Association 3 – Emporia, Slagle, and Craven-Uchee Complex Soil Association 10 borings
- Soil Association 4 – Kempsville, Emporia, Emporia Complex, and Craven-Uchee Complex Soils Association 10 borings

A single surface soil sample was collected from each of the forty soil borings advanced throughout the Activity. These samples were collected from a depth of 0 to 6 inches bgs. Surface soil samples were divided in to four separate data bases based on soil association groups. A separate database was created that includes all forty surface soil samples combined into a single data set.

The combined data set should only be used if the origin of the sample to be compared to background can not be determined. Different soil types have properties that effect ion attraction and retention. Therefore, it is anticipated that the arithmetic mean for the combined data set will be higher than the arithmetic mean for sands and lower than the arithmetic mean for clayey soils. The result of this difference in arithmetic means may result in the listing of a sample result as a contaminant of potential concern instead of indicative of background concentrations, or vice versa. The combination of sample results into this combined data set will dilute the range of inorganics naturally occurring in clays at CAX.

4.3 Subsurface Soil Investigation

As for surface soil, a single subsurface soil sample was collected from each of the forty soil borings advanced throughout the Activity. These samples were collected from a depth of 6 to 24 inches bgs. As for surface soils, the subsurface samples were divided into four data sets of 10

samples each based on the soil association group to which they belonged. A separate database was created that includes all forty subsurface soil samples combined into a single data set. However, for the reasons discussed in the preceding section, this combined data set should only be used if the origin of the sample to be compared to background can not be determined.

4.4 Groundwater Investigation

Groundwater was collected from twelve monitoring wells installed throughout the Activity. Groundwater data were separated in to four data sets of three samples each based on the soil association group in which wells were located. In addition, a separate database was created that includes all twelve groundwater samples.

5.0 BACKGROUND FIELD INVESTIGATION

The field investigation began on July 23, 2001 and was completed on August 24, 2001. Sampling was conducted in accordance with the approved Project Plans (Baker, 2001d) and USEPA Region III Standard Operating Procedures (SOP). Activities conducted during the field program consisted of a soil investigation, including sampling and exploratory drilling; and a groundwater investigation, including monitoring well installation, development, and sampling. All field activities were conducted using Level D personal protection. The following sections discuss these investigative activities as well as the Quality Assurance/Quality Control (QA/QC) samples collected, the decontamination procedures employed, and management of investigation derived waste (IDW) generated during the field program.

5.1 Sample Designation

In order to identify and accurately track the various samples, all samples collected during this Background Investigation, including QA/QC samples, were designated with a unique number. The number serves to identify the investigation, soil association group, sample media, sampling location, depth (soil) or round (groundwater) of sample, and any QA/QC sample types.

The sample designation format follows:

> Investigation Identification – Soil Association - Media – Location - Depth/Round – Duplicate/Filtered Sample Indicator

An explanation of each of these identifiers is given below.

> Investigation Identification
>
> All samples discussed in this report were collected for the Background Investigation and were identified by the letters "BG" (soil samples) or "CXBG" (groundwater and QA/QC samples).

> Soil Association
>
> Soil and groundwater samples were identified by the number of the soil association group from which they were collected.

1	=	Soil Association 1
2	=	Soil Association 2
3	=	Soil Association 3
4	=	Soil Association 4

Media

The following media were collected:

SB	=	Subsurface Soil Sample
SS	=	Surface Soil Sample
GW	=	Groundwater Sample
FB	=	Field Blank (QA/QC sample)
RS	=	Equipment Rinsate (QA/QC sample)

Location

Location numbers identify the sampling location and include soil locations or monitoring well numbers.

Depth/Round

Depth indicators are used for soil samples. The number refers to the sample interval.

00	=	0 to 6 inches bgs (all surface soil samples)
01	=	6 to 24 inches bgs (all subsurface soil samples)

Duplicate/Filtered Sample Indicator

Duplicate samples were indicated with a D at the end of the sample number designation.

Filtered (dissolved) aqueous samples were designated with an F at the end of the sample number designation.

Using this sample designation format, the example sample number BG01-SB02-01D refers to:

BG1-SB02-01D	Background Investigation
BG1-SB02-01D	Soil Association Group #1
BG1-SB02-01D	Subsurface Soil Sample
BG1-SB02-01D	Sample Location #2
BG1-SB02-01D	Depth of sample is from 6 to 24 inches bgs
BG1-SB02-01D	Duplicate sample

Using this sample designation format, sample CXBG2-GW01DF refers to:

CXBG2-GW01DF	Background Investigation
CXBG2-GW01DF	Soil Associaiton Group #2
CXBG2-GW01DF	Groundwater Sample
CXBG2-GW01DF	Monitoring Well #01
CXBG2-GW01DF	Duplicate Sample
CXBG2-GW01DF	Filtered Sample

The sample format described above has been modified somewhat from that reported in the FSAP (Baker, 2001d) for this project. This sample format was followed throughout the project. Tables 5-1 and 5-2 list all samples collected for the Background Investigation and the analytical parameters for which they were analyzed.

5.2 General Field Operations and Pre-Sampling Activities

General field operations were conducted from Building 116 on CAX and Baker's Field Trailer located on WPNSTA Yorktown near Building 1806. Both locations are equipped with electricity and a telephone. The field office was where the field team met at the beginning and end of each day and the site manager coordinated all investigative operations. Further details of project management are described in Section 6.0 of the Background Investigation Work Plan (Baker, 2001d).

Before initiation of the background field investigation, a site visit was conducted by Baker personnel, at which time proposed sampling locations were marked. To prevent damage to existing utilities, all proposed sampling locations were cleared by both WPNSTA Public Works and local utility personnel contacted via Miss Utility (the Virginia state required contact line). If necessary, sampling locations were off-set from proposed locations based upon site conditions and professional judgement, or to obtain utility clearance.

5.3 Soil Investigation

Soil sampling for the background investigation commenced July 23, 2001 and continued through August 24, 2001. Surface and subsurface soil samples were collected from each of forty soil sample locations. Ten sample locations were in each of the four soil associations in areas that had no history of activity that could increase naturally occurring concentrations of inorganics or

anthropogenic chemicals in surface and subsurface soils. One duplicate sample from each depth was collected in each soil association. Figure 5-1 depicts the background soil sample locations. In general, the field procedures and sampling methods employed for the soil investigation included sample collection, handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in Section 5 of the FSAP.

All soil samples were collected using a stainless steel hand auger. Augers were decontaminated prior to and following sample collection. Surface soil samples were collected from 0 to 6 inches bgs. If present, the upper heavily rooted layer of topsoil and matted roots were removed (approximately the top half-inch of material). Subsurface soil samples were collected from 6 to 24 inches bgs. The type, color, and other significant characteristics of the soils were noted in the field logbooks. Each soil boring was back-filled with soil cuttings.

Each of the surface soil samples was analyzed for Target Compound List (TCL) Semivolatile Organic Compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), Target Analyte List (TAL) inorganics (including cyanide), and Total Organic Carbon (TOC). Each of the subsurface soil samples was analyzed for TCL Volatile Organic Compounds (VOCs), SVOCs, pesticides, PCBs, and TAL metals (including cyanide). Table 5-1 summarizes the samples collected and the analytical parameters for these samples.

Soil samples submitted for laboratory analysis were prepared according to USEPA Region III SOPs. Samples for VOCs were placed directly in to sampling containers. All other samples were thoroughly homogenized before being placed in to the appropriate laboratory container. All samples were labeled and temporarily stored in an ice filled cooler. Sample identification number, collection date and time, analytical parameters, and sampler were recorded on the sample label and the chain-of-custody form. The samples were appropriately grouped and packed in an ice filled cooler and sent by Federal Express overnight service to CompuChem Environmental Laboratories in Cary, North Carolina for analysis. Chain-of-custody forms accompanied samples to the laboratory and are provided in Appendix A.

5.4 Drilling Procedures

Drilling activities for the Background Investigation occurred from August 7, 2001 to August 22, 2001. Parratt Wolff, Inc, of Hillsboro, North Carolina was the drilling contractor. During the drilling program, two 100-foot exploratory soil borings were advanced to provide lithologic information

and 11 soil borings were advanced in the process of installing shallow groundwater monitoring wells. Each of the borings provided information regarding hydrogeologic conditions. Exploratory soil borings are discussed in Section 5.5. Monitoring well installation is discussed in Section 5.6.1. Figure 5-1 shows the location of monitoring wells and the exploratory borings.

5.5 Exploratory Soil Borings

Two 100-foot exploratory soil borings were advanced for lithologic content. One of these borings was located within Soil Association 2, offset from CXBG-MW-03 by approximately 20-feet. The other boring was located within Soil Association 3, offset from CXBG-MW01 by approximately 20-feet. These locations are indicated on Figure 5-1. Both of the exploratory borings were advanced via hollow stem auger and were continuously sampled vial split spoons (2-foot intervals) the entire length of the boring. Each split-spoon sample was classified visually by the site geologist. The classification included characterization of soil type, color, moisture content, relative density, plasticity, and other pertinent information such as evidence of contamination. No environmental samples were collected from either boring. Lithological descriptions are provided on the Test Boring and Well Construction Records in Appendix B. Exploratory soil borings were filled by grouting from the bottom of the boring to the ground surface.

5.6 Groundwater Investigation

The groundwater sampling program developed for the background investigation was designed to obtain an understanding of naturally occurring concentrations of inorganic and organic constituents at CAX and the northern portions of WPNSTA. The following sections describe monitoring well installation, well development, and groundwater sampling procedures.

5.6.1 Monitoring Well Installation Procedures

As part of the background investigation, eleven monitoring wells were installed for the collection of groundwater samples. The newly installed monitoring wells were number according to the following scheme:

CXBG1-MW01

where: CX = Cheatham Annex
BG = Background Investigation
1 = Soil Association Group Number
MW = Monitoring Well
01 = Well Identification Number

The subsections below describe the wells installed within each soil association group. The wells themselves were constructed of 2-inch diameter polyvinyl chloride (PVC) with a 5-foot 0.01-inch slot screen. A volume of No. 1 silica sand was placed within the borehole around the screen so that a minimum of 2 feet of sand settled above the screen around the riser (the non-slotted PVC that is connected to the screen and rises above ground surface). A minimum of 2 feet of bentonite was placed above the sand pack and hydrated to seal off the screen. The remaining portion of the borehole was grouted to the surface with a mixture of bentonite and cement grout. A typical monitoring well construction diagram is provided as Figure 5-2. Additional information pertaining to the procedures for monitoring well installation and completion are described in the FSAP (Baker, 2001d).

Each split-spoon or hand auger sample generated during the well installation process was classified visually by the site geologist. The classification included characterization of soil type, color, moisture content, relative density, plasticity, and other pertinent information such as evidence of contamination. Lithological descriptions are provided on the Test Boring and Well Construction Records in Appendix B. A summary of construction data for monitoring wells installed for the Background Investigation is presented on Table 5-3.

5.6.1.1 Soil Association 1 (Bohicket, Johnson, and Axis Soil Association)

Three monitoring wells were installed within Soil Association 1 (refer to Figure 5-1), one along King Creek between WPNSTA and the Virginia Fuel Farm (CXBG1-MW01), one on the spit between King Creek and the York River (CXBG1-MW02) and one in the marsh along Queen Creek and slightly northwest of Cheatham Pond (CXBG1-MW03). These well locations did not allow for drill rig access; therefore, each soil boring was advanced via a hand auger.

5.6.1.2 Soil Association 2 (Dogue, Pamunkey, and Uchee Soil Association)

Three monitoring wells were installed within Soil Association 2 (refer to Figure 5-1), one off of Ringfield Road (toward Felgates Creek) in the northern part of the Restricted Area on WPNSTA (CXBG2-MW01), one off of Chase Road (toward Cheatham Pond) on CAX (CXBG2-MW02), and one off of B Street (toward Cheatham Pond) on CAX (CXBG2-MW03). These well locations were accessible with a drill rig; therefore, each soil boring was advanced via hollow stem augers.

5.6.1.3 Soil Association 3 (Slagle, Emporia, and Craven-Uchee Complex Soil Association)

Three monitoring wells were installed within Soil Association 3 (refer to Figure 5-1). These wells triangulate Jones Pond and are located off Patrol Road 5, one on the southern end of Jones Pond (CXBG3-MW01), one to the northeast (CXBG3-MW02) and one to the northwest (CXBG3-MW03). These well locations were accessible with a drill rig; therefore, each soil boring was advanced via hollow stem augers.

5.6.1.4 Soil Association 4 (Emporia, Emporia Complex, Kempsville, and Craven-Uchee Complex Soil Association)

Three monitoring wells were proposed for the portion of Soil Association 4 that is located in the northern part of the Restricted Area on WPNSTA. One of the proposed well locations was located off of Felgates Road, approximately 1,600 feet east of the Ringfeld Road/Felgates Road intersection. However, field reconnaissance revealed the existence of monitoring well BGGW01, which had been installed as part of the 1994 background investigation for WPNSTA. This well was located relatively close to the new well's proposed location (approximately 1,400 feet east). Therefore, it was decided that it would substitute for CXBG4-MW03.

Consequently, two monitoring wells were installed within Soil Association 4, one approximately 200 feet north of Building 163 inside the adjacent woods (CXBG4-MW01) and one off of the dirt road that connects Felgates Road with Burma Road, west of Magazine Group 22 (CXBG4-MW02) (refer to Figure 5-1). Well CXBG4-MW01's location did not allow for drill rig access; therefore, the soil boring was advanced with a hand auger. Well CXBG4-MW02's location was accessible with a drill rig; therefore, its soil boring was advanced via hollow stem auger.

5.6.2 Well Development Procedures

Prior to groundwater sampling, the eleven newly installed wells and one existing well were developed by removing from each well a minimum of five well volumes of groundwater, plus the volume of any water added during the drilling or installation process. The wells were developed with a Wattera™ pump, which agitates the water inside a well in order to put silt/particulates into suspension for their removal as the well water is pumped off. Development water was discharged into a 5-gallon bucket to measure the amount of water removed, then it was dumped on-site, directly onto the ground (see Section 5.11, Investigation Derived Waste Management). Monitoring well development was performed only after the grout used to construct the new monitoring wells was allowed to adequately set (i.e., greater than 24 hours). This method helped ensure that no grout was introduced into the screened interval during well development. Additional details for monitoring well development are found in the FSAP (Baker, 2001d).

Development was complete when five consecutive field measurements for pH, specific conductance, and temperature were considered stable (i.e., readings within 10 percent of each other). Development information, including water clarity, pH, specific conductivity, salinity, temperature, and comments was recorded in a field logbook. Appendix A, Section 201 of the Master Project Plans presents the SOPs for "On-Site Water Quality Testing" (Baker, 1994b).

5.6.3 Groundwater Sampling Procedures

One round of groundwater samples was collected from the eleven newly installed wells and the one existing well. Prior to groundwater sampling, static water levels were measured and used to calculate well volumes. Three to five well volumes of groundwater were purged from each monitoring well to ensure representative groundwater from the aquifer was sampled. A low-flow purge was desired to keep water turbidity low (i.e., less than 5 nephelometric turbidity units [NTUs], if practical). Therefore, either a Grunfos Redi-flow submersible pump (for wells deeper than 30 feet) or a peristaltic pump (for wells less than 30 feet deep) was used to purge and sample the wells.

Field measurements of turbidity, pH, specific conductivity, and temperature were taken after each well volume. Purging was considered complete when three successive field measurements of each parameter were within 10 percent of each other and turbidity stabilized (i.e., was less than 5 NTUs, if practical). Monitoring well purging and groundwater sampling procedures are detailed in the FSAP (Baker, 2001d).

Groundwater samples were analyzed for TCL Organics (VOC, SVOC, Pesticides, PCB) and TAL Inorganics (metals – total and dissolved and cyanide). Table 5-1 summarizes the environmental groundwater samples that were collected and the analytical parameters for these samples.

5.7 Quality Assurance/Quality Control Samples

Six types of QA/QC samples were collected and analyzed including field duplicate samples, equipment rinsate blanks, field blanks, trip blanks, temperature blanks, and matrix spike/ matrix spike duplicate (MS/MSD) samples. A description of each of these types of QA/QC samples is provided in Section 5.7 of the FSAP (Baker, 2001d).

Field duplicate samples were collected from both the soil and groundwater samples at a rate of one duplicate per ten samples. Equipment rinsate blanks were collected from decontaminated or unused disposable sampling equipment with laboratory-grade deionized water. Three field blanks were collected, one from each water source that could have an effect on sample analytic results. These water sources were (1) store-bought distilled water that was used to decontaminate reusable sampling equipment, such as stainless steel spoons and hand auger heads, (2) laboratory-grade deionized water that was used to collect equipment rinsate blanks, and (3) non-potable water stored in the drill rig support truck tank that was used during monitoring well installation. In addition, trip blanks accompanied all VOC samples during their shipment to the laboratory, and temperature blanks were placed in each sample cooler prior to shipment. MS/MSD samples were collected from both the soil and groundwater samples at a rate of one MS and one MSD per twenty samples.

Table 5-2 summarizes all of the QA/QC samples collected as part of the Background Investigation.

5.8 Sample Handling and Analysis

The following sections present information regarding sample preservation and handling, and chain-of-custody procedures.

5.8.1 Sample Preservation and Handling

Analytical methods, data quality level, laboratory turnaround times, preservation requirements, bottle requirements, and holding times are presented in the Quality Assurance Project Plan (QAPP) submitted as part of the Final Project Plans (Baker, 2001d). Field activities were conducted according to USEPA protocol.

5.8.2 Chain-of-Custody Forms

Chain-of-custody procedures were followed throughout the field program to ensure a documented, traceable link between analytical results and the sample/parameter that they represent. These procedures are intended to provide a legally acceptable record of sample collection, identification, preparation, storage, shipping, and analysis.

A chain-of-custody form was completed for each container (shipping cooler) in which the samples were shipped. After the samples were properly packaged, the coolers were sealed and prepared for shipment. Custody seals were placed on the outside of the coolers to ensure that the samples were not disturbed prior to reaching the laboratory. Chain-of-custody forms are presented in Appendix A.

5.8.3 Sample Analysis

Samples sent for TCL Organics and TAL inorganics analysis were subject to Contract Laboratory Program (CLP) methods with Level D QA/QC. These analytical methods, their contract required detection limits or practical quantitation limits, and QA/QC procedures are described in Section 6.0 of the QAPP (Baker, 2001d).

5.8.4 Data Validation

Data validation was performed by an independent data validator for all samples collected, using Level D guidelines. The procedures for validation followed the appropriate Level D guidelines listed in the NEESA guidance document (NEESA 20.2-047B). Further details concerning data validation are found in Section 7.0 of the QAPP (Baker, 2001d). Data that are evaluated and do not pass the validation standards are reported but flagged with qualifiers (see Section 7.1).

5.9 Field Screening and Air Monitoring

Air monitoring and field screening procedures were implemented during soil sampling and drilling activities for health and safety and initial contaminant monitoring. Each soil sample was monitored with a photoionization detector (PID). Compounds with an ionization potential less than or equal to the electron volt (eV) capacity of the lamp (11.7 eV for the instrument used during this investigation) can be detected by the PID. Data obtained in the field were recorded in a field logbook. Prior to daily monitoring, the instruments were calibrated, with pertinent documentation recorded in field logbooks and/or on calibration forms. Specific screening and monitoring requirements are outlined in the project Health and Safety Plan (HASP) (Baker, 2001d).

5.10 Decontamination Procedures

Equipment decontamination was conducted in accordance with the Final Background Investigation Project Plans (Baker, 2001d). Specific procedures are discussed in Section 7 of the HASP and Section 5 of the FSAP.

5.11 Investigation Derived Waste Management

IDW generated during the field investigation included soil from the subsurface borings (cuttings), groundwater (from developing and purging wells), decontamination fluids (steam cleaning water and decontamination chemicals) and miscellaneous items such as gloves, Tyvek™, and other used personal protective equipment (PPE).

IDW management (soil and groundwater) was conducted in accordance with guidance from USEPA's Guide to Management of Investigation-Derived Wastes (USEPA, 1992). This document states that "most IDW (with the exception of non-indigenous IDW) generated during the course of the investigation are intrinsic elements of the site and should be managed with other wastes from the site, consistent with final remedy." The IDW management procedures are described below.

5.11.1 Soil

Soil cuttings derived from the monitoring well installation and hand augering activities were used to fill the sample hole or were spread on the ground surface near the well location.

5.11.2 Liquid

Liquid IDW generated during field activities included development and purge water (groundwater) from monitoring wells, decontamination water from steam cleaning activities, and decontamination water, solvents and acids used to clean small, reusable sampling equipment. These liquids were segregated and stored as noted below.

Development and purge water generated from monitoring wells at the sites and decontamination water (generated by steam cleaning and decontamination of PPE) from the sites was discharged on the ground near its source.

Decontamination water containing acids and solvents used for cleaning small, reusable sampling equipment was placed into a 30-gallon drum that is labeled and stored on a pallet at a secure location at Baker's staging area at WPNSTA, Yorktown. This drum contains liquid IDW both from the Background Investigation and from three field programs conducted prior to the Background Investigation, and is currently just over one-third full. This liquid IDW will be sent to an independent off-site disposal company following analytical requirements, as specified by the disposal company. Typical analysis includes TCL organics, nitramine compounds (if applicable), TAL inorganics, and RCRA characteristics (including reactive cyanide, reactive sulfide, ignitability, and corrosivity [pH]). IDW sampling procedures are described in FSAP (Baker, 2001d).

5.11.3 Personal Protective Equipment

Items of PPE, such as disposable gloves and Tyvek™, were double-bagged in plastic garbage bags and placed in the trash dumpster at Baker's Field Trailer.

5.12 Global Positioning System Survey

Monitoring wells and soil sample locations were surveyed using Global Positioning System (GPS) techniques. The GPS Pathfinder Pro XR is a mapping and GIS data capture system that integrates the use of off-shore beacons with satellites to enhance its accuracy. After postprocessing differential correction, the data system provides a horizontal accuracy between the range of 75 centimeters to 10 cm (with 20-minute occupation at the location) and a vertical accuracy range of 1.5 meter to 20 cm (with 20-minute occupation at the location). Local environmental conditions (e.g. ionosphereic, obstructions of the sky by buildings, and heavy tree canopy) may degrade the accuracy by interfering with signal reception. Optimal accuracy is obtained by collecting data in an environment that is devoid of large reflective surfaces and also has a clear view of the sky. The majority of sample locations were surveyed with the GPS unit; however, some sample locations were not compatible with the GPS unit due to satellite blockage. At these locations conventional surveying will be used to locate the sampling points. GPS and conventional surveying data will also be used to determine elevations of monitoring wells. In the final version of this report, survey data regarding monitoring well elevations will be presented on Table 5-3 and survey data indicating horizontal locations of sampling points will be represented on Figure 5-1.

TABLES

TABLE 5-1

SUMMARY GROUNDWATER AND SOIL SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

MEDIUM	SAMPLE IDENTIFICATION	DATE COLLECTED	REQUESTED ANALYSES			COMMENTS
			TCL Organics[1]	TAL Inorganics	CN	
Groundwater Samples	CXBG1-GW01	8/21/01	X	X	X	
	CXBG1-GW02	8/15/01	X	X	X	
	CXBG1-GW03	8/20/01	X	X	X	
	CXBG2-GW01	8/23/01	X	X	X	
	CXBG2-GW02	8/14/01	X	X	X	
	CXBG2-GW03	8/14/01	X	X	X	
	CXBG3-GW01	8/20/01	X	X	X	
	CXBG3-GW02	8/21/01	X	X	X	
	CXBG3-GW03	8/15/01	X	X	X	
	CXBG4-GW01	8/24/01	X	X	X	
	CXBG4-GW02	8/24/01	X	X	X	
	CXBG4-GW03	8/23/01	X	X	X	

[1] TCL organics include volatile organic compounds, semivolatile organic compounds, pesticides, and PCBs.

TCL = Target Compound List
TAL = Target Analyte List

TABLE 5-1
(Continued)
SUMMARY GROUNDWATER AND SOIL SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

MEDIUM	SAMPLE IDENTIFICATION	DATE COLLECTED	SAMPLE DEPTH	REQUESTED ANALYSES			COMMENTS
				TCL Organics[2]	TAL Inorganics	CN	
Surface Soil Samples	CXBG1-SS01-00	8/06/01	0-6 inches	X	X	X	
	CXBG1-SS02-00	7/25/01	0-6 inches	X	X	X	
	CXBG1-SS03-00	7/25/01	0-6 inches	X	X	X	
	CXBG1-SS04-00	8/06/01	0-6 inches	X	X	X	
	CXBG1-SS05-00	8/06/01	0-6 inches	X	X	X	
	CXBG1-SS06-00	8/06/01	0-6 inches	X	X	X	
	CXBG1-SS07-00	7/25/01	0-6 inches	X	X	X	
	CXBG1-SS08-00	7/25/01	0-6 inches	X	X	X	
	CXBG1-SS09-00	7/25/01	0-6 inches	X	X	X	
	CXBG1-SS10-00	7/25/01	0-6 inches	X	X	X	
	CXBG2-SS01-00	7/27/01	0-6 inches	X	X	X	
	CXBG2-SS02-00	7/24/01	0-6 inches	X	X	X	
	CXBG2-SS03-00	7/25/01	0-6 inches	X	X	X	
	CXBG2-SS04-00	7/26/01	0-6 inches	X	X	X	
	CXBG2-SS05-00	7/26/01	0-6 inches	X	X	X	
	CXBG2-SS06-00	7/27/01	0-6 inches	X	X	X	
	CXBG2-SS07-00	7/24/01	0-6 inches	X	X	X	
	CXBG2-SS08-00	7/24/01	0-6 inches	X	X	X	
	CXBG2-SS09-00	7/24/01	0-6 inches	X	X	X	
	CXBG2-SS10-00	7/25/01	0-6 inches	X	X	X	

[2] TCL organics include semivolatile organic compounds, pesticides, and PCBs.

TCL - Target Compound List
TAL - Target Analyte List

TABLE 5-1
(Continued)
SUMMARY GROUNDWATER AND SOIL SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

MEDIUM	SAMPLE IDENTIFICATION	DATE COLLECTED	SAMPLE DEPTH	REQUESTED ANALYSES			COMMENTS
				TCL Organics[2]	TAL Inorganics	CN	
Surface Soil Samples	CXBG3-SS01-00	7/23/01	0-6 inches	X	X	X	
	CXBG3-SS02-00	7/24/01	0-6 inches	X	X	X	
	CXBG3-SS03-00	7/24/01	0-6 inches	X	X	X	
	CXBG3-SS04-00	7/23/01	0-6 inches	X	X	X	
	CXBG3-SS05-00	7/24/01	0-6 inches	X	X	X	
	CXBG3-SS06-00	7/24/01	0-6 inches	X	X	X	
	CXBG3-SS07-00	7/24/01	0-6 inches	X	X	X	
	CXBG3-SS08-00	7/24/01	0-6 inches	X	X	X	
	CXBG3-SS09-00	7/23/01	0-6 inches	X	X	X	
	CXBG3-SS10-00	7/23/01	0-6 inches	X	X	X	
	CXBG4-SS01-00	7/26/01	0-6 inches	X	X	X	
	CXBG4-SS02-00	7/27/01	0-6 inches	X	X	X	
	CXBG4-SS03-00	7/26/01	0-6 inches	X	X	X	
	CXBG4-SS04-00	7/26/01	0-6 inches	X	X	X	
	CXBG4-SS05-00	7/26/01	0-6 inches	X	X	X	
	CXBG4-SS06-00	7/26/01	0-6 inches	X	X	X	
	CXBG4-SS07-00	7/27/01	0-6 inches	X	X	X	
	CXBG4-SS08-00	7/27/01	0-6 inches	X	X	X	
	CXBG4-SS09-00	7/27/01	0-6 inches	X	X	X	
	CXBG4-SS10-00	7/26/01	0-6 inches	X	X	X	

[2] TCL organics include semivolatile organic compounds, pesticides, and PCBs.

TCL = Target Compound List
TAL = Target Analyte List

TABLE 5-1
(Continued)
SUMMARY GROUNDWATER AND SOIL SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

MEDIUM	SAMPLE IDENTIFICATION	DATE COLLECTED	SAMPLE DEPTH	REQUESTED ANALYSES			COMMENTS
				TCL Organics[3]	TAL Inorganics	CN & TOC	
Subsurface Soil Samples	CXBG1-SB01-01	8/06/01	6-24 inches	X	X	X	
	CXBG1-SB02-01	7/25/01	6-24 inches	X	X	X	
	CXBG1-SB03-01	7/25/01	6-24 inches	X	X	X	
	CXBG1-SB04-01	8/06/01	6-24 inches	X	X	X	
	CXBG1-SB05-01	8/06/01	6-24 inches	X	X	X	
	CXBG1-SB06-01	8/06/01	6-24 inches	X	X	X	
	CXBG1-SB07-01	7/25/01	6-24 inches	X	X	X	
	CXBG1-SB08-01	7/25/01	6-24 inches	X	X	X	
	CXBG1-SB09-01	7/25/01	6-24 inches	X	X	X	
	CXBG1-SB10-01	7/25/01	6-24 inches	X	X	X	
	CXBG2-SB01-00	7/27/01	6-24 inches	X	X	X	
	CXBG2-SB02-00	7/24/01	6-24 inches	X	X	X	
	CXBG2-SB03-00	7/25/01	6-24 inches	X	X	X	
	CXBG2-SB04-00	7/26/01	6-24 inches	X	X	X	
	CXBG2-SB05-00	7/26/01	6-24 inches	X	X	X	
	CXBG2-SB06-00	7/27/01	6-24 inches	X	X	X	
	CXBG2-SB07-00	7/24/01	6-24 inches	X	X	X	
	CXBG2-SB08-00	7/24/01	6-24 inches	X	X	X	
	CXBG2-SB09-00	7/24/01	6-24 inches	X	X	X	
	CXBG2-SB10-00	7/25/01	6-24 inches	X	X	X	

[3] TCL organics include volatile organic compounds, semivolatile organic compounds, pesticides, and PCBs.

TCL = Target Compound List
TAL = Target Analyte List
TOC = Total Organic Carbon

TABLE 5-1
(Continued)
SUMMARY GROUNDWATER AND SOIL SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

MEDIUM	SAMPLE IDENTIFICATION	DATE COLLECTED	SAMPLE DEPTH	REQUESTED ANALYSES			COMMENTS
				TCL Organics[3]	TAL Inorganics	CN & TOC	
Subsurface Soil Samples	CXBG3-SB01-01	7/23/01	6-24 inches	X	X	X	
	CXBG3-SB02-01	7/24/01	6-24 inches	X	X	X	
	CXBG3-SB03-01	7/24/01	6-24 inches	X	X	X	
	CXBG3-SB04-01	7/23/01	6-24 inches	X	X	X	
	CXBG3-SB05-01	7/24/01	6-24 inches	X	X	X	
	CXBG3-SB06-01	7/24/01	6-24 inches	X	X	X	
	CXBG3-SB07-01	7/24/01	6-24 inches	X	X	X	
	CXBG3-SB08-01	7/24/01	6-24 inches	X	X	X	
	CXBG3-SB09-01	7/23/01	6-24 inches	X	X	X	
	CXBG3-SB10-01	7/23/01	6-24 inches	X	X	X	
	CXBG4-SB01-01	7/26/01	6-24 inches	X	X	X	
	CXBG4-SB02-01	7/27/01	6-24 inches	X	X	X	
	CXBG4-SB03-01	7/26/01	6-24 inches	X	X	X	
	CXBG4-SB04-01	7/26/01	6-24 inches	X	X	X	
	CXBG4-SB05-01	7/26/01	6-24 inches	X	X	X	
	CXBG4-SB06-01	7/26/01	6-24 inches	X	X	X	
	CXBG4-SB07-01	7/27/01	6-24 inches	X	X	X	
	CXBG4-SB08-01	7/27/01	6-24 inches	X	X	X	
	CXBG4-SB09-01	7/27/01	6-24 inches	X	X	X	
	CXBG4-SB10-01	7/26/01	6-24 inches	X	X	X	

[3] TCL organics include volatile organic compounds, semivolatile organic compounds, pesticides, and PCBs.

TCL = Target Compound List
TAL = Target Analyte List
TOC = Total Organic Carbon

TABLE 5-2

SUMMARY QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

QA/QC TYPE (MEDIUM)	SAMPLE IDENTIFICATION	DATE COLLECTED	REQUESTED ANALYSES			COMMENTS
			TCL Organics[1]	TAL Inorganics	CN	
Field Blanks (Aqueous)	CXBG-FB01	7/30/01	X	X	X	Distilled Water for Equipment Decon
	CXBG-FB02	7/30/01	X	X	X	Deionized Water for Rinsate Blanks
	CXBG-FB03	8/08/01	X	X + filtered	X	Tank Water from Rig Support Truck
Rinsate Blanks (Aqueous)	CXBG-RS01	7/24/01	X	X	X	Disposable Pie Pan Rinsed
	CXBG-RS02	7/24/01	X	X	X	Hand Auger Bucket Rinsed
	CXBG-RS03	7/25/01	X	X	X	Stainless Steel Spoon Rinsed
	CXBG-RS04	7/30/01	X	X	X	Disposable Pie Pan Rinsed
	CXBG-RS05	8/08/01	X	X	X	Disposable Pie Pan Rinsed
	CXBG-RS06	8/14/01	X	X + filtered	X	Rigid & Flex Tubing Rinsed
	CXBG-RS07	8/20/01	X	X + filtered	X	¼" Black Tubing Rinsed
	CXBG-RS08	8/24/01	X	X + filtered	X	Flex Tubing Rinsed
Trip Blanks (Aqueous)	CXBG-TB01	7/25/01	X			VOC analysis only
	CXBG-TB02	7/27/01	X			"
	CXBG-TB03	7/30/01	X			"
	CXBG-TB04	8/06/01	X			"
	CXBG-TB05	8/15/01	X			"
	CXBG-TB06	8/21/01	X			"
	CXBG-TB07	8/24/01	X			"

(1) TCL organics include volatile organic compounds (VOC), semivolatile organic compounds, pesticides, and PCBs.

TCL = Target Compound List
TAL = Target Analyte List

TABLE 5-2
(Continued)
SUMMARY QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) SAMPLES AND ANALYSES
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

QA/QC TYPE (MEDIUM)	SAMPLE IDENTIFICATION	DATE COLLECTED	SAMPLE DEPTH	REQUESTED ANALYSES			COMMENTS
				TCL Organics[1]	TAL Inorganics	CN	
Matrix Spike/ Matrix Spike Duplicate (Aqueous)	CXBG3-GW01	8/20/01	NA	X	X	X	MS and MSD
Duplicates (Aqueous)	CXBG1-GW03D	8/20/01	NA	X	X	X	
	CXBG3-GW01D	8/20/01	NA	X	X	X	
Matrix Spike/ Matrix Spike Duplicate (Soil)	CXBG1-SS05-00	8/06/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG1-SB05-01	8/06/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis
	CXBG2-SS01-00	7/27/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG2-SB01-01	7/27/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis
	CXBG4-SS01-00	7/26/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG4-SB01-01	7/26/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis
Duplicates (Soil)	CXBG1-SS05-00D	8/06/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG1-SB05-01D	8/06/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis
	CXBG2-SS01-00D	7/27/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG2-SB01-01D	7/27/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis
	CXBG3-SS01-00D	7/23/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG3-SB06-01D	7/23/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis
	CXBG4-SS01-00D	7/26/01	0-6 inches	X	X	X	MS & MSD, No VOC analysis
	CXBG4-SB01-01D	7/26/01	6-24 inches	X	X	X	MS & MSD, plus TOC analysis

[1] TCL organics include volatile organic compounds (VOC), semivolatile organic compounds, pesticides, and PCBs.

NA = Not Applicable
TCL=Target Compound List
TAL=Target Analyte List
TOC = Total Organic Carbon

TABLE 5-3

SUMMARY OF WELL CONSTRUCTION DETAILS
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

Monitoring Well	Date Installed	Boring Depth (feet bgs)	Well Depth (feet bgs)	Screen Interval (feet)	Sand Pack Interval (feet)	Bentonite Interval (feet)
CXBG1-MW01	8/12/2001	10.0	10.0	5.0 - 10.0	3.0 - 10.0	1.0 - 3.0
CXBG1-MW02	8/12/2001	10.0	10.0	3.0 - 10.0	2.0 - 10.0	1.0 - 2.0
CXBG1-MW03	8/12/2001	7.0	7.0	2.0 - 7.0	1.5 - 7.0	0.5 - 1.5
CXBG2-MW01	8/21/2001	16.0	16.0	6.0 - 16.0	4.0 - 16.0	2.0 - 4.0
CXBG2-MW02	8/9/2001	19.0	19.0	9.0 - 19.0	7.0 - 19.0	5.0 - 7.0
CXBG2-MW03	8/9/2001	26.0	26.0	16.0 - 26.0	14.0 - 26.0	12.0 - 14.0
CXBG3-MW01	8/8/2001	38.0	38.0	23.0 - 38.0	21.0 - 38.0	19.0 - 21.0
CXBG3-MW02	8/7/2001	38.0	38.0	23.0 - 38.0	21.0 - 38.0	19.0 - 21.0
CXBG3-MW03	8/8/2001	32.0	32.0	22.0 - 32.0	20.0 - 32.0	18.0 - 20.0
CXBG4-MW01	8/22/2001	9.0	9.0	4.0 - 9.0	2.0 - 9.0	0.5 - 2.0
CXBG4-MW02	8/22/2001	44.0	44.0	34.0 - 44.0	32.0 - 44.0	30.0 - 32.0

Notes:

bgs = Below ground surface

6.0 PHYSICAL RESULTS OF FIELD INVESTIGATION

The following subsections present results of the investigation and information pertaining to the physiography, geologic and hydrogeologic conditions, and field measurements.

The geologic and hydrogeologic conditions at CAX and the northern portions of WPNSTA were investigated through the classification of two 100-foot exploratory soil borings and eleven borings made in conjunction with monitoring well installation. Records of the subsurface lithology, well completion details, geotechnical characteristics (Standard Penetration Test [SPT] values and other physical features such as color, grain size, moisture content, etc.,) are recorded on Test Boring/Well Construction Records, which are presented in Appendix B.

6.1 General Physiography

Cheatham Annex (CAX) is located in the southeast portion of Virginia on the York-James Peninsula. The annex is located in northern portion of York County and is adjacent to James City County. CAX is situated in the Atlantic Coastal Plain Physiographic Province. This province extends from the Atlantic Ocean westward for 75 to 90 miles where it borders the Piedmont Physiographic Province. The Coastal Plain consists of unconsolidated sediments, with its topography split into a number of terraces of different elevations each bounded by scarp (cut out) features. The fluctuating levels of the sea and subsequent shoreline erosion process formed these terraces and scarps over geologic history (Brockman et al, 1997).

The Coastal Province is comprised of four terraces. The terraces from highest to lowest are: Lackey Plain, Croaker Flat, Huntington Flat, and Grafton Plain. Three scarps are also found within this province; the Kingsmill, the Lee Hall, and the Camp Peary. The terraces and scarps at CAX parallel the York River. They are identified from west to east as the Lackey Plain and Croaker Flat terraces, and the Camp Peary scarp (Brockman et al, 1997).

6.2 Geologic and Hydrogeologic Conditions

The following subsections present descriptions of the geologic and hydrogeologic settings at CAX and are based on the findings of this investigation.

6.2.1 Geologic Setting

The Atlantic Coastal Plain physiographic province is underlain by unconsolidated sediments of Quaternary, Tertiary, and Cretaceous ages that dip gently to the southeast and have a combined thickness of approximately 1,900 ft in the vicinity of CAX (Teifke, 1973).

Most of the surficial unconsolidated sediment at CAX has been mapped as the Shirley Formation of the Pleistocene series (Mixon et. al., 1989). This formation is composed of gravel, sand, silt, clay, and peat deposited in river and estuarine environments. Its thickness is estimated to vary from 0- to 80-ft. The Chuckatuck Formation of Pleistocene age underlies the Shirley Formation and is described as sand, silt, and clay with minor amounts of peat deposited in bay environments. The Chuckatuck Formation rests on the top of the Windsor Formation, also of Pleistocene age. This formation is composed of a series of sand and silt deposited in marine and estuarine environments. Its thickness is estimated to vary from 0- to 40-ft.

The Bacons Castle Formation of Pliocene age underlies the Windsor Formation and is described as a clayey silt and silty fine-grained sand. The Bacons Castle Formation rests unconformably on the weathered top of the Upper Yorktown Formation, also of Pliocene age. Identification of the Yorktown Formation has been well established with the presence of calcite-cemented shells and shell fragments, which are common characteristics of the upper portion of the formation. This type of lithology was encountered during this field investigation. Figure 6-1 provides a relationship between age, geologic unit and hydrogeological unit of formations mentioned above.

The strata encountered at the background monitoring well locations consist of layers of sand, silt, clay, shell/shell fragments, and combinations thereof. Gravel-sized oxidation nodules (ferricrete) and quartzitic fragments were also encountered (but are not wide spread).

Two cross-sections were generated from the soil boring and monitoring well lithologic logs. Figure 6-2 presents the location of Cross-section A to A' in the northeast to southwest traverse and Cross-section B to B' in the north to south traverse. Figures 6-3 and 6-4 present Cross-sections A- to A' and B- to B'. The strata encountered at the background monitoring well locations consist of layers of sand, silt, clay, shell/shell fragments, and combinations thereof. Gravel-sized oxidation nodules (ferricrete) and quartzitic fragments were also encountered (but are not wide spread). Refer to the boring logs in Appendix B for detailed descriptions of the strata encountered at each monitoring well location.

6.3 CAX Hydrogeology

The Atlantic Coastal Plain sediments are the most important source of potable water in the region. Recharge to the groundwater system is derived from precipitation. Approximately 50 percent of the precipitation is lost to evapotranspiration. The remaining 50 percent either results in surface runoff or infiltrates and is introduced into the groundwater regime. Recharge of aquifers may occur at the surface near outcrop zones, or from downward migration from overlying strata.

The hydrogeology of the York County shallow aquifer system at CAX Yorktown is comprised of the following five units: (1) the Columbia aquifer, (2) the Cornwallis Cave confining unit, (3) the Cornwallis Cave aquifer, (4) the Yorktown confining unit, and (5) the Yorktown-Eastover aquifer. Below this shallow aquifer system is the Eastover-Calvert confining unit (Brockman et al, 1997). These hydrogeologic units are discussed below and their relation to the geologic units are listed in Figure 6-1.

The undivided York County shallow aquifer system exists where one or more of the confining units commonly present in other areas of the county is absent (typically adjacent to the York River), and two or more aquifers form one hydraulic unit. The Columbia aquifer consists of sandy deposits, which exist under unconfined (water table) conditions. This surficial aquifer was not identified during this investigation. Clayey or silty sediments typically comprise the Cornwallis Cave confining unit, which underlie the Columbia aquifer. Most of York County is underlain by the Columbia aquifer and Cornwallis Cave confining unit, but the units are missing in areas of western and west-central York County and at CAX Yorktown along the York River in an area referred to as the Camp Peary scarp.

The Cornwallis Cave aquifer consists of sandy and shelly sediments and is defined by the water table (where unconfined). This aquifer is usually distinguished by the discontinuous shell hash deposits of the Yorktown Formation but for the most part this aquifer is comprised of silt, clay, with minor amounts of fine grained sand. During this field investigation the Cornwallis Cave aquifer was encountered.

The Yorktown confining unit, which underlies the Cornwallis Cave aquifer, is comprised of clay and silt and is usually distinguishable by its dark greenish gray color.

The Yorktown-Eastover aquifer underlies the Yorktown confining unit, which is comprised of sandy and shelly sediments which is typically confined, but locally may be unconfined (e.g., adjacent to the York River).

The basal unit within York County is the Eastover-Calvert confining unit, which consists of silt and clay.

6.4 Field Measurements

Field measurements recorded during the background investigation include groundwater level measurements and water quality parameters associated with purging.

6.4.1 Water Quality Parameters

Specific conductance, temperature, pH, and turbidity, were recorded in association with monitoring well purging prior to groundwater sample collection as discussed in Section 5.6.3. Monitoring well purge data are presented on Table 6-1.

6.4.1.1 Specific Conductance

Specific conductance is defined as the tendency of fluid to transmit an electrical current and is related to the concentration and charge of ions present. Specific conductance values ranged from approximately 53 to 810 micromhos per centimeter (µmhos/cm). Values of specific conductance were greater than 200 µmhos/cm except for the groundwater sample collected from monitoring well CXBG3-MW01 (approximately 53 µmhos/cm).

6.41.2 Groundwater Temperature

Groundwater temperatures varied from approximately 16 to 23 degrees Celsius. The majority of the wells sampled had groundwater temperatures below 19 degrees Celsius except CXBG1-MW02, CXBG1-MW03, CXBG3-MW03, and CXBG4-MW02. These wells had average temperature the ranged from 20.1 degrees Celsius (CXBG4-MW02) and 22.6 degrees Celsius (CXBG1-MW03).

6.4.1.3 pH

The water quality parameter pH is defined as the negative logarithm (base 10) of hydrogen ion activity. Water is acidic if the pH is less than 7, neutral if the pH is equal to 7, and alkaline if the pH is greater than 7. In most groundwater, pH ranges from 6 to 8.5 (Driscoll, 1986). The pH values for the groundwater sample collected from the background monitoring wells ranged from approximately 4.64 (CXBG3-MW01) to 7.3 (CXBG4-MW03).

TABLES

TABLE 6-1

GROUNDWATER FIELD PARAMETERS
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

Well Number Sample Date	Measuring Time	Well Volumes	Field Parameters			
			Temperature (°C)	pH (S.U.)	Specific Conductance (umhos/cm)	Turbidity (N.T.U.)
CXBG1-MW01 8/21/01	1510	1.0	18.9	6.67	809	141
	1517	2.0	18.3	6.70	805	35.6
	1525	3.0	18.3	6.70	804	19.4
	1533	4.0	18.4	6.71	810	5.1
CXBG1-MW02 8/15/01	1335	1.0	23.5	6.45	210	7.4
	1341	2.0	22.3	6.51	203	5.74
	1350	3.0	22.1	6.57	203	10
	1402	4.0	--	--	--	3.3
CXBG1-MW03 8/20/01	1135	1.0	22.9	5.20	259	9.75
	1155	2.0	22.1	5.10	252	5.83
	1210	3.0	22.3	5.10	247	1.8
CXBG2-MW01 8/23/01	1240	1.0	17.7	6.90	640	5.21
	1253	2.0	17.5	6.82	638	0.9
	1303	3.0	17.9	6.80	631	0.2
CXBG2-MW02 8/14/01	1624	1.0	16.7	6.80	673	13
	1628	2.0	17.5	6.40	693	43
	1638	3.0	17.0	6.90	697	18
	1645	4.0	16.6	6.96	697	90
	1652	5.0	--	--	--	40
	1722	11.0	--	--	--	5.9
CXBG2-MW03 8/14/01	1515	1.0	16.7	6.51	635	310
	1520	2.0	16.3	6.47	645	22
	1529	3.0	16.0	6.58	650	6.3
	1536	4.0	--	--	--	4.3

Notes:

°C = Degrees Centigrade
S.U. = Standard Units
umhos/cm = Micro ohms per centimeter
mg/L = Milligrams per liter
N.T.U. = Nephlometric Turbidity Units
NA = Not Available
-- = Water quality readings stable, additional readings not taken

TABLE 6-1(continued)

GROUNDWATER FIELD PARAMETERS
BACKGROUND INVESTIGATION
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

Well Number Sample Date	Measuring Time	Well Volumes	Field Parameters			
			Temperature (°C)	pH (S.U.)	Specific Conductance (umhos/cm)	Turbidity (N.T.U.)
CXBG3-MW01	1414	1.0	17.6	4.69	70.6	>999
8/20/01	1423	2.0	17.8	4.64	52.8	>999
	1434	3.0	18.3	4.83	65.4	174
	1442	4.0	19.0	4.90	65.1	48.3
	1448	5.0	18.7	4.97	65.4	16.1
	1500	6.0	18.5	5.00	64.4	7.48
	15.09	7.0	--	--	--	4.99
CXBG3-MW02	0912	1.0	16.1	7.07	663	>999
8/15/01	0939	2.0	16.6	7.11	518	970
	1001	3.0	17.2	7.12	500	189
	1027	4.0	17.1	7.14	495	26.8
	1039	5.0	--	--	--	12.6
	1044	6.0	--	--	--	10.4
	1051	7.0	--	--	--	7.8
	1109	8.0	--	--	--	4.72
CXBG3-MW03	1020	1.0	--	--	--	--
8/15/01	1026	2.0	21.4	7.18	570	1100
(1)	1044	3.0	22.5	7.08	578	1100
	1105	4.0	20.4	7.11	574	1059
CXBG4-MW01	1240	1.0	17.7	6.90	640	5.21
8/23/01	1253	2.0	17.5	6.82	638	0.9
	1303	3.0	17.9	6.80	631	0.2
CXBG4-MW02	1200	1.0	20.1	6.80	685	303
8/24/01	1212	2.0	20.1	6.40	674	125
	1226	3.0	20.1	6.90	679	20.6
	1321	8.0	--	--	--	10.3
CXBG4-MW03	1350	1.0	17.5	7.30	404	391
8/14/01	1355	2.0	17.3	7.19	420	268
	1405	3.0	18.2	7.25	411	115
	1440	8.0	--	--	--	5.02

Notes:

°C = Degrees Centigrade
S.U. = Standard Units
umhos/cm = Micro ohms per centimeter
mg/L = Milligrams per liter
N.T.U. = Nephlometric Turbidity Units
NA = Not Available
-- = Water quality readings stable, additional readings not taken
(1) Well pumped dry and allowed to recharge three times before sampling.

7.0 ANALYTICAL RESULTS

This section presents the quantitative findings of the background investigation, performed from July through August 2001. Surface soil, subsurface soil, and groundwater samples collected as part of the background investigation were analyzed for characterization purposes to identify ambient levels of inorganic and organic constituents at CAX. Background locations were chosen in areas that were unimpacted by past operations at CAX. These data will provide a basis for evaluating the naturally occurring or anthropogenic concentrations of inorganic and organic constituents against concentrations associated with site-related contamination. Positive detections from each media are presented on Tables 7-1 through 7-3. Complete data and statistical summary tables are presented in Appendices C through E.

7.1 Data Quality

The quality of the data collected as part of this investigation has been assessed for its accuracy and precision with respect to prescribed requirements or specifications. To make these determinations, data quality evaluations were conducted by an independent, third-party, data validator. Data were evaluated in accordance with the criteria established by USEPA guidelines, Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses (USEPA, 1988), specific method requirements in OLM02.1, USEPA Region III modifications, Level D data requirements, and professional judgement. Validation of the analytical data serves to reduce the inherent uncertainties with its usability.

Analytical data were evaluated to determine the usability of the results as well as contractual compliance relative to deliverables and the previously cited requirements. Data validation also provided an interpretation of the reported quality control results. At a minimum, ten percent of all laboratory calculations were verified as part of this validation. In addition, all instrument output (e.g., spectra, chromatograms) for each sample were carefully reviewed. Data quality was evaluated based on, but not limited to the following analyses:

- Data completeness
- Holding times
- Calibrations
- Blanks
- Surrogate recoveries

- Laboratory control samples
- Laboratory and field duplicates
- MS/MSD samples
- Internal standard performance
- Compound identification
- Compound quantitation

Based upon the results of this evaluation, some analytical results have been "qualified" with regard to usability. Qualified data are typically flagged with a letter qualifier, representing an associated explanatory note needed to clarify the corresponding analytical results. Many qualifiers, such as "J," "K," "L," and "P" indicate that the value reported is estimated. Estimated results within a data set are common and considered to be usable by the USEPA (USEPA, 1989). Data may be qualified as estimated for several reasons including an exceedance of holding times, high or low surrogate recovery, or intra-sample variability. In addition, values may be assigned and estimated qualifier if the reported value is below the Contract Required Detection Limit (CRDL) or the Contract Required Quantitation Limit (CRQL). Data qualified with the letter "U" or "B" were considered to be non-detects. Data assigned a rejected, "R" qualifier, were excluded from the usable data set. Other qualified data were retained in the usable data set.

The qualifiers appearing in the analytical tables include the following:

B – Not detected substantially above the level reported in laboratory or field blanks

E – Analyte present. Concentration exceeded upper level of calibration range of instrument.

J – Analyte present. Reported value may not be accurate or precise.

K – Analyte present. Reported value may be biased high. Actual value is expected to be lower.

L – Analyte present. Reported value may be biased low. Actual value is expected to be higher.

N – Analyte presumed to be present. Tentatively identified compound.

P – Analyte present. Pesticide or Aroclor target analyte with greater than 25 percent difference for detected concentrations between two gas chromatograph columns.

R – Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result. Data are excluded from usable data set.

U – Not detected. The associated number indicated approximate sample concentration necessary to be detected. When used in conjunction with another qualifier, "U" indicates that the compound is not detected and that the quantitation limit is estimated.

NA – Not analyzed/Not applicable. Compound was either not analyzed for or, in the case of statistical summaries, value could not be calculated or does not apply.

7.2 Data Management and Tracking

The management and tracking of samples and subsequent data from the time of field collection to receipt of the validated electronic analytical results is of primary importance for the overall quality of the analytical results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody forms, included as Appendix A. The chain-of-custody forms were checked against the Final FSAP (Baker, 2001d) to determine if all designated samples were collected for the appropriate parameters. Upon receipt of the laboratory results, a comparison of the field information was made to determine if each sample received by the laboratory was analyzed for the correct parameters. Similarly, the validated information was compared to laboratory information as a final check. In summary, the tracking information was used to identify the following items:

- Identify sample discrepancies between the analysis plan and the field investigation;
- Verify that the laboratory received all samples, and analyzed for the correct parameters;
- Verify that the data validator received a complete data set; and
- Ensure that a complete data set was available for each media of concern prior to entering results into the databases.

7.3 QA/QC Sample Results

As part of the requirements for field quality control under the Naval Facilities Engineering Service Center (NFESC), three types of QA/QC blanks were evaluated: field blanks, equipment rinsate blanks, and trip blanks. Laboratory QC samples (extra volume collected for MS/MSD) were collected in the field. In addition, laboratory and field duplicate sample results were

evaluated during validation based on relative percent difference (RPD) to assess variabilities of the measurement process and sampling techniques, respectively.

This section discusses the results of field blanks, equipment rinsate blanks, and trip blanks. MS/MSD sample results and laboratory duplicate sample results are not presented in this section because they represent laboratory quality control checks that are evaluated by the data validator. Analytical results for field duplicates are presented with media-specific data on Tables 7-1 through 7-3. The analytical results for organic and inorganic parameters for field blanks, equipment rinsate blanks, and trip blanks are provided on Tables 7-4 through 7-6. The following subsections discuss the results for each set of blanks.

7.3.1 Field Blanks

Three field blanks were collected as part of the Background Investigation. CXBG-FB01 was collected from distilled water used for equipment decontamination, CXBG-FB02 was collected from deionized water used for equipment rinsate blanks, and CXBG-FB03 was collected from tank water from the drill rig support truck. Table 7-4 summarizes compounds detected in one or more field blanks. The field blanks were analyzed for TCL organics and TAL inorganics (unfiltered) and cyanide. CXBG-FB03 was also analyzed for filtered fractions of TAL inorganics.

No chemicals were detected in CXBG-FB01.

The inorganics potassium and sodium were detected in CXBG-FB02. Potassium and sodium are essential nutrients that are commonly present in low concentrations in water supplies. The pesticide alpha-chlordane was also detected in CXBG-FB02 at an estimated concentration of 0.015 ug/L. This is a low-level detection and is qualified as estimated because it is below the method reporting limit. It is noted that although CXBG-FB02 was a sample of the water used for equipment rinsates, alpha-chlordane was not detected in any of the equipment rinsate samples.

The organics dibromodichloromethane, chloroform, dibromochloromethane, and bis(2-ethylhexyl)phthalate were detected in CXBG-FB03. A number of inorganics were also detected in CXBG-FB03 including barium calcium, copper (filtered only), iron, magnesium, manganese, nickel, potassium, sodium, and zinc (filtered only). These constituents occur naturally in groundwater and surface water and are commonly present at low concentrations in water supplies.

7.3.2 Equipment Rinsate Blanks

Eight equipment rinsate blanks were collected as part of the Background Investigation. Table 5-2 provides information regarding the source of each rinsate blank. Each sample was analyzed for TCL organics and TAL inorganics (unfiltered) and cyanide. CXBG-RS06, CXGB-RS7, and CXBG-RS08 were also analyzed for filtered fractions of TAL inorganics. Table 7-5 summarizes compounds detected in one or more equipment rinsate blanks.

The volatile organic compounds acetone, methylene chloride, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate were detected in multiple rinsate blanks. These compounds are common laboratory contaminants. The pesticide aldrin was detected in CXBG-RS06 and the pesticide heptachlor epoxide was detected in CXBG-RS02 and CXBG-RS06 at low levels. Low levels of inorganic constituents (total fraction) were detected in all equipment rinsate blanks except CXBG-RS03, CXBG-RS06, and CXBG-RS07. These inorganics included antimony, barium, chromium, cobalt, nickel, selenium, sodium, and vanadium. Dissolved fractions of chromium and silver were detected in CXBG-RS07. Inorganic constituents occur naturally in soil and groundwater and are commonly present at low concentrations in water supplies.

7.3.3 Trip Blanks

Seven trip blanks were collected during the Background Investigation and were analyzed for VOCs. Table 7-6 summarizes compounds detected in one or more trip blanks. Methylene chloride was detected in two of the seven samples at low levels. Methylene chloride is a common laboratory contaminant.

7.4 Background Surface Soil Sample Results

Forty-four surface soil samples (including four duplicate samples) were collected and analyzed for TCL Organics (SVOCs, pesticides, and PCBs), TAL Inorganics, and cyanide. Thirteen SVOCs, 17 pesticides, and 22 inorganic compounds were detected in surface soils.

Table 7-7 presents the range and frequency of detections for the combined surface soil data set and for each soil association. Inorganics were detected in all 44 surface soil samples. Cadmium and cyanide were not detected in any of the surface soil samples. The SVOC bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected in 22 of the 44 surface soil samples. No other SVOC was detected more than once in a given soil association. One or more pesticides were detected in 25 of the surface soil samples.

Surface soil samples were collected from within all four of the soil associations present at CAX and northern WPNSTA. These soil associations include: 1) Bohicket, Johnston, and Axis Soil Association – found on marshes and floodplains in water-deposited material; 2) Dogue, Pamunkey, and Uchee Soil Association - formed on river terraces; 3) Emporia, Slagle, and Craven-Uchee Complex Soils Association – formed on coastal plain uplands; and 4) Kempsville, Emporia, Emporia Complex, and Craven-Uchee Complex Soils Association – as with Group 3, formed on coastal plain uplands (see Section 3). Positive detections in surface soils from each soil association are presented on Table 7-7.

The following constituents were detected at least once in each of the soil associations: acetophenone, bis(2-ethylhexyl)phthalate, 4,4'-DDE, alpha-chlordane, gamma-chlordane, aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, vanadium, and zinc.

The majority (68 percent) of the maximum detected concentrations of inorganics was detected in Soil Association 1. Those inorganics with maximum concentrations in Soil Association 1 include aluminum, antimony, beryllium, calcium, chromium, copper, lead, magnesium, mercury, nickel, potassium, selenium sodium, vanadium, and zinc. Soils in this association are located on marshes and floodplains in water-deposited material. They are commonly nearly level, waterlogged, and often flooded. These soils typically receive seepage and runoff from higher lying areas. Soils such as these can serve as sources, sinks, or transformers of chemicals depending on the soil type and hydrologic conditions. Soils such as these have been shown, under favorable conditions, to remove organic and inorganic constituents (and toxic materials) from water that flows across them (Mitsch, 1986). This removal can be attributed to many factors including, but not limited to: a reduction in velocity as water enters these areas causing some chemicals to "drop into" the soils; a variety of anaerobic and aerobic processes such as chemical precipitation, that remove certain chemicals from the water; and, a high contact rate between water and soils leading to a significant exchange of nutrients. In addition, as marshes and low terraces are typically zones of low energy (i.e., low velocity transport mechanism), the particle size is typically smaller than those soils deposited in higher energy environments. The mineralogy of the fine-grained soils (silts and clays) may differ from the coarser grained soils (sands and gravels).

Maximum concentrations of silver were found in Soil Association 2, on the terrace of the York River. Maximum concentrations of barium were found in Soil Association 3 and maximum concentrations of arsenic, cobalt, iron, manganese, and thallium were found in Soil Association 4. Soil Associations 3 and 4 are located in upland habitat.

7.5 Background Subsurface Soil Sample Results

Forty-four subsurface soil samples (including four duplicate samples) were collected and analyzed for TCL Organics (VOCs, SVOCs, pesticides, and PCBs), TAL Inorganics, and cyanide. Eight VOCs, three SVOCs, 11 pesticides, 18 inorganic compounds, and cyanide were detected in subsurface soils.

Table 7-8 presents the range and frequency of detections for the combined subsurface soil data set and for each soil association. Inorganics were detected in all 44 surface soil samples. Antimony, beryllium, cadmium, silver, and thallium were not detected in any of the surface soil samples. The SVOC bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected in 17 of the 44 subsurface soil samples. One or more pesticides were detected in 13 of the subsurface soil samples.

Like surface soils, subsurface soil samples were collected from within all four of the soil associations present at CAX and northern WPNSTA. Frequency of detection and the range of positive detections from each soil association are presented on Table 7-8. The following constituents were detected in subsurface soils at least once in each of the soil associations: alpha-chlordane, aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc.

As for surface soil samples, the majority (63 percent) of the maximum detected concentrations of inorganics in subsurface soils were detected in Soil Association 1. Those inorganics with maximum concentrations in Soil Association 1 include aluminum, chromium, copper, cyanide, lead, magnesium, nickel, potassium, selenium, sodium, vanadium, and zinc. Maximum concentrations of calcium were found in Soil Association 2, maximum concentrations of cobalt and manganese were found in Soil Association 3, and maximum concentrations of arsenic, barium, iron, and mercury were found in Soil Association 4.

7.6 Background Groundwater Sample Results

Fourteen groundwater samples (including four duplicate samples) were collected and analyzed for TCL Organics (VOCs, SVOCs, pesticides, and PCBs), TAL Inorganics (filtered and unfiltered), and cyanide. Three VOCs, 16 inorganic compounds (total fraction), and 12 inorganic compounds (filtered fraction) were detected in groundwater.

Table 7-9 presents the range and frequency of detections for the combined groundwater data set and for groundwater collected from each soil association. Inorganics were detected in all 14 groundwater samples. In unfiltered water, beryllium, cadmium, lead, mercury, nickel, selenium, silver, and cyanide were not detected. In filtered water, aluminum, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc were not detected.

The VOC carbon disulfide was detected in 4 groundwater samples, all collected from monitoring wells in Soil Association 1. Methylene chloride, a common laboratory contaminant, was detected in groundwater from Soil Associations 1 and 3. Toluene, another common laboratory contaminant, was detected in groundwater from Soil Associations 1 and 4.

Total fractions of antimony and chromium and dissolved fractions of potassium were detected at least once from groundwater in each soil association. Fifty-six percent of maximum detected concentrations of total (unfiltered) inorganics were detected in groundwater from monitoring wells in Soil Association 1. These total inorganics include calcium, copper, iron, magnesium, manganese, potassium, sodium, thallium, and vanadium. Maximum detected concentrations of cobalt and zinc were found in groundwater from Soil Association 3. Maximum detections of antimony were found in groundwater from Soil Associations 3 and 4. Maximum detections of aluminum, arsenic, barium, and chromium were found in groundwater from Soil Association 4.

Seventy-five percent of maximum detected concentrations of dissolved (filtered) inorganics were detected in groundwater from Soil Association 1. These dissolved inorganics include calcium, iron, magnesium, manganese, potassium, silver, sodium, thallium, and vanadium. Maximum dissolved concentrations of cobalt were detected in groundwater from Soil Association 3. Maximum dissolved concentrations of antimony and arsenic were detected in groundwater from Soil Association 4.

As discussed in Section 5.6.3, low-flow purging and sampling procedures were employed in order to decrease the quantity of suspended particulates in groundwater samples. For the Background Investigation, the detected concentrations of analytes in filtered groundwater samples are only slightly lower than those for unfiltered samples. Silver was detected in one filtered groundwater sample but not in any of the non-filtered samples. Aluminum, barium, chromium, copper, and zinc were detected in unfiltered but not filtered groundwater samples.

YORK
RIVER

LIVE FIRE
AREA

BOUNDRY
STAKES

TOP OF BANK

H.H.

SKEET
RANGE

℄ RANGE

℄ RADIUS

90.0'

360'

18.0'

282.0'

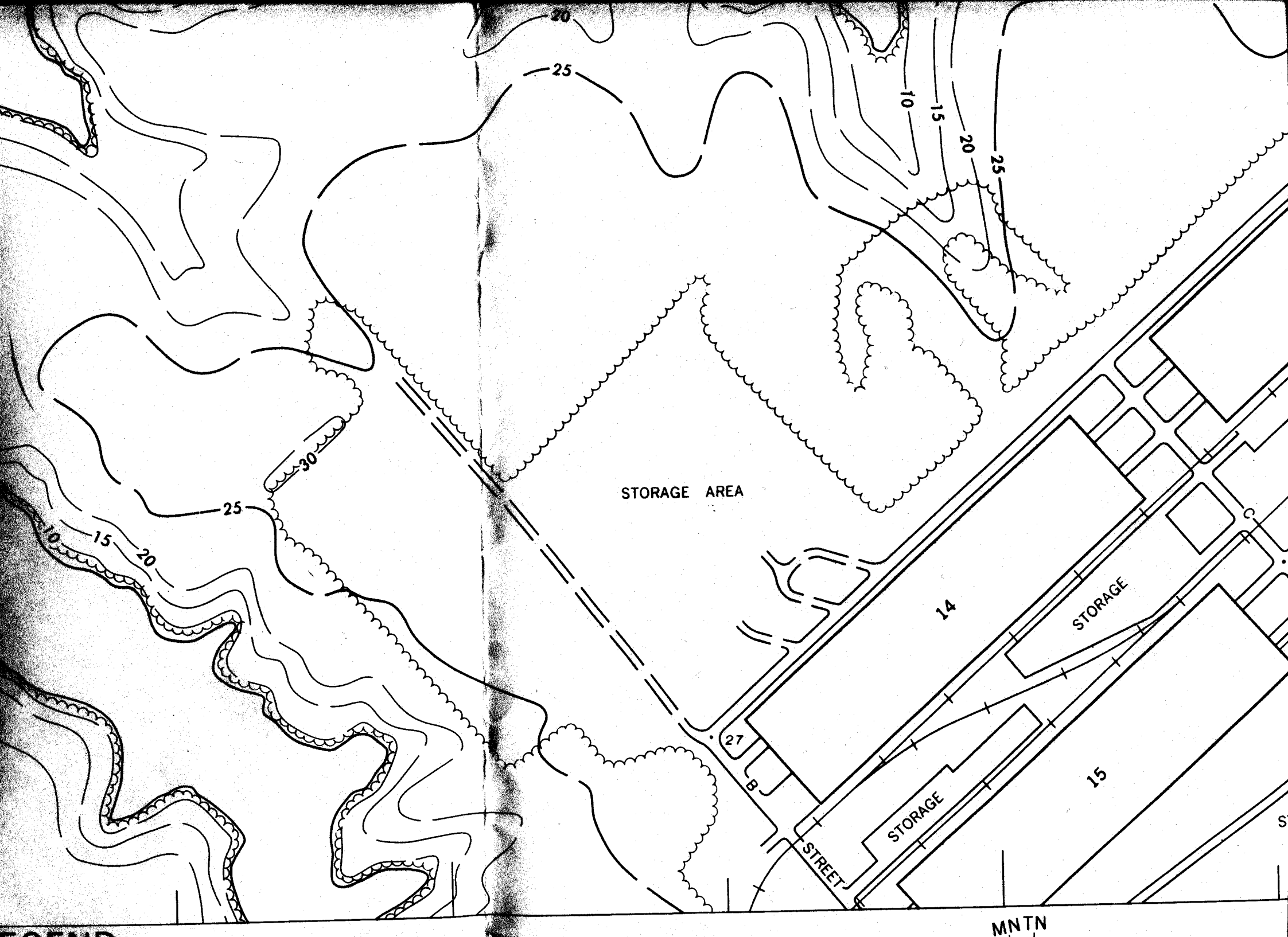
180.0'

PISTOL
RANGE

BURM

GATE

WALK-IN
GATE


20
25
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20
STORAGE AREA
14
STORAGE
C
27
B
STORAGE
15
STREET
MNTN

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INTRODUCTION

An inventory for rare, threatened and endangered species occurring within the boundaries of Cheatham Annex was conducted by the science staff of the Virginia Department of Conservation and Recreation's Division of Natural Heritage (DNH) and by its network scientists.

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The DNH staff would like to acknowledge the assistance of the following individuals and organizations in providing information on and access to Cheatham Annex and/or assistance in collecting data:

Captain K.A. Kowalski - Captain Supply Corp, Cheatham Annex
Steven M. Martin - NFEC Norfolk
Walt E. Fuerer - Conservation Ranger, Cheatham Annex
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PURPOSE OF THE NATURAL HERITAGE INVENTORY

In 1989, the Department of the Navy asked the Virginia Department of Conservation and Recreation, through its DNH, to conduct a rare, threatened, endangered species inventory within Cheatham Annex. This survey for the presence of rare vertebrates

PHYSICAL ENVIRONMENT

The Base (hereafter called the "study area") is located entirely within the Coastal Plain physiographic province, but on the eastern edge of the Upper Coastal Plain biotic region (Div. Natural Heritage, unpublished data). The elevation ranges from sea level to approximately 80 feet. Queen and King Creeks, bounding the study area on the north and south, are tidal saltwater creeks.

The eastern half of the base is on relatively flat land while the western portion is more highly dissected. The ridges of the Upper Coastal Plain are cut by springs and temporary streams and often expose the underlying Miocene/Pliocene marine deposits. The stream cuts generally have very steep side slopes, yet they are short. Three large impoundments are located throughout the study area: Penniman Lake, Cheatham Pond, and Jones Millpond. The latter two are within the dissected uplands while Penniman Lake is within the flat lowlands. In addition, there are several smaller ponds on the study area.

The soils of the study area are dominated by two series, as identified in the county soil survey (Soil Conservation Service, 1985). Soils of the marshes and slopes to the uplands are of the Emporia-Bohicket-Slagle series and dominated by loam and clay. The soils on the upland ridges and slopes of Cheatham Annex are of the Emporia-Craven-Uchee series. Also loamy and clayey, this series is better drained with a moderately high tree productivity.

The climate is categorized as moderate, as it is close to the Chesapeake Bay and Atlantic Ocean, as well as to the York River. The average annual temperature is 69.7° and the average precipitation 47.29 in. The precipitation is relatively evenly distributed throughout the year but with slightly more falling during the spring and summer.

PERTINENT CULTURAL HISTORY

The proximity of the study area to the first permanent English settlement in North America suggests that the land has potentially been affected by human use longer than other portions of the United States. Nearby Jamestown was the colonial capitol of Virginia from 1607 to 1698. After Jamestown burned in 1698, the capitol was moved to Williamsburg, less than three miles from the study area. The town of Williamsburg served as Virginia's capitol until 1779.

Agriculture, timbering, and fishing have dominated the York County landscape since the earliest recorded history, and were important even before. The Indians of the Chesapeake Bay region of Virginia were largely agrarian in the vicinity of their villages; however, the nature of native American impacts on their

habitat remains an unresolved question. The documentation provided by the English settlers and the numerous military activities near Jamestown and Williamsburg indicate that significant habitat alteration occurred over much of the area. Most of the impacts were associated with the agricultural economy of eastern Virginia, especially that of the cash crop, tobacco.

Military activity in the study area included the surrender of British General Cornwallis to the American colonialists and their French allies. Civil War battles also affected the study area, particularly the Peninsula Campaign. During World Wars I and II, several important military facilities were established in York County, including Cheatham Annex. These areas remain important to the mission of the Department of Defense and contribute significantly to the local economy.

Most of York County and adjacent James City County was recognized as rural until quite recently. With the development of Colonial Williamsburg (and the associated Colonial National Historical Parkway), Busch Gardens, and Water World, the area is becoming a major tourist attraction for regional visitors. The area is currently recognized as one of the most desirable retirement areas in the United States. This fact and its geographic location in the "Golden Crescent" of Virginia (the area connecting Washington, D.C., Richmond, and Hampton Roads), makes the area one of the fastest growing regions of Virginia. Development in the past decade was primarily residential and this continues at a rapid rate; however, commercial, recreational, and industrial developments are also increasing.

GOALS OF THE NATURAL HERITAGE INVENTORY

Between March 1989 and April 1990 the Division of Natural Heritage conducted field surveys and other inventory work in Cheatham Annex to complete the following tasks (as identified in the Interagency Service Agreement between the Department of the Navy (Cheatham Annex) and the Department of Conservation and Recreation (Virginia Division of Natural Heritage):

1) Arrange to conduct a field survey for rare species with potential occurrences on Cheatham Annex.

2) Provide a list of rare species which historically and presently occur on Cheatham Annex.

3) Provide maps outlining significant habitat for each rare species found.

4) Provide specific management recommendations to protect and perpetuate each rare species found.

James City Counties as well as more general regional and state checklists were searched for additional information. The preliminary results of the Virginia breeding bird atlas project, "Virginia's Breeding Birds: An Atlas Workbook (Va. Society of Ornithology 1989) were included in the literature survey. In addition, knowledgeable individuals were contacted to learn of unpublished or historical information. Museum searches were also made for previously collected material from the York and James City County areas, particularly amphibian and reptile records. From these sources a list of rare species recorded from York and James City Counties was created (Table 1).

Field investigation

Fish: No rare, threatened, or endangered species of fish are known or expected to inhabit the man-made pond habitats at Cheatham Annex. Therefore, no specific collections of fish were made.

Amphibians and Reptiles: Standard field methods were used in terrestrial habitats, including lifting cover objects and hand-collecting. Aquatic habitats were sampled with dipnets, swim-in type turtle traps and scoping with binoculars or spotting scope. Amphibians and reptiles were also captured with drift fence arrays and pitfall traps (see methods for mammals).

Birds: Breeding birds were sought during May, June, and July 1989. Birds were observed or identified by song and breeding status determined by criteria developed by the Virginia Society of Ornithology's Breeding Bird Atlas Project. Significant habitats for wintering or migrating birds were sought during the respective seasons. Several line transects were established and periodically a census was made for avian species.

Mammals: A variety of methods were used to conduct inventory for rare mammals. Two Natural Heritage style drift fence arrays were installed in habitat deemed to be the most probable for the occurrence of rare mammals. These included a seepage area adjacent to a northern cove along Cheatham Pond and a beech/oak forest on the east side of Jones Mill Pond. Other habitats in the study area were sampled through the use of pitfall traps and snap-trap grids. Potential bat roosting areas were investigated (old buildings). Sampling sites are indicated in Figure 2. Considering all methods, trap nights totalled 6020, including 50 trap-nights using snap traps.

Sub-population B: In this sub-population, 9 flowering plants produced 45 capsules, with one additional non-flowering individual observed. The plants covered approximately 20 square feet in the moist soil of a marl ravine just above the ravine bottom. A clearing approximately 60 feet upslope from the population provides some light to this area of the forested seep.

Sub-population C: This small sub-population had 6 plants which produced 15 capsules. The plants occurred on approximately four square feet on a leafy slope near the bottom of a marl ravine. The area was mostly shaded but receives some sun from a road 35 feet away.

Sub-population D: This is the smallest sub-population, with only two plants, one of which flowered in 1989. Data on capsule production was not obtained. The plants occurred on a mesic, gentle slope above a marl ravine about 16 feet below a road that provided some sun to the forest floor.

Threats: All of the populations of Liparis loeselii were near openings in the forest, suggesting that loss of light may threaten the species. This threat is evident only in sub-population B which is near a clearing that will become forested without intervention. Sub-populations A, C, and D are near roads which should persist as openings.

Another threat to the Liparis loeselii is the exotic grass Eualia viminea (synonym is Microstegium vimineum). This species was found growing in the mesic woods throughout the Annex. None of the base's populations of Liparis loeselii are currently syntopic with the exotic grass. Data on the competitive ability of the Liparis loeselii versus the Eualia viminea are not available, but it is likely that this weed has had negative impacts on other rare species and will probably do so with Liparis loeselii.

Malaxis spicata, Florida Adder's-mouth

Status: G3G4/S2 (Rare over its entire range; very rare in Virginia).
Malaxis spicata was recommended for special concern status at the 1989 Virginia Endangered Species Symposium.

Distribution: This species has been found throughout the Southeastern United States. It occurs in seven Coastal Plain counties in Virginia (Harvill, et al., 1986).

Sub-population F: A group of approximately 60 plants plus a number of scattered individuals were found in the ravine at this site.

Sub-population G: Two patches of Ponthieva, including fewer than 100 plants, were found in the ravine at this site.

Sub-population H: A number of small colonies found in the ravine at this site included fewer than 50 plants.

Sub-population I: Many patches of Ponthieva comprised a total of between 500 and 1000 individuals in the ravine at this site.

Sub-population J: Like sub-population H, many patches were observed along a ravine which, when combined, totalled between 500 and 1000 individuals.

Threats: As is the case with Liparis loeselii, the exotic grass, Eualia viminea may be a threat to the Ponthievia racemosa. This grass does occur with the Ponthieva in some areas but data on the competitive interaction is not available. It is likely that Eualia will have some negative effects on the Ponthieva populations at Cheatham. No other threats to Ponthieva racemosa have been identified at Cheatham Annex.

Stewartia ovata, Mountain Camellia

Status: G4/S2 (Common in many localities over its entire range; very rare in Virginia)
Stewartia ovata was recommended for special concern status at the 1989 Virginia Endangered Species Symposium.

Distribution: Found throughout the Southeastern United States. In Virginia S. ovata occurs in three mountain and two Coastal Plain counties (Harvill, et al. 1986).

Description: Stewartia ovata is a large shrub or small tree with alternate, simple, decidious leaves. The large, showy, white flowers bloom in Summer.

Project Findings: A relatively thorough search turned up only one shrub (see Figure 6). The plant was found in a mixed decidious woods with a dense understory of Ilex opaca and Polystichum acrostichoides. The plant measured seven feet high but had much dead wood. There was no evidence of sexual reproduction.

Threats: With only one tree, this species could easily be lost at Cheatham Annex. No other specific threats were identified.

ANIMALS

Summary of existing information.

Fish: No rare fish were expected from Cheatham Annex.

Amphibians: No records were found for rare amphibians on Cheatham Annex. However, since Cheatham Annex is located near the eastern edge of the upper Coastal Plain physiographic province, we had hoped to locate several rare amphibians that are known from the lower Coastal Plain. These include Ambystoma mabeei (Mabee's salamander), Ambystoma tigrinum (Eastern tiger salamander), Rana virgatipes (Carpenter frog), and Hyla gratiosa (Barking treefrog). Rana virgatipes was previously reported from a site in James City County, however, after study of the collected specimens, the DNH zoologist concluded that the specimens were Green frogs (Rana clamitans), a common species.

Reptiles: The Canebrake rattlesnake (Crotalus horridus atricaudatus (G5TU2/S1, recommended State Endangered) was historically recorded from lower York County in the vicinity of Grafton. Currently, its range in Virginia has been reduced to a few areas in Tidewater, Virginia. Although no records are known from Cheatham Annex or the immediate vicinity, it was considered a remote possibility.

Birds: A Bald Eagle (Haliaeetus leucocephalus) nest is located nearby on Yorktown Naval Weapons Station. Cheatham Annex is also near the northern edge of the historic Red-cockaded woodpecker sites. A 1975 record exists for York County (Va. Society of Ornithology, 1989).

Mammals: No rare mammals were previously recorded for York and James City Counties or Cheatham Annex. The study site is located within the probable range of the cotton mouse (Peromyscus gossipinus).

Field investigation.

Using our compiled list of rare species with potential to occur on Cheatham Annex and our knowledge of the individual species habitat requirements, we planned and conducted our inventory. No rare vertebrate species were found during the 1989-90 field investigations.

Fifteen species of amphibians were captured, or heard, in the case of frogs, on Cheatham Annex (Table 2). Four of the amphibian species were salamanders and the remainder were anurans (frogs and toads). However no rare, threatened, or endangered species were found.

DISCUSSION

RARE PLANTS

The DNH's survey of Cheatham Annex's rare plants produced a list of six species, four of which were observed in 1989 (Liparis loeselii, Ponthieva racemosa, Stewartia ovata, and Typha domingensis) and two of which were last seen in 1975 (Malaxis spicata and Tridens strictus).

The abundance of the Ponthieva racemosa was unexpected and indicated that this species may not be as rare in the Commonwealth as earlier records had indicated. The abundance of Ponthieva racemosa, the occurrence of Liparis loeselii, and the common occurrence of other calciphiles such as Pedicularis lanceolata and Verbesina virginica in the marl ravines indicated that the marl communities of Cheatham are of statewide significance.

RARE ANIMALS

The inventory of Cheatham Annex did not produce any rare vertebrate species. However, overall diversity was fairly high. Cheatham Annex has been intensively managed. The management strategies used have resulted in a variety of habitat types and traditional "game" wildlife species have flourished. In addition, the upper Coastal Plain physiographic province is not known to be particularly rich in rarities.

Bat species are difficult to inventory. The solitary roosting habits of many species, the difficulty in efficient trapping, and their ability to move over large areas make any inventory results tentative. Nonetheless, known roosting sites such as abandoned buildings and large hollow trees were searched when possible. No bats were found. Some bats were observed hunting at dusk, but appeared to be common species. Two rare species, Lasionycteris noctivagans (silver-haired bat) and Lasiurus cinereus (hoary bat) may winter in the area, but migrate north for the summer. Neither are particularly known to roost in buildings.

OTHER NATURAL HERITAGE ELEMENTS

The Division of Natural Heritage also monitors rare and exemplary natural communities, significant geological features, invertebrates, important corridors, animal congregation sites, large forested tracts of land, and several other categories. While this study was constructed for vertebrate animals and plants, all other significant resources were noted.

Jones Mill Pond Northeast Special Interest Area

(Botanical Area)

Jones Millpond Northeast, contains the only ravine system in the Jones Millpond section of the Annex where either Ponthieva racemosa or Liparis loeselii were recorded (Figure 7). In addition to the rare plants, an intact unit of hardwoods and the uncommon Glade Fern (Athyrium pycnocarpon) are found. The boundaries of this section include the rare species populations, a protection zone around these populations, and the other significant features found in this area.

Cub Creek Special Interest Area

(Botanical Area)

Cub Creek Special Interest Area includes populations of all rare plants found in Cheatham Annex during this study: Liparis loeselii, Ponthieva racemosa, Stewartia ovata, and Typha domingensis. The boundaries of this area contain all of the rare species populations and provide a protection area around each of these populations (Figure 8). This area is named Cub Creek after the tidal creek where the Typha domingensis was found.

Cheatham Pond Ravines Special Interest Area

(Botanical Area)

Cheatham Pond Ravines, includes the largest sub-population of Liparis loeselii and the two largest sub-populations of Ponthieva racemosa found at Cheatham Annex. The boundary includes these rare species populations and a protection area around these populations (Figure 9).

FUTURE WORK

The negative data provided by rare species surveys often do not show that species do not occur, simply that no evidence was found of their presence. In many cases, such as the Red-cockaded Woodpeckers, no appropriate habitat and nest trees, which are easily recognized, were found. There is little likelihood that this species was missed. On the other hand, several rare bat species could be present and utilizing the hollows of the remaining old trees on Cheatham Annex. The difficulty in surveying for these species combined with their secretive habits cast a certain amount of doubt on negative findings. However, within reason, results of this survey indicated that additional rare species and their habitats are not found at this Naval facility.

TABLE 1

RARE VERTEBRATE ANIMALS OF YORK AND JAMES CITY COUNTIES

Amphibians

Ambystoma mabeei (Mabee's salamander)
Ambystoma tigrinum (Tiger salamander)
Siren lacertina (Greater siren)
Hyla gratiosa (Barking treefrog)
Rana virgatipes (Carpenter frog)

Reptiles

Crotalus horridus atricaudatus (Canebrake rattlesnake)

Birds

Least Bittern
Bald Eagle
Northern Harrier
Peregrine Falcon
Great Blue Heron
Great Egret
King Rail
Red-cockaded Woodpecker
Spotted Sandpiper

MAMMALS

Condylura cristata parva (Star-nosed mole)
Sylvilagus palustris (Marsh rabbit)

TABLE 3

REPTILES ENCOUNTERED DURING INVENTORY
CHEATHAM ANNEX

TURTLES

Clemmys guttata	Spotted turtle
Chelydra serpentina	Common snapping turtle
Chrysemys picta	Painted turtle
Trachemys scripta	Yellow-bellied slider
Pseudemys rubriventris	Red-bellied turtle
Kinosternon subrubrum	Eastern mud turtle
Terrapene carolina	Eastern box turtle
Sternotherus odoratus	Musk turtle (Stinkpot)

SNAKES

Carphophis amoenus	Worm snake
Coluber constrictor	Black racer
Diadophis punctatus	Ringneck snake
Nerodia sipedon	Northern water snake
Elaphe obsoleta	Black rat snake
Opheodrys aestivus	Rough green snake
Virginia valeriae	Smooth earth snake
Virginia striatula	Rough earth snake

LIZARDS

Eumeces fasciatus	Five-lined skink
Sceloporus undulatus	Fence lizard
Scincella lateralis	Ground skink

Eastern Meadowlark	S
Common Grackle	LF
Brown-headed Cowbird	LF
Orchard Oriole	S
House Finch	LF
American Goldfinch	
House Sparrow	LF

North American Breeding Bird Codes Used:

O	observed, but no evidence of breeding

Possible Nesting

(blank)	seen in suitable nesting habitat

Probable Nesting

P	pair observed in suitable habitat.
A	agitated behavior.
S	permanent territory presumed through song at same location 7 or more days apart.
T	permanent territory presumed through defense of territory

Confirmed Nesting

CN	carrying nesting material
FL	recently fledged young
ON	occupied nest
CF	carrying food
FY	feeding young
NY	nest with young

Additional Codes

W	winter resident
M	fall or spring migrant

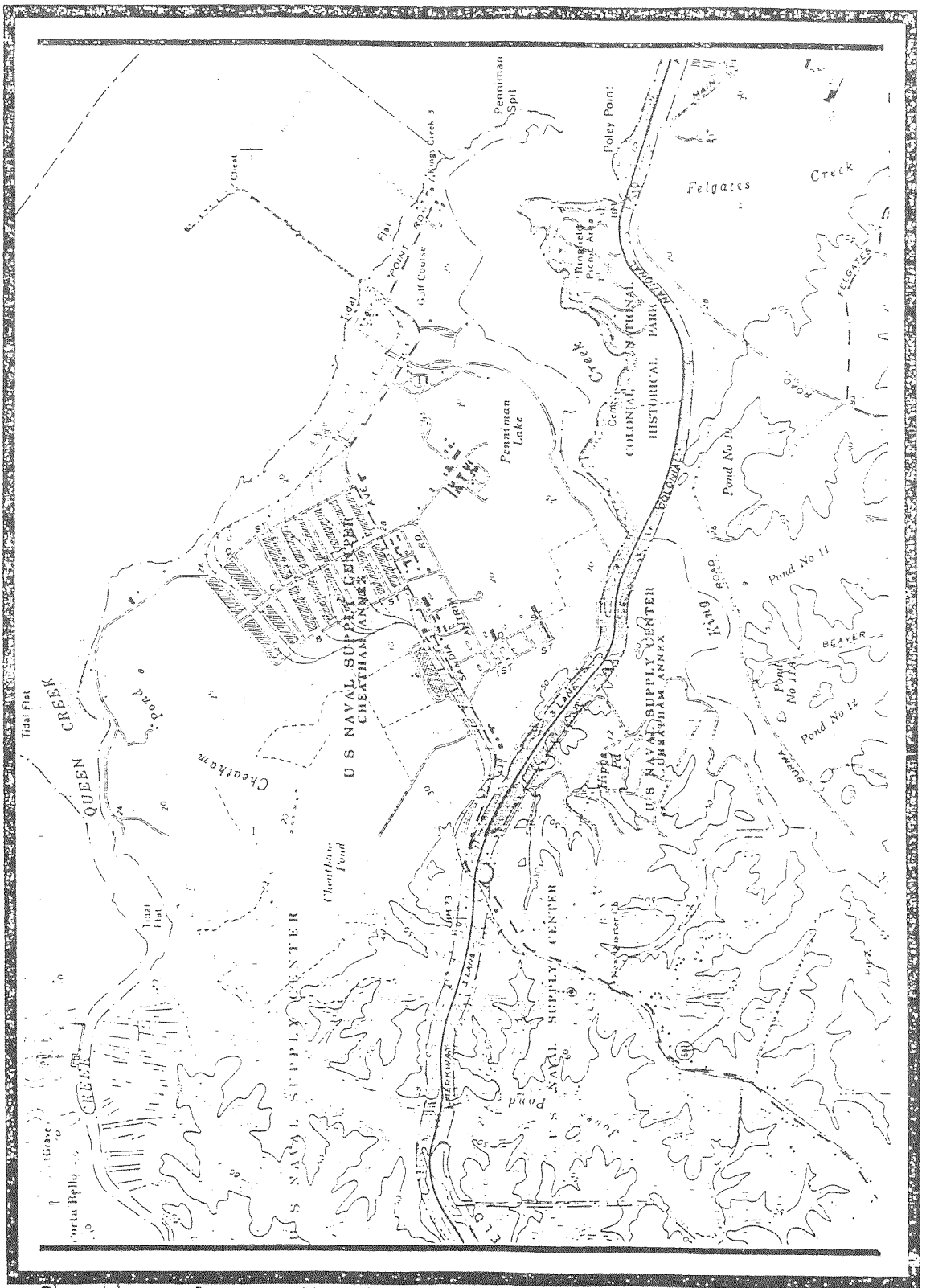

Figure 1. Cheatham Annex Naval Supply Station and immediate vicinity.

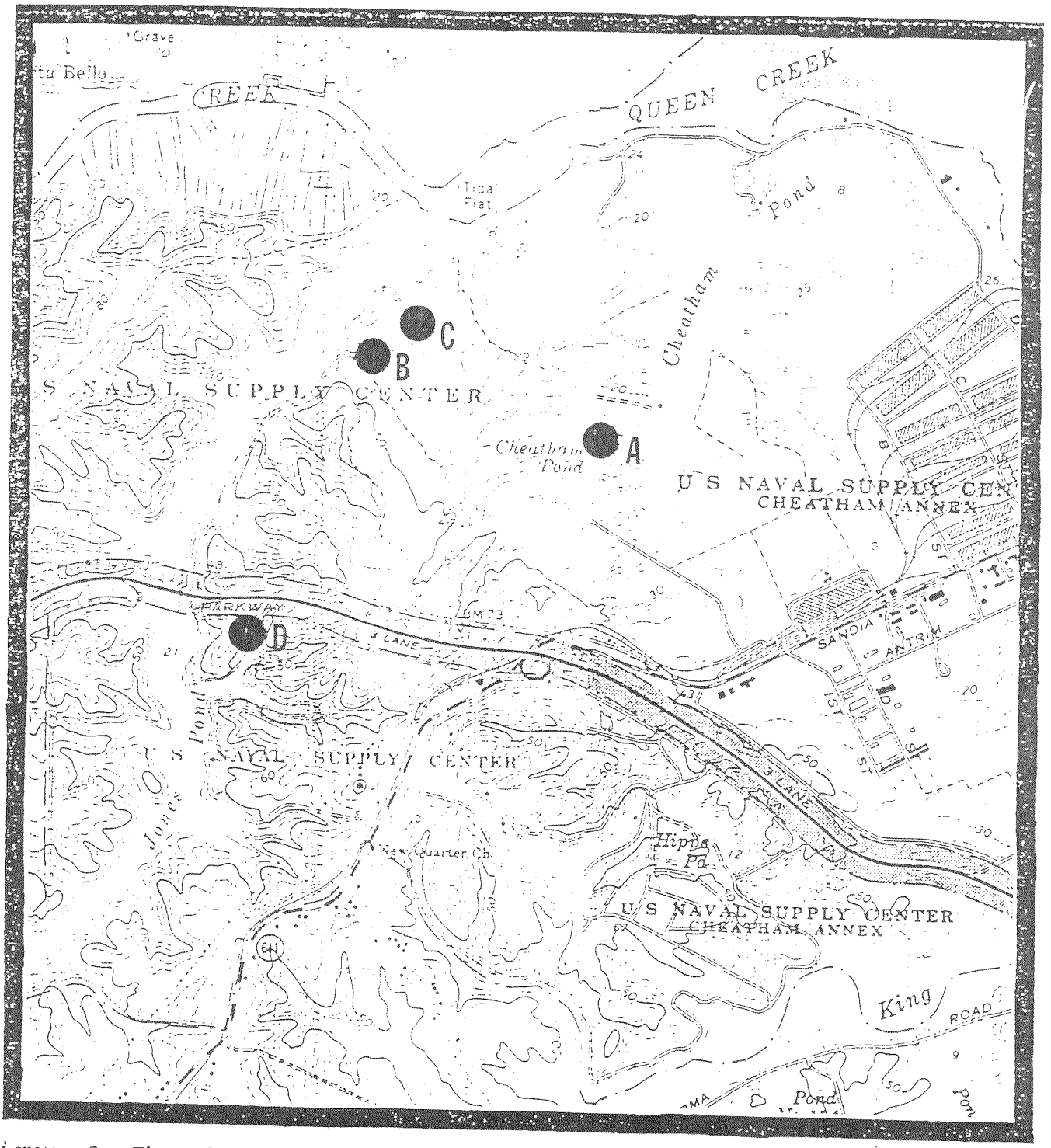

Figure 3. The locations of the rare plant Liparis loeselii, Loesel's trayblade, in the study area with sub-populations indicated.

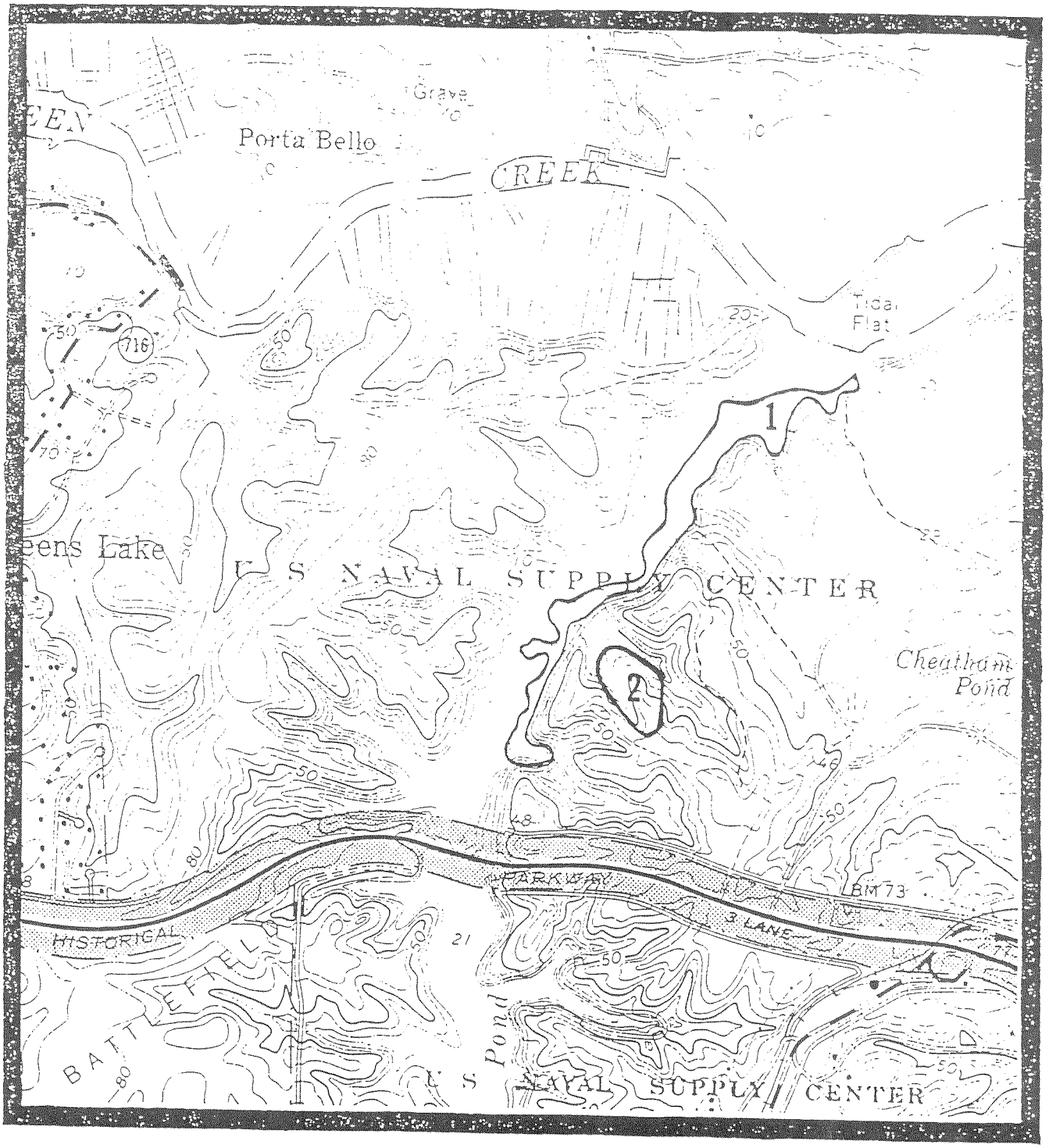

Figure 5. The locations of Typha domingensis, southern cattail (1), and Stewartia ovata, mountain camellia (2), in the study area.

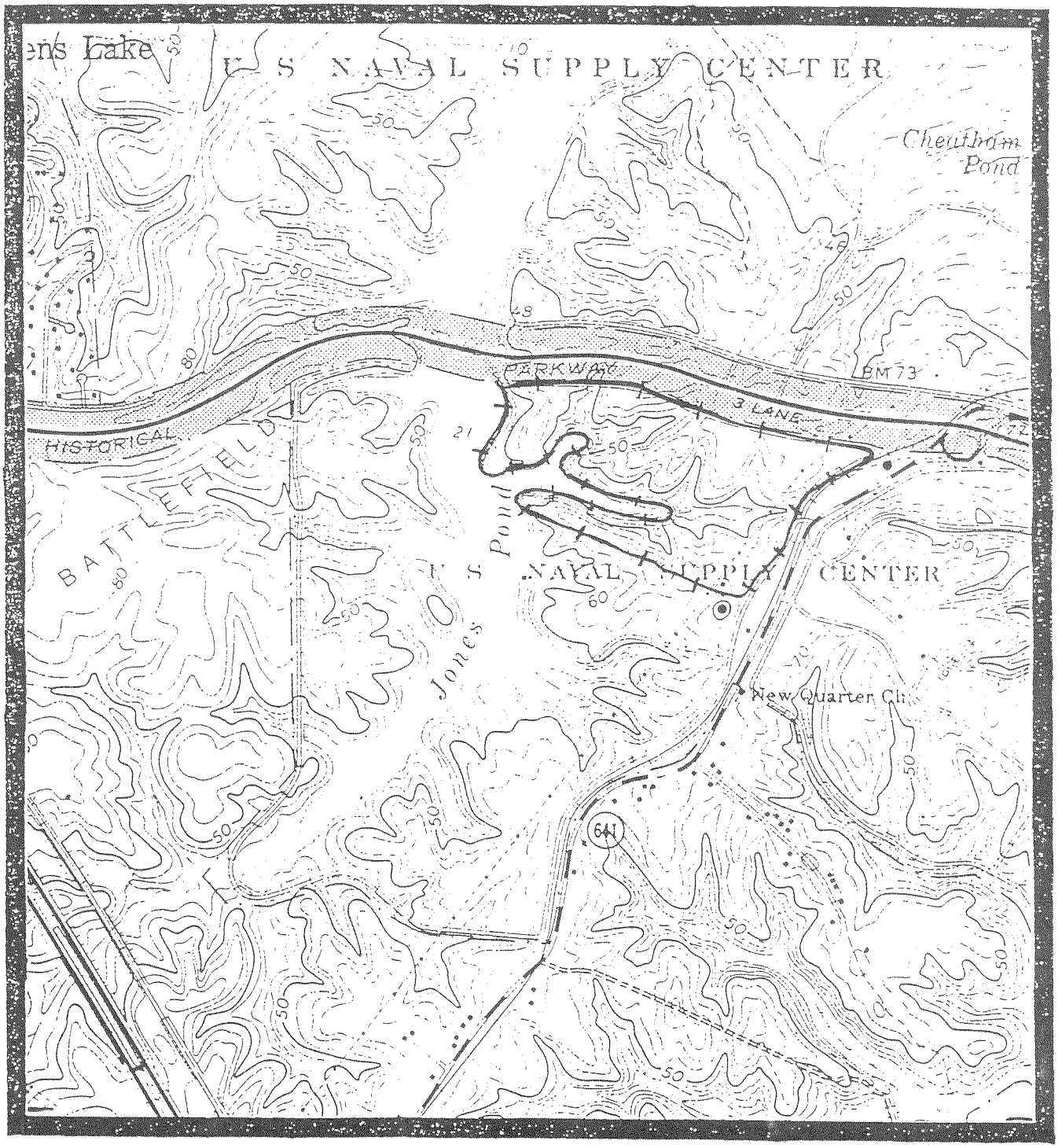

Figure 7. The recommended boundaries for Jones Mill Pond Special Interest Area (Botanical Area).

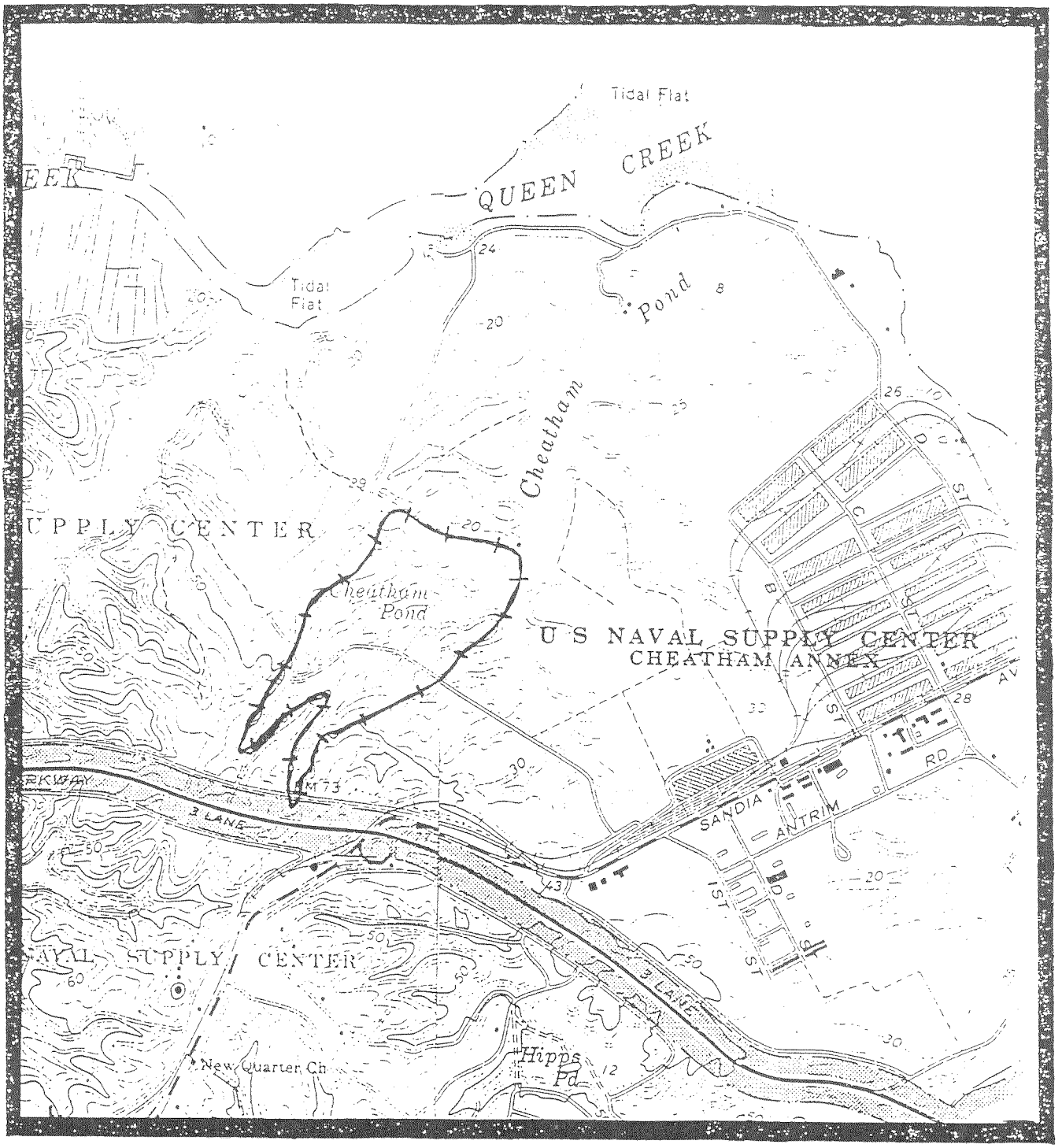

Figure 9. The recommended boundaries for Cheatham Pond Ravines Special Interest Area (Botanical Area).

APPENDICES

DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE

GLOSSARY OF RARE ELEMENTS OF VIRGINIA

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
ABACION TESSELATUM	A MILLIPEDE	G5	S2		
ABIES BALSAMEA	BALSAM FIR	G5	S2		RSC
ABIES FRASERI	FRASER FIR	G2G3	S2	C2	RE
ACANTHARCHUS POMOTIS	MUD SUNFISH	G5	S3		
ACCIPITER COOPERII	COOPER'S HAWK	G4	S1S2		RSU
ACIPENSER BREVIROSTRUM	SHORTNOSE STURGEON	G3	SX	LE	LE
ACIPENSER OXYRHYNCHUS	ATLANTIC STURGEON	G3	S2		RSC
ACTITIS MACULARIA	SPOTTED SANDPIPER	G5	S2		RSU
ADIANTUM CAPILLUS-VENERIS	SOUTHERN MAIDENHAIR-FERN	G5	SH		
AEGOLIUS ACADICUS	NORTHERN SAW-WHET OWL	G5	S1		RSU
AESCHYNOMENE VIRGINICA	SENSITIVE JOINT-VETCH	G2	S2	C2	C
AESHNA CANADENSIS		G5	S1		
AESHNA CLEPSYDRA		G3G4	S?		
AESHNA CONSTRICTA		G5	S1		
NA INTERRUPTA		G5	S?		
NA MUTATA		G3G4	S1		LT
AESHNA TUBERCULIFERA		G4	S1		
AESHNA VERTICALIS		G5	S1		
AGALINIS DECEMLOBA	BLUE RIDGE FALSE-FOXGLOVE	G3G4	S2S3		
AGALINIS TENELLA	PENNELL FALSE-FOXGLOVE	G3G5Q	S1		RSC
AGALINIS VIRGATA	PINE-BARREN GERARDIA	G3G4	S1		RSC
AGAVE VIRGINICA	FALSE ALOE	G5	S1		RSC
AGROPYRON TRACHYCAULUM	SLENDER WHEATGRASS	G5T5	S2		RSC
AIMOPHILA AESTIVALIS	BACHMAN'S SPARROW	G3	S1	C2	RE
ALASMIDONTA HETERODON	DWARFWEDGE MUSSEL	G1	SH	LE	
ALASMIDONTA MARGINATA	ELKTOE	G5	S2		RSC
ALASMIDONTA VARICOSA	BROOK FLOATER	G3	S1		RSC
ALASMIDONTA VIRIDIS	SLIPPERSHELL MUSSEL	G4	S1		RE
ALETRIS AUREA	GOLDEN COLICROOT	G5	S1		RSC
ALLIUM OXYPHILUM	SHALE BARREN ONION	G3Q	SU	3C	RSU
ALNUS RUGOSA	SPECKLED ALDER	G5	S1		RSC
ALOSA MEDIOCRIS	HICKORY SHAD	G5	S3		
AMARANTHUS PUMILUS	SEABEACH PIGWEED	G2	SH	C2	
AMBLOPLITES CAVIFRONS	ROANOKE BASS	G3	S3		RSC
AMBLYSCIRTES ALTERNATA	BLUE-DUSTED ROADSIDE SKIPPER	G3G4	S1S3		
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC
AMBYSTOMA TALPOIDEUM	MOLE SALAMANDER	G5	SU		RSC
AMBYSTOMA TIGRINUM	TIGER SALAMANDER	G5	S1		LE
AMEIURUS BRUNNEUS	SNAIL BULLHEAD	G4	S2		
URUS PLATYCEPHALUS	FLAT BULLHEAD	G4?	S3		
GONISCUS HENROTI	POWELL VALLEY TERRESTRIAL CAVE ISOPOD	G2	S1S2		
AMMOCRYPTA CLARA	WESTERN SAND DARTER	G3	S1		RT
AMMODRAMUS CAUDACUTUS	SHARP-TAILED SPARROW	G5	S2		RSC
AMMODRAMUS HENSLOWII	HENSLOW'S SPARROW	G4	S1		RE

DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE

GLOSSARY OF RARE ELEMENTS OF VIRGINIA

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
ARETHUSA BULBOSA	SWAMP-PINK	G4	S1		RE
ARGIA BIPUNCTULATA		G4	S2		
ARGIA SEDULA		G5	S2		
ARGIA TIBIALIS		G5	S2		
ARGIA TRANSLATA		G5	S2		
ARIGOMPHUS FURCIFER		G5	S1		
ARIGOMPHUS PALLIDUS		G4	S?		
ARIGOMPHUS VILLOSIPES		G5	S2		
ARISTIDA TUBERCULOSA	SEABEACH NEEDLEGRASS	G5	S1S2		
ARMORACIA AQUATICA	LAKE CRESS	G4?	S1	C2	
ASCLEPIAS LONGIFOLIA	LONG-LEAF MILKWEED	G4G5	S1		RSC
ASCLEPIAS RUBRA	RED MILKWEED	G4G5	S2		
ASIMINA PARVIFLORA	DWARF PAW-PAW	G5	S2		RSC
'SIO FLAMMEUS	SHORT-EARED OWL	G5	S1		RSU
IO OTUS	LONG-EARED OWL	G5	S1		RSU
ASTER ELLIOTTII	ELLIOTT'S ASTER	G3G4	S1		RSC
ASTER ERICOIDES	WHITE HEATH ASTER	G5	S2		
ASTER PRAEALTUS	WILLOW ASTER	G5	S1		RSC
ASTER RACEMOSUS	COASTAL-PLAIN ASTER	G3?Q	S1		RSC
ASTER RADULA	ROUGH-LEAVED ASTER	G5	S1		RSC
ASTER SCHISTOSUS	FALL ASTER	G1Q	SU	C2	RSU
ASTER SHORTII	SHORT'S ASTER	G4G5	S2		RSC
ASTER SURCULOSUS	CREEPING ASTER	G3G5	S1		RSC
ASTRAGALUS DISTORTUS	BENT MILK-VETCH	G5	S1		RE
ASTRAGALUS NEGLECTUS	COOPER'S MILKVETCH	G3G4	S1		RE
ATLIDES HALESUS	GREAT PURPLE HAIRSTREAK	G5	S3		
ATRYTONE AROGOS AROGOS	ARGOS SKIPPER	G4T3	SH		
AUTOCHTON CELLUS	GOLDEN-BANDED SKIPPER	G4	S3		
AUTURUS ERYTHROPYGOS	A MILLIPEDE	G3	S1		RSC
BACOPA CAROLINIANA	CAROLINA WATER-HYSSOP	G4G5	S1		RSC
BACOPA MONNIERI	COASTAL WATER-HYSSOP	G5?	S1S2		RSC
BACOPA SIMULANS	CHICKAHOMINY WATER-HYSSOP	G1Q	S1	3B	
BACOPA STRAGULA	MAT-FORMING WATER-HYSSOP	G1Q	S1	3B	LE
BAPTISIA ALBA	PRAIRIE FALSE-INDIGO	G4	S1		RSC
BAPTISIA CINEREA	HAIRY WILD-INDIGO	G2G3	S1?		RSU
BARTRAMIA LONGICAUDA	UPLAND SANDPIPER	G5	S1S2		RE
BETULA PAPYRIFERA	PAPER BIRCH	G5	S2S3		RSC
BETULA POPULIFOLIA	GRAY BIRCH	G5	S1		RSC
BETULA UBER	VIRGINIA ROUND-LEAF BIRCH	G1Q	S1	LE	LE
'ARINA BREVICAUDA TELMALESTES	DISMAL SWAMP SHORT-TAILED SHREW	G5T3	S3	3C	
BLEPHILIA HIRSUTA	HAIRY WOODMINT	G4?	S1S2		RSC
BOLORIA SELENE MYRINA	SILVER BORDERED FRITILLARY	G5T5	SU		
BOLTONIA ASTEROIDES	ASTER-LIKE BOLTONIA	G5	S2S3		
BOLTONIA CAROLINIANA	CAROLINA BOLTONIA	G2Q	S2S3		

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CALOPTERYX AEQUABILIS		G5	S2		
CALOPTERYX AMATA		G3G4	S1		RSC
CALOPTERYX ANGUSTIPENNIS		G4	S1		RSC
CALOPTERYX DIMIDIATA		G5	S2		
CALYCANTHUS FLORIDUS	SWEET-SHRUB	G5	S2		RSC
CAMASSIA SCILLOIDES	WILD HYACINTH	G4G5	S2S3		RSC
CAMBALA HUBRICHTI	A MILLIPEDE	G5	S3		
CAMBALA MINOR	A MILLIPEDE	G5	S3		
CAMBARINCOLA FALLAX		G1	S1		
CAMBARUS CHASMODACTYLUS	NEW RIVER RIFFLE CRAYFISH	G4G5	SU	C2	
CAMPANULA ROTUNDIFOLIA	AMERICAN HAREBELL	G5	S1		RSC
CARDAMINE CLEMATITIS	MOUNTAIN BITTER CRESS	G2	S1	C2	RSC
CARDAMINE FLAGELLIFERA	BITTER CRESS	G3	S2		
CARDAMINE LONGII	LONG'S BITTER CRESS	G3G4	S3	3C	RSC
CARDAMINE PRATENSIS	CUCKOOFLOWER	G5	S1S2		RSC
CARETTA CARETTA	LOGGERHEAD SEA TURTLE	G3	S1S2	LT	LT
CAREX APPALACHICA	APPALACHIAN SEDGE	G?	S1S2		
CAREX ATHERODES	AWNED SEDGE	G5	S1		RE
CAREX BARRATTII	BARRATT'S SEDGE	G3	S1	3C	RE
CAREX BUXBAUMII	BROWN BOG SEDGE	G5	S2		RSC
CAREX CAREYANA	CAREY'S SEDGE	G5	S1		RSC
CAREX CHAPMANII	CHAPMAN'S SEDGE	G2G3	SH	C2	
CAREX COLLINSII	COLLINS' SEDGE	G4	S2S3		RSC
CAREX CONOIDEA	FIELD SEDGE	G4	S1		RSC
CAREX CRISTATELLA	CRESTED SEDGE	G5	S1		RSC
CAREX CRUS-CORVI	RAVENFOOT SEDGE	G5	S1		
CAREX DECOMPOSITA	EPIPHYTIC SEDGE	G3G4	S1	3C	
CAREX HIRTIFOLIA	PUBESCENT SEDGE	G5	S1S2		
CAREX HITCHCOCKIANA	HITCHCOCK'S SEDGE	G5	S2		
CAREX INTERIOR	INLAND SEDGE	G5	S2S3		RSC
CAREX LACUSTRIS	LAKE-BANK SEDGE	G5	S1		RSC
CAREX LEPTONERVIA	FINELY-NERVED SEDGE	G4	S2		RSC
CAREX LUCORUM	A SEDGE	G4	S1		RSC
CAREX LUPULIFORMIS	FALSE HOP SEDGE	G3G4Q	S1S2		RSC
CAREX MEADII	MEAD'S SEDGE	G4G5	S1		RSC
CAREX PALLESCENS	PALE SEDGE	G5	S1		RE
CAREX PEDUNCULATA	LONGSTALK SEDGE	G5	S2		
CAREX POLYMORPHA	VARIABLE SEDGE	G2	S1	C2	LE
CAREX PRAIREA	PRAIRIE SEDGE	G5?	S1		RSC
CAREX PURPURIFERA	PURPLE SEDGE	G3?	S1	C2	RSC
CAREX RENIFORMIS	RENIFORM SEDGE	G4?	S1		RSC
CAREX ROSTRATA	BEAKED SEDGE	G5	S1		RSC
CAREX SCHWEINITZII	SCHWEINITZ'S SEDGE	G3	S1?		RSC
CAREX SILICEA	SEA-BEACH SEDGE	G5	S1		RSC
CAREX STRAMINEA	STRAW SEDGE	G5	S2		RSC

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CHEROKIA GEORGIANA LATASSA	A MILLIPEDE	G4T?	S1		
CHITRELLA CAVICOLA	A PSEUDOSCORPION	G3	S3		
CHITRELLA SUPERBA	A PSEUDOSCORPION	G1	S1		
CHLOROCHROA DISMALIA	DISMAL SWAMP GREEN STINK BUG	G1	S1	C2	
CHOLOGASTER CORNUTA	SWAMPFISH	G5	S3		
CHONDESTES GRAMMACUS	LARK SPARROW	G5	SH		
CHROMAGRION CONDITUM		G5	S2		
CICINDELA ABDOMINALIS		G4	S1?		RE
CICINDELA ANCOCISCONENSIS	A CICINDELID BEETLE	G3	S2		
CICINDELA DORSALIS DORSALIS	NORTHEASTERN BEACH TIGER BEETLE	G4T2	S1	C1	RE
CICINDELA DORSALIS MEDIA	A TIGER BEETLE	G5T3T4	S3		RSC
CICINDELA FORMOSA GENEROSA	A TIGER BEETLE	G5T5	S1?		RSC
CICINDELA LEPIDA	LITTLE WHITE TIGER BEETLE	G4	S1		RE
CICINDELA LIMBALIS	A TIGER BEETLE	G5	S1		RSC
CICINDELA MARGINATA	A TIGER BEETLE	G5	S3S4		
CICINDELA PATRUELA	A TIGER BEETLE	G3	S1		
CICINDELA PURITANA	PURITAN TIGER BEETLE	G1	SU	C1	
CICINDELA PURPUREA	A TIGER BEETLE	G5	S3		
CICINDELA SPLENDIDA	A TIGER BEETLE	G5	S2		RSC
CICINDELA UNIPUNCTATA	A TIGER BEETLE	G4	S3?		RSC
CICUTA BULBIFERA	BULB-BEARING WATER-HEMLOCK	G5	SH		
CIMICIFUGA RUBIFOLIA	APPALACHIAN BUGBANE	G3	S1S2	C2	RSC
CINNA LATIFOLIA	SLENDER WOOD REEDGRASS	G5	S1S2		RSC
CIRCUS CYANEUS	NORTHERN HARRIER	G5	S1S2		RE
CIRSIUM ALTISSIMUM	TALL THISTLE	G5	S2S3		RSC
CIRSIUM CAROLINIANUM	CAROLINA THISTLE	G5	S1		RSC
CIRSIUM NUTTALLII	NUTTALL THISTLE	G5	S1		RSC
CIRSIUM REPANDUM	COASTAL-PLAIN THISTLE	G5	S1		
CIRSIUM VIRGINIANUM	VIRGINIA THISTLE	G3G4	S2S3		
CISTOTHORUS PLATENSIS	SEDGE WREN	G5	S1		RE
CLADIUM JAMAICENSE	SAWGRASS	G5	S1		RSC
CLADIUM MARISCOIDES	TWIG RUSH	G5	S2		RSC
CLEIDOGONA FIDELITOR	A MILLIPEDE	G1	S1		
CLEIDOGONA HOFFMANI	A MILLIPEDE	G2	S2		
CLEIDOGONA LACHESIS	A MILLIPEDE	G2	S1		
CLEIDOGONA MEDIALIS	A MILLIPEDE	G1	S1		
CLEISTES DIVARICATA	SPREADING POGONIA	G4	S1S2		RSC
CLEMATIS ADDISONII	ADDISON'S LEATHERFLOWER	G2	S2	3C	RE
CLEMATIS ALBICOMA	WHITE-HAIRED LEATHERFLOWER	G4	S3	3C	RSC
CLEMATIS CATESBYANA	SATIN-CURLS	G4G5	S1		RSC
CLEMATIS COACTILIS	VIRGINIA WHITE-HAIR LEATHER-FLOWER	G3	S3		RSC
CLEMATIS GLAUCOPHYLLA	WHITE-LEAVED LEATHER-FLOWER	G3?	S1		RSC
CLEMATIS VITICAULIS	MILLBORO LEATHERFLOWER	G1	S1S2	C2	RE

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CUSCUTA ROSTRATA	BEAKED DODDER	G4?	S1		
CYNOCTONUM MITREOLA	LAX HORNPOD	G5	S2		RSC
CYNOCTONUM SESSILIFOLIUM	A MITREWORT	G4G5	S1?		
CYPERUS ACUMINATUS	SHORT-POINT FLATSEDGE	G5	S2		
CYPERUS DENTATUS	TOOTHED SEDGE	G4	S1		RE
CYPERUS DIANDRUS	UMBRELLA FLATSEDGE	G5	S2S3		RSC
CYPERUS ENGELMANNII	ENGELMANN'S UMBRELLA-SEDGE	G4Q	S1		RSC
CYPERUS GRANITOPHILUS	GRANITE-LOVING FLATSEDGE	G3Q	S1	3C	RE
CYPERUS HASPAN	SHEATHED FLATSEDGE	G5	S2S3		RSC
CYPERUS HOUGHTONII	HOUGHTON'S UMBRELLA-SEDGE	G4	S1?		
CYPRINELLA GALACTURA	WHITETAIL SHINER	G5	S3		
CYPRINELLA LABROSA	THICKLIP CHUB	G3	SH		
CYPRINELLA MONACHA	SPOTFIN SHINER	G2	S1	LT	LTRE
CYPRINELLA WHIPPLEI	STEELCOLOR SHINER	G5	S2		RT
?RIPEDIUM REGINAE	SHOWY LADY'S-SLIPPER	G4	S1		RE
?ROGENIA STEGARIA	FANSHELL	G1	S1	PE	RE
CYSTOPTERIS TENNESSEENSIS	TENNESSEE BLADDERFERN	G5	S1		RSU
DALIBARDA REPENS	ROBIN RUNAWAY	G5	S1		RSC
DEIROCHELYS RETICULARIA RETICULARIA	EASTERN CHICKEN TURTLE	G5T5	S1		LE
DENDROICA FUSCA	BLACKBURNIAN WARBLER	G5	S2		
DENDROICA MAGNOLIA	MAGNOLIA WARBLER	G5	S2		RSU
DEROCERAS LAEVE	MARSH SLUG	G4G5	S3		
DESCHAMPSIA CESPITOSA	TUFTED HAIRGRASS	G5	S1		RSC
DESMODIUM CANADENSE	SHOWY TICK-TREFOIL	G5	S1S2		RSC
DESMODIUM OCHROLEUCUM	CREAMFLOWER TICK-TREFOIL	G5?	S2		RSC
DESMODIUM SESSILIFOLIUM	SESSILE-LEAF TICK-TREFOIL	G5	S1		RSC
DESMODIUM STRICTUM	PINELAND TICK-TREFOIL	G2G4	S2		RSC
DESMOGNATHUS WRIGHTI	PIGMY SALAMANDER	G4	S2		RSC
DESMONUS EARLEI	A MILLIPEDE	G5	S1		
DIAMORPHA SMALLII	SMALL'S STONECROP	G3G4	S1		RE
DIARRHENA AMERICANA	AMERICAN BEAKGRAIN	G5	S2S3		
DICHROMENA COLORATA	A SEDGE	G4G5	S1		RSC
DICLIPTERA BRACHIATA	WILD MUDWORT	G5	S1		RSC
DIGITARIA SEROTINA	DWARF CRABGRASS	G5?	SH		
DIPHYLLEIA CYMOSA	UMBRELLA-LEAF	G3	S2?		RSC
DISCUS CATSKILLENSIS	ANGULAR DISC	G3G5	S3		RSC
DISCUS CRONKHITEI	FOREST DISC	G5	S3		
DISCUS NIGRIMONTANUS	BLACK MOUNTAIN DISC	G4	S1		RSC
?ISPORUM MACULATUM	NODDING MANDRIN	G5	S2S3		RSC
IORIA BROOKSI	A MILLIPEDE	G1	S1		RSC
?IXIORIA CORONATA	A MILLIPEDE	G2	S2		
DIXIORIA FOWLERI	A MILLIPEDE	G2	S2		
DOLICHONYX ORYZIVORUS	BOBOLINK	G5	S1		
DOROCORDULIA LEPIDA		G5	S?		

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ENALLAGMA HAGENI		G5	S1		RSC
ENALLAGMA MINUSCULUM		G3G4	S?		
ENALLAGMA PALLIDUM		G4	S1		RSC
ENALLAGMA TRAVIATUM WESTFALLI		G5T5	S2		
ENALLAGMA VESPERUM		G5	S2		
ENALLAGMA WEEWA		G5	S1		RSC
ENEMION BITERNATUM	FALSE RUE-ANEMONE	G5	S1		RE
ENNEACANTHUS CHAETODON	BLACKBANDED SUNFISH	G5	S1		LERT
EPILOBIUM LEPTOPHYLLUM	LINEAR-LEAVED WILLOW-HERB	G5	S1		RSC
EPILOBIUM STRICTUM	DOWNY WILLOW-HERB	G5?	S1		RSC
EPIOBLASMA BREVIDENS	CUMBERLAND COMBSHELL	G2	S1	C2	LE
EPIOBLASMA CAPSAEFORMIS	OYSTER MUSSEL	G1	S1	C2	LE
EPIOBLASMA FLORENTINA WALKERI	TAN RIFFLESHELL	G1T1	S1	LE	LE
EPIOBLASMA TORULOSA VACULUM	GREEN-BLOSSOM PEARLY MUSSEL	G2T1	S1	LE	LE
OBLASMA TRIQUETRA	SNUFFBOX	G4	S1		LE
EQUISETUM FLUVIATILE	WATER HORSETAIL	G5	S1		RSC
EQUISETUM SYLVATICUM	WOODLAND HORSETAIL	G5	S1		RSC
ERIANTHUS BREVIBARBIS	SHORT-BEARD PLUMEGRASS	G3G5	S1		RSC
ERICYMBA BUCCATA	SILVERJAW MINNOW	G5	S3		
ERIGERON QUERCIFOLIUS	OAK-LEAF FLEABANE	G5	SH		
ERIGERON VERNUS	WHITE-TOP FLEABANE	G5	S1		RSC
ERIMYZON SUCETTA	LAKE CHUBSUCKER	G5	S2		
ERIOCAULON COMPRESSUM	FLATTENED PIPEWORT	G5	S1		RSC
ERIOCAULON DECANGULARE	TEN-ANGLE PIPEWORT	G5	S1		RSC
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S3	3C	RSC
ERIOCAULON SEPTANGULARE	WHITE BUTTONS	G5	S1		RE
ERORA LAETA	EARLY HAIRSTREAK	G4	S3S4		
ERPETOGOMPHUS DESIGNATUS		G5	S2		
ERYNNIS LUCILIUS	COLUMBINE DUSKYWING	G4	S3S4		
ERYNNIS PERSIUS PERSIUS	PERSIUS DUSKYWING	G4T3	SU		
ERYSIMUM CAPITATUM	WESTERN WALLFLOWER	G5	S1		RE
ERYTHRODIPLAX MINUSCULA		G5	S2		
ERYTHROECIA HEBARDI	HEBARD'S NOCTUID MOTH	GU	SH	C2	
ERYTHRONIUM ALBIDUM	WHITE TROUT-LILY	G5	S2		RSC
ETHEOSTOMA ACUTICEPS	SHARPHEAD DARTER	G3G4	S1	3C	LE
ETHEOSTOMA CAERULEUM	RAINBOW DARTER	G5	S2		
ETHEOSTOMA CAMURUM	BLUEBREAST DARTER	G3	S2		RSC
ETHEOSTOMA CHLOROBRANCHIUM	GREENFIN DARTER	G3	S1		RT
ETHEOSTOMA CINEREUM	ASHY DARTER	G2	SH		
ETHEOSTOMA COLLIS	CAROLINA DARTER	G3	S2		LERC
ETHEOSTOMA JESSIAE	BLUESIDE DARTER	G4Q	S1		LE
ETHEOSTOMA KANAWHAE	KANAWHA DARTER	G2	S2		
ETHEOSTOMA LONGIMANUM	LONGFIN DARTER	G3	S3		
ETHEOSTOMA MEADIAE	SPECKLED DARTER	G5	S1		

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FUSCONAIA COR	SHINY PIGTOE	G1	S1	LE	LE
FUSCONAIA CUNEOLUS	FINE-RAYED PIGTOE	G1	S1	LE	LE
FUSCONAIA MASONI	ATLANTIC PIGTOE	G2	S2		RT
GALIUM BOREALE	NORTHERN BEDSTRAW	G5	S1S2		RSC
GALIUM HISPIDULUM	COAST BEDSTRAW	G5	S1S2		RSC
GALLINULA CHLOROPUS	COMMON MOORHEN	G5	S1		RSU
GASTROCOPTA CLAPPI		G5	S1S2		
GASTROCOPTA CRISTATA	CRESTED SNAGGLETOOTH	G?	S3		RSC
GASTROCOPTA HOLZINGERI	LAMBDA SNAGGLETOOTH	G4G5	S3		
GASTROCOPTA PELLUCIDA	SLIM SNAGGLETOOTH	G4G5	S1		
GASTROCOPTA TAPPANIANA		G5	S3		
GASTRODONTA FONTICULA	BROWN BELLYTOOTH	G3G4	S1		
GAYLUSSACIA BRACHYCERA	BOX HUCKLEBERRY	G2	S1S2	3C	RSC
GENTIANA ANDREWSII	FRINGE-TOP BOTTLE GENTIAN	G4	S1		RSC
ANA AUSTROMONTANA	APPALACHIAN GENTIAN	G3Q	SU	3C	
IANA AUTUMNALIS	PINE BARREN GENTIAN	G3	SH	3C	
GENTIANA CRINITA	FRINGED GENTIAN	G4	S1		RE
GEOCENTROPHORA CAVERNICOLA		G?	S1		
GERANIUM ROBERTIANUM	HERB-ROBERT	G5	S1		RSC
GEUM ALEPPICUM	YELLOW AVENS	G5	SH		
GEUM LACINIATUM	ROUGH AVENS	G5	S1S2		RSC
GILLENIA STIPULATA	AMERICAN IPECAC	G5	S1		RSC
GLAUCOMYS SABRINUS COLORATUS	NORTHERN FLYING SQUIRREL	G5T1	S1	LE	LE
GLAUCOMYS SABRINUS FUSCUS	NORTHERN FLYING SQUIRREL	G5T2	S1	LE	LE
GLYCERIA GRANDIS	AMERICAN MANNAGRASS	G5	S1		RSC
GLYPHYALINIA CUMBERLANDIANA	HILL GLYPH	G4	S3		
GLYPHYALINIA LEWISIANA	PALE GLYPH	G4	S2		
GLYPHYALINIA LUTICOLA	FURROWED GLYPH	G4	S2		
GLYPHYALINIA PICEA	RUST GLYPH	G3	S1		RSC
GLYPHYALINIA PRAECOX	BRILLIANT GLYPH	G4	S1		RSC
GLYPHYALINIA RADERI	MARYLAND GLYPH	G2	S1	C2	RSC
GLYPHYALINIA SCULPTILIS	SUBORB GLYPH	G4	S1		RSC
GLYPHYALINIA VIRGINICA	DEPRESSED GLYPH	G3	S2S3		
GNAPHALIUM ULIGINOSUM	A CUDWEED	G5	S2S3		RSC
GNAPHALIUM VISCOSUM	WINGED CUDWEED	G3G5	S1		RSU
GOMPHAESCHNA ANTILOPE		G5	S2		
GOMPHAESCHNA FURCILLATA		G5	S2		
GOMPHURUS CRASSUS		G3G4	S?		
GOMPHURUS DILATATUS		G3G4	S?		
IRUS EXTERNUS		G5	S?		
URUS FRATERNUS		G5	S1		
GOMPHURUS HYBRIDUS		G3	S?		
GOMPHURUS SEPTIMA		G1G2	S1	C2	RE
GOMPHURUS VENTRICOSUS		G3G4	S1		RT
GOMPHUS ABBREVIATUS		G3	S2		

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HEXASTYLIS SHUTTLEWORTHII	LARGE-FLOWERED HEARTLEAF	G4	S2		RSC
HIERACIUM TRAILLII	TRAILL GREEN'S HAWKWEED	G4?Q	S2S3		RSC
HIMANTOPUS MEXICANUS	BLACK-NECKED STILT	G5	S1		
HOLSINGERIA UNTHANKSENSIS		G1	S1		RE
HOUSTONIA CANADENSIS	LONGLEAF BLUETS	G4G5	S1		RSC
HOUSTONIA SERPYLLIFOLIA	MICHAUX BLUET	G3G5	S1S2		RSC
HYBOPSIS AMBLOPS	BIGEYE CHUB	G4?	S3		
HYBOPSIS CAHNI	SLENDER CHUB	G2	S1	LT	LT
HYBOPSIS DISSIMILIS	STREAMLINE CHUB	G4?	S3		
HYBOPSIS HYPSINOTUS	HIGHBACK CHUB	G4	S3		
HYBOPSIS INSIGNIS	BLOTCHED CHUB	G4?	S3		
HYDRAENA MAUREENAE	MAUREEN'S HYDRAENAN MINUTE MOSS BEETLE	G1G3	S1S3	C2	
ASTIS CANADENSIS	GOLDEN SEAL	G4	S2S3	3C	RSC
JCOTYLE BONARIENSIS	COASTAL-PLAIN PENNY-WORT	G5	S1		RSC
LA GRATIOSA	BARKING TREEFROG	G5	S3		RSC
HYPENTELIUM ROANOKENSE	ROANOKE HOG SUCKER	G3?	S3		
HYPERICUM ADPRESSUM	CREEPING ST. JOHN'S-WORT	G4	S1?		
HYPERICUM MITCHELLIANUM	BLUE RIDGE ST. JOHN'S-WORT	G3	S1?		RSC
HYPERICUM TUBULOSUM	LARGE MARSH ST. JOHN'S WORT	G3G5	S1		RSC
HYPOXIS LONGII	LONG'S YELLOW STAR-GRASS	G4	SH	3C	RSU
HYPPA CONTRASTA		G4	SH		
ICHTHYOMYZON BDELLIUM	OHIO LAMPREY	G3	S2		
ICHTHYOMYZON GREELEYI	MOUNTAIN BROOK LAMPREY	G3	S2		
ILEX COLLINA	LONG-STALKED HOLLY	G3	S1S2	3C	LE
ILEX CORIACEA	BAY-GAIL HOLLY	G5	S1		RSC
ILIAMNA COREI	PETER'S MOUNTAIN MALLOW	G1Q	S1	LE	LE
ILIAMNA REMOTA	KANKAKEE GLOBE-MALLOW	G1	S1	C2	
INCISALIA POLIOS	HOARY ELFIN	G5	S1S3		
IO FLUVIALIS	SPINY RIVERSNAIL	G2	S2	C1	RT
IRESINE RHIZOMATOSA	EASTERN BLOODLEAF	G5	S1		RSC
IRIS VERSICOLOR	BLUEFLAG	G5	S2		RSC
ISCHNURA KELLICOTTI		G4	S1		RSC
ISCHNURA PROGNATHA		G4	S1		RSC
ISCHNURA RAMBURII		G5	S2		
ISOETES MACROSPORA	LAKE QUILLWORT	G5	S1		RE
ISOETES VIRGINICA	VIRGINIA QUILLWORT	G1G2Q	S1	C2	RSU
ISOTRIA MEDEOLOIDES	SMALL WHORLED POGONIA	G2	S1	LE	LE
VA IMBRICATA	SEA-COAST MARSH-ELDER	G5?	S2S3		RSC
RYCHUS EXILIS	LEAST BITTERN	G5	S2		RSU
CUS ABORTIVUS	PINEBARREN RUSH	G4G5	S1?		RE
JUNCUS ARTICULATUS	JOINTED RUSH	G5	S1		
JUNCUS BALTICUS	BALTIC RUSH	G5	S1		RSC
JUNCUS CAESARIENSIS	NEW JERSEY RUSH	G2	S2	C2	RE
JUNCUS CRASSIFOLIUS	A RUSH	G?	S2		RSC

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SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
LEPIDOCHELYS KEMPII	KEMP'S RIDLEY SEA TURTLE	G1	S1	LE	LE
LEPTOCHLOA FILIFORMIS	RED SPANGLE-TOP	G5	S2S3		
LEPTODEA FRAGILIS	FRAGILE PAPERSHELL	G5	S2		RSC
LEPTOLOMA COGNATUM	MOUNTAIN HAIRGRASS	G5	S2S3		RSC
LEPTOXIS PRAEROSA		G1G3	SU	C2	
LEPUS AMERICANUS	SNOWSHOE HARE	G5	S1		RE
LESTES CONGENER		G5	S?		
LESTES DISJUNCTUS AUSTRALIS		G5T5	S2		
LESTES DISJUNCTUS DISJUNCTUS		G5T5	S1		
LESTES DRYAS		G5	S1		RSC
LESTES EURINUS		G4	S1		RSC
LESTES FORCIPATUS		G5	S2		
LESTES INAEQUALIS		G5	S1		
LESTES UNGUICULATUS		G5	S?		
LESTES VIGILAX		G5	S2		
LEUCORRHINIA FRIGIDA		G5	S1		
LEUCORRHINIA GLACIALIS		G5	S?		
LEUCORRHINIA HUDSONICA		G5	S1		
LEUCORRHINIA INTACTA		G5	S2		
LEUCORRHINIA PROXIMA		G5	S1		
LEUCOTHOE FONTANESIANA	HIGHLAND DOG-HOBBLE	G5	S1		RSC
LEUROGNATHUS MARMORATUS	SHOVELNOSE SALAMANDER	G4	S2?		RSC
LEXINGTONIA DOLABELLOIDES	SLABSIDE PEARLYMUSSEL	G2	S2	C2	RT
LEXINGTONIA SUBPLANA	VIRGINIA PIGTOE	G1Q	S1		RE
LIATRIS ASPERA	TALL GAY-FEATHER	G4G5	S1		RE
LIBELLULA AURIPENNIS		G5	S1		
LIBELLULA AXILENA		G5	S1		
LIBELLULA FLAVIDA		G5	S2		
LIBELLULA QUADRIMACULATA		G5	S1		
LIGUMIA NASUTA	EASTERN PONDMUSSEL	G4	S2		RSC
LIGUMIA RECTA	BLACK SANDSHELL	G5	S2		RT
LILAEOPSIS CAROLINENSIS	CAROLINA LILAEOPSIS	G3	S1	3C	RT
LILIUM CATESBAEI	SOUTHERN RED LILY	G4	SH		RSU
LILIUM GRAYI	GRAY'S LILY	G2	S2	C2	RSU
LIMNAOEDUS OCULARIS	LITTLE GRASS FROG	G5	S3		
LIMNOBIUM SPONGIA	AMERICAN FROG'S-BIT	G5	S2		RSC
LIMNOTHLYPIS SWAINSONII	SWAINSON'S WARBLER	G4	S2		RT
LIMOSELLA AUSTRALIS	MUDWORT	G4	S1?		RSC
LINUM SULCATUM	GROOVED YELLOWFLAX	G5	S2		RSC
LISTERA LOESELII	LOESEL'S TWAYBLADE	G5	S2		RSC
LIPIA NODIFLORA	COMMON FROG-FRUIT	G5	S1		RSC
LIRCEUS CULVERI	RYE CAVE ISOPOD	G1	S1	C2	RSC
LIRCEUS USDAGALUN	LEE COUNTY CAVE ISOPOD	G2	S1S2	C2	
LISTERA AUSTRALIS	SOUTHERN TWAYBLADE	G4	S2S3		RSC
LISTERA CORDATA	HEARTLEAF TWAYBLADE	G5	S1?		

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MELOSPIZA GEORGIANA	SWAMP SPARROW	G5	S1		RSU
MENYANTHES TRIFOLIATA	BUCKBEAN	G5	S1		RE
MERGUS MERGANSER	COMMON MERGANSER	G5	S1		
MEROPLEON COSMION		G4	SH		
MESODON ANDREWSAE	BALSAM GLOBE	G3	S1		RSC
MESODON APPRESSUS LAEVIOR		G4T3T4	S1		
MESODON CHRISTYI	GLOSSY COVERT	G3	S1		RSC
MESODON CLAUSUS	YELLOW GLOBELET	G5	S2		
MESODON ELEVATUS	PROUD GLOBE	G5	S2		
MESODON INFLECTUS	SHAGREEN	G5	S3		
MESODON KALMIANUS	BROWN GLOBELET	G3	S1		RSC
MESODON PANSELENUS	VIRGINIA BLADETOOTH	G3G4	S2		
MESODON SAYANUS	SPIKE-LIPPED CRATER	G4G5	S3		
ODON WHEATLEYI		G4	S1		
UMPHIX CAPNODES	DUSKY BUTTON	G4G5	S3		
MESOMPHIX PERLAEVIS	SMOOTH BUTTON	G4	S3		
MESOMPHIX RUGELI	WRINKLED BUTTON	G3G4	S3		
MESOMPHIX SUBPLANUS		G3G4	S2		
MICRANTHEMUM MICRANTHEMOIDES	NUTTALL'S MICRANTHEMUM	GH	SH	C1*	C
MICRANTHEMUM UMBROSUM	SHADE MUDFLOWER	G5	S1		RSC
MICROCREAGRIS VALENTINEI	A PSEUDOSCORPION	G1	S1		
MICROPTERUS PUNCTULATUS	SPOTTED BASS	G5	S3		
MICROTUS CHROTORRHINUS CAROLINENSIS	SOUTHERN ROCK VOLE	G5T3	S1	C2	RE
MIKTONISCUS RACOVITZAE	RACOVITZA'S TERRESTRIAL CAVE ISOPOD	G2	S1		
MILIUM EFFUSUM	TALL MILLET-GRASS	G5	S1		RSC
MITOURA HESSELI	HESSEL'S HAIRSTREAK	G3G4	S2S3	3C	
MORONE CHRYSOPS	WHITE BASS	G5	S3		
MORONE SAXATILIS	STRIPED BASS	G5	S3		
MOXOSTOMA ARIOMMUM	BIGEYE JUMPROCK	G2	S2		
MOXOSTOMA CARINATUM	RIVER REDHORSE	G4	S3		RSC
MOXOSTOMA DUQUESNEI	BLACK REDHORSE	G5	S3		
MOXOSTOMA HAMILTONI	RUSTYSIDE SUCKER	G2	S2	3C	RSC
MOXOSTOMA ROBUSTUM	SMALLFIN REDHORSE	G3G4	SH		
MUHLENBERGIA BUSHII	BUSH'S MUHLY	G5	S2		RSU
MUHLENBERGIA CUSPIDATA	PLAINS MUHLENBERGIA	G4	S1		RE
MUHLENBERGIA EXPANSA	CUT-OVER MUHLY	G5	SH		
HLENBERGIA GLABRIFLORA	A MUHLY	G3G4Q	S2		RSU
ENBERGIA GLOMERATA	MARSH MUHLY	G5	S1		RSC
ORDOCHTHONIUS HOLSINGERI	A PSEUDOSCORPION	G1	S1		
MUSCULIUM LACUSTRE	LAKE FINGERNAILCLAM	G5	S3		
MUSCULIUM SECURIS	POND FINGERNAILCLAM	G5	S3		
MYOTIS GRISESCENS	GRAY BAT	G2	S1	LE	LE
MYOTIS LEIBII	EASTERN SMALL-FOOTED BAT	G3	S1	C2	

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NOTURUS ELEUTHERUS	MOUNTAIN MADTOM	G5	S3		
NOTURUS FLAVIPINNIS	YELLOWFIN MADTOM	G2	S1	LTXN	LT
NOTURUS FLAVUS	STONECAT	G5	S3		RSC
NOTURUS GILBERTI	ORANGEFIN MADTOM	G2	S1	C2	RT
NUPHAR SAGITTIFOLIUM	YELLOW COWLILY	G3Q	S2		RSC
NYCTANASSA VIOLACEUS	YELLOW-CROWNED NIGHT-HERON	G5	S1		RT
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	G5	S3		
NYMPHOIDES AQUATICA	BIG FLOATING-HEART	G5	S1		RSC
OKEANOBATES AMERICANUS	A MILLIPEDE	G4	S1		
OLDENLANDIA BOSCII	BOSC'S BLUET	G5	S1?		RSC
ONOMERIS UNDERWOODI	A MILLIPEDE	G5	S1		
OPHEODRYS AESTIVUS CONANTI	BARRIER ISLANDS ROUGH GREEN SNAKE	G5T?	S2		
ODRYS VERNALIS	SMOOTH GREEN SNAKE	G5	S3		RSU
OGLOSSUM PETIOLATUM	LONGSTEM ADDER'S-TONGUE FERN	G5	S1		RSC
PHIOGLOSSUM VULGATUM VAR PSEUDOPODUM	ADDER'S-TONGUE	G5T5	S1		RSC
OPHIOGOMPHUS ANOMALUS		G2	S?	C2	
OPHIOGOMPHUS CAROLUS		G5	S1		
OPHIOGOMPHUS RUPINSULENSIS		G5	S2		
OPHIONUROIDES HOWEI		G2G3	S1	C2	RE
OPHIONURUS ALLEGHANIENSIS		G3G4TU	S1	C2	RE
OPHIONURUS ASPERSUS		G3G4	S1		RT
OPHIONURUS INCURVATUS		G3G4	S1		RT
OPHIONURUS MAINENSIS		G3G4	S1		
OPHISAURUS VENTRALIS	EASTERN GLASS LIZARD	G5	S1		RT
OPORORNIS PHILADELPHIA	MOURNING WARBLER	G5	S1		RSC
ORCONECTES VIRGINIENSIS	CHOWAN RIVER CRAYFISH	G2	S2		
ORINISOBATES NIGRIOR	A MILLIPEDE	G4	S1		
ORTHEMIS FERRUGINEA		G5	S?		
OSMANTHUS AMERICANUS	WILD OLIVE	G5	S1		RSC
OXYLOMA SUBEFFUSUM		G4	S1		RSC
OXYPOLIS FILIFORMIS	WATER COWBANE	G5	SH		RSU
PACHISTIMA CANBYI	CANBY'S MOUNTAIN-LOVER	G2	S2S3	C2	RT
PALLIFERA HEMPHILLI	BLACK MANTLESLUG	G3	S1		
PALLIFERA VARIA	VARIABLE MANTLESLUG	G2	S2S3		
PANAX QUINQUEFOLIUS	AMERICAN GINSENG	G4	S3S4	3C	LT
PANICUM HEMITOMON	MAIDENCANE	G5?	S1S2		RSC
ICUM HIANS	GAPING PANIC GRASS	G5	S1		RSC
UM SCABRIUSCULUM	PANIC GRASS	G4	SU		
CUM STRIGOSUM	ROUGH-HAIR WITCHGRASS	G5	SU		
PAPAIPEMA CIRCUMLUCENS		G4	SHSU		
PARAVITREA BLARINA	SHREW SUPERCOIL	G3	S1		RSC
PARAVITREA DENTILLA	COMB SUPERCOIL	G1	S1		RSC
PARAVITREA HERA	SPIRIT SUPERCOIL	G1	S1		RE

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PHENACOBIUS CRASSILABRUM	FATLIPS MINNOW	G3	S2		RSC
PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	G5	S2		
PHENACOBIUS TERETULUS	KANAWHA MINNOW	G3	S3	C2	
PHENACOBIUS URANOPS	STARGAZING MINNOW	G4	S3		
PHILADELPHUS HIRSUTUS	STREAMBANK MOCK-ORANGE	G5	S1		RSC
PHILOMYCUS VENUSTRUS	BROWNSPOTTED MANTLESLUG	G4	S3		
PHILOMYCUS VIRGINICUS	VIRGINIA MANTLESLUG	G3	S3		
PHLOX AMPLIFOLIA	LARGE-LEAVED PHLOX	G3G5	S1		RSC
PHLOX BUCKLEYI	SWORD-LEAVED PHLOX	G2G3	S2S3	3C	RSC
PHLOX NIVALIS	TRAILING PHLOX	G4	S2		RSC
PHLOX PILOSA	DOWNY PHLOX	G5	S2		
PHYCIODES BATESII	TAWNY CRESCENTSPOT	G3G4	SH	C2	
PHYCIODES PASCOENSIS	NORTHERN PEARLY CRESCENTSPOT	G5	S1S3		
~'YSALIS VISCOSA	STICKY GROUND-CHERRY	G4G5	S1		RSC
SOSTEGIA LEPTOPHYLLA	SLENDER-LEAVED DRAGON-HEAD	G4G5	S1S2	C2	RSC
↓COIDES BOREALIS	RED-COCKADED WOODPECKER	G2	S1	LE	LE
PIERIS VIRGINIENSIS	WEST VIRGINIA WHITE	G4	S3S4		
PIMEPHALES VIGILAX	BULLHEAD MINNOW	G5	S1		
PINUS PALUSTRIS	LONG-LEAF PINE	G4G5	S1		RSC
PISIDIUM ADAMSI	ADAM PEACLAM	G3	S3		
PISIDIUM DUBIUM	GREATER EASTERN PEACLAM	G5	S3		
PISIDIUM EQUILATERALE	ROUND PEACLAM	G5	S2		
PISIDIUM PUNCTATUM	PERFORATED PEACLAM	G5	S3		
PISIDIUM PUNCTIFERUM	STRIATE PEACLAM	G5	S3		
PISIDIUM VARIABILE	TRIANGULAR PEACLAM	G5	S3		
P↓SIDIUM WALKERI	WALKER PEACLAM	G5	S3		
PITUOPHIS MELANOLEUCUS	PINE SNAKE	G5	SU		RSU
PLANTAGO CORDATA	HEART-LEAVED PLANTAIN	G3	SH	3C	
PLANTAGO MARITIMA	SEASIDE PLANTAIN	G5	S1		RSC
PLECOTUS RAFINESQUII	EASTERN BIG-EARED BAT	G4	S1	C2	LE
PLECOTUS TOWNSENDII VIRGINIANUS	VIRGINIA BIG-EARED BAT	G5T2	S1	LE	LE
PLEGADIS CHIHI	WHITE-FACED IBIS	G5	SA	C2	
PLEGADIS FALCINELLUS	GLOSSY IBIS	G5	S2		RSC
PLETHOBASUS CYPHYUS	SHEEPNOSE	G3	S1		RE
PLETHODON DORSALIS	ZIGZAG SALAMANDER	G5Q	SU		RSU
PLETHODON HUBRICHTI	PEAKS OF OTTER SALAMANDER	G2	S2	C2	RSC
PLETHODON KENTUCKI	CUMBERLAND SALAMANDER	G3	S3		
PLETHODON PUNCTATUS	WHITE-SPOTTED SALAMANDER	G3	S2	C2	RSC
THODON SHENANDOAH	SHENANDOAH SALAMANDER	G1	S1	LE	LE
.THODON WELLERI	WELLER'S SALAMANDER	G4	S2		RSC
PLETHODON YONAHLOSSEE	YONAHLOSSEE SALAMANDER	G4	S3		
PLEUROBEMA COLLINA	JAMES SPINYMUSSEL	G1	S1	LE	LE
PLEUROBEMA CORDATUM	OHIO RIVER PIGTOE	G3	S1		RE
PLEUROBEMA OVIFORME	TENNESSEE CLUBSHELL	G3	S3	C2	RSC

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PROGOMPHUS BELLEI		G1G3	S?	C2	
PROMENETUS EXACUOUS	SHARP SPRITE	G?	S3		
PRUNUS ALLEGHANIENSIS	ALLEGHANY PLUM	G3	S2S3	3C	RSC
PRUNUS NIGRA	CANADA PLUM	G4G5	S1		RSC
PRUNUS PUMILA	SAND CHERRY	G5	S1		RSC
PSEUDANOPHTHALMUS AVERNUS		G1	S1		
PSEUDANOPHTHALMUS CORDICOLLIS		G1	S1		
PSEUDANOPHTHALMUS DECEPTIVUS		G1	S1		
PSEUDANOPHTHALMUS DELICATUS		G2	S2		
PSEUDANOPHTHALMUS EGBERTI		G1	S1		
PSEUDANOPHTHALMUS GRACILIS		G1	S1		
PSEUDANOPHTHALMUS HIRSUTUS		G1	S1		
PSEUDANOPHTHALMUS HOFFMANI		G1?	S1		
PSEUDANOPHTHALMUS HOLSINGERI		G1	S1		
PSEUDANOPHTHALMUS HORTULANUS		G1	S1		
PSEUDANOPHTHALMUS HUBBARDI		G1	S1		
PSEUDANOPHTHALMUS HUBRICHTI		G1	S1		
PSEUDANOPHTHALMUS INTERSECTUS		G1	S1		
PSEUDANOPHTHALMUS LIMICOLA		G1	S1		
PSEUDANOPHTHALMUS LONGICEPS		G1	S1		
PSEUDANOPHTHALMUS NELSONI		G1	S1		
PSEUDANOPHTHALMUS PARVICOLLIS		G1	S1		
PSEUDANOPHTHALMUS PETRUNKEVITCHI		G1	S1		
PSEUDANOPHTHALMUS PONTIS		G1	S1		
PSEUDANOPHTHALMUS POTOMACA		G1	S1		
PSEUDANOPHTHALMUS PRAETERMISSUS		G1	S1		
PSEUDANOPHTHALMUS PUNCTATUS		G1	S1		
PSEUDANOPHTHALMUS PUSIO		G1?	S1		
PSEUDANOPHTHALMUS QUADRATUS		G1	S1		
PSEUDANOPHTHALMUS ROTUNDATUS		G1	S1		
PSEUDANOPHTHALMUS SANCTIPAULI		G1	S1		
PSEUDANOPHTHALMUS SECLUSUS		G1	S1		
PSEUDANOPHTHALMUS SERICUS		G1	S1		
PSEUDANOPHTHALMUS SP. 10		G1	S1		
PSEUDANOPHTHALMUS SP. 11		G1	S1		
PSEUDANOPHTHALMUS SP. 4		G1	S1		
PSEUDANOPHTHALMUS SP. 5		G1	S1		
PSEUDANOPHTHALMUS SP. 6		G1	S1		
PSEUDANOPHTHALMUS SP. 7		G1	S1		
PSEUDANOPHTHALMUS SP. 9		G1	S1		
PSEUDANOPHTHALMUS THOMASI		G1	S1		
PSEUDANOPHTHALMUS VICARIUS		G2	S1		
PSEUDANOPHTHALMUS VIRGINIANUS		G1	S1		

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REGULUS SATRAPA	GOLDEN-CROWNED KINGLET	G5	S2		RSU
RHAMNUS ALNIFOLIA	ALDERLEAF BUCKTHORN	G5	S1		RE
RHAMNUS LANCEOLATA	LANCE-LEAVED BUCKTHORN	G4G5	S2		RSC
RHEXIA ARISTOSA	AWNED MEADOWBEAUTY	G2	SU	C2	
RHEXIA PETIOLATA	CILIATE MEADOW-BEAUTY	G3G5	S1		RSC
RHODODENDRON ARBORESCENS	SMOOTH AZALEA	G4G5	S2		RSC
RHODODENDRON CUMBERLANDENSE	CUMBERLAND RHODODENDRON	G3Q	S2S3		RSC
RHYNCHOSPORA ALBA	WHITE BEAKRUSH	G5	S1		RSC
RHYNCHOSPORA CAPILLACEA	CAPILLARY BEAKRUSH	G5	S1		RSC
RHYNCHOSPORA FASCICULARIS	FASCICULATE BEAKRUSH	G5	S1		RSC
RHYNCHOSPORA FILIFOLIA	THREAD-LEAVED BEAKRUSH	G5	S1		RSC
RHYNCHOSPORA GRAYI	GRAY'S BEAKRUSH	G4	S1		RSC
RHYNCHOSPORA HARVEYI	HARVEY BEAKRUSH	G4	S1		RSC
RHYNCHOSPORA INUNDATA	DROWNED HORNEDRUSH	G3G4	SU		
RHYNCHOSPORA MILIACEA	MILLET BEAKRUSH	G5	S1		RSC
RHYNCHOSPORA PALLIDA	PALE BEAKRUSH	G2G3	SH		
RHYNCHOSPORA PERPLEXA	A BEAK-RUSH	G5	S1		RSC
RHYNCHOSPORA WRIGHTIANA	WRIGHT BEAK-RUSH	G5	SU		
RIBES AMERICANUM	WILD BLACK CURRANT	G5	S1		
RIBES GLANDULOSUM	SKUNK CURRANT	G5	S2S3		RSC
RIBES LACUSTRE	BRISTLY BLACK CURRANT	G5	S1		
RORIPPA SESSILIFLORA	STALKLESS YELLOWCRESS	G3G5	S1		RSC
ROSA SETIGERA	PRAIRIE ROSE	G5	S2		RSC
RUBUS IDAEUS	COMMON RED RASPBERRY	G5	S1		RSC
RUDBECKIA HELIOPSIDIS	SUN-FACING CONEFLOWER	G2	S1	C2	RE
RUDBECKIA TRILOBA VAR PINNATILOBA	PINNATE-LOBED BLACK-EYED SUSAN	G4T1T2	S1	C2	
RUDILORIA KLEINPETERI	A MILLIPEDE	G1	S3		
RUDILORIA TRIMACULATA TORTUA	A MILLIPEDE	G2T?	S2		
RUMEX ORBICULATUS	WATER DOCK	G5	S1		
RYNCHOPS NIGER	BLACK SKIMMER	G5	S3		
SABATIA BRACHIATA	NARROW-LEAF PINK	G5?	S1		RSC
SABATIA CALYCINA	COAST ROSE-GENTIAN	G3G5	S1S2		RSC
SABATIA DIFFORMIS	TWO-FORMED PINK	G4G5	S1		RSC
SAGITTARIA CALYCINA	LONG-LOBE ARROWHEAD	G5	S1		RSC
SAGITTARIA ENGELMANNIANA	ENGELMANN ARROWHEAD	G5?	S1		RSC
SAGITTARIA RIGIDA	SESSILE-FRUITED ARROWHEAD	G5	S1		RSC
SAGITTARIA SPATHULATA		G?	S1		
SALIX INTERIOR	SANDBAR WILLOW	G5	S1S2		RSC
SALIX LUCIDA	SHINING WILLOW	G5	S1		
SALIX PETIOLARIS	MEADOW WILLOW	G3G5	SH		
SANGUISORBA CANADENSIS	CANADA BURNET	G5	S1		RSC
SANICULA TRIFOLIATA	LARGE-FRUITED SANICLE	G4	S2		RSC
SARRACENIA FLAVA	YELLOW PITCHER-PLANT	G4G5	S1S2		RE
SARRACENIA PURPUREA	NORTHERN PITCHER-PLANT	G5	S1S2		RSC

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SMILAX ECIRRHATA	UPRIGHT GREENBRIER	G5?	S1		RSC
SMILAX SMALLII	SMALL'S GREENBRIER	G5?	S1		RSC
SOLIDAGO ELLIOTTII	ELLIOTT GOLDENROD	G5	S1		RSC
SOLIDAGO HARRISII	SHALE BARREN GOLDENROD	G3Q	S2		RSC
SOLIDAGO PATULA	ROUNDLEAF GOLDENROD	G5	S2S3		RSC
SOLIDAGO RACEMOSA	STICKY GOLDEN-ROD	G3G4	SU		RSC
SOLIDAGO RADULA	WESTERN ROUGH GOLDENROD	G5?	SU		
SOLIDAGO RANDII	RAND'S GOLDENROD	G2G4	S?		RSC
SOLIDAGO RUPESTRIS	ROCK GOLDENROD	G2?Q	S1		RSU
SOLIDAGO SALICINA	ROUND-LEAVED GOLDENROD	G3?	S1		RSC
SOLIDAGO TORTIFOLIA	A GOLDENROD	G3G5	S1		RSC
SOLIDAGO ULIGINOSA	BOG GOLDENROD	G4G5	S1		RSC
SOMATOCHLORA ELONGATA		G5	S1		
SOMATOCHLORA FILOSA		G5	S1		
SOMATOCHLORA FORCIPATA		G5	S?		
SOMATOCHLORA GEORGIANA		G3G4	S1		RT
SOMATOCHLORA INCURVATA		G2G3	S?		
SOMATOCHLORA LINEARIS		G5	S2		
SOMATOCHLORA PROVOCANS		G3G4	S1		
SOMATOCHLORA WALSHII		G5	S?		
SOMATOCHLORA WILLIAMSONI		G5	S1		
SOMATOGYRUS PENNSYLVANICUS	SHALE PEBBLESNAIL	G?	S3		
SOMATOGYRUS VIRGINICUS	PIEDMONT PEBBLESNAIL	G?	S1S2		RSC
SOREX DISPAR	LONG-TAILED OR ROCK SHREW	G5	S3	C2	
SOREX LONGIROSTRIS FISHERI	DISMAL SWAMP SOUTHEASTERN SHREW	G5T2Q	S2	LT	LT
SOREX PALUSTRIS PUNCTULATUS	SOUTHERN WATER SHREW	G5T3	S1	C2	RE
SPARGANIUM ANDROCLADUM	BRANCHING BUR-REED	G4G5	S1		
SPARGANIUM CHLOROCARPUM	NARROW-LEAF BURREED	G5	S2		RSC
SPARTINA PECTINATA	FRESH WATER CORDGRASS	G5	S1S2		RSC
SPEYERIA DIANA	DIANA	G3	S3		
SPEYERIA IDALIA	REGAL FRITILLARY	G3	SH	C2	
SPHAERIUM STRIATINUM	STRIATED FINGERNAILCLAM	G5	S3		
SPHAERODERUS SCHAUMI		G?	S2	C2	
SPHALLOPLANA CHANDLERI	A PLANARIAN	G1	S1		
SPHALLOPLANA CONSIMILIS	POWELL VALLEY PLANARIAN	G1G2	S1		
SPHALLOPLANA HOLSINGERI	HOLSINGER'S GROUNDWATER PLANARIAN	GH	SX	3A	
SPHALLOPLANA SUBTILIS	BIGGER'S GROUNDWATER PLANARIAN	GH	SX	3A	
SPHALLOPLANA VIRGINIANA	ROCKBRIDGE COUNTY CAVE PLANARIAN	G1	S1	C2	
SPHENOPHOLIS FILIFORMIS	LONG-LEAF WEDGESCALE	G3G4	S1		RSC
SPHINX FRANCKII		G4	SHSU		
SPHYRAPICUS VARIUS	YELLOW-BELLIED SAPSUCKER	G5	S1		
SPIRAEA VIRGINIANA	VIRGINIA SPIRAEA	G1	S1	PT	LE

DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE

GLOSSARY OF RARE ELEMENTS OF VIRGINIA

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
STYGOBROMUS CUMBERLANDUS	CUMBERLAND CAVE AMPHIPOD	G2	S1S2		
STYGOBROMUS EPHEMERUS	EPHEMERAL CAVE AMPHIPOD	G1	S1	3C	RSC
STYGOBROMUS ESTESI	CRAIG COUNTY CAVE AMPHIPOD	G1	S1		RSC
STYGOBROMUS FERGUSONI	MONTGOMERY COUNTY CAVE AMPHIPOD	G1	S1		RSC
STYGOBROMUS GRACILIPES	SHENANDOAH VALLEY CAVE AMPHIPOD	G2	S1	3C	
STYGOBROMUS HOFFMANI	ALLEGHANY COUNTY CAVE AMPHIPOD	G1	S1		RSC
STYGOBROMUS INDENTATUS	TIDEWATER AMPHIPOD	G?	S1	C2	
STYGOBROMUS INTERITUS	NEW CASTLE MURDER HOLE AMPHIPOD	G1	S1		
STYGOBROMUS KENKI	ROCK CREEK GROUNWATER AMPHIPOD	G1	S1		
STYGOBROMUS LEENSIS	LEE COUNTY CAVE AMPHIPOD	G1	S1		
STYGOBROMUS MACKINI	SOUTHWESTERN VIRGINIA CAVE AMPHIPOD	G3G4	S2	3C	
YGOBROMUS MORRISONI	MORRISON'S CAVE AMPHIPOD	G3	S1S2	C2	
STYGOBROMUS MUNDUS	BATH COUNTY CAVE AMPHIPOD	G2	S1S2	C2	RSC
STYGOBROMUS OBRUTUS	PITTSYLVANIA WELL AMPHIPOD	G1	S1		
STYGOBROMUS PHREATICUS	NORTHERN VIRGINIA WELL AMPHIPOD	G2	S1S2		
STYGOBROMUS PIZZINII	PIZZINI'S AMPHIPOD	G2	S1S2	C2	
STYGOBROMUS PSEUDOSPINOSUS	LURAY CAVERNS AMPHIPOD	G1	S1		RSC
STYGOBROMUS SPINOSUS	BLUE RIDGE MOUNTAIN AMPHIPOD	G2G3	S1		
STYGOBROMUS STEGERORUM	MADISON CAVE AMPHIPOD	G1	S1		RT
STYGOBROMUS TENUIS	A GROUNDWATER AMPHIPOD	G4G5	S2S3		
STYLOPHORUM DIPHYLLUM	CELANDINE POPPY	G5	S2		RSC
STYLURUS AMNICOLA		G3G4	S1		
STYLURUS IVAE		G2G3	S?		
STYLURUS LAURAE		G?	S1		
STYLURUS NOTATUS		G3G4	S1	C2	
STYLURUS PLAGIATUS		G5	S2		
STYLURUS SCUDDERI		G3G4	S1		
STYLURUS SPINICEPS		G5	S2		
STYLURUS TOWNESI		G1G3	S?	C2	
STYRAX AMERICANA	AMERICAN SNOWBELL	G5	S2		RSC
SUAEDA MARITIMA	WHITE SNOWBELL	G5	S1		
SUCCINEA CAMPESTRIS	CRINKLED AMBERSNAIL	G4	S3		RSC
SUCCINEA CHITTENANGOENSIS	CHITTENANGO OVATE AMBER SNAIL	G1	S1	LT	
SUCCINEA WILSONI	WILSON AMBERSNAIL	G4	S2		RSC
LLIVANTIA SULLIVANTII	SULLIVANTIA	G3Q	S1	3C	RT
VILAGUS FLORIDANUS HITCHENSI	SMITHS ISLAND COTTONTAIL	G5THQ	SH	C2	RSU
SYMPETRUM AMBIGUUM		G5	S1		
SYMPETRUM COSTIFERUM		G5	S?		
SYMPETRUM INTERNUM		G5	S1		

DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE

GLOSSARY OF RARE ELEMENTS OF VIRGINIA

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
TRILLIUM NIVALE	SNOW TRILLIUM	G4	S1		RSC
TRILLIUM PUSILLUM VAR MONTICULUM	VIRGINIA LEAST TRILLIUM	G3T1Q	S1	C2	
TRILLIUM PUSILLUM VAR VIRGINIANUM	VIRGINIA LEAST TRILLIUM	G3T2	S2	C2	RSC
TRIODOPSIS ALABAMENSIS	ALABAMA THREE-TOOTH	G4	S1		RSC
TRIODOPSIS BURCHI	PITTSYLVANIA THREE-TOOTH	G3G4	S3		
TRIODOPSIS FALLAX AFFINIS		G5T4	S1		
TRIODOPSIS MESSANA	PINHOLE SAND THREE-TOOTH	G4	S1		RSC
TRIODOPSIS OBSOLETA	SMOOTH-LIPPED SAND THREE-TOOTH	G4	S3		
TRIODOPSIS PENDULA	HANGING ROCK THREE-TOOTH	G3	S1		RSC
TRIODOPSIS PICEA	SPRUCE KNOB THREE-TOOTH	G3	S1		RSC
TRIODOPSIS RUGOSA		G3	S1		
ODOPSIS TENNESSEENSIS	BUDDED THREE-TOOTH	G4	S3		
ONYX SPINIFERUS	SPINY SOFTSHELL	G5	SU		RSU
TRIPHORA TRIANTHOPHORA	NODDING POGONIA	G4	S1		RSC
TROGLODYTES TROGLODYTES	WINTER WREN	G5	S2		RSU
TRUNCILLA TRUNCATA	DEERTOE	G4	S1		RE
TYPHA DOMINGENSIS	SOUTHERN CATTAIL	G4G5	S2S3		RSC
UNIOLA SESSILIFLORA	LONG-LEAF SPIKEGRASS	G5	S2		
UROBLANIULUS CANADENSIS	A MILLIPEDE	G5	S2		
UROBLANIULUS JERSEYI	A MILLIPEDE	G3	S2		
UROBLANIULUS SP 1	A MILLIPEDE (BURKES GARDEN)	G?	S1		
UTRICULARIA CORNUTA	HORNED BLADDERWORT	G5	S1		RSC
UTRICULARIA FIBROSA	FIBROUS BLADDERWORT	G4G5	S1S2		RSC
UTRICULARIA GEMINISCAPA	HIDDEN-FRUITED BLADDERWORT	G4G5	S2S3		RSC
UTRICULARIA PURPUREA	PURPLE BLADDERWORT	G5	S1S2		RSC
UTRICULARIA VULGARIS	GREATER BLADDERWORT	G5	S1S2		RSC
VACCINIUM CRASSIFOLIUM	CREEPING BLUEBERRY	G4G5	S1		RSC
VACCINIUM MACROCARPON	LARGE CRANBERRY	G4	S2S3		RSC
VALERIANA PAUCIFLORA	VALERIAN	G3G4	S1		RSC
VALLONIA PARVULA	TRUMPET VALLONIA	G4	S1		RSC
VALLONIA PERSPECTIVA	THIN-LIPPED VALLONIA	G4G5	S3		
VALVATA BICARINATA	TWORIDGED VALVATA	G?	S3		
VALVATA TRICARINATA	THREERIDGED VALVATA	G?	S3		
VENTRIDENS ACERRA	GLOSSY DOME	G4	S3		
VENTRIDENS ARCELLUS	GOLDEN DOME	G4	S3		
VENTRIDENS COELAXIS	BIDENTATE DOME	G3	S2		
TRIDENS INTERTEXTUS	PYRAMID DOME	G5	S3		
RIDENS LASMODON	HOLLOW DOME	G4	S2		
TRIDENS LAWAE	ROUNDED DOME	G4	S1		RSC
VENTRIDENS PILSBRYI	YELLOW DOME	G4	S2		
VENTRIDENS THELOIDES	COPPER DOME	G4G5	S2		
VERBENA SCABRA	SANDPAPER VERVAIN	G5	S2S3		RSC
VERMIVORA BACHMANII	BACHMAN'S WARBLER	GH	SA	LE	LE

General Soil Associations and Map - Cheatham Annex

A soil association is a landscape that has distinctive proportional pattern of soils. It normally consist of one or more major soils and at least one minor soil. It is named for the major soils. The soils in one association may appear in another but in a different pattern. The soil associations for the station are shown on the map that follows the soil association descriptions.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want ot compare it to other areas, or want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful, general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, drainage and other characteristics that affect their management.

The soil associations of Cheatham Annex have been grouped in four kinds of landscapes for broad interpretive purposes. Each of the following broad groups and the soil associations are described below.

1. Soils on marches and low terraces.

2. Soils on river terraces.

3. Soils on Coastal Plain uplands with narrow to medium ridges and steep to very steep side slopes.

4. Soils on Coastal Plain uplands with medium to narrow ridges and steep to very steep side slopes.

1. Soils formed on marshes and flood plains - Bohicket, Johnston, and Axis soil association

The soils of this association formed in water-deposited material that range from muck to sandy clay loams. They are mainly along King, Queen and Cub Creeks and along the York River. The soils are commonly nearly level, are waterlogged and flooded by salt tides daily or during high water. They receive seepage and runoff from higher lying areas. In the upper parts of the tributaries the marshes are brackish or fresh water.

Bohicket and Axis soils are along the tidal part of the creeks and river. Johnson soils are in the upper tributaries. Bohicket soils are mucky and have mucky silt loam mucky silty clay subsoils. Axis soils have mucky surface layers but generally have sandy loam or sandy clay loam subsoils. The Johnson complex soils are mucky in the surface layers but have stratified sand, silt and silty substrata or weakly developed subsoils.

Among the soils of minor extent are beaches and made land areas. Most of the marshes are in native vegetation of salt tolerant species of grasses, reeds and shrubs. This association is best suited to wildlife habitat and recreation.

2. Soils formed on river terraces - Dogue, Pamunkey and Uchee soil association

Deep moderately well and well and poorly drained soils that have clayey and loamy subsoils. This association is along the York River, and King, Queen, and Cub creeks. It is mainly on broad to medium ridges that are not flooded and slightly concave areas that are ponded for brief periods. These soils are mostly gently sloping or nearly level. Short steep side slopes and escarpments are common along drainageways, small streams and terrace breaks.

Dogue and Pamunkey soils are nearly level and gently sloping; they occur mainly on ridge points and on medium to broad ridges about a mile wide, with the back escarpment being approximately parallel with the York River. Drainageways cutting into this terrace formed dendritic drainage patterns. The slopes along these drainageways are short steep and very steep. The Dogue soils are moderately well drained and have clayey subsoils. The Pamunkey soils are well drained and have loamy subsoils. Chickahominy soils are poorly drained and have clayey subsoils and are on nearly level slopes and depressions.

Among minor soils and miscellaneous areas are urban soils, Udorthents - loamy, Emporia complex soils, Uchee soils, Bojac, Munden, Slagle and Newflat soils. These soils are on broad to narrow gently sloping ridges, and Emporia complex soils are on steep to very steep side slopes. This association is used for most of the developed area of Cheatham Annex.

3. Soils on Coastal Plan Upland with medium to narrow ridges andd sloping to very steep side slopes - Emporia, Slagle, and Craven-Uchee Complex soils association

Deep well and moderately well-drained soils that have loamy and clayey subsoils. This association formed in laomy and clayey Coastal Plain sediments. Emporia and Slagle soils are on medium width ridges. Emporia soils, commonly occupy the higher landscape position and slagle soils the lower landscape position. Craven and Uchee soils are on the narrower ridge points and the sloping area between the ridges and the steep and very steep side slopes. Emporia Complex soils are on the steep and very steep side slopes. The Emporia soils are well-drained and moderately slowly permeable. They have a clay loam or sandy clay loam subsoil, and a seasonal water table at 3 to 5 feet. The Slagle soils are moderately well-drained and moderately slow or slow meability and have a seasonal water table of 1 1/2 feet. The Craven soils are moderately well-drained and have a clay silty clay subsoil, a slow permeability and a seasonal high water table at 1 1/2 feet. The Uchee soils are well-drained, have a moderately slow permeability, a subsoil of sandy clay loam, clay loam and sandy clay, and a seasonal high water table at 3 1/2 to 5 feet.

Among the soils of minor extent are Caroline, Kempsville, Udorthents loamy. Most of this association is wooded but some areas are in small buildings and fuel storage.

4. Soils on Coastal Plain uplands with medium to narrow ridges and sloping to very steep sideslopes - Kempsville, Emporia, Emporia Complex, and Craven-Uchee Complex soils association

Deep well and moderately well drained soils that have loamy and clayey subsoils. This association formed in loamy and clayey Coastal Plain sediments. Kempsville and Emporia soils are on medium ridges. Kempsville and Emporia soils occur on the landscape. Emporia Complex soils are on the steep and very steep side slopes. Craven and Uchee soils are on narrow ridge points, and on the sloping area between the ridges and the steep and very steep side slopes.

The Kempsville soils are well drained moderately permeable. They have sandy clay loam and clay loam subsoils, and have a water table at 5 feet or greater. The Emporia soils are well drained and slowly permeable. They have a clay loam or sandy clay loam subsoil, and a seasonal water table of 3 to 5 feet. The Craven soils are moderately well drained with a clayey subsoil, slow permeability and seasonal high water table at 1 1/2 feet. The Uchee soils are well drained and have a moderately slow permeabilty, a sandy clay loam, and sandy clay subsoil, and a seasonal high water table of 3 1/2 to 5 feet.

Among the soils of minor extent are Caroline, Slagle, Dogue, Johnston Complex, and Udorthents-loamy. Most of this area is wooded but some areas are in fuel storage.

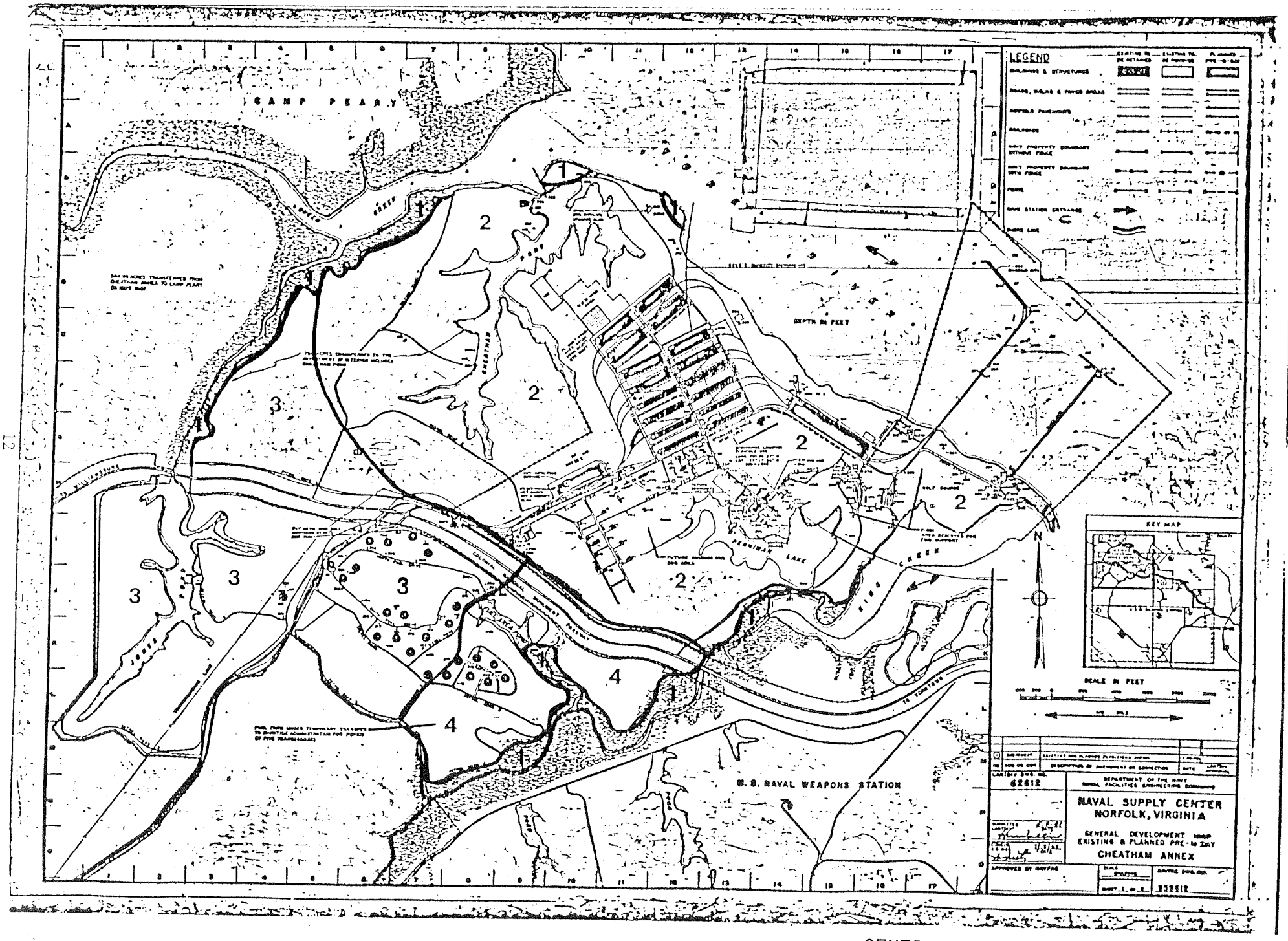
GENERAL SOIL ASSOCIATION LEGEND

1. Soils formed on marshes and low terraces - Bohicket, Johnson, and Axis soils association.

2. Soils formed on river terraces - Dogue, Pamunkey and Chickahominy soils association.

3. Soils on Coastal Plain upland, narrow to medium ridges and steep to very steep side slopes - Emporia, Slagle and Craven-Uchee soils association.

4. Soils on Coastal Plan uplands with medium to narrow ridges, and sloping to very steep side slopes - Kempsville, Emporia, Emporia Complex, and Craven-Uchee Complex soils association.



GENERAL SOIL ASSOCIATION MAP

TABLE I

SOIL INDEX AND ACRES

Soil Index Symbol	Soil Name	Approximate Acres	Percent of Total
7B	Newflat silt loam	30	1.9
9B	Dogue loam	157	9.9
10B, 27B	Slagle fine sandy loam	115	7.3
19	Beach	5	.3
28B	Kempsville-Emporia Complex	11	.7
30B	Emporia fine sandy loam	39	2.4
37	Johnston Complex	4	.2
41	Axis mucky loam	15	.9
42	Bohicket mucky silty clay loam	14	.9
50B	Uchee loamy fine sand	57	3.6
53C	Craven-Uchee Complex	212	13.4
70, 75	Udorthents loamy (made land, borrow pits)	150	9.4
72B, 73B	Pamunkey Soils	58	3.6
74B	Bojac sandy loam	16	1.0
81	Chickhominy silt loam	48	3.0
93D	Emporia Complex	8	.5
93E	Emporia Complex	41	2.5
93F	Emporia Complex	234	15.7
95	Urban Land	234	14.1
149B	Munden loamy fine sand	19	1.0
300	Udorthents-Dumps Complex	5	.3
Ponds		116	7.4
	Total	1,578	100.0

NATURAL HERITAGE RESOURCES OF VIRGINIA:

RARE ANIMAL SPECIES

MARCH 2003

VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION
DIVISION OF NATURAL HERITAGE
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Cover illustrations (left to right) by Megan Rollins

Red-cockaded Woodpecker
Indiana Myotis
Regal Fritillary

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NATURAL HERITAGE RESOURCES OF VIRGINIA:
RARE ANIMAL SPECIES
MARCH 2003

INTRODUCTION

The Virginia Department of Conservation and Recreation's Division of Natural Heritage (DCR-DNH) was established to protect Virginia's biological diversity. DCR-DNH is the state's first comprehensive program for conservation of our natural heritage, and includes an intensive statewide biological inventory, field surveys, electronic and manual database management, environmental review capabilities, and natural area protection and stewardship. Through its actions the Division identifies Natural Heritage Resources that are in need of conservation attention while creating an efficient means of evaluating the impacts of balanced economic growth. Natural Heritage Resources are defined in the Virginia Natural Area Preserves Act of 1989 (Section 10.1-209 through 217, Code of Virginia), as the habitat of rare, threatened, and endangered plant and animal species; exemplary natural communities, habitats, and ecosystems; and other natural features of the Commonwealth.

To achieve this protection, DCR-DNH maintains lists of the most significant elements of our natural diversity. These lists focus the Division's inventory on the Natural Heritage Resources most likely to be lost without conservation action in the near future. Most importantly, these lists are useful not only for DCR-DNH, but can be used by other agencies, organizations, and individuals to assist in the determination of actions in protection and development decision-making. In formulating these lists, the Division uses information from previous studies, museum records, observations and opinions of experts, DCR-DNH staff scientists, and field inventories.

The Virginia Rare Animal List contains information on the legal and biological status of Virginia's rarest known native animals, including vertebrates, insects, and selected other invertebrate groups. This list includes those species that are believed to be sufficiently rare or threatened to merit an inventory of their status and locations. Certain marine species that are listed as federally endangered or threatened are only included in the appendices. Only those species that use discrete habitat patches or can directly benefit from habitat protection are included on the main taxonomic lists.

Natural Heritage Resource lists are necessarily dynamic, with updates occurring as new data become available. Such revisions assure the most current knowledge of the status of Virginia's animals. Animals are added to the list when it is determined that they have become rare or threatened to such an extent that their continued existence in the Commonwealth is in jeopardy. Animals are deleted from the list when additional field surveys or other new data indicate they are more common than previously believed and do not warrant priority conservation efforts.

The watchlists that are included in this report contain information on the biological status of animal species that are uncommon or of uncertain status in Virginia. More information is needed on most of these species, which may or may not be of high conservation concern at this time. Some species included on the watchlists were formerly on the Rare Animal List but have been determined to be more common than previously believed.

All animals that are officially protected by federal or state endangered species acts are included in this list (except as noted above). Federally listed species are protected by the Endangered Species Act of 1973, as amended. The U.S. Department of the Interior's Fish and Wildlife Service administers the Act, listing and protecting federally endangered and threatened species. The Virginia Department of Game and Inland Fisheries has the regulatory responsibility for the listing and protection of the state's endangered and threatened animals (excluding the Class Insecta) under the Virginia Endangered Species Act (Section 29.1-564 through 570, Code of Virginia). The Office of Plant Protection within the Virginia Department of Agriculture and Consumer Services has regulatory responsibility for the listing and protection of the state's insects (and plants) under the Virginia Endangered Plant and Insect Act (Section 3.1-1020 through 1030, Code of Virginia). DCR-DNH is a primary source of recommendations to each of the regulatory agencies for species that are in need of listing as endangered or threatened.

The Virginia Department of Conservation and Recreation, the U.S. Fish and Wildlife Service, the Virginia Department of Game and Inland Fisheries, and the Virginia Department of Agriculture and Consumer Services work cooperatively to insure the continued survival of Virginia's diverse fauna and other elements of natural diversity. The Division of Natural Heritage also works closely with many other state and federal agencies, local governments, conservation organizations,

and many other organizations and individuals to seek adequate protection of Virginia's natural heritage.

LIST FORMAT

The Rare Animal List is sorted by broad taxonomic groups and then ordered alphabetically by scientific name within each group. The list format consists of six fields: scientific name, common name, global rank, state rank, federal status, and state status. These fields are also used in the lists appearing in Appendices 1-5. To aid in the interpretation of the lists, a brief explanation of each field and a summary of abbreviations follow.

Column 1. Scientific name:

Nomenclature of animals is not contained in any single source. The most recent taxonomic sources are examined by the staff zoologist and, when necessary, direct consultations with experts are used to maintain the most scientifically accepted names for all animal groups. Divergences from these opinions are rare and generally occur only while an ongoing taxonomic study is being conducted. Contact the staff zoologist if you have questions or comments regarding the scientific names used herein.

Column 2. Common name:

A common name is provided for the convenience of the user. Standard common names have been developed and universally adopted for only a few animal groups; therefore, the user is cautioned to use scientific names whenever possible. The common names for birds, fishes, and a few selected aquatic invertebrate groups (e.g., mussels) are recognized as stable. Most invertebrate species lack common names and it may not be practical to provide such names. They are usually indicated in the list as "a tiger beetle", "a millipede", etc. The primary sources of common names applied to species in selected groups included in this list can be found on page 5. Many other common names that appear in the list, especially those of invertebrates, are not widely used or universally accepted.

Column 3. Global rank:

Global ranks are assigned by a consensus of the network of natural heritage programs, scientific experts, and NatureServe (a non-profit conservation organization) to designate the rangewide rarity of a species or subspecies. This system was originally developed by The Nature Conservancy and is widely used by other agencies (e.g., U.S. Fish and Wildlife Service, U.S. Forest Service) and organizations as the best available scientific and objective assessment of an animal's rarity and the level of threat to its existence. The ranks are assigned after considering a suite of factors including the number of occurrences (populations), number of individuals, and severity of threats to the species and its habitats. Global ranks found in the Rare Animal List are explained below:

G1 Extremely rare and critically imperiled with 5 or fewer occurrences or very few remaining individuals; or because of some factor(s) making it especially vulnerable to extinction.

G2 Very rare and imperiled with 6 to 20 occurrences or few remaining individuals; or because of some factor(s) making it vulnerable to extinction.

G3 Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range; or vulnerable to extinction because of other factors. Usually fewer than 100 occurrences are documented.

G4 Common and apparently secure globally, although it may be rare in parts of its range, especially at the periphery.

G5 Very common and demonstrably secure globally, although it may be rare in parts of its range, especially at the periphery.

GH Formerly part of the world's fauna with some expectation that it may be rediscovered; generally applies to species that have not been verified for an extended period (usually >15 years) and for which some inventory has

been attempted recently.

GX Believed to be extinct throughout its range with virtually no likelihood of rediscovery.

GU Possibly rare, but status uncertain and more data needed.

G? Unranked, or, if following a numerical ranking, rank uncertain (e.g., G3?).

G_G_ The rank is uncertain, but considered to be within the indicated range (e.g., G2G4) of ranks (also, T_T_).

G_Q Taxon has a questionable taxonomic assignment (e.g., G3Q).

G_T_ Signifies the rank of a subspecies (e.g., G5T1 would apply to a subspecies if the species is demonstrably secure globally (G5) but the subspecies warrants a rank of T1, critically imperiled.)

Column 4. State rank:

State ranks are assigned in a manner similar to that described for global ranks, with values that generally range from S1-S5, but consider only factors within the political boundaries of Virginia. For example, an animal that is endemic to Virginia (found nowhere else in the world) will have the same global and state ranks, whereas a species that may be common in the northeastern United States but only known from a few occurrences in Virginia will have global and state ranks that differ. State ranks found in the Rare Animal List are explained below:

S1 Extremely rare and critically imperiled with 5 or fewer occurrences or very few remaining individuals in Virginia; or because of some factor(s) making it especially vulnerable to extirpation in Virginia.

S2 Very rare and imperiled with 6 to 20 occurrences or few remaining individuals in Virginia; or because of some factor(s) making it vulnerable to extirpation in Virginia.

S3 Rare to uncommon in Virginia with between 20 and 100 occurrences; may have fewer occurrences if found to be common or abundant at some of these locations; may be somewhat vulnerable to extirpation in Virginia.

S4 Common and apparently secure in Virginia, although it may be rare in parts of its range.

SH Formerly part of Virginia's fauna with some expectation that it may be rediscovered; generally applies to species that have not been verified in the state for an extended period (usually >15 years) and for which some inventory has been attempted recently.

SX Believed to be extirpated from Virginia with virtually no likelihood of rediscovery.

SR Reported for Virginia, but without persuasive documentation that would provide a basis for either accepting or rejecting the report.

SU Possibly rare, but status uncertain and more data needed.

S_? Rank uncertain. For example the rank S2? denotes a species that may range from S1 to S3.

S_S_ Rank is uncertain, but considered to be within the indicated range of ranks (e.g., S1S4).

S_B/S_N Breeding and nonbreeding status of an animal (primarily used for birds) in Virginia, when they differ.

SZN Long distance migrant whose occurrences outside of the breeding season are not monitored or a species whose wintering populations are transitory and usually do not occur regularly at specific localities.

SN? Long distance migrant that has been recorded north and south of Virginia waters and should eventually be found

along the coast of Virginia.

SA State accidental; not a regular member of the Virginia fauna but recorded in the state at least once.

Column 5. Federal status:

Federal status is determined by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. This status is used for all animals listed as endangered or threatened by the U.S. government and receiving protection under the federal Endangered Species Act. The list also notes those species that have been formally proposed for listing or are currently candidates under consideration for listing. The federal status formerly known as "Category 2, candidate species" was abolished on February 28, 1996; species formerly designated as "Category 1, candidate species" are now referred to simply as "candidate species."

LE Listed Endangered. A taxon threatened with extinction throughout all or a significant portion of its range.

LT Listed Threatened. A taxon likely to become endangered in the foreseeable future.

LT/SA Listed as Threatened due to Similarity of Appearance. The species so closely resembles an endangered or threatened species or population that enforcement personnel of the U.S. Fish and Wildlife Service cannot readily distinguish between the taxa (e.g., the northern population of the bog turtle is federally listed as endangered, but turtles from the southern population, which includes Virginia, are not readily distinguishable from them).

LT/PDL Listed as Threatened but proposed for delisting. The U.S. Fish and Wildlife Service has proposed that this species be removed from the list of Endangered and Threatened wildlife. However, at the present time, the species is still listed as Threatened pending further action and is thus protected under the Endangered Species Act.

PE Proposed Endangered. A taxon proposed for listing as endangered.

PT Proposed Threatened. A taxon proposed for listing as threatened.

C Candidate. There is enough available information to propose the species for listing, but listing is "precluded by other pending proposals of higher priority". (Formerly Candidate, Category 1)

Column 6. State status:

State status is determined by the Virginia Department of Game and Inland Fisheries (all animals except insects) and the Virginia Department of Agriculture and Consumer Services (insects only). No insects are currently listed as state endangered or threatened by the Virginia Department of Agriculture and Consumer Services, although several have been formally proposed (as of September, 2002) for such listing. An informal list of "Special Concern" species has also been developed by the Virginia Department of Game and Inland Fisheries.

LE Listed Endangered; defined as a species that is in danger of extinction throughout all or a significant portion of its range.

LT Listed Threatened; defined as a species that is likely to become endangered within the foreseeable future.

PE Proposed Endangered. A taxon proposed for listing as endangered.

PT Proposed Threatened. A taxon proposed for listing as threatened.

SC Special Concern; animals that merit special concern according to the Virginia Department of Game and Inland Fisheries. This is not a legal category.

PRIMARY SOURCES OF COMMON NAMES

Fish

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American Ornithologists' Union. 1998. Check-list of North American Birds. Seventh Edition. American Ornithologists' Union, Washington, D.C. 829 pp.

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Covell, C. V., Jr. 1984. A Field Guide to the Moths of Eastern North America. Houghton Mifflin Company, Boston. 496 pp.

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VIRGINIA RARE ANIMAL LIST

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
VERTEBRATES					
FISH					
Acipenser brevirostrum	Shortnose sturgeon	G3	SX	LE	LE
Acipenser oxyrhynchus	Atlantic sturgeon	G3	S2		SC
Ameiurus brunneus	Snail bullhead	G4	S2		
Ammocrypta clara	Western sand darter	G3	S1		LT
= *Etheostoma clarum*					
Aplodinotus grunniens	Freshwater drum	G5	S2		
Cottus baileyi	Black sculpin	G4Q	S2		
Cottus cognatus	Slimy sculpin	G5	S2		
Cottus sp 1	Bluestone sculpin	G2	S2		
Cottus sp 4	Clinch sculpin	G1G2	S1S2		
Cottus sp 5	Holston sculpin	G2	S2		
Cyprinella labrosa	Thicklip chub	G4	SH		
= *Hybopsis labrosa*					
Cyprinella monacha	Turquoise shiner (or spotfin chub)	G2	S1	LT	LT
= *Hybopsis monacha*					
Cyprinella whipplei	Steelcolor shiner	G5	S1		LT
= *Notropis whipplei*					
Enneacanthus chaetodon	Blackbanded sunfish	G4	S1		LE
Erimystax cahni	Slender chub	G1	S1	LT	LT
= *Hybopsis cahni*					
Erimyzon sucetta	Lake chubsucker	G5	S2		
Etheostoma acuticeps	Sharphead darter	G3	S1		LE
Etheostoma caeruleum	Rainbow darter	G5	S2		
Etheostoma camurum	Bluebreast darter	G4	S2		SC
Etheostoma chlorobranchium	Greenfin darter	G4	S1		LT
Etheostoma cinereum	Ashy darter	G2G3	S1		
Etheostoma collis	Carolina darter	G3	S2		LT
Etheostoma denoncourti	Golden darter	G2	S1		LT*
= *Etheostoma tippecanoe* (in part)					
Etheostoma jessiae	Blueside darter	G4Q	S1		
= *Etheostoma stigmaeum jessiae*					
Etheostoma meadiae	Bluespar darter	G4	S2		
= *Etheostoma stigmaeum meadiae*					
Etheostoma osburni	Candy darter	G3	S1		SC
Etheostoma percnurum	Duskytail darter	G1	S1	LE	LE
Etheostoma swannanoa	Swannanoa darter	G4	S2		
Etheostoma variatum	Variegate darter	G5	S1		LE
Etheostoma vulneratum	Wounded darter	G3	S2S3		
Fundulus lineolatus	Lined topminnow	G5	S2S3		
Fundulus rathbuni	Speckled killifish	G4	S2		SC
Hybopsis hypsinotus	Highback chub	G4	S2		
= *Notropis hypsinotus*					
Ichthyomyzon bdellium	Ohio lamprey	G3G4	S2		
Ichthyomyzon greeleyi	Mountain brook lamprey	G3G4	S2		
Labidesthes sicculus	Brook silverside	G5	S2		SC

*Listed as state threatened under the name Tippecanoe Darter (*Etheostoma tippecanoe*)

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FISH (continued)					
Lythrurus lirus = *Notropis lirus*	Mountain shiner	G4	S2S3		
Moxostoma carinatum	River redhorse	G4	S2S3		SC
Notropis alborus	Whitemouth shiner	G4	S1		LT
Notropis ariommus	Popeye shiner	G3	S2S3		SC
Notropis atherinoides	Emerald shiner	G5	S1S2		LT
Notropis bifrenatus	Bridle shiner	G5	S2		SC
Notropis semperasper	Roughhead shiner	G2G3	S2S3		SC
Notropis spectrunculus	Mirror shiner	G4	S2		SC
Notropis stramineus	Sand shiner	G5	S2		
Noturus eleutherus	Mountain madtom	G4	S2S3		
Noturus flavipinnis	Yellowfin madtom	G1	S1	LT	LT
Noturus flavus	Stonecat	G5	S2		SC
Noturus gilberti	Orangefin madtom	G2	S2		LT
Noturus insignis ssp 1	Spotted margined madtom	G5T1Q	S1		
Percina aurantiaca	Tangerine darter	G4	S2S3		
Percina burtoni	Blotchside logperch	G2	S1		SC
Percina copelandi	Channel darter	G4	S2		SC
Percina crassa	Piedmont darter	G4	S1		
Percina evides	Gilt darter	G4	S2		
Percina macrocephala	Longhead darter	G3	S1S2		LT
Percina maculata	Blackside darter	G5	SX		
Percina rex	Roanoke logperch	G1G2	S1S2	LE	LE
Percina sciera	Dusky darter	G5	S1S2		
Percopsis omiscomaycus	Trout-perch	G5	SX		
Phenacobius crassilabrum	Fatlips minnow	G3G4	S2		SC
Phenacobius mirabilis	Suckermouth minnow	G5	S1S2		
Phenacobius teretulus	Kanawha minnow	G3G4	S2S3		
Phoxinus cumberlandensis	Blackside dace	G2	S1	LT	
Phoxinus tennesseensis	Tennessee dace	G3	S1		LE
Phoxinus sp 1	A dace	G1	S1		
Pimephales vigilax	Bullhead minnow	G5	S1		
Polyodon spathula	Paddlefish	G4	S1		LT
Scartomyzon sp 1	Brassy jumprock	G4	S1S2		
Stizostedion canadense	Sauger	G5	S2S3		SC
Thoburnia hamiltoni = *Moxostoma hamiltoni*	Rustyside sucker	G3	S2		SC

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SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
AMPHIBIANS					
Ambystoma mabeei	Mabee's salamander	G4	S1S2		LT
Ambystoma talpoideum	Mole salamander	G5	S1S2		SC
Ambystoma tigrinum	Tiger salamander	G5	S1		LE
Bufo quercicus	Oak toad	G5	S1S2		SC
Cryptobranchus alleganiensis	Hellbender	G3G4	S2S3		SC
Desmognathus marmoratus = *Leurognathus marmoratus*	Shovel-nosed salamander	G4	S2		SC
Desmognathus wrighti	Pygmy salamander	G3G4	S2		SC
Eurycea wilderae	Blue Ridge two-lined salamander	G5	S2		
Hyla gratiosa	Barking treefrog	G5	S1		LT
Necturus maculosus	Mudpuppy	G5	S2		
Necturus punctatus	Dwarf waterdog	G4	S2S3		
Plethodon hubrichti	Peaks of Otter salamander	G2	S2		SC
Plethodon punctatus	Cow Knob salamander	G3	S2		SC
Plethodon shenandoah	Shenandoah salamander	G1	S1	LE	LE
Plethodon ventralis	Southern zigzag salamander	G4	S1		
Plethodon virginia	Shenandoah Mountain salamander	G2G3Q	S2		
Plethodon welleri	Weller's salamander	G3	S2		SC
Siren intermedia	Lesser siren	G5	S2		
REPTILES					
Apalone spinifera	Spiny softshell	G5	S2		
Caretta caretta	Loggerhead (sea turtle)	G3	S1B/S1N	LT	LT
Crotalus horridus atricaudatus	Canebrake rattlesnake	G4TUQ	S1		LE
Deirochelys reticularia	Chicken turtle	G5	S1		LE
Eumeces anthracinus	Coal skink	G5	S2		
Glyptemys insculpta = *Clemmys insculpta*	Wood turtle	G4	S2		LT
Glyptemys muhlenbergii = *Clemmys muhlenbergii*	Bog turtle	G3	S1S2	LT/SA	LE
Graptemys geographica	Northern map turtle	G5	S2S3		
Lampropeltis getula nigra	Eastern black kingsnake	G5T5	S2		
Lepidochelys kempii	Kemp's ridley (sea turtle)	G1	S1N	LE	LE
Ophisaurus ventralis	Eastern glass lizard	G5	S1		LT
Pituophis melanoleucus	Pine snake	G4	S1S3		
Regina rigida	Glossy crayfish snake	G5	S1		
Sternotherus minor	Loggerhead musk turtle	G5	S2		
Tantilla coronata	Southeastern crowned snake	G5	S2		
Trachemys scripta troostii	Cumberland slider	G5T3T4	S1		
Virginia valeriae pulchra	Mountain earthsnake	G5T3T4	S1		SC

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SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
BIRDS					
Actitis macularia	Spotted Sandpiper	G5	S2B/SZN		
Aegolius acadicus	Northern Saw-whet Owl	G5	S1B/S1N		SC
Aimophila aestivalis	Bachman's Sparrow	G3	S1B		LT
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	G4	S2B/S3N		SC
Ammodramus henslowii	Henslow's Sparrow	G4	S1B		LT
Anas discors	Blue-winged Teal	G5	S1B/S2N		
Anas strepera	Gadwall	G5	S2B/S3N		
Aquila chrysaetos	Golden Eagle	G5	SHB/S1N		
Ardea alba	Great Egret	G5	S2B/S3N		SC
Asio flammeus	Short-eared Owl	G5	S1B/S3N		
Asio otus	Long-eared Owl	G5	S1		SC
Bartramia longicauda	Upland Sandpiper	G5	S1B/SZN		LT
Botaurus lentiginosus	American Bittern	G4	S1B/S2N		
Carpodacus purpureus	Purple Finch	G5	S1B/S5N		SC
Catharus guttatus	Hermit Thrush	G5	S1B/S5N		SC
Catharus ustulatus	Swainson's Thrush	G5	S1B/SZN		
Charadrius melodus	Piping Plover	G3	S2B/S1N	LT	LT
Charadrius wilsonia	Wilson's Plover	G5	S1B/SZN		LE
Chondestes grammacus	Lark Sparrow	G5	SHB/SZN		
Circus cyaneus	Northern Harrier	G5	S1B/S3S4N		SC
Cistothorus platensis	Sedge Wren	G5	S1B/S1S2N		SC
Contopus cooperi = *Nuttallornis borealis*	Olive-sided Flycatcher	G4	SHB/SZN		
Dendroica fusca	Blackburnian Warbler	G5	S2B/SZN		
Dendroica magnolia	Magnolia Warbler	G5	S2B/SZN		SC
Egretta caerulea	Little Blue Heron	G5	S2B/S3N		SC
Egretta thula	Snowy Egret	G5	S2B/S3N		
Egretta tricolor	Tricolored Heron	G5	S2B/S3N		SC
Empidonax alnorum	Alder Flycatcher	G5	S1B/SZN		SC
Empidonax flaviventris	Yellow-bellied Flycatcher	G5	S1B/SZN		SC
Eudocimus albus	White Ibis	G5	S1B/SAN		
Falco peregrinus	Peregrine Falcon	G4	S1B/S2N		LT
Fulica americana	American Coot	G5	S1B/S5N		
Gallinula chloropus	Common Moorhen	G5	S1B/S1N		SC
Haliaeetus leucocephalus	Bald Eagle	G4	S2S3B/S3N	LT/PDL	LT
Himantopus mexicanus	Black-necked Stilt	G5	S1B		
Lanius ludovicianus	Loggerhead Shrike	G4	S2B/S3N		LT
Laterallus jamaicensis	Black Rail	G4	S2B/S2N		
Limnothlypis swainsonii	Swainson's Warbler	G4	S2B/SZN		SC
Loxia curvirostra	Red Crossbill	G5	S1B/SZN		SC
Melospiza georgiana	Swamp Sparrow	G5	S1B/S4S5N		
Mergus merganser	Common Merganser	G5	S1B/S4N		
Nyctanassa violacea = *Nycticorax violaceus*	Yellow-crowned Night-heron	G5	S2S3B/S3N		SC
Oporornis philadelphia	Mourning Warbler	G5	S1B/SZN		SC
Pelecanus occidentalis	Brown Pelican	G4	S1B/S3N		SC
Picoides borealis	Red-cockaded Woodpecker	G3	S1	LE	LE
Plegadis falcinellus	Glossy Ibis	G5	S2B/S1N		SC
Podilymbus podiceps	Pied-billed Grebe	G5	S1S2B/S3N		
Porzana carolina	Sora	G5	S1B/S2N		

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BIRDS (continued)					
Rallus elegans	King Rail	G4G5	S2B/S3N		
Rallus limicola	Virginia Rail	G5	S2B/S3N		
Regulus satrapa	Golden-crowned Kinglet	G5	S2B/S5N		SC
Rynchops niger	Black Skimmer	G5	S2B/S1N		
Seiurus noveboracensis	Northern Waterthrush	G5	S1B/SZN		
Sitta canadensis	Red-breasted Nuthatch	G5	S2B/S4N		SC
Sphyrapicus varius	Yellow-bellied Sapsucker	G5	S1B/S4N		
Sterna antillarum	Least Tern	G4	S2B/SZN		SC
Sterna caspia	Caspian Tern	G5	S1B/S2N		SC
Sterna dougallii	Roseate Tern	G4	SHB/SZN	LE	LE
Sterna maxima	Royal Tern	G5	S2B/SZN		
Sterna nilotica	Gull-billed Tern	G5	S2B/SZN		LT
Sterna sandvicensis	Sandwich Tern	G5	S1B/SZN		SC
Thryomanes bewickii altus	Appalachian Bewick's Wren	G5T2Q	S1B/SZN		LE
Troglodytes troglodytes	Winter Wren	G5	S2B/S4N		SC
MAMMALS					
Corynorhinus rafinesquii macrotis = *Plecotus rafinesquii macrotis*	Eastern big-eared bat	G3G4	S2		LE
Corynorhinus townsendii virginianus = *Plecotus townsendii virginianus*	Virginia big-eared bat	G4T2	S1	LE	LE
Glaucomys sabrinus coloratus	Carolina northern flying squirrel	G5T1	S1	LE	LE
Glaucomys sabrinus fuscus	Virginia northern flying squirrel	G5T2	S1	LE	LE
Lepus americanus	Snowshoe hare	G5	S1		LE
Martes pennanti	Fisher	G5	S1		
Microtus chrotorrhinus carolinensis	Southern rock vole	G4T3	S1		LE
Myotis austroriparius	Southeastern myotis (bat)	G3G4	S1S2		
Myotis grisescens	Gray myotis (bat)	G3	S1	LE	LE
Myotis leibii	Eastern small-footed myotis (bat)	G3	S1		
Myotis sodalis	Indiana myotis (bat)	G2	S1	LE	LE
Puma concolor couguar = *Felis concolor couguar*	Eastern cougar	G5TH	SX	LE	LE
Sciurus niger cinereus	Delmarva fox squirrel	G5T3	S1	LE	LE
Sorex longirostris fisheri	Dismal Swamp southeastern shrew	G5T4	S2		LT
Sorex palustris punctulatus	Southern water shrew	G5T3	S1S2		LE
Sylvilagus floridanus hitchensi	Smith Island cottontail	G5THQ	SH		

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INVERTEBRATES					
TURBELLARIA (FLATWORMS)					
Geocentrophora cavernicola	A cave planarian	G3G4	S1		
Procotyla typhlops	A groundwater planarian	G1G2	S1S2		
Sphalloplana chandleri	Chandler's planarian	G1G3	S1		
Sphalloplana consimilis	Powell Valley planarian	G2G3	S1		
Sphalloplana holsingeri	Holsinger's groundwater planarian	GH	SH		
Sphalloplana hypogea	A groundwater planarian	G1G2	S1S2		
Sphalloplana subtilis	Bigger's groundwater planarian	GH	SH		
Sphalloplana virginiana	Rockbridge County cave planarian	G1	S1		
GASTROPODA (SNAILS)					
Anguispira jessica = *Anguispira alternata jessica*	Mountain disc	G3G4	S1		
Catinella hubrichti	Snowhill ambersnail	G3	S1S3		
Discus nigrimontanus	Black Mountain disc	G4	S1S3		
Euchemotrema leai = *Stenotrema leai alicia*	Lowland pillsnail	G5	S1S3		
Fontigens bottimeri	Appalachian springsnail	G2	S1S2		
Fontigens morrisoni	Virginia springsnail	G1	S1		
Fumonelix christyi = *Mesodon christyi*	Glossy covert	G3	S1S3		
Fumonelix wheatleyi clingmanicus = *Mesodon clingmanicus*	Clingman covert	G4T3T4	S1S2		
Gastrocopta clappi = *Gastrocopta armifera clappi*	Bluegrass snaggletooth	G3G5	S1S2		
Gastrocopta pellucida	Slim snaggletooth	G4G5	S1S3		
Gastrodonta fonticula = *Gastrocopta interna fonticula*	Appalachia bellytooth	G3G4	S1S3		
Glyphyalinia picea	Rust glyph	G3	S1S3		
Glyphyalinia praecox	Brilliant glyph	G4	S1S3		
Glyphyalinia raderi	Maryland glyph	G2	S1S2		SC
Glyphyalinia sculptilis	Suborb glyph	G4	S1		
Glyphyalinia virginica	Depressed glyph	G3	S2S3		
Helicodiscus diadema	Shaggy coil	G1	S1		LE
Helicodiscus lirellus	Rubble coil	G1	S1		LE
Helicodiscus multidens	Twilight coil	G2	S2		
Helicodiscus shimeki	Temperate coil	G4	S1		
Helicodiscus triodus	Talus coil	G2	S1S2		
Holsingeria unthanksensis	Unthanks Cave Snail	G1	S1		LE
Holsingeria sp 1	Skyline Caverns snail	G1Q	S1		
Inflectarius kalmianus = *Mesodon kalmianus*	Brown globelet	G3	S1S3		
Io fluvialis	Spiny riversnail	G2	S2		LT
Leptoxis praerosa = *Anculosa subglobosa*	Onyx rocksnail	G5	S1S3		
Megapallifera wetherbyi	Blotchy mantleslug	G2G3	S1?		
Mesodon andrewsae	Balsam globe	G3	S1		
Mesodon elevatus	Proud globe	G5	S2		
Mesomphix subplanus	Flat button	G3	S2		

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SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
GASTROPODA (continued)					
Millerelix plicata	Cumberland liptooth	G3G4	S1S3		
= Polygyra plicata					
Oxyloma subeffusum	Chesapeake ambersnail	G3	S1		
Pallifera hemphilli	Black mantleslug	G3	S1		
Pallifera varia	Variable mantleslug	G2G4	S2?		
Paravitrea blarina	Shrew supercoil	G2	S1		
Paravitrea calcicola	Pearl supercoil	G1	SR		
Paravitrea dentilla	Comb supercoil	G1	S1		
Paravitrea hera	Spirit supercoil	G1	S1		LE
Paravitrea mira	Funnel supercoil	G2	S2		
Paravitrea placentula	Glossy supercoil	G3	S1S3		
Paravitrea pontis	Natural Bridge supercoil	G3	S2		
Paravitrea reesei	Round supercoil	G2	S2		
Paravitrea septadens	Brown supercoil	G1	S1		LT
Paravitrea seradens	Barred supercoil	G3	S1S3		
Paravitrea subtilis	Slender supercoil	G2	S1S2		
Patera panselenus	Virginia bladetooth	G2	S2		
= Mesodon panselenus					
Polygyriscus virginianus	Virginia fringed mountain snail	G1	S1	LE	LE
Pomatiopsis cincinnatiensis	Brown walker	G4	S2		
Pupilla muscorum	Widespread column	G5	S1		
Somatogyrus virginicus	Panhandle pebblesnail	G1G2	S1S2		
Stagnicola neopalustris	Piedmont pondsnail	GH	SH		
Stenotrema altispira	Highland slitmouth	G2	S1		
Stenotrema pilula	Pygmy slitmouth	G3G4	S1		
Stenotrema spinosum	Carinate slitmouth	G3G4	S2		
Striatura exigua	Ribbed striate	G4G5	S2		
Striatura milium	Fine-ribbed striate	G4	S1S3		
Triodopsis anteridon	Carter threetooth	G2G3	S2S3		
Triodopsis messana	Pinhole threetooth	G4	S1S3		
Triodopsis pendula	Hanging Rock threetooth	G3	S1S3		
Triodopsis picea	Spruce Knob threetooth	G3	S1		
Vallonia parvula	Trumpet vallonia	G4	S1		
Ventridens coelaxis	Bidentate dome	G3	S2		
Ventridens decussatus	Crossed dome	G2G3	S1		
Ventridens lawae	Rounded dome	G3G4	S1S3		
Ventridens pilsbryi	Yellow dome	G4	S2?		
Vertigo bollesiana	Delicate vertigo	G3	S1S3		
Vertigo clappi	Cupped vertigo	G1G2	S1S2		
Vertigo oralis	Palmetto vertigo	G5	S1S3		
Vertigo teskeyae	Swamp vertigo	G4	S1S3		
Vertigo ventricosa	Five-tooth vertigo	G3G4	S1S3		
Vitrinizonites latissimus	Glassy grapeskin	G4	S2?		

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BIVALVIA (MUSSELS & CLAMS)					
Mussels					
Alasmidonta heterodon	Dwarf wedgemussel	G1G2	S1	LE	LE
Alasmidonta marginata	Elktoe	G4	S2		SC
Alasmidonta varicosa	Brook floater	G3	S1		LE
Alasmidonta viridis	Slippershell mussel	G4G5	S1		LE
= Alasmidonta minor					
Cumberlandia monodonta	Spectacle case	G2G3	S1		LE
Cyprogenia stegaria	Fanshell	G1	S1	LE	LE
= Cyprogenia irrorata					
Dromus dromas	Dromedary pearlymussel	G1	S1	LE	LE
Elliptio crassidens	Elephant ear	G5	S1		LE
Elliptio lanceolata	Yellow lance	G2G3	S2S3		SC
Elliptio roanokensis	Roanoke slabshell	G2G3	S1		SC
Epioblasma brevidens	Cumberland combshell	G1	S1	LE	LE
Epioblasma capsaeformis	Oyster mussel	G1	S1	LE	LE
Epioblasma florentina walkeri	Tan riffleshell	G1T1	S1	LE	LE
Epioblasma torulosa gubernaculum	Green-blossom pearlymussel	G2TX	SX	LE	LE
Epioblasma triquetra	Snuffbox	G3	S1		LE
Fusconaia barnesiana	Tennessee pigtoe	G2G3	S2S3		SC
Fusconaia cor	Shiny pigtoe	G1	S1	LE	LE
= Fusconaia edgariana					
Fusconaia cuneolus	Fine-rayed pigtoe	G1	S1	LE	LE
Fusconaia masoni	Atlantic pigtoe	G2	S2		LT
Hemistena lata	Cracking pearlymussel	G1	S1	LE	LE
= Lastena lata					
Lampsilis abrupta	Pink mucket	G2	SX	LE	LE
= Lampsilis orbiculata					
Lampsilis cariosa	Yellow lampmussel	G3G4	S2		SC
Lampsilis radiata	Eastern lampmussel	G5	S2		SC
Lasmigona holstonia	Tennessee heelsplitter	G3	S1		LE
Lasmigona subviridis	Green floater	G3	S2		SC
Lemiox rimosus	Birdwing pearlymussel	G1	S1	LE	LE
= Conradilla caelata					
Leptodea fragilis	Fragile papershell	G5	S2		LT
Lexingtonia dolabelloides	Slabside pearlymussel	G2	S2	C	LT
Lexingtonia subplana	Virginia pigtoe	G1Q	S1		
Ligumia recta	Black sandshell	G5	S2		LT
= Ligumia recta latissima					
Pegias fabula	Little-winged pearlymussel	G1	S1	LE	LE
Plethobasus cyphyus	Sheepnose	G3	S1		LT
Pleurobema collina	James spinymussel	G1	S1	LE	LE
Pleurobema cordatum	Ohio pigtoe	G3	S1		LE
Pleurobema oviforme	Tennessee clubshell	G3	S2S3		
= Pleurobema maculatum					
Pleurobema plenum	Rough pigtoe	G1	SH	LE	LE
Pleurobema rubrum	Pyramid pigtoe	G2	S1		LE
= Pleurobema pyramidatum					
Ptychobranchus subtentum	Fluted Kidneyshell	G2G3	S2	C	

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Mussels (continued)					
Quadrula cylindrica strigillata	Rough rabbits foot	G3T2	S2	LE	LE
Quadrula intermedia	Cumberland monkeyface	G1	S1	LE	LE
Quadrula pustulosa	Pimple back	G5	S2		LT
Quadrula sparsa	Appalachian monkeyface	G1	S1	LE	LE
Toxolasma lividus	Purple liliput	G2	S1		LE
= Carunculina lividus, Carunculina glans					
Truncilla truncata	Deertoe	G5	S1		LE
Villosa fabalis	Rayed bean	G1G2	SX		
Villosa perpurpurea	Purple bean	G1	S1	LE	LE
Villosa trabalis	Cumberland bean	G1	SX	LE	LE
Clams					
Pisidium equilaterale	Round peaclam	G5	S2		
ANNELIDA (SEGMENTED WORMS)					
Spelaedrilus multiporus	A cave lumbriculid worm	G1G2	S1		
Stylodrilus beattiei	A cave lumbriculid worm	G2G3	S1		
ARACHNIDA (SPIDERS, PSEUDOSCORPIONS & RELATIVES)					
Spiders					
Amaurobius borealis	An amaurobiid spider	G4	S1S3		
Anahita punctulata	Southeastern wandering spider	G4	S1S3		
Anthrobia mammouthia	A cave spider	G3G4	S1		
= Anthrobia monmouthia					
Antrodiaetus robustus	Robust trapdoor spider	G3?	S2		
Barronopsis jeffersi	A funnel-web spider	G3	S1S3		
Bathyphantes weyeri	A cave spider	G3G4	S1		
Castianeira trilineata	A two-clawed hunting spider	G4?	S1S3		
Clubiona spiralis	A two-clawed hunting spider	G4	S1S3		
Drassyllus louisianus	A gnaphosid spider	G4?	S1S3		
Hypochilus pococki	Pocock’s lampshade-web spider	G4G5	S2		
Hypochilus thorelli	Thorell's lampshade-web spider	G4	S1		
Islandiana muma	A cave spider	G2G3	S1		
Nesticus holsingeri	Holsinger’s cave spider	G2G3	S1S2		
Nesticus mimus	A cave spider	G2	S1		
Nesticus paynei	A cave spider	G2G3	S1		
Nesticus tennesseensis	A cave spider	G2G4	S2		
Pisaurina dubia	A nursery-web spider	G4	S1S3		
Xysticus emertoni	Emerton’s crab spider	G5	S1S3		
Mites					
Foveacheles paralleloseta	A cave mite	G1	S1		
Poecilophysis extraneostella	A cave mite	G2?	S1		
Poecilophysis weyerensis	A cave mite	G3?	S1		
Rhagidia varia	A cave mite	G3	S2?		

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ARACHNIDA (continued)					
Pseudoscorpions					
Apochthonius coecus	A cave pseudoscorpion	G1	S1		
Apochthonius holsingeri	A cave pseudoscorpion	G1G2	S1		
Chitrella superba	A cave pseudoscorpion	G1	S1		
Chitrella sp 1	A cave pseudoscorpion	G1	S1		
Kleptochthonius anophthalmus	A cave pseudoscorpion	G1	S1		
Kleptochthonius binoculatus	A cave pseudoscorpion	G1	S1		
Kleptochthonius gertschi	Gertsch's cave pseudoscorpion	G1	S1		
Kleptochthonius lutzi	Lutz's cave pseudoscorpion	G1	S1		
Kleptochthonius polychaetus	Shenandoah pseudoscorpion	G1G3	S1S3		
Kleptochthonius proximosetus	A cave pseudoscorpion	G1	S1		
Kleptochthonius regulus	A cave pseudoscorpion	G1	S1		
Kleptochthonius similis	A cave pseudoscorpion	G1	S1		
Kleptochthonius sp 1 = *Kleptochthonius* sp B	A cave pseudoscorpion	G1	S1		
Microcreagris valentinei	Valentine's cave pseudoscorpion	G1G3	S1		
Mundochthonius holsingeri	A cave pseudoscorpion	G1	S1		
Scorpions					
Vaejovis carolinianus	Carolina scorpion	G5	S1		
CRUSTACEA (AMPHIPODS, ISOPODS & DECAPODS)					
Amphipods					
Bactrurus angulus	Cumberland Gap cave amphipod	G1	S1		
Crangonyx gracilis	Big white amphipod	G4	S1S3		
Crangonyx sp 3	Bland County amphipod	G1?	S1?		
Crangonyx sp 5	Lancaster County amphipod	G1?	S1?		
Stygobromus abditus	James Cave amphipod	G2	S2		
Stygobromus baroodyi	Rockbridge County cave amphipod	G2	S1S2		
Stygobromus biggersi	Bigger's cave amphipod	G2G4	S1S2		
Stygobromus conradi	Burnsville Cove cave amphipod	G1G3	S1S2		
Stygobromus cumberlandus	Cumberland cave amphipod	G2G3	S1S2		
Stygobromus ephemerus	Ephemeral cave amphipod	G1	S1		SC
Stygobromus estesi	Craig County cave amphipod	G1G2	S1S2		
Stygobromus fergusoni	Montgomery County cave amphipod	G1G2	S1		
Stygobromus finleyi	Finley's cave amphipod	G1G3	S1		
Stygobromus gracilipes	Shenandoah Valley cave amphipod	G2G4	S2S3		SC
Stygobromus hoffmani	Alleghany County cave amphipod	G1	S1		
Stygobromus interitus	New Castle Murder Hole amphipod	G1	S1		
Stygobromus kenki	Rock Creek groundwater amphipod	G1G3	SH		
Stygobromus leensis	Lee County cave amphipod	G1	S1		
Stygobromus morrisoni	Morrison's cave amphipod	G2G3	S1S2		SC
Stygobromus mundus	Bath County cave amphipod	G2G3	S1S2		SC
Stygobromus obrutus	Pittsylvania well amphipod	G1	SH		
Stygobromus phreaticus	Northern Virginia well amphipod	G1	S1		
Stygobromus pizzinii	Pizzini's amphipod	G2G4	S1S2		SC
Stygobromus pseudospinosus	Luray Caverns amphipod	G1	S1		

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Amphipods (continued)					
Stygobromus stegerorum	Madison Cave amphipod	G1	S1		LT
Stygobromus sp 7	Sherando spinosoid amphipod	G2	S2		
Stygobromus sp 8	A groundwater amphipod	G2G3	S2S3		
Stygobromus sp 9	A cave amphipod (Shenandoah Co.)	G1	S1		
Stygobromus sp 10	A cave amphipod (Botetourt Co.)	G1	S1		
Stygobromus sp 11	A cave amphipod (Nelson Co.)	G1	S1		
Stygobromus sp 12	A cave amphipod (Rockbridge Co.)	G1	S1		
Stygobromus sp 15	A groundwater amphipod	G1	S1		
Stygobromus sp 16	Helsley's Cave amphipod	G1	S1		
Stygobromus sp 17	Massanutten spring amphipod	G2	S2		
Stygobromus sp 18	Big Levels spring amphipod	G1?	S1?		
Stygobromus sp 19	A cave amphipod (Scott Co.)	G1	S1		
Stygobromus sp 20	A cave amphipod (Bath, Highland Co.)	G1	S1		
Stygobromus sp 21	Rappahannock spring amphipod	G1G2	S1S2		
Stygobromus sp 23	Shenandoah Mountain spring amphipod	G1?	S1?		
Isopods					
Amerigoniscus henroti	Powell Valley terrestrial cave isopod	G1G2	S1S2		
Antrolana lira	Madison Cave isopod	G2	S2	LT	LT
Caecidotea attenuatus	Dismal Swamp isopod	G1?	S1?		
Caecidotea bowmani	Natural Bridge cave isopod	G1	S1		
Caecidotea cumberlandensis	Cumberland Gap cave isopod	G1	S1		
Caecidotea henroti	Henrot's cave isopod	G2G3	S1S2		
Caecidotea holsingeri	Greenbrier Valley cave isopod	G3	S1		
Caecidotea incurva	Incurved cave isopod	G2G3	S1S2		
Caecidotea phreatica	Phreatic isopod	G1G2	S1		
Caecidotea pricei	Price's cave isopod	G3G4	S2S3		
Caecidotea richardsonae	Tennessee Valley cave isopod	G3G5	S2		
Caecidotea vandeli	Vandel's cave isopod	G2G3	S1S2		
Ligidium elrodii leensis	Lee County terrestrial cave isopod	G4G5T1T2	S1S2		
Ligidium elrodii scottensis	Scott County terrestrial cave isopod	G4G5T1T2	S1S2		
Lirceus culveri	Rye Cove isopod	G1	S1		SC
Lirceus usdagalun	Lee County cave isopod	G1	S1	LE	LE
Miktoniscus racovitzai	Racovitza's terrestrial cave isopod	G3G4	S2		
Decapods					
Cambarus buntingi	Bunting's crayfish	G4	S2		
Cambarus jezerinaci	Powell River crayfish	G1G2	S1S2		
Cambarus monongalensis	Monongahela crayfish	G5	S1?		
Cambarus parvoculus	A crayfish	G4	S2?		
Cambarus sciotensis	Scioto crayfish	G5	S2S3		
Cambarus veteranus	A crayfish	G3G4	S1S2		
Macrobrachium ohione	Ohio river shrimp	G4	S1		
Orconectes virginiensis	Chowanoke crayfish	G3	S2S3		

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DIPLOPODA (MILLIPEDES)					
Abacion tesselatum	A millipede	G5	S2		
Aniulus orientalis	A millipede	G2	S1		
Aniulus sp 1	A millipede (Elm Hill)	G?	S1		
Auturus erythropygos	A millipede	G3	S1		
Boraria infesta	A millipede	G4	S2		
Brachoria cedra	Cedar millipede	G1G2	S1		
Brachoria dentata	A millipede	G1	S1		
Brachoria falcifera	Big Cedar Creek millipede	G1	S1		
Brachoria hoffmani	Hoffman's xystodesmid millipede	G2	S2		
Brachoria insolita	A millipede	G1	S1		
Brachoria laminata	Keeton's millipede	G1	S1		
Brachoria mendota	Collinwood millipede	G1	S1		
Brachoria separanda calcaria	A millipede	G2T?	S2		
Brachoria separanda hamata	A millipede	G2T?	S2		
Brachoria separanda versicolor	A millipede	G2T?	S2		
Brachoria turneri	Turner's millipede	G1	S1		
Brachoria sp 1	Powell Mountain millipede sp 1	G1?	S1?		
Brachoria sp 2	Powell Mountain millipede sp 2	G1?	S1?		
Buotus carolinus	A millipede	G1	S1		
Chaetaspis albus	A millipede	G4	S2		
Cherokia georgiana latassa	A millipede	G4T?	S1		
Cleidogona fidelitor	Faithful millipede	G1	S1		
Cleidogona hoffmani	Hoffman's cleidogonid millipede	G2	S2		
Cleidogona lachesis	A millipede	G2	S1		
Cleidogona medialis	Blowing Rock millipede	G1	S1		
Conotyla aeto	Aeto millipede	G1	S1		
Conotyla celeno	Celeno millipede	G1	S1		
Conotyla melinda	Melinda millipede	G2	S2		
Conotyla venetia	Venetia millipede	G2	S2		
Conotyla sp 1	A millipede (Burkes Garden)	G1	S1		
Desmonus earlei	A millipede	G5	S1		
Dixioria brooksi	Brooks millipede	G1	S1		
Dixioria fowleri	A millipede	G2	S2		
Dixioria pela coronata = *Dixioria coronata*	A millipede	G?T2	S2		
Euryurus leachi fraternus	A millipede	G4T?	S1		
Gyalostethus monticolens	A millipede	G4	S2		
Nannaria conservata	Duke Forest xystodesmid millipede	G1	S1		
Nannaria ericacea	McGraw Gap xystodesmid millipede	G2	S2		
Nannaria laminata	Smith Creek xystodesmid millipede	G1	S1		
Nannaria shenandoah	Shenandoah Mountain xystodesmid millipede	G1	S1		
Nannaria simplex	A millipede	G1	S1		
Nannaria sp 1	Roaring Branch Nannaria millipede	G1?	S1?		
Okeanobates americanus	A millipede	G4	S1		
Onomeris underwoodi	A millipede	G5	S1		
Orinisobates nigrior	A millipede	G4	S1		
Petaserpes rosalbus	A millipede	G5	S2		
Petaserpes strictus	A millipede	G5	S1		
Pseudopolydesmus paludicolous	A millipede	G3?	S2		
Pseudotremia alecto	A millipede	G1	S1		
Pseudotremia armesi	A millipede	G2	S2		
Pseudotremia cavernarum	Ellett Valley Pseudotremia millipede	G2G4	S1		LT

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DIPLOPODA (continued)					
Pseudotremia momus	A millipede	G2	S2		
Pseudotremia princeps	South Branch Valley cave millipede	G1	S1		
Pseudotremia sublevis	A millipede	G1	S1		
Pseudotremia tuberculata	A millipede	G2	S1S2		
Pseudotremia sp 2	Roaring Branch Pseudotremia millipede	G1?	S1?		
Pseudotremia sp 3	A cave millipede	G1	S1		
Rudiloria trimaculata tortua	A millipede	G5T2	S2		
Semionellus placidus	A millipede	G3	S2		
Sigmoria whiteheadi	Laurel Creek xystodesmid millipede	G1	S1		LT
Striaria causeyae	A millipede	G1	S1		
Striaria columbiana	A millipede	G2	S2		
Striaria granulosa	A millipede	G2	S1		
Striaria sp 1	A millipede	G1	S1		
Thalassisobates littoralis	A millipede	G5	S1		
Trichomeris sinuata	A millipede	G5	S1		
Trichopetalum dux	A millipede	G1	S1		
Trichopetalum lunatum	A millipede	G5	S2		
Trichopetalum packardi	Packard's blind cave millipede	G4	S2		
Trichopetalum weyeriensis	Grand Caverns blind cave millipede	G3G4	S2		
Trichopetalum whitei	Luray Caverns blind cave millipede	G3G4	S2		
Uroblaniulus canadensis	A millipede	G5	S2		
Uroblaniulus jerseyi	A millipede	G3	S2		
Uroblaniulus sp 1	A millipede (Burkes Garden)	G?	S1		
Virgoiulus minutus	A millipede	G5	S2		
CHILOPODA (CENTIPEDES)					
Escaryus cryptorobius	Montane centipede	G2	S2		
Escaryus ethopus	A centipede	G?	S1S2		
Escaryus orestes	Whitetop Mountain centipede	G1G2	S1S2		
Nampabius turbator	A cave centipede	G1G2	S1		
COLLEMBOLA (SPRINGTAILS)					
Arrhopalites caedus	A cave springtail	G1G2	S1		
Arrhopalites carolynae	A cave springtail	G2G3	S1		
Arrhopalites clarus	A cave springtail	G2G4	S1		
Arrhopalites commorus	A cave springtail	G1G2	S1		
Arrhopalites lacuna	A cave springtail	G1G2	S1S2		
Arrhopalites marshalli	A cave springtail	G3	S2		
Arrhopalites pavo	A cave springtail	G1G2	S1		
Arrhopalites sacer	A cave springtail	G1G2	S1		
Arrhopalites silvus	A cave springtail	G1G2	S1		
Oncopodura hubbardi	A cave springtail	G1	S1		
Pseudosinella bona	A cave springtail	G1G2	S1S2		
Pseudosinella erehwon	A cave springtail	G1	S1		
Pseudosinella extra	A cave springtail	G1	S1		
Pseudosinella gisini virginia	A cave springtail	G3G4T1	S1		
Pseudosinella granda	A cave springtail	G3	S2		
Pseudosinella hirsuta	A cave springtail	G2G4	S1		
Schaefferia hubbardi	A cave springtail	G3	S2		
Typhlogastrura valentini	A cave springtail	G1	S1		

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DIPLURA (DIPLURANS)					
Litocampa cookei	Cooke's cave dipluran	G4G5	S2		
Litocampa pucketti	Puckett's cave dipluran	G2	S2		
Litocampa sp 1	A cave dipluran (Salamander Cave)	G1	S1		
Litocampa sp 3	A cave dipluran	G2	S2		
Litocampa sp 4	A cave dipluran	G2	S1S2		
EPHEMEROPTERA (MAYFLIES)					
Ameletus cryptostimulus	Allegheny mayfly	G4	S1S3		
Ameletus tarteri	Tarter's Ameletus mayfly	G1	S1		
Baetisca rubescens	A mayfly	G2	S1		
Barbaetis benfieldi	Benfield's bearded small minnow mayfly	G2	S1		
Ephemerella berneri	Berner's Ephemerella mayfly	G3	S1S3		
Ephemerella inconstans	A mayfly	G3	S1S3		
Habrophlebiodes celeteria	A mayfly	G2	S1?		
Isonychia arida	A mayfly	G5	S2		
Isonychia georgiae	Georgia Isonychia mayfly	G3	S1S3		
Isonychia hoffmani	Hoffman's Isonychia mayfly	G1	S1		
Isonychia serrata	A mayfly	G4	S1S3		
Isonychia tusculanensis	A mayfly	G3	S2		
Leptophlebia johnsoni	Johnson's pronggill mayfly	G4	S1		
Paraleptophlebia assimilis	A mayfly	G3	S1S3		
Paraleptophlebia jeanae	A mayfly	G3	S1S3		
Pseudiron centralis	White sand-river mayfly	G5	S1		
Rhithrogena anomala	A mayfly	G2	S1?		
Siphloplecton costalense	Spieth's great speckled olive mayfly	G2	SH		
ODONATA (DAMSELFLIES & DRAGONFLIES)					
Damselflies					
Calopteryx aequabilis	River jewelwing	G5	S2?		
Calopteryx amata	Superb jewelwing	G4	S1		
Calopteryx angustipennis	Appalachian jewelwing	G4	S2		
Enallagma cyathigerum	Northern bluet	G5	S1		
Enallagma dubium	Burgundy bluet	G5	S2		
Enallagma ebrium	Marsh bluet	G5	S1		
Enallagma hageni	Hagen's bluet	G5	S2		
Enallagma pallidum	Pale bluet	G4	S1		
Enallagma weewa	Blackwater bluet	G5	S2		
Lestes disjunctus disjunctus	Northern common spreadwing	G5T5	S1S2		
Lestes dryas	Emerald spreadwing	G5	S1		
Lestes vidua	Carolina spreadwing	G5	SH		
Nehalennia gracilis	Sphagnum sprite	G5	S2		
Nehalennia integricollis	Southern sprite	G5	S2		
Nehalennia irene	Sedge sprite	G5	S1		
Dragonflies					
Aeshna canadensis	Canada darner	G5	S1		
Aeshna constricta	Lance-tipped darner	G5	S1		
Aeshna mutata	Spatterdock darner	G3G4	S2		
Aeshna tuberculifera	Black-tipped darner	G4	S2S3		
Aeshna verticalis	Green-striped darner	G5	S1		

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Dragonflies (continued)					
Aphylla williamsoni	Two-striped forceptail	G5	S1		
Arigomphus furcifer	Lilypad clubtail	G5	SH		
Celithemis martha	Martha's pennant	G4	S2		
Celithemis ornata	Faded pennant	G5	SH		
Cordulegaster diastatops	Delta-spotted spiketail	G5	S1		
Cordulia shurtleffii	American emerald	G5	S2		
Coryphaeschna ingens	Regal darner	G5	S1		
Epitheca canis	Beaverpond baskettail	G5	S1		
= *Tetragoneuria canis*					
Epitheca costalis	Stripe-winged baskettail	G4	S2		
= *Tetragoneuria costalis*					
Epitheca semiaquea	Mantled baskettail	G4	S1		
= *Tetragoneuria semiaquea*					
Epitheca spinosa	Robust baskettail	G4	S2		
= *Tetragoneuria spinosa*					
Gomphus abbreviatus	Spine-crowned clubtail	G3G4	S2S3		
Gomphus adelphus	Moustached clubtail	G4	S1		
= *Gomphus brevis*					
Gomphus apomyius	Banner clubtail	G4	S1		
Gomphus borealis	Beaverpond clubtail	G4	S1		
Gomphus consanguis	Cherokee clubtail	G2G3	S2		
= *Stenogomphurus consanguis*					
Gomphus descriptus	Harpoon clubtail	G4	S1		
Gomphus fraternus	Midland clubtail	G5	S1		
Gomphus parvidens	Piedmont clubtail	G4	S1		
Gomphus quadricolor	Rapids clubtail	G3G4	S1		
Gomphus septima	Septima's clubtail	G2	SR		
Gomphus ventricosus	Skillet clubtail	G3	S1		
Gomphus viridifrons	Green-faced clubtail	G3	S2		
Helocordulia selysii	Selys' sundragon	G4	S2		
Ladona exusta	White corporal skimmer	G4	S1		
= *Libellula exusta*					
Ladona julia	Chalk-fronted corporal skimmer	G5	S1		
= *Libellula julia*					
Lanthus parvulus	Northern pygmy clubtail	G4	S2		
Leucorrhinia frigida	Frosted whiteface	G5	SH		
Leucorrhinia hudsonica	Hudsonian whiteface	G5	S1		
Leucorrhinia intacta	Dot-tailed whiteface	G5	S2S3		
Leucorrhinia proxima	Red-waisted whiteface	G5	SH		
Macromia alleghaniensis	Allegheny river cruiser	G4	S2		
Macromia margarita	Mountain river cruiser	G3	S1		
Nannothemis bella	Elfin skimmer	G4	S1		
Neurocordulia virginiensis	Cinnamon shadowdragon	G4	S1		
Neurocordulia yamaskanensis	Stygian shadowdragon	G5	S2		
Ophiogomphus alleghaniensis	Allegheny snaketail	G3Q	S1		
=*Ophiogomphus incurvatus alleghaniensis*					
Ophiogomphus aspersus	Brook snaketail	G3G4	S1		
Ophiogomphus carolus	Riffle snaketail	G5	S1		
Ophiogomphus howei	Pygmy snaketail	G3	S1S2		
Ophiogomphus incurvatus	Appalachian snaketail	G3	S1		
=*Ophiogomphus incurvatus incurvatus*					
Ophiogomphus mainensis	Maine snaketail	G4	S1		

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Dragonflies (continued)					
Somatochlora elongata	Ski-tailed emerald	G5	S1S2		
Somatochlora filosa	Fine-lined emerald	G5	S2		
Somatochlora georgiana	Coppery emerald	G3G4	S1		
Somatochlora provocans	Treetop emerald	G4	S2		
Somatochlora williamsoni	Williamson's emerald	G5	SH		
Stylurus amnicola	Riverine clubtail	G4	S1		
Stylurus laurae	Laura's clubtail	G4	S2		
Stylurus notatus	Elusive clubtail	G3	S1		
Stylurus scudderi	Zebra clubtail	G4	S1S2		
Sympetrum corruptum	Variegated meadowhawk	G5	S1		
Sympetrum janeae	Jane's meadowhawk	G5	SH		
Sympetrum obtrusum	White-faced meadowhawk	G5	S1		
PLECOPTERA (STONEFLIES)					
Acroneuria flinti	Manassas stonefly	GH	SH		
Acroneuria kosztarabi	Virginia stonefly	G1	S1		
Allocapnia fumosa	Smokies snowfly	G2	S1S2		
Allocapnia illinoensis	Illinois snowfly	G3	S1S3		
Allocapnia simmonsi	Spatulate snowfly	G2	S1S2		
Allocapnia stannardi	Blue Ridge snowfly	G3	S1S3		
Alloperla banksi	Tufted sallfly	G4	S1S3		
Alloperla biserrata	Dusky sallfly	G3	S2S3		
Alloperla idei	Vernal sallfly	G3	S1S3		
Alloperla nanina	Swannanoa sallfly	G4	S1S3		
Alloperla neglecta	Tennessee sallfly	G3	S1S2		
Bolotoperla rossi	Smoky willowfly	G4	S1S3		
Cultus decisus isolatus	Southern springfly	G4T2	S1S2		
Diploperla kanawholensis	Kanawhole springfly	G3	S1S3		
Diploperla morgani	Virginia springfly	G2	S2		
Hansonoperla appalachia	Appalachian stonefly	G3	S1S3		
Isogenoides varians	Rock Island springfly	G3	S1S3		
Isoperla major	Big stripetail stonefly	G1	S1		
Leuctra mitchellensis	Mitchell needlefly	G3	S1S2		
Leuctra monticola	Montane needlefly	G1Q	S1		
Megaleuctra flinti	Shenandoah needlefly	G2	S2		
Megaleuctra williamsae	Smokies needlefly	G2	S2		
Ostrocerca complexa	Notched forestfly	G4	S1S3		
Ostrocerca prolongata	Bent forestfly	G3	S1S3		
Paragnetina ichusa	Widecollar stonefly	G3	S1S3		
Perlesta frisoni	Blue Ridge stonefly	G3	S1S2		
Perlesta teaysia	Teays stonefly	G3	S1S3		
Prostoia hallasi	Swamp forestfly	G3	S1S3		
Pteronarcys comstocki	Spiny salmonfly	G3	S1S3		
Pteronarcys scotti	Carolina salmonfly	G4	S1S3		
Remenus kirchneri	Blue Ridge springfly	G2	S2		
Strophopteryx limata	Newfound willowfly	G3	S1S2		
Sweltsa holstonensis	Holston sallfly	G1	S1		
Sweltsa voshelli	Virginia sallfly	G3	S2		
Taeniopteryx nelsoni	Cryptic willowfly	G1	S1		
Tallaperla cornelia	Southeastern roachfly	G4	S1S3		
Tallaperla lobata	Lobed roachfly	G2	S1S2		
Yugus arinus	Highlands springfly	G3	S1S3		

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ORTHOPTERA (GRASSHOPPERS, KATYDIDS, CRICKETS & RELATIVES)					
Appalachia hebardi	Appalachian grasshopper	GH	SH		
Melanoplus pachycercus	A spur-throat grasshopper	G2G3	S1S3		
Melanoplus sp 55	A spur-throat grasshopper	G1G2	S1S2		
Melanoplus sp 59	A spur-throat grasshopper	G1G2	S1S2		
Scudderia septentrionalis	Northern bush katydid	G3?	S1S3		
HETEROPTERA (TRUE BUGS)					
Acantholomidea denticulata	A shield bug	G?	SH		
Allopodops mississippiensis	Mississippi turtle bug	G2G3	SH		
Bothynotus johnstoni	A mirid bug	G3	S1S3		
Botocudo modestus	A seed bug	G5	S1S3		
Chelinidea vittiger	Opuntia squash bug	G3G5	SR		
Chlorochroa dismalia	Dismal Swamp green stink bug	GU	S1S3		
Ctenotrachelus shermani	Combneck assassin bug	G3	S1S3		
Elasmostethus atricornis	Hercules club stink bug	G3?	S1S3		
Eurygaster alternata	A shield bug	G5	SH		
Galgupha denudata	A shield bug	G3	S1S3		
Isthmocorius piceus	Black stalk-eyed bug	G5	S1S2		
Limnoporus dissortis	A water strider	G5	S1		
Melanaethus cavicollis	A burrower bug	G4	S1S3		
Oncozygia clavicornis	A turtle bug	G3	SH		
Ploiaria carolina	Carolina thread-legged bug	G4?	S1S3		
Ploiaria hirticornis	An assassin bug	G3?	S1S3		
Pnirontis brimleyi	Brimley's assassin bug	G2	S1S3		
Pycnoderiella virginiana	Seashore plant bug	GU	SU		
Ramphocorixa acuminata	Acuminate water boatman	G4	S1		
Ranatra drakei	Drake's water scorpion	G4	S1S3		
Sigara depressa	Virginia Piedmont water boatman	G1G2	S1S2		PE
Stachyocnemus apicalis	Sandpit alydid bug	G4	SH		
Stenocoris tipuloides	Neotropical rice bug	G5	S1S3		
HOMOPTERA (CICADAS, LEAFHOPPERS & RELATIVES)					
Puto kosztarabi	Buffalo Mountain mealybug	G1	S1		PE
COLEOPTERA (BEETLES)					
Anthophylax hoffmani	A longhorned beetle	G?	S1S3		
Arianops jeanneli	A cave pselaphid beetle	G1	S1		
Atheta annexa	A rove beetle	G2G4	S2		
Atheta troglophila	A rove beetle	G1	S1		
Calligrapha pnirsa	A leaf beetle	G3?	S1S3		
Cicindela abdominalis	Orange-bellied tiger beetle	G5	S1		
Cicindela ancocisconensis	Riverbank tiger beetle	G3	S2		
Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	G4T2	S2	LT	PT
Cicindela formosa generosa	A tiger beetle	G5T5	SH		
Cicindela gratiosa	A tiger beetle	G5	S1		
Cicindela lepida	Spectral tiger beetle	G4	S1		
Cicindela limbalis	A tiger beetle	G5	SH		
Cicindela patruela	Barrens tiger beetle	G3	S2		
Cicindela trifasciata	A tiger beetle	G5	S1		
Cyclotrachelus incisus	A ground beetle	G2	S1		

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COLEOPTERA (continued)					
Dryobius sexnotatus	Six-banded longhorn beetle	G?	S1S3		
Hydraena maureenae	Maureen's shale stream beetle	G1G3	S1S3		
Laccophilus schwarzi	Schwarz' diving beetle	G?	S1S3		
Lordithon niger	Black lordithon rove beetle	GU	SH		
Nicrophorus americanus	American burying beetle	G2G3	SH	LE	
Pentagonica picticornis	A ground beetle	G?	S1S3		
Phloeoxena signata	A ground beetle	G3?	S1S3		
Pseudanophthalmus avernus	Avernus cave beetle	G1	S1		
Pseudanophthalmus cordicollis	Little Kennedy Cave beetle	G1	S1		
Pseudanophthalmus deceptivus	Deceptive cave beetle	G1	S1		
Pseudanophthalmus delicatus	Delicate cave beetle	G2	S2		
Pseudanophthalmus egberti	New River Valley cave beetle	G1	S1		
Pseudanophthalmus gracilis	A cave beetle	G1G2	S1S2		
Pseudanophthalmus hirsutus	Cumberland Gap cave beetle	G1	S1		
Pseudanophthalmus hoffmani	Hoffman's cave beetle	G1G2	S1S2		
Pseudanophthalmus holsingeri	Holsinger's cave beetle	G1	S1	C	PE
Pseudanophthalmus hortulanus	Burkes Garden cave beetle	G1	S1		
Pseudanophthalmus hubbardi	Hubbard's cave beetle	G1	S1		
Pseudanophthalmus hubrichti	Hubricht's cave beetle	G1	S1		
Pseudanophthalmus intersectus	Crossroads Cave beetle	G1	S1		
Pseudanophthalmus limicola	Mud-dwelling cave beetle	G1	S1		
Pseudanophthalmus longiceps	Long-headed cave beetle	G1	S1		
Pseudanophthalmus nelsoni	Nelson's cave beetle	G1	S1		
Pseudanophthalmus parvicollis	Thin-neck cave beetle	G1	S1		
Pseudanophthalmus petrunkevitchi	Petrunkevitch's cave beetle	G1G2	S1		
Pseudanophthalmus pontis	Natural Bridge cave beetle	GH	SH		
Pseudanophthalmus potomaca potomaca	South Branch Valley cave beetle	G2T2	S2		
Pseudanophthalmus praetermissus	Overlooked cave beetle	G1	S1		
Pseudanophthalmus punctatus	Spotted cave beetle	G1	S1		
Pseudanophthalmus pusio	A cave beetle	G3	S1S2		
Pseudanophthalmus quadratus	Straley's Cave beetle	G1	S1		
Pseudanophthalmus rotundatus	Rotund cave beetle	G1G3	S1		
Pseudanophthalmus sanctipauli	Saint Paul cave beetle	G1	S1		
Pseudanophthalmus seclusus	A cave beetle	G1	S1		
Pseudanophthalmus sericus	Silken cave beetle	G1	S1		
Pseudanophthalmus thomasi	Thomas' cave beetle	G1	S1		
Pseudanophthalmus vicarius	Vicariant cave beetle	G1G2	S1S2		
Pseudanophthalmus virginicus	Maiden Spring cave beetle	GH	SH		
Pseudanophthalmus sp 4 = *P.* sp A (*jonesi* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 5 = *P.* sp A (*petrunkevitchi* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 6 = *P.* sp. B (*petrunkevitchi* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 7 = *P.* sp C (*petrunkevitchi* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 8 = *P.* sp A (*hubbardi* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 9 = *P.* sp A (*hubrichti* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 10 = *P.* sp B (*hubrichti* group)	A cave beetle	G1	S1		

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COLEOPTERA (continued)					
Pseudanophthalmus sp 11 = *P.* sp A (*pusio* group)	A cave beetle	G1	S1		
Pseudanophthalmus sp 12 = *P.* sp B (*pusio* group)	Catawba Cave beetle	G1	S1		
Pseudanophthalmus sp 13 = *P.* sp B (*hubbardi* group)	McMullan Cave beetle	G1	S1		
Pseudanophthalmus sp 14 = *P.* sp C (*pusio* group)	Karl's Pit cave beetle	G1	S1		
Pseudaptinus lecontei	A ground beetle	G?	S1S3		
Sosylus costatus	A beetle	G?	S1S3		
Sphaeroderus schaumi	Schaum's ground beetle	G4	S2		
Stenelmis gammoni	Gammon's riffle beetle	G1G3	S1		
Stenocorus schaumi	Schaum's longhorn beetle	G?	S1S3		
Thalpius pygmaeus = *Pseudaptinus pygmaeus*	A ground beetle	G?	S1		
MECOPTERA (SCORPIONFLIES)					
Boreus nivoriundus	A snow scorpionfly	G4	S1S2		
Brachypanorpa jeffersoni	Jefferson's short-nosed scorpionfly	G2	S1S2		
TRICHOPTERA (CADDISFLIES)					
Anabolia apora	A limnephilid caddisfly	G1G3	S1S3		
Nemotaulius hostilis	A limnephilid caddisfly	G5	S1		
Rhyacophila appalachia	Appalachian rhyacophilid caddisfly	G3?	S1S3		
Rhyacophila tricornuta	A rhyacophilid caddisfly	G1G3	S1S3		
Wormaldia thyria	A philopotamid caddisfly	G3?	S1S3		
LEPIDOPTERA (BUTTERFLIES, SKIPPERS & MOTHS)					
Butterflies					
Anaea andria	Goatweed leafwing	G5	S1		
Boloria selene	Silver-bordered fritillary	G5	S2		
Calephelis borealis	Northern metalmark	G3G4	S2S3		
Calephelis virginiensis	Little metalmark	G4	S1		
Callophrys hesseli = *Mitoura hesseli*	Hessel's hairstreak	G3G4	S1		
Callophrys irus = *Incisalia irus, Deciduphagus irus*	Frosted elfin	G3	S2		
Callophyrs polios = *Incisalia polios, Deciduphagus polios*	Hoary elfin	G5	S1S3		
Colias interior	Pink-edged sulphur	G5	S1S2		
Euchloe olympia	Olympia marble	G4G5	S2S3		
Lycaena hyllus	Bronze copper	G5	S1		
Neonympha areolata areolata	Georgia satyr	G4T3T4	S2S3		
Neonympha mitchellii francisci	Saint Francis' satyr	G1G2T1	S1	LE	PT
Phyciodes batesii batesii	Tawny crescent	G4T1	SH		
Phyciodes cocyta = *Phyciodes pascoensis, Phyciodes selenis*	Northern crescent	G5	S1S3		
Satyrium caryaevorum	Hickory hairstreak	G4	S1S3		
Satyrium kingi	King's hairstreak	G3G4	S2S3		
Speyeria atlantis	Atlantis fritillary	G5	S2		
Speyeria idalia idalia	Regal fritillary	G3T1Q	S1		

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LEPIDOPTERA (continued)					
Skippers					
Amblyscirtes alternata	Dusky roadside-skipper	G3G4	S1		
Atrytone arogos arogos	Arogos skipper	G3G4T1T2	SH		
Erynnis lucilius	Columbine duskywing	G4	S1S3		
Erynnis martialis	Mottled duskywing	G3G4	S1S3		
Erynnis persius persius	Persius duskywing	G5T2T3	S1		
Euphyes bimacula	Two-spotted skipper	G4	S2		
Euphyes conspicua	Black dash	G4	S1S3		
Euphyes dukesi	Dukes' skipper	G3	S2		
Euphyes pilatka	Palatka skipper	G3G4	SH		
Hesperia attalus slossonae	Dotted skipper	G3G4T3	SH		
Megathymus yuccae	Yucca giant-skipper	G5	SH		
Polites mystic	Long dash	G5	S1?		
Problema bulenta	Rare skipper	G2G3	S1		
Pyrgus wyandot = *Pyrgus centaureae wyandot*	Appalachian grizzled skipper	G2	S1S2		PT
Moths					
Acherdoa ferraria	Chocolate moth	G5	S1S2		
Acrapex relicta	Cane-boring moth	G4	S1S3		
Acronicta albarufa	Barrens dagger moth	G3G4	S1S3		
Acronicta brumosa	A dagger moth	G4?	S1		
Anaplectoides brunneomedia	Brown-lined dart moth	G4	S1S3		
Apamea smythi	Smyth's Apamea moth	GH	SH		
Apamea sp 1	Cane Apamea moth	G3G4	S1S2		
Aplectoides condita	A noctuid moth	G4	S1S3		
Argillophora furcilla	A cane moth	G2G4	S1S3		
Argyrostrotis deleta	A noctuid moth	G4G5	S1S3		
Argyrostrotis sylvarum	A noctuid moth	G4	S1S3		
Arugisa watsoni	Watson's Arugisa moth	G4	S1S3		
Brachionycha borealis	Boreal fan moth	G4	S1S3		
Callosamia securifera	Sweetbay silkmoth	G4	S1S2		
Catocala consors sorsconi	Consort underwing	G4T2T4	SH		
Catocala dulciola	Sweet underwing	G3	S1S3		
Catocala herodias gerhardi	Pine barrens underwing	G3T3	S2S3		
Catocala marmorata	Marbled underwing	G3G4	S2		
Catocala messalina	Messalina underwing	G4	SH		
Catocala pretiosa pretiosa	Precious underwing	G4T2T3	SH		
Catocala ulalume	Ulalume underwing	G4	S1S3		
Crambidia cephalica	Yellow-headed lichen moth	G4	S1S2		
Cymatophora approximaria	A geometrid moth	G4G5	S1S3		
Drasteria graphica atlantica	Atlantic graphic moth	G4T4	S2S3		
Dysstroma citrata	A geometrid moth	G5	S1S3		
Emarginea percara	A noctuid moth	G4	S1S3		
Erythroecia hebardi	Hebard's noctuid moth	GU	SH		
Euchlaena milnei	Milne's Euchlaena moth	G2G4	S2		
Euxoa immixta	Mixed dart moth	G4	SH		
Faronta rubripennis	Pink-streak moth	G3G4	S1S3		
Franclemontia interrogans	A cane moth	G3G4	S1S3		
Hadena ectypa	A noctuid moth	G3G4	S1S3		
Heterocampa astarte	A prominent moth	G4G5	S1S2		
Hypomecis buchholzaria	Buchholz's gray moth	G3G4	S1S3		

VIRGINIA RARE ANIMAL LIST

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Moths (continued)					
Hyppa contrasta	A noctuid moth	G4	S1S3		
Idaea tacturata	A geometrid moth	G4	S1S2		
Itame ribearia	Currant spanworm moth	G4	S1S3		
Itame sp 1	Barrens Itame moth	G3	S1S3		
Leucania calidior	A cane moth	GU	S1S3		
Lithacodia sp 1	A noctuid moth	G4	S1S2		
Lithophane lemmeri	Lemmer's pinion moth	G3G4	S1S3		
Lithophane lepida adipel	A pinion moth	G4T4	S1S3		
Lophosis labeculata	A geometrid moth	GU	S1S3		
Lytrosis permagnaria	A geometrid moth	G3G4	S1S3		
Merolonche dolli	Doll's Merolonch moth	G3G4	S1S3		
Meropleon cosmion	A noctuid moth	G4	S1S3		
Meropleon titan	A noctuid moth	G2G4	S1S3		
Metarranthis sp 1	A geometrid moth	G3	S1S3		
Metria amella	A noctuid moth	G5	S1S2		
Nemoria elfa	Elfin emerald	G?	S1S3		
Nemoria tuscarora	Tuscarora emerald	GU	S1S3		
Oxycilla mitographa	A noctuid moth	G4	SH		
Paectes abrostolella	A noctuid moth	G4	S1S2		
Panopoda repanda	Orange Panopoda moth	G5	S1S2		
Papaipema astuta	Yellow stoneroot borer moth	G3G4	S1S3		
Papaipema duovata	Seaside goldenrod borer moth	G4	S1S3		
Papaipema duplicata	Dark stoneroot borer moth	G2G4	S1S3		
Papaipema necopina	Sunflower borer moth	G4?	S1S3		
Papaipema speciosissima	Osmunda stem borer moth	G4	S1S3		
Papaipema stenocelis	Chain fern borer moth	G4	S1S3		
Papaipema sp 3	Southeastern cane borer moth	G4	S2S3		
Polychrysia morigera	A noctuid moth	G4	S2S3		
Properigea sp 1 (= *Properigea costa* ?)	A noctuid moth	G2G3Q	S1S3		
Ptichodis bistrigata	Southern Ptichodis moth	G3	S1S3		
Pygarctia abdominalis	Yellow-edged Pygarctia moth	G3G4	S1S2		
Richia grotei	A noctuid moth	G4	S1S3		
Schinia siren = *Schinia inclara*	A flower moth	G?	S1S2		
Semiothisa distribuaria	A geometrid moth	G4	S1S2		
Sphinx franckii	Franck's sphinx	G4	S2S3		
Synanthedon castaneae	Chestnut clearwing moth	G3G5	SH		
Syngrapha rectangula	Salt-and-pepper looper moth	G5	S1S3		
Tischeria perplexa	Chestnut leaf-mining moth	GHQ	SH		
Xanthorhoe iduata	A geometrid moth	G4	S1S3		
Zale curema	A noctuid moth	G3G4	S1S3		
Zale sp 1	Pine barrens Zale moth	G3G4	S1S3		
Zale sp 2	A Zale moth	G4Q	S1S3		
Zale sp 3	Maritime Zale moth	G3?	S2		
Zanclognatha gypsalis	A noctuid moth	G4	S1S3		
DIPTERA (TRUE FLIES)					
Basilia boardmanni	Southeastern myotis bat fly	G3	S1S2		
Fletcherimyia fletcheri	Pitcher plant fly	G5	S1S2		
Metriocnemus knabi	Pitcher plant midge	G5	S2		
Spelobia tenebrarum	A cave fly	G4G5	S1		
Wyeomyia haynei	Southern pitcher plant mosquito	G4	S2		

APPENDIX 1. FEDERALLY ENDANGERED AND THREATENED VERTEBRATE ANIMALS OF VIRGINIA

(exclusive of extirpated species, see Appendix 3)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
VERTEBRATES					
FISH					
Cyprinella monacha = *Hybopsis monacha*	Turquoise shiner (or spotfin chub)	G2	S1	LT	LT
Erimystax cahni = *Hybopsis cahni*	Slender chub	G1	S1	LT	LT
Etheostoma percnurum	Duskytail darter	G1	S1	LE	LE
Noturus flavipinnis	Yellowfin madtom	G1	S1	LT	LT
Percina rex	Roanoke logperch	G1G2	S1S2	LE	LE
Phoxinus cumberlandensis	Blackside dace	G2	S1	LT	
AMPHIBIANS					
Plethodon shenandoah	Shenandoah salamander	G1	S1	LE	LE
REPTILES					
Caretta caretta	Loggerhead (sea turtle)	G3	S1B/S1N	LT	LT
Chelonia mydas	Green turtle	G3	SZN	LT	LT
Dermochelys coriacea	Leatherback (sea turtle)	G2	SZN	LE	LE
Eretmochelys imbricata	Atlantic hawksbill (sea turtle)	G3	SA	LE	LE
Glyptemys muhlenbergii = *Clemmys muhlenbergii*	Bog turtle	G3	S1S2	LT/SA	LE
Lepidochelys kempii	Kemp's ridley (sea turtle)	G1	S1N	LE	LE
BIRDS					
Charadrius melodus	Piping Plover	G3	S2B/S1N	LT	LT
Dendroica kirtlandii	Kirtland's Warbler	G1	SZN	LE	LE
Haliaeetus leucocephalus	Bald Eagle	G4	S2S3B/S3N	LT/PDL	LT
Picoides borealis	Red-cockaded Woodpecker	G3	S1	LE	LE
Sterna dougallii	Roseate Tern	G4	SHB/SZN	LE	LE
MAMMALS					
Balaenoptera borealis	Sei whale	G3	SN?	LE	LE
Balaenoptera musculus	Blue whale	G3G4	SN?	LE	LE
Balaenoptera physalus	Fin whale	G3G4	SZN	LE	LE
Corynorhinus townsendii virginianus = *Plecotus townsendii virginianus*	Virginia big-eared bat	G4T2	S1	LE	LE
Eubalaena glacialis = *Balaena glacialis*	Northern right whale	G1	SZN	LE	LE
Glaucomys sabrinus coloratus	Carolina northern flying squirrel	G5T1	S1	LE	LE
Glaucomys sabrinus fuscus	Virginia northern flying squirrel	G5T2	S1	LE	LE
Megaptera novaeangliae	Humpback whale	G3	SZN	LE	LE
Myotis grisescens	Gray myotis (bat)	G3	S1	LE	LE
Myotis sodalis	Indiana myotis (bat)	G2	S1	LE	LE
Physeter macrocephalus = *Physeter catodon*	Sperm whale	G3G4	SA	LE	LE
Sciurus niger cinereus	Delmarva Peninsula fox squirrel	G5T3	S1	LE	LE
Trichechus manatus	West Indian manatee	G2	SA	LE	LE

APPENDIX 2. FEDERALLY ENDANGERED AND THREATENED INVERTEBRATE ANIMALS OF VIRGINIA

(exclusive of extirpated species, see Appendix 3)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
INVERTEBRATES					
GASTROPODA (SNAILS)					
Polygyriscus virginianus	Virginia fringed mountain snail	G1	S1	LE	LE
BIVALVIA (MUSSELS)					
Alasmidonta heterodon	Dwarf wedgemussel	G1G2	S1	LE	LE
Cyprogenia stegaria	Fanshell	G1	S1	LE	LE
= Cyprogenia irrorata					
Dromus dromas	Dromedary pearlymussel	G1	S1	LE	LE
Epioblasma brevidens	Cumberland combshell	G1	S1	LE	LE
Epioblasma capsaeformis	Oyster mussel	G1	S1	LE	LE
Epioblasma florentina walkeri	Tan riffleshell	G1T1	S1	LE	LE
Fusconaia cor	Shiny pigtoe	G1	S1	LE	LE
= Fusconaia edgariana					
Fusconaia cuneolus	Fine-rayed pigtoe	G1	S1	LE	LE
Hemistena lata	Cracking pearlymussel	G1	S1	LE	LE
= Lastena lata					
Lemiox rimosus	Birdwing pearlymussel	G1	S1	LE	LE
= Conradilla caelata					
Pegias fabula	Little-winged pearlymussel	G1	S1	LE	LE
Pleurobema collina	James spinymussel	G1	S1	LE	LE
Pleurobema plenum	Rough pigtoe	G1	SH	LE	LE
Quadrula cylindrica strigillata	Rough rabbits foot	G3T2	S2	LE	LE
Quadrula intermedia	Cumberland monkeyface	G1	S1	LE	LE
Quadrula sparsa	Appalachian monkeyface	G1	S1	LE	LE
Villosa perpurpurea	Purple bean	G1	S1	LE	LE
CRUSTRACEA (AMPHIPODS, ISOPODS & DECAPODS)					
Antrolana lira	Madison Cave isopod	G2	S2	LT	LT
Lirceus usdagalun	Lee County cave isopod	G1	S1	LE	LE
INSECTA (INSECTS)					
Beetles					
Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	G4T2	S2	LT	PT
Nicrophorus americanus	American burying beetle	G2G3	SH	LE	
Butterflies					
Neonympha mitchellii francisci	Saint Francis' satyr	G1G2T1	S1	LE	PT

APPENDIX 3. EXTINCT AND EXTIRPATED ANIMALS OF VIRGINIA

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
VERTEBRATES					
FISH					
Acipenser brevirostrum	Shortnose sturgeon	G3	SX	LE	LE
Moxostoma lacerum = *Lagochila lacera*	Harelip sucker	GX	SX		
Percina maculata	Blackside darter	G5	SX		
Percopsis omiscomaycus	Trout-perch	G5	SX		
BIRDS					
Conuropsis carolinensis	Carolina parakeet	GX	SX		
Cygnus buccinator	Trumpeter swan	G4	SXN		
Ectopistes migratorius	Passenger pigeon	GX	SX		
Vermivora bachmanii	Bachman's warbler	GH	SX	LE	LE
MAMMALS					
Bos bison = *Bison bison*	Bison	G4	SX		
Canis lupus	Gray wolf	G4	SX	LE	LE
Canis rufus	Red wolf	G1	SX	LE	
Cervus elaphus	Wapiti or elk	G5	SX		
Erethizon dorsatum	Porcupine	G5	SX		
Puma concolor couguar = *Felis concolor couguar*	Eastern cougar	G5TH	SX	LE	LE
INVERTEBRATES					
BIVALVIA (MUSSELS)					
Epioblasma haysiana	Acornshell	GX	SX		
Epioblasma lenior	Narrow catspaw	GX	SX		
Epioblasma torulosa gubernaculum	Green-blossom pearlymussel	G2TX	SX	LE	LE
Lampsilis abrupta	Pink mucket	G2	SX	LE	LE
Villosa fabalis	Rayed bean	G1G2	SX		
Villosa trabalis	Cumberland bean	G1	SX	LE	LE

APPENDIX 4. NATURAL HERITAGE VERTEBRATE WATCH LIST

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
FISH					
Ambloplites cavifrons	Roanoke bass	G3	S3		SC
Chologaster cornuta	Swampfish	G5	S3		
Enneacanthus obesus	Banded sunfish	G5	S3		
Erimystax dissimilis = *Hybopsis dissimilis*	Streamline chub	G4	S3		
Erimystax insignis = *Hybopsis insignis*	Blotched chub	G3G4	S3		
Etheostoma kanawhae	Kanawha darter	G4	S3		
Etheostoma zonale	Banded darter	G5	S3		
Fundulus catenatus	Northern studfish	G5	S3		
Lampetra aepyptera	Least brook lamprey	G5	S3		
Lampetra appendix	American brook lamprey	G4	S3		
Margariscus margarita = *Semotilus margarita*	Pearl dace	G5	S3		
Moxostoma duquesnei	Black redhorse	G5	S3		
Notropis chalybaeus	Ironcolor shiner	G4	S3		
Notropis chiliticus	Redlip shiner	G4	S3		
Notropis sp 4	Sawfin shiner	G4	S3		
Percina caprodes	Logperch	G5	S3		
Percina gymnocephala	Appalachia darter	G4	S3		
Percina oxyrhynchus	Sharpnose darter	G4	S3		
Phenacobius uranops	Stargazing minnow	G4	S3		
Scartomyzon ariommus = *Moxostoma ariommum*	Bigeye jumprock	G4	S3		
AMPHIBIANS					
Aneides aeneus	Green salamander	G3G4	S3		
Desmognathus orestes	Blue Ridge dusky salamander	G4	S3		
Plethodon kentucki	Cumberland Plateau salamander	G4	S3		
Plethodon yonahlossee	Yonahlossee salamander	G4	S3		
Pseudacris ocularis = *Limnaoedus ocularis*	Little grass frog	G5	S3		
Rana virgatipes	Carpenter frog	G5	S3		SC
Siren lacertina	Greater siren	G5	S3		
Stereochilus marginatus	Many-lined salamander	G5	S3		
REPTILES					
Farancia erytrogramma	Rainbow snake	G5	S3		
Liochlorophis vernalis = *Opheodrys vernalis*	Smooth greensnake	G5	S3		
Malaclemys terrapin terrapin	Northern diamond-backed terrapin	G4T4	S4		

NATURAL HERITAGE VERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
BIRDS					
Accipiter cooperii	Cooper's Hawk	G5	S3B/S3N		
Ardea herodias	Great Blue Heron	G5	S3B/S5N		
Certhia americana	Brown Creeper	G5	S3B/S5N		SC
Dendroica cerulea	Cerulean Warbler	G4	S3S4B/SZN		
Dendroica virens waynei	Wayne's Black-throated Green Warbler	G5TU	S2B/SZN		
Dolichonyx oryzivorus	Bobolink	G5	S1B/SZN		
Empidonax minimus	Least Flycatcher	G5	S3S4B/SZN		
Ictinia mississippiensis	Mississippi Kite	G5	S1B		
Ixobrychus exilis	Least Bittern	G5	S3B/S3N		
Nycticorax nycticorax	Black-crowned Night-heron	G5	S3B/S4N		
Passerculus sandwichensis	Savannah Sparrow	G5	S3S4B/S4N		
Petrochelidon pyrrhonota	Cliff Swallow	G5	S3S4B/SZN		
Phalacrocorax auritus	Double-crested Cormorant	G5	S2B/S4S5N		
Riparia riparia	Bank Swallow	G5	S3B/SZN		
Sitta pusilla	Brown-headed Nuthatch	G5	S3S4		
Spiza americana	Dickcissel	G5	S3B/SZN		SC
Sterna forsteri	Forster's Tern	G5	S3B/S3N		SC
Sterna hirundo	Common Tern	G5	S3B/SZN		
Tyto alba	Barn Owl	G5	S3B/S3N		SC
Vermivora chrysoptera	Golden-winged Warbler	G4	S3B/SZN		SC
Vermivora pinus	Blue-winged Warbler	G5	S3B/SZN		
Wilsonia canadensis	Canada Warbler	G5	S3S4B/SZN		
MAMMALS					
Blarina brevicauda telmalestes	Dismal Swamp short-tailed shrew	G5T3	S3		
Lasionycteris noctivagans	Silver-haired bat	G5	SUB/S4N		
Lasiurus cinereus	Hoary bat	G5	SUB/S3N		
Lontra canadensis = *Lutra canadensis*	River otter	G5	S4		SC
Mustela nivalis	Least weasel	G5	S3		
Myotis septentrionalis	Northern myotis (bat)	G4	S3S4		
Neotoma magister	Allegheny woodrat	G3G4	S3		
Peromyscus gossypinus	Cotton mouse	G5	S3		
Peromyscus leucopus easti	Pungo mouse	G5T1	S1?		
Sciurus niger niger	Southeastern fox squirrel	G5T5	S3		
Sorex dispar	Long-tailed or rock shrew	G4	S3		
Spilogale putorius	Eastern spotted skunk	G5	S3S4		
Sylvilagus palustris	Marsh rabbit	G5	S3		SC
Synaptomys cooperi helaletes	Dismal Swamp bog lemming	G5T3	S3		

APPENDIX 5. NATURAL HERITAGE INVERTEBRATE WATCH LIST

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
GASTROPODA (SNAILS)					
Elimia arachnoidea	Spider Elimia	G3	S3		
Elimia catenaria	Gravel Elimia	G4	S3		
Euconulus chersinus	Wild hive	G4	SR		
Ferrissia fragilis	Fragile ancylid	G5	SU		
Ferrissia parallelus	Oblong ancylid	G5	SU		
Fontigens orolibas	Blue Ridge springsnail	G3	S3		
Fossaria dalli	Dusky Fossaria	G5	SU		
Gyraulus deflectus	Flexed Gyro	G5	SU		
Hendersonia occulta	Cherrystone Drop	G4	S3		
Lobosculum pustuloides	Tiny Liptooth	G3G4	S2S4		
Mesomphix rugeli	Wrinkled button	G3	S3		
Patera laevior	Smooth Bladetooth	G4	S2S4		
Philomycus virginicus	Virginia mantleslug	G3	S3		
Pleurocera gradata	Bottle hornsnail	G3	S3?		
Pleurocera uncialis	Pagoda hornsnail	G5	S3?		
Promenetus exacuous	Sharp Sprite	G5	SU		
Somatogyrus pennsylvanicus	Shale pebblesnail	G3	SU		
Triodopsis burchi	Pittsylvania three-tooth	G3	S3		
Triodopsis fradulenta	Baffled three-tooth	G3	S3		
Triodopsis tennesseensis	Budded three-tooth	G3G4	S3		
Valvata bicarinata	Two-ridge Valvata	G5	SU		
Valvata tricarinata	Three-ridge Valvata	G5	SU		
Ventridens arcellus	Golden dome	G3G4	S3		
Ventridens lasmodon	Hollow dome	G3	S3		
Vertigo parvula	Smallmouth Vertigo	G1G3	SU		
BIVALVIA (MUSSELS & CLAMS)					
Mussels					
Alasmidonta undulata	Triangle floater	G4	S3S4		
Anodonta implicata	Alewife floater	G5	S3S4		
Fusconaia subrotunda	Longsolid	G3	S3		
Leptodea ochracea	Tidewater mucket	G4	S3		
Ligumia nasuta	Eastern pondmussel	G4G5	S3		
Medionidus conradicus	Cumberland moccasin	G3G4	S3S4		
Strophitus undulatus	Creeper	G5	S3S4		
Uniomerus caroliniana = *Uniomerus obesus*	Florida pondhorn	G4	S3		
Utterbackia imbecillis = *Anodonta imbecillis, Pyganodon imbecillis*	Paper pondshell	G5	S3		
Villosa constricta	Notched rainbow	G3	S3		
ARACHNIDA (SPIDERS, PSEUDOSCORPIONS & RELATIVES)					
Spiders					
Gasteracantha cancriformis	Crablike spiny orb weaver	G5	S3		
Gnaphosa fontinalis	A gnaphosid spider	G4?	S3		
Hypochilus gertschi	Gertsch's lampshade-web spider	G3	S3		
Lycosa lenta	A wolf spider	G4	S3		
Sphodros atlanticus	Atlantic purse-web spider	G4	S3		
Sphodros coylei	Coyle's purse-web spider	G4?	S3		
Sphodros niger	Black purse-web spider	G4G5	S3		
Sphodros rufipes	Red-legged purse-web spider	G4	SU		

NATURAL HERITAGE INVERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Pseudoscorpions					
Chitrella cavicola	A cave pseudoscorpion	G3	S3		
CRUSTACEA (AMPHIPODS, ISOPODS & DECAPODS)					
Amphipods					
Crangonyx antennatus	Appalachian Valley cave amphipod	G3G5	S3		
Gammarus pseudolimnaeus	Northern spring amphipod	G5	S3		
Stygobromus araeus	Tidewater interstitial amphipod	G3	S3		SC
Stygobromus indentatus	Tidewater amphipod	G3	S3		SC
Stygobromus spinosus	Blue Ridge spring amphipod	G3	S3		
Isopods					
Caecidotea recurvata	Southwestern Virginia cave isopod	G3	S3		
Decapods					
Cambarus angularis	Clinch River crayfish	G3	S3		
Cambarus chasmodactylus	New River riffle crayfish	G4	S3		
Cambarus diogenes	Devil crawfish	G5	S3		
Cambarus longirostris	A crayfish	G5	S3		
Fallicambarus fodiens = *Fallicambarus uhleri*	A crayfish	G5	S3		
Orconectes obscurus	A crayfish	G5	S3		
Orconectes spinosus	A crayfish	G5	S3		
Branchiopods					
Eulimnadia sp 1	A clam shrimp	G?	SU		
Ostracods					
Ascetocythere cosmeta	Grayson crayfish ostracod	G?	SU		
COLLEMBOLA (SPRINGTAILS)					
Pseudosinella orba	A cave springtail	G4G5	S3		
Sinella barri	Barr's cave springtail	G5	S3		
Sinella hoffmani	Hoffman's cave springtail	G4G5	S3		
ODONATA (DAMSELFLIES & DRAGONFLIES)					
Damselflies					
Amphiagrion saucium	Eastern red damsel	G5	S3		
Argia bipunctulata	Seepage dancer	G4	S3		
Calopteryx dimidiata	Sparkling jewelwing	G5	S3		
Enallagma daeckii	Attenuated bluet	G4	S3		
Enallagma doubledayi	Atlantic bluet	G5	S3		
Enallagma traviatum	Slender bluet	G5	S3		
Enallagma vesperum	Vesper bluet	G5	S3		
Hetaerina titia	Smoky rubyspot	G5	S3		
Ischnura kellicotti	Lilypad forktail	G5	S3		
Ischnura prognata	Furtive forktail	G4	S3		
Lestes congener	Spotted spreadwing	G5	S3		
Lestes eurinus	Amber-winged spreadwing	G4	S3		
Lestes forcipatus	Sweetflag spreadwing	G5	S3		
Lestes inaequalis	Elegant spreadwing	G5	S3		
Lestes vigilax	Swamp spreadwing	G5	S3		
Telebasis byersi	Duckweed firetail	G5	S3		

NATURAL HERITAGE INVERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Dragonflies					
Anax longipes	Comet darner	G5	S3		
Boyeria grafiana	Ocellated darner	G5	S3		
Brachymesia gravida	Four-spotted pennant	G5	S3		
Celithemis fasciata	Banded pennant	G5	S3		
Celithemis verna	Double-ringed pennant	G5	S3		
Cordulegaster erronea	Tiger spiketail	G4	S3		
Cordulegaster obliqua	Arrowhead spiketail	G4	S3		
Dythemis velox	Swift setwing	G5	S2S4		
Erpetogomphus designatus	Eastern ringtail	G5	S3		
Gomphaeschna antilope	Taper-tailed darner	G4	S3		
Gomphaeschna furcillata	Harlequin darner	G5	S3		
Gomphus lineatifrons	Splendid clubtail	G4	S3		
Gomphus rogersi	Sable clubtail	G4	S3		
Lanthus vernalis	Southern pygmy clubtail	G4	S3		
Libellula auripennis	Golden-winged skimmer	G5	S3		
Libellula flavida	Yellow-sided skimmer	G5	S3		
Macromia taeniolata	Royal river cruiser	G5	S3		
Nasiaeschna pentacantha	Cyrano darner	G5	S3		
Neurocordulia obsoleta	Umber shadowdragon	G4	S3		
Stylogomphus albistylus	Least clubtail	G5	S3		
Stylurus plagiatus	Russet-tipped clubtail	G5	S3		
Stylurus spiniceps	Arrow clubtail	G5	S3		
Sympetrum ambiguum	Blue-faced meadowfly	G5	S3		
Tachopteryx thoreyi	Gray petaltail	G4	S3		
ORTHOPTERA (GRASSHOPPERS, KATYDIDS, CRICKETS & RELATIVES)					
Melanoplus celatus	A spur-throat grasshopper	GU	SU		
Melanoplus devius	A spur-throat grasshopper	GU	SU		
Melanoplus impudicus	Immodest spur-throat grasshopper	G4G5	SU		
HETEROPTERA (TRUE BUGS)					
Ctenotrachelus brimleyi	An assassin bug	G?	S2S4		
Isocytus chapmani	Chapman's shore bug	G?	SU		
Nepa apiculata	A water scorpion	G?	S2S4		
Plagiognathus repetitus	Pine barrens plant bug	G?	SU		
Pnirontis languida	An assassin bug	G4?	S2S4		
Ranatra australis	Southern water scorpion	G5	S3		
Tominotus communis	A burrower bug	G5	S2S4		
HOMOPTERA (CICADAS, LEAFHOPPERS & RELATIVES)					
Trialeurodes phlogis	Phlox whitefly	GU	SU		
COLEOPTERA (BEETLES)					
Cicindela dorsalis media	Southeastern beach tiger beetle	G4T4	S3		
Cicindela purpurea	Purple tiger beetle	G5	S3		
Cicindela splendida	Splendid tiger beetle	G5	S3		
Cicindela unipunctata	Flightless tiger beetle	G4	S3		
Diabrotica cristata	A leaf beetle	G?	SU		
Dicaelus sculptilis	A ground beetle	G4G5	S2S4		
Helluomorphoides nigripennis	A flat-horned ground beetle	G4?	S2S4		
Hoperius planatus	A predaceous diving beetle	G?	SU		
Hydraena appalachicola	Minute moss beetle	G?	SU		

NATURAL HERITAGE INVERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
COLEOPTERA (continued)					
Hydrobiomorpha casta	A water scavenger beetle	G?	SU		
Megacephala carolina = *Tetracha carolina*	Carolina big-headed tiger beetle	G5	S3		
Nicrophorus defodiens	A burying beetle	G4	S3		
Paralichas trivittis = *Odontonyx trivittis*	A beetle	G?	SU		
Pseudolampsis guttata	A leaf beetle	G?	SU		
Rhadine caudata	A ground beetle	G3	S3		
Rybaxis sp 1	A pselaphid beetle	GU	SU		
Urographis triangulifer = *Graphisurus triangulifer*	A longhorned beetle	G4?	SU		
TRICHOPTERA (CADDISFLIES)					
Heteroplectron americanum	A caddisfly	G?	SU		
Rhyacophila shenandoahensis	Shenandoah rhyacophilid caddisfly	G3	S3		
LEPIDOPTERA (BUTTERFLIES, SKIPPERS & MOTHS)					
Butterflies					
Atlides halesus	Great purple hairstreak	G5	S3		
Celastrina nigra = *Celastrina ebenina*	Dusky azure	G4	S3S4		
Enodia creola	Creole pearly-eye	G3G4	S3S4		
Erora laeta	Early hairstreak	G3G4	S3		
Fixsenia favonius ontario	Northern hairstreak	G4T4	S3		
Pieris virginiensis	West Virginia white	G3G4	S3S4		
Polygonia faunus smythi	Smyth's green comma	G5T3T4	S3?		
Pontia protodice	Checkered white	G4	S3S4		
Satyrium edwardsii	Edwards' hairstreak	G4	S3S4		
Speyeria diana	Diana fritillary	G3	S3		
Skippers					
Amblyscirtes aesculapias	Lace-winged roadside-skipper	G3G4	S3		
Amblyscirtes carolina	Carolina roadside-skipper	G3G4	S3S4		
Amblyscirtes reversa	Reversed roadside-skipper	G3G4	S3		
Autochton cellus	Golden-banded skipper	G4	S3		
Hesperia leonardus	Leonard's skipper	G4	S3		
Poanes aaroni	Aaron's skipper	G4	S3		
Poanes yehl	Yehl skipper	G4	S3		
Thorybes confusis	Confused cloudywing	G4	S2S4		
Moths					
Abrostola ovalis	A noctuid moth	G4	S1S4		
Acontia delecta	Delightful Bird-dropping moth	G4?	S1S4		
Acronicta dactylina	Fingered dagger moth	G5	SU		
Acronicta funeralis	Funerary dagger moth	G4G5	S1S4		
Acronicta haesitata	Hesitant dagger moth	G5	S1S4		
Acronicta hamamelis	Witch hazel dagger moth	G4?	S2S4		
Acronicta radcliffei	Radcliffe's dagger moth	G5	S2S4		
Acronicta spinigera	Nondescript dagger moth	G4	S1S3		
Acronicta subochrea	Puzzling dagger moth	G4?	S1S4		
Acronicta superans	Splendid dagger moth	G5	S1S3		
Acronicta tristis	A dagger moth	G?	S1S3		

NATURAL HERITAGE INVERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Moths (continued)					
Amolita obliqua	A noctuid moth	G5	S1S4		
Anaplectoides prasina	Green arches	G5	S1S3		
Anticlea multiferata	Many-lined carpet	G5	S1S3		
Anticlea vasiliata	A geometrid moth	G?	S1S3		
Apamea cariosa	A noctuid moth	G4	S1S3		
Apamea finitima	Bordered Apamea moth	G?	S1S3		
Apamea lignicolora	Wood-colored Apamea moth	G5	S1S3		
Apamea plutonia	A noctuid moth	G4	S1S4		
Apameini new genus 1, sp 1	A cane moth	G?	S1S3		
Apameini new genus 2, sp 1	A cane moth	G?	S1S3		
Apameini new genus 2, sp 2	A cane moth	G?	S1S3		
Apameini new genus 2, sp 3	A cane moth	G?	S1S3		
Apodrepanulatrix liberaria	New Jersey tea inchworm moth	G4	S2S4		
Archanara oblonga	Oblong sedge borer moth	G5	S1S3		
Argyrostrotis quadrifilaris	Four-lined chocolate moth	G4	S2S4		
Autographa ampla	Large looper moth	G5	S1S3		
Balsa tristrigella	Three-lined Balsa moth	G5	S1S3		
Bellura anoa	A wetland borer moth	G?	S2S4		
Bellura brehmei	A wetland borer moth	G?	S1S3		
Bellura melanopyga	A wetland borer moth	G?	S1S4		
Cabera quadrifasciaria	Four-lined Cabera moth	G?	S1S3		
Cabera variolaria	Pink-striped willow spanworm moth	G?	S1S4		
Callopistria granitosa	Granitosa fern moth	G4	S1S3		
Caripeta angustiorata	Brown pine looper moth	G?	S1S3		
Catocala angusi	Angus' underwing	G4	S2S4		
Catocala antinympha	Sweetfern underwing	G5	S1S4		
Catocala concumbens	Sleepy underwing	G5	S1S3		
Catocala crataegi	Hawthorn underwing	G5	S1S3		
Catocala insolabilis	Inconsolable underwing	G5	S1S4		
Catocala maestosa	Sad underwing	G5	S1S4		
Catocala miranda	Miranda underwing	G4	S2S4		
Catocala parta	Miranda underwing	G5	S2S4		
Catocala relicta	White underwing	G5	S2S4		
Catocala robinsoni	Robinson's underwing	G4	S2S4		
Catocala sappho	Sappho underwing	G4	S1S3		
Catocala serena	Serene underwing	G5	S1S4		
Chortodes inquinata	A noctuid moth	G?	SU		
Crambidia casta	Pearly-winged lichen moth	G4	S1S4		
Crambidia pura	Pure lichen moth	G4	S1S3		
Cucullia alfarata	A noctuid moth	G4	S1S4		
Cucullia asteroides	Asteroid moth	G5	S1S4		
Cucullia florea	A noctuid moth	G?	S1S4		
Cutina aluticolor	A cypress moth	G4	S3		
Cutina distincta	A cypress moth	G4	S3		
Cyclophora myrtaria	A geometrid moth	G5	S2S4		
Cycnia inopinatus	Unexpected Cycnia moth	G4	S1S4		
Darapsa versicolor	Hydrangea sphinx	G4	S2S4		
Dasychira pinicola	Pine tussock moth	G4	S1S3		
Dasychira plagiata	A tussock moth	G?	S1S4		
Diachrysia balluca	A noctuid moth	G?	S1S3		
Dysstroma truncata	Marbled carpet	G?	S2S4		
Erastria coloraria	Broad-lined Erastria moth	G4	S2S4		
Erastria cruentaria	Thin-lined Erastria moth	G4	S1S3		
Euchlaena marginaria	A geometrid moth	G?	S1S3		
Euchlaena muzaria	A geometrid moth	G?	S2S4		

NATURAL HERITAGE INVERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Moths (continued)					
Euchlaena tigrinaria	Mottled Euchlaena moth	G?	S1S4		
Eueretagrotis attenta	Attentive dart moth	G4	S1S3		
Eueretagrotis perattenta	Two-spot dart moth	G5	S1S3		
Eueretagrotis sigmoides	Sigmoid dart moth	G5	S1S3		
Eulithis explanata	White Eulithis moth	G?	S1S4		
Eulithis molliculata	Dimorphic Eulithis moth	G4	S1S4		
Eupithecia peckorum	Peck's Eupithecia moth	G?	S1S4		
Eutelia pulcherrima	Beautiful Eutelia moth	G5	S1S4		
Euxoa bostoniensis	Boston dart moth	G?	S2S4		
Euxoa declarata	A dart moth	G4G5	S1S3		
Euxoa fumalis	A dart moth	G?	S1S3		
Euxoa obeliscoides	A dart moth	G?	S2S4		
Euxoa redimicula	Fillet dart moth	G?	S2S4		
Euxoa scholastica	Scholastic dart moth	G?	S1S4		
Euxoa violaris	Violet dart moth	G4	S1S3		
Feralia comstocki	Comstock's sallow	G4	S1S3		
Glena cognataria	Blueberry Gray	G4	S1S4		
Haploa colona	Colona moth	G4	S2S4		
Heliomata infulata	Rare spring moth	G2G4	S2S4		
Homochlodes disconventa	Dark Homochlodes moth	G?	S1S4		
Hydraecia stramentosa	Figwort borer moth	G4	S2S4		
Hydriomena bistriolata	A geometrid moth	G?	S1S4		
Hydriomena divisaria	Black-dashed Hydriomena moth	G?	S1S4		
Hypena edictalis = *Bomolocha edictalis*	Large Hypena moth	G5	S1S4		
Hypena sordidula = *Bomolocha sordidula*	Sordid Hypena moth	G4	S2S4		
Iridopsis pergracilis = *Anacamptodes pergracilis*	A geometrid moth	G?	S1S3		
Isoparce cupressi	Cypress sphinx	G4	S3		
Itame abruptata	A geometrid moth	G4	S1S4		
Itame subcessaria	Barred Itame moth	G4?	S2S4		
Lacinipolia lustralis	A noctuid moth	G?	SU		
Lacinipolia olivacea	Olive arches	G5	S1S4		
Leucania commoides	A noctuid moth	G?	S1S4		
Lithacodia albidula	A noctuid moth	G5	S1S3		
Lithacodia concinnimacula	Red-spotted Lithacodia moth	G4	S1S3		
Lithophane innominata	Nameless pinion moth	G5	S1S4		
Lithophane querquera	Shivering pinion moth	G?	S2S4		
Melanchra assimilis	Black arches	G5	SU		
Melipotis jucunda	Merry Melipotis moth	G5	S1S3		
Mesoleuca ruficillata	White-ribboned carpet	G4	S2S4		
Metanema inatomaria	Pale Metanema moth	G?	S1S3		
Metarranthis amyrisaria	A geometrid moth	G4	S1S3		
Metarranthis indeclinata	Pale Metarranthis moth	G4G5	S2S4		
Metarranthis mestusata	A geometrid moth	G?	S1S3		
Morrisonia sp 1	A noctuid moth	G3G4	S2S4		
Nemoria mimosaria	An emerald moth	G?	S1S4		
Oligia crytora	A noctuid moth	G?	S1S3		
Oligia exhausta	A noctuid moth	G?	S1S3		
Orthofidonia exornata	A geometrid moth	G?	S1S4		
Orthosia revicta	Subdued Quaker moth	G?	S1S4		
Pangrapta sp 1	A noctuid moth	G?	S1S3		
Panthea acronyctoides	Black zipzag	G5	S2S4		
Papaipema araliae	Aralia shoot borer moth	G3G4	S3		
Papaipema impecuniosa	Aster borer moth	G5	S1S4		

NATURAL HERITAGE INVERTEBRATE WATCH LIST (continued)

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
Moths (continued)					
Papaipema nelita	Coneflower borer moth	G4	S1S4		
Papaipema nepheleptena	Turtlehead borer moth	G4	S2S4		
Papaipema polymniae	Leafcup borer moth	G4	S3		
Papaipema pterisii	Bracken fern borer moth	G5	S3		
Papaipema unimoda	Meadow rue borer moth	G5	S2S4		
Pero zalissaria	A geometrid moth	G4	S2S4		
Petrophora subaequaria	Northern Petrophora moth	G?	S1S4		
Phlogophora iris	Olive angle shades	G?	S1S3		
Plusia putnami	Putnam's looper moth	G?	SU		
Psaphida grandis = *Eutolype grandis*	Gray sallow	G4	S1S3		
Psaphida thaxterianus	A noctuid moth	G4	S2S4		
Pseudohermonassa tenuicula = *Xestia tenuicula*	A dart moth	G4	S1S3		
Pyrrhia adela	A sallow moth	G?	S1S3		
Rheumaptera hastata	Spear-marked black moth	G5	S1S3		
Rhodoecia aurantiago	Aureolaria seed borer moth	G4	S2S4		
Schinia bina	Bina flower moth	G4	S1S4		
Schinia florida	Primrose moth	G5	SU		
Schinia nubila	A flower moth	G?	S2S4		
Schinia saturata	Brown flower moth	G4	S1S4		
Sideridis congermana	German cousin moth	G?	S1S3		
Sphinx chersis	Great ash sphinx	G4G5	S2S4		
Sphinx drupiferarum	Wild cherry sphinx	G4	S1S3		
Sphinx eremitus	Hermit sphinx	G4	S1S3		
Sphinx kalmiae	Laurel sphinx	G5	S2S4		
Spragueia dama	Southern Spragueia moth	G5	S1S4		
Trichosilia manifesta = *Agrotis manifesta*	A noctuid moth	G4	S2S4		
Ulolonche modesta	Modest Quaker moth	G5	S1S4		
Venusia cambrica	Welsh wave moth	G5	S1S4		
Xanthorhoe labradorensis	Labrador carpet	G4	S1S4		
Xestia youngii = *Anomogyna youngii*	Young's dart moth	G?	S1S3		
Zale calycanthata	Double-banded Zale moth	G4	S2S4		
Zale submediana	A noctuid moth	G4	S2S4		
Zanclognatha sp 1	A noctuid moth	G3G4	S2S4		

APPENDIX 6. RARE SPECIES SIGHTING FORM

Virginia Department of Conservation and Recreation, Division of Natural Heritage
217 Governor Street, Richmond, Virginia 23219
(804) 786-7951

An important component of the natural heritage inventory and protection process involves gathering information from state experts, professionals, and avocational naturalists throughout the state. To facilitate this, the Division of Natural Heritage has developed this rare species sighting form. If you would like to participate in our inventory and protection activities, please take a few moments to complete the attached form for any species from our rare species list. These data will be evaluated for incorporation into the natural heritage database and used exclusively for the protection of the rare species and its habitat. Please send the form to the staff zoologist at the address above. Thank you for your support. The Division of Natural Heritage can only realize the protection of the Commonwealth's natural diversity by working through a network of knowledgeable and concerned individuals.

SPECIES OBSERVED:

DATE OBSERVED:

COUNTY:

USGS QUADRANGLE MAP NAME (if known; mark location on a photocopy of the appropriate map and submit with this form):

LOCATION (Provide a detailed description, including directions from nearest town, road intersection, etc.):

HABITAT DESCRIPTION (Include associated species, elevation, natural features, natural community type, etc.):

POPULATION DATA (Number of individuals observed, age, size, evidence of reproduction,etc.):

LANDOWNER (If know, provide name, address, and phone number):

THREATS TO SPECIES OR EVIDENCE OF HABITAT DISTURBANCE:

REPORTED BY (Include name, address, and phone number):

DATE OF REPORT:

Final

Round Two
Remedial Investigation Report
Site 12
Naval Weapons Station Yorktown
Yorktown, Virginia

Text - Volume I of III

Prepared For

Department of the Navy
Atlantic Division

Naval Facilities Engineering Command

Norfolk, Virginia

Under The

LANTDIV CLEAN Program

Comprehensive Long-Term Environmental Action Navy

TABLE OF CONTENTS

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents general information regarding the environmental setting of WPNSTA Yorktown and Site 12 including geography, meteorology, surface water hydrology, soil, geology, and hydrogeology.

3.1 Physical Geography

WPNSTA Yorktown is located on the York-James Peninsula, which is an embayed portion of the Atlantic Coastal Plain physiographic province (Virginia State Water Control Board [VSWCB], 1973). This elongated peninsula is situated due northwest of the mouth of the Chesapeake Bay and trends northwest to southeast. The York-James Peninsula occupies an area of approximately 1,752 square miles of which WPNSTA Yorktown covers approximately 16 square miles. The peninsula is bordered on the southwest by the James River, on the northeast by the York River, and on the southeast by the confluence of the James River and the Chesapeake Bay. At WPNSTA Yorktown, the peninsula is approximately 6 miles wide.

The local terrain is gently rolling and dissected by ravines and stream valleys trending predominantly northeastward toward the York River. Ground elevations at WPNSTA Yorktown range from sea level along the eastern boundary, which borders the York River, to a maximum elevation of approximately 90 feet above msl near the central portions of the York-James Peninsula, roughly coincident with the Old Williamsburg Road. Valleys consisting of 40- to 60-foot ravines with steep slopes (i.e., slopes exceeding 1:10 horizontal to vertical gradient) occur along several of the creeks that drain WPNSTA Yorktown, particularly in the northern section of the installation along the York River.

3.2 Meteorology

The climate of the Virginia Peninsula is maritime and is influenced by the moderating effects of the Atlantic Ocean. This results in mild winters and long, warm summers. High humidity occurs frequently along the coast and less frequently inland. The average relative humidity in midafternoon is approximately 60 percent. Humidity is higher at night, and the average humidity at dawn is approximately 80 percent (Hodges et al., 1982). Ground fog is frequent in the late summer,

traverses the north-central section of WPNSTA Yorktown, is the main drainage feature of the facility. Site 12 drains to Ballard Creek.

Extensive wetlands are found along the creeks that drain the Station and also along some shoreline areas of the York River. The tidal reaches of the York River extend across much of WPNSTA Yorktown. The tributary creeks draining WPNSTA Yorktown are tidal up to one mile inland from the riverbanks. The tidal reaches of the York River, including the vicinity of WPNSTA Yorktown, are classified as shellfish waters.

The portion of WPNSTA Yorktown located south of the York County/James City County boundary and Old Williamsburg Road is situated in the James River Basin. Blows Mill Run, the main drainage feature in this area, discharges off-Station into Skiffes Creek Reservoir, which drains southward through Skiffes Creek to the James River. The Skiffes Creek Reservoir is one of the water impoundments of the City of Newport News that provides potable water supplies to WPNSTA Yorktown and the surrounding communities.

The surface water drainage from Site 12 is predominately to the south, through several stream channels, as shown on Figure 1-3. The surface water runs through these channels to Ballard Creek. The surface water within two of these channels was monitored from August 30, 1994 to October 19, 1994 by utilizing staff gauges. The staff gauges were measured when static water levels were obtained from the monitoring wells on site. Table 2-8 presents a summary of the water level data collected from the monitoring wells and the staff gauges. The data indicates that the shallow groundwater discharges to these tributaries.

3.4 Soil

The soil at WPNSTA Yorktown has been classified according to its physical characteristics and assigned to associations or landscapes with distinctive proportional soil patterns. This classification, completed by the Virginia Polytechnic Institute and Virginia State University in 1982 (Hodges et al.), is specific for WPNSTA Yorktown and identifies five types of soil associations present at the Station. These soil associations are somewhat different than the U.S. Soil Conservation Service classifications that were discussed in the Round One RI. However, because the following

is medium to rapid and soil erosion is moderate to severe (C. C. Johnson & Associates, Inc. and CH2M Hill, 1984).

One soil association, Slagle, Emporia, Emporia Complex Association (No. 4 described above), was observed at the Site 12 study area.

3.5 Geology

The following sections describe the regional geology of WPNSTA Yorktown and the site-specific geology of Site 12.

3.5.1 Regional Geology

The Atlantic Coastal Plain physiographic province is underlain by unconsolidated sediment of Quaternary, Tertiary, and Cretaceous ages that dip gently to the southeast and have a combined thickness of approximately 1,900 feet in the vicinity of WPNSTA Yorktown (Teifke, 1973). Geologic units in York County are shown on Figure 3-2. A generlized geologic cross section is presented on Figure 3-3.

Most of the surficial unconsolidated sediment at WPNSTA Yorktown has been mapped as the Windsor Formation of the Pleistocene series (Johnson, 1972; Mixon et al., 1989a). This formation is composed of a series of sand and silt deposited in marine and estuarine environments. Its thickness is estimated to vary from 0- to 40-feet at WPNSTA Yorktown.

In the easternmost portions of WPNSTA Yorktown, the Chuckatuck and Lower Shirley Formations have been mapped (Mixon et al., 1989b). The Chuckatuck Formation consists of light- to medium-gray, yellowish-orange, and reddish-brown sandy silt and clay and minor amounts of brownish-black peat. Surficial deposits of river terraces and relic baymouth barriers and bay floodplains constitute the Shirley Formation. This formation consists of gray and brown sand, gravel, silt, clay, and organics with some mollusk fossils.

In the Virginia Coastal Plain, Pleistocene sediment is regionally undifferentiated. The Bacons Castle Formation of Pliocene age underlies the Windsor Formation and is described as a clayey silt and

monitoring wells installed during the expanded groundwater investigation completed in February 1996) throughout Site 12. The Test Boring Records are provided in Appendix B.

Cross-sections depicting the subsurface geologic conditions underlying the site were developed based on information obtained during the drilling program. As shown on Figure 3-4, four cross sections at the site were traversed. In general, cross-sections A to A' and B to B' (Figures 3-5 and 3-6) traverse northeast to southwest, while cross-sections C to C' and D to D' (Figures 3-7 and 3-8) traverse southwest to northeast.

During field investigative activities, two thin-walled (Shelby) tube samples were collected from monitoring well boring 12GW02A within the Morgarts Beach Member of the Yorktown Formation at depths of 39- to 41-feet bgs and 56- to 58-feet bgs. Grain size and hydraulic conductivity analyses were performed on the samples. The test results classified (using the Unified Soil Classification System) the two samples as CL and CH, silty fine sandy clays of low and high plasticity, respectively. The hydraulic conductivity of the two samples were 2.5×10^{-8} centimeters per second (cm/sec) and 2.8×10^{-8} cm/sec which is within the range of hydraulic conductivity for marine clays (Fetter, 1988). Test results of the samples are presented in Appendix D.

3.6 Hydrogeology

General information pertaining to local and site hydrogeology is presented below.

3.6.1 York County Hydrogeology

The Atlantic Coastal Plain sediments are the most important source of potable water in the region. Recharge to the groundwater system is derived from precipitation. Approximately fifty percent of the precipitation is lost to evapotranspiration. The remaining fifty percent either results in surface runoff or infiltrates and is introduced into the groundwater regime. Recharge of aquifers may occur at the surface near outcrop zones, or from downward migration from overlying strata.

The shallow aquifer system in York County is comprised of the following seven units: (1) the undivided York County shallow aquifer system, (2) the Columbia aquifer, (3) the Cornwallis Cave confining unit, (4) the Cornwallis Cave aquifer, (5) the Yorktown confining unit, (6) the

increased primary porosity due to these large voids creates localized areas of preferential flow and highly variable flow patterns (Johnson, 1995).

The Yorktown confining unit is defined as the silt or clay of the Morgarts Beach Member of the Yorktown Formation (Brockman and Richardson, 1992). This unit serves as a "marker" bed at WPNSTA Yorktown and is distinguishable by its dark greenish-gray color and silty clay texture.

Underlying the Yorktown confining unit is the Yorktown-Eastover aquifer, which is comprised of sandy or shelly deposits of the lower portions of the Yorktown Formation and the upper portions of the Eastover Formation. The aquifer, which is typically confined, but locally may be unconfined, provides the water source for most domestic well supplies in the county (Brockman and Richardson, 1992). The top of the aquifer is defined by the water table (where unconfined) or by the Yorktown confining unit (where confined).

The basal unit of the York County shallow aquifer system is the Eastover-Calvert confining unit, which consists of the silt and clay sediments of the Calvert, St. Marys, and lower Eastover Formations of Miocene age. This confining unit is approximately equivalent to the St. Marys and Calvert confining units of Meng and Harsh, 1988 (Brockman and Richardson, 1992).

Vertical migration of groundwater is typically impeded in areas where the confining units are present, continuous, relatively thick, and comprised primarily of low permeability strata such as clay or silt.

Depth to groundwater at WPNSTA Yorktown ranges from less than 1 foot bgs near surface water bodies to greater than 30 feet bgs in upland areas. The groundwater flow direction within the shallow system is generally toward groundwater discharge zones coincident with surface drainages and streams. Therefore, the water level elevations roughly reflect the surface topography. Seasonal variations in groundwater flow direction within the shallow aquifer were not evident based upon historical water level measurements.

The dominant source of domestic water supply for WPNSTA Yorktown and the surrounding community is from surface water reservoirs operated by the City of Newport News. However,

Yorktown Eastover aquifer as shown on Figure 3-11. The overall groundwater flow direction is towards the southeast.

The average horizontal groundwater gradient across the site was calculated based on the February 20, 1995 shallow groundwater level data. Based on these measurements, the average horizontal groundwater gradient across the site is 0.023 feet/feet. Groundwater gradient calculations are presented in Appendix D.

In situ hydraulic conductivity ("slug") tests were performed on October 6, 1994, in monitoring well 12GW01A and on October 21, 1994, in monitoring wells 12GW07, and 12GW07A. The static water level for monitoring well 12GW07 was below the top of the screen. Therefore, during falling head slug tests, this condition created an artificially high rate of fall in the water table due to induced head change recharging the unsaturated zone and sand pack surrounding the well screen. This phenomenon tends to overestimate the hydraulic conductivity (Bouwer, 1989). Therefore, only rising head test data were used to estimate the specific hydraulic conductivities for this shallow (Type II) monitoring well. Falling and rising head tests were conducted in the two deep (Type III) monitoring wells where the static water level encompassed the entire screen section. Specific testing procedures are outlined in Section 4.4.9 of the Final Work Plan for Sites 6, 7, 12, 16, SSA 16, and Background (Baker, 1994).

The field data were evaluated using the Geraghty and Miller aquifer test solver (AQTESOLV) program. The shallow (Type II) monitoring well data was evaluated using the Bouwer and Rice (1976) method for unconfined aquifers. The hydraulic conductivity of 12GW07 was comparable to the data obtained during the Round One RI field activities; therefore, the previous data were used to determine the average hydraulic conductivity for the shallow water-bearing zone. The average hydraulic conductivity for the Cornwallis Cave aquifer at the site is 5.2 feet per day (ft/day) or 1.83 x 10^{-3} cm/sec. The results of the hydraulic conductivity tests are summarized on Table 3-2. Transmissivity of the aquifer was determined at 78 ft^2/day using the average saturated aquifer thickness of 65 ft. These values are within the range of hydraulic conductivities for silty sand deposits (Fetter, 1988).

The deep (Type III) monitoring well data were evaluated using both the Cooper et al (1967) and the Bouwer and Rice (1976) methods for confined aquifer. The average hydraulic conductivity for the

3.7 References

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International Station Meteorological Climate Summary, U.S. Navy, U.S. Air Force, U.S. Department of Commerce Version 2, June 1992.

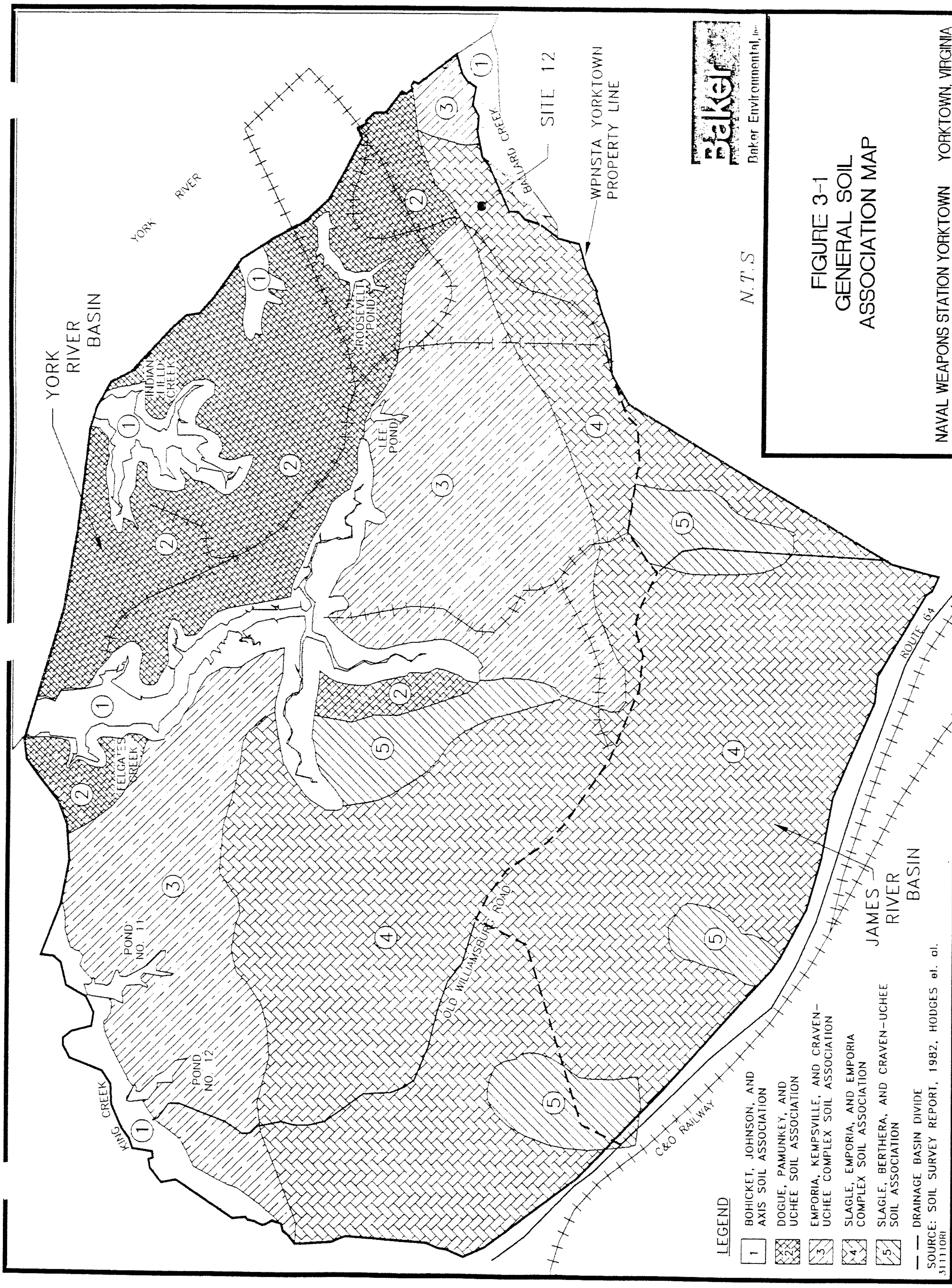
TABLE 3-1

REPRESENTATIVE METEOROLOGICAL DATA
WPNSTA YORKTOWN REGION [1]

Month	Temperature (°F)		
	Average Daily Maximum	Average Daily Minimum	Monthly Average
January	48	34	41
February	55	35	43
March	58	41	50
April	68	50	59
May	76	59	67
June	83	68	75
July	87	72	80
August	86	72	79
September	80	67	73
October	70	56	63
November	61	46	53
December	52	37	44

Note:

[1] Daily maximum, minimum, and average temperatures by month for the 1945 to 1990 period of record, Norfolk Naval Air Station (International Station Meteorological Climate Summary, U.S. Navy, U.S. Air Force, U.S. Department of Commerce Version 2, June 1992.



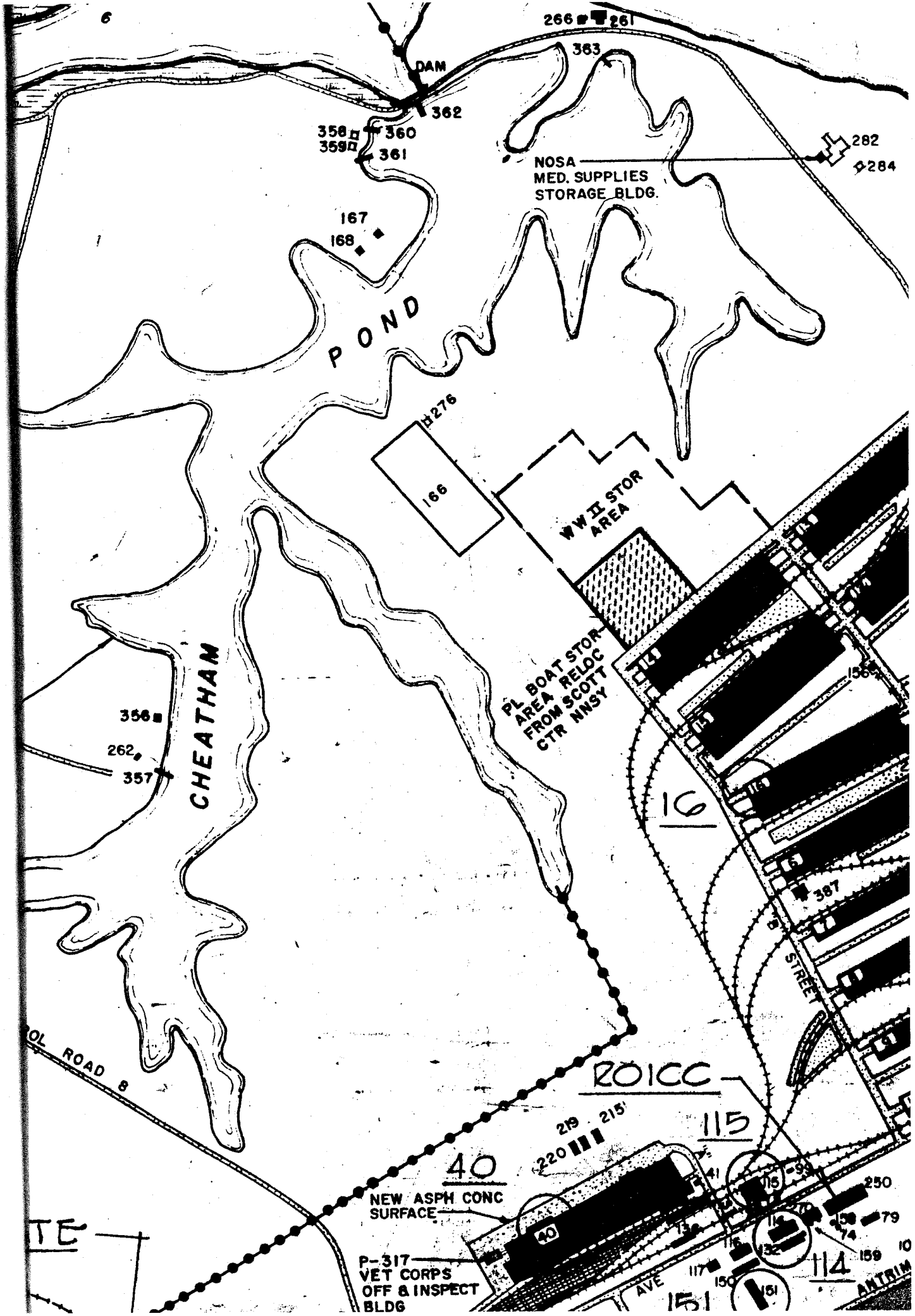
HYDROGEOLOGIC FRAMEWORK OF THE SHALLOW AQUIFER SYSTEM OF YORK COUNTY, VIRGINIA:
U.S. GEOLOGICAL SURVEY WATER-RESOURCES INVESTIGATIONS REPORT 92-4111.

Baker Environmental, Inc.

FIGURE 3-2
GEOLOGIC AND HYDROGEOLOGIC UNITS
IN YORK COUNTY

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

(2)


6
266
261
363
DAM
362
358
359
360
361
282
284
NOSA
MED. SUPPLIES
STORAGE BLDG.
167
168
POND
276
166
WW II STOR
AREA
PL BOAT STOR
AREA RELOC
FROM SCOTT
CTR NNSY
CHEATHAM
356
262
357
16
387
STREET
ROAD 8
ROICC
115
219
215'
220
40
NEW ASPH CONC
SURFACE
P-317
VET CORPS
OFF & INSPECT
BLDG
250
79
74
159
114
AVE
151
ANTRIM

DRAFT

SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SITES 4 AND 9

NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA
AND
CHEATHAM ANNEX SITE
WILLIAMSBURG, VIRGINIA

CONTRACT TASK ORDER 0195

JUNE 29, 2001

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-95-D-6007

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2.0 ENVIRONMENTAL SETTING

This section describes the environmental setting (e.g., habitats and biota) at CAX, including information regarding threatened and endangered species and critical habitats. The description of the facility background was adapted from the *Final Installation Restoration Program Site Management Plan, Fiscal Year 2001 at Naval Weapons Station Yorktown (WPNSTA), Cheatham Annex Site (CAX)* (Baker, 2001).

CAX located near Williamsburg, Virginia, was established in June 1943 as a satellite unit of the Naval Supply Depot to provide bulk storage facilities. Prior to 1943, CAX had been the location of the Penniman Shell Loading Plant, which was a large powder and shell-loading facility operated by Dupont during World War I. The facility closed in 1918. Between 1918 and 1943, the facility property was used for farming or left idle until CAX was commissioned in 1943. Since 1943, CAX has been used for receiving, storing, packaging, and shipping materials to federal facilities on the East Coast and to major distribution centers in Europe.

Previously operated as an annex to the Navy Fleet and Industrial Supply Center (FISC), Norfolk, which is the world's largest Navy supply center, CAX provided logistic and supply support to naval shore installations. CAX is the Navy Sea System Command's East Coast consolidated stock point for major shipboard mechanical, electronic, and some navigational equipment. In addition to receiving, storing, issuing, packing and shipping Navy stock material, particularly large, bulky (often unique) shipboard equipment (e.g., submarine periscopes, ship propellers, bull gears, antennae, and sonar domes), CAX provides warehouse and distribution services for 39 Storage Authorization Programs and tenant organizations.

In July 1987, CAX was designated the Hampton Roads Navy Recreational Complex. Today the mission of CAX includes supplying Atlantic Fleet ships and providing recreational opportunities to military and civilian personnel; 55% of CAX is underdeveloped and rich in natural resources. Outdoor recreational facilities and activities include: 13 cabins, 19 recreational vehicle (RV) sites, camp sites, an 18-hole golf course, swimming pool, ball fields, freshwater and saltwater fishing, boating, wildlife watching and hunting (DON, 1998). CAX currently operates under the Naval Weapons Station (WPNSTA) Yorktown. The transition of CAX control from FISC to WPNSTA occurred in 1998.

CAX is located on the York-James Peninsula, which is an embayed portion of the Atlantic Coastal Plain Physiographic province. This elongated peninsula is situated due northwest of the mouth of the Chesapeake Bay and trends northwest to southeast. The James River, York River, and confluence of the Chesapeake Bay and James border the peninsula on the southwest, the northeast, and the southeast, respectively. At inception, CAX occupied approximately 3,349 acres. Several portions of the original base have since been declared surplus and transferred to other government jurisdictions, including the National Park Service, the Commonwealth of Virginia, and York County. CAX is currently comprised of 1,578 acres. The Activity is divided into two separate parcels, with the larger parcel situated along the banks of the York River (see Figure 2-1). Almost all activities at CAX (administration, training, maintenance, support, and housing) take place in this portion of the Activity. The smaller parcel is located south of the Colonial National Historic Parkway (Colonial Parkway). This area contains the Activity's water supply (Jones Pond) and is used mainly as a watershed protection.

2.1 Sites 4 and 9 Description

The location of the sites evaluated by this SERA are presented on Figure 2-2. Site 4 (Medical Supplies Disposal Area) is located along an unnamed pond just upgradient of Youth Pond, between buildings CAD 11 and CAD 12 (see Figure 4-1). As much as 7,000 cubic yards of out-of-date medical supplies including syringes and empty intravenous (IV) bottles were unloaded in the area and covered with soil in the late 1960's (NEESA, 1984). Though previous efforts have been made to remove the material, a considerable volume remains. Significant volumes of syringes and tubing have been reported in both the adjacent unnamed pond and Youth Pond after heavy rains. A culvert leads from the northeast edge of Youth Pond into the tidal York River. Medical waste has been reported on the beach near this discharge point, representing further migration during periods of high water (Baker 2000a). The Site 4 study area includes AOC 3 (see Figure 2-3). AOC 3 consists of an approximately 20 foot by 20 foot by 10 foot high pile of metal banding along the north bank of the unnamed pond, north of D Street.

Site 9 (Transformer Storage Area) is located adjacent to the northwest corner of building 16 and covers approximately 7,000 square feet (see Figure 5-1). Between six and thirty electrical transformers, some of which contained polychlorinated biphenyls (PCBs), were stored at the site between 1973 and 1980. Information regarding possible spills or leaks of the PCB oil is unknown. This site is located upgradient of both Site 4 and the receiving waters of Youth Pond.

Stormwater sewers drain Site 9 and empty through culverts directly into the Site 4 disposal area. Flow into the Site 4 area is frequent enough and heavy enough to form two small, persistent streams cutting down though the upland habitat surrounding the disposal area. Water travels from the streams into the unnamed pond at the bottom of the disposal area. In periods of high flow, water drains through this unnamed pond through a culvert into Youth Pond and then through another culvert into the York River.

2.2 Rare, Threatened, or Endangered Species

A review of Virginia Department of Conservation Natural Heritage Program (VDCR, 2001) and Virginia Department of Game and Inland Fisheries (VDGIF, 2001) county databases as well as the Cheatham Annex Natural Resources Management Plan (USDA, 1988) and Natural Heritage Inventory (VDCR, 1990) indicated that no federally or state listed endangered or threatened species are currently using CAX habitats. Suitable habitat exists on CAX for both the Red-cockaded woodpecker (federally endangered) and the Bald Eagle (federally threatened, state endangered), though neither species was resident during the 1992 Natural Heritage inventory. In the past, infrequent sightings of other endangered/threatened avian species, including the Peregrine falcon and Bachman's and Kirtland's warblers, were made in the general area. (NEESA, 1984). Bordering the CAX property is the York River, which provides seasonal habitat for federally and state endangered Kemp's Ridley sea turtles and federally threatened Loggerhead sea turtles. The shoreline along the York River may also provide habitat for federally threatened Piping Plovers. Table 2-1 lists federal and state endangered, threatened, and sensitive species of concern known from York County.

Rare resources and communities identified from CAX in the Virginia Department of Conservation and Recreation (VDCR) Natural Heritage Program database and the CAX Natural Heritage Inventory include a significant great blue heron colony, low salt marsh and salt scrub habitats, coastal plain depression ponds, non-riverine wet hardwood forests, and coastal plain calcareous seepage swamps. The calcareous (marl) ravines and swamps were identified in the Natural Heritage Inventory as "state-significant rare plant habitats." VDCR also recognizes these areas as providing potential shell/marl groundwater habitat for the globally rare Tidewater amphipod (*Stygobromus araeus*) (Fleming, 2001). To protect these areas from invasion by exotic grasses and other threats, the Inventory recommended establishment of four special interest areas

within the Cheatham Annex property line (VDCR, 1990). Site 9 and Site 4 are both located outside the boundaries of the special interest areas.

2.3 Habitats and Biota

Characterization of CAX habitats and biota has been adapted from Baker (2000a). The topography of CAX is characterized by gently rolling terrain dissected by ravines and stream valleys trending northeastward toward the York River. Ground elevations at CAX vary from sea level along the eastern boundary, which borders the York River, to a maximum elevation of approximately 50 feet (ft) about mean sea level (msl) on a few scattered hills in the western portion of the Activity. Valleys consisting of 40 to 60 ft ravines with steep slopes (exceeding 1:1) occur along the major creeks draining CAX.

2.3.1 Terrestrial Habitat

Terrestrial flora on CAX consists of predominantly woodland species. Three types of forest are present: pine stands composed primarily of loblolly and Virginia pines, mixed pine and hardwood stands, and hardwood stands. Elevated level areas are the predominant locations of pine stands, while hardwood stands are found on slopes and ravines. These wooded areas are important in reducing soil erosion and providing wildlife habitat. Native tree species found at CAX include beech, black cherry, red maple, sweet gum, various pines, white ash, and white oak.

The woodland's understory is composed of various seedling trees and vine species, such as Virginia creeper, briars, and honeysuckle. Ferns are found in many moist, shaded areas. Ornamental trees and shrubs have been planted in the improved areas and along major roadways. None of the plant species that thrive at CAX are listed on the federal or Commonwealth endangered lists.

Small undeveloped tracts of land at CAX support a variety of indigenous wildlife species. Whitetail deer, beaver, skunks, bobcats, red and gray foxes, squirrels, raccoons, opossums, and rabbits are present. Game birds such as wild turkey, quail, duck, and pheasants are also resident. Songbirds common to the eastern Virginia area are in abundance at CAX, along with a raptor population consisting of small hawks, owls, and osprey. Carrion-feeding birds such as crows and turkey vultures are also common. The southern bald eagle (listed on the federal threatened/state

endangered lists) is known to nest nearby at WPNSTA Yorktown. Suitable habitat exists for roosting and perching in the area, but only occasional sightings of eagles have been made.

2.3.2 Wetlands/Aquatic Habitat

Wetlands are mainly found along principal tributaries to the York River and along the York River shoreline at CAX. Four major marsh types exist in the vicinity: Type I, Salt-marsh cordgrass community; Type V, Big cordgrass community; Type VI, Cattail community; and Type XII, Brackish water mixed community. The wetlands are grouped into classifications based on their estimated environmental value per acre. Group One marshes, including salt-marsh cordgrass and brackish water mixed communities, are characterized by the highest productivity and use by waterfowl and wildlife, and maintain close associations with fish spawning and nursery areas. They are also important to the shellfish industry and as shoreline erosion inhibitors. These wetlands merit the highest order of protection. The majority of wetlands on CAX are of this type. Big cordgrass and cattail community type marshes are in Group Two and are only slightly less valued than the Group One marshes. Because these marshes are found at higher elevations, there is less opportunity for detritus (loose soil or organic particles) to be washed into nearby waterways by the tides. Group Two marshes are also valuable as flood buffers and should be preserved. CAX wetlands are also prime habitats for migrating waterfowl.

Oysters, blue crabs, and hard- and soft-shell clams are found in the York River offshore of CAX. This area of the York River is designated as a crab pot fishery. In addition, the river immediately north of CAX is a spawning and nursery ground for blue crabs. Fish species commonly found in the York River include hogchocker, white perch, white catfish, channel catfish, bay anchovy, oyster toadfish, and striped bass. Seasonal inhabitants include Atlantic croaker, weakfish, spotted hake, and spotted and silver perch. Upriver of CAX, freshwater reaches of the York River additionally serve as important anadromous fish spawning ground for river herring, blueback herring, american shad, hickory shad, and striped bass. Several species of endangered sea turtles (namely the green, hawksbill, leatherback, loggerhead, and Kemp's Ridley) are known to feed in the Chesapeake Bay and occasionally swim up the York River during the summer.

Table 2-2 summarizes an inventory of plant and animal species observed utilizing CAX during the 1988 United States Department of Agriculture (USDA) and 1990 VDCR surveys, which represent the last two species surveys performed at the site.

5.0 SITE 9, TRANSFORMER STORAGE AREA

5.1 Screening-Level Problem Formulation

As described in Section 1.3.1, in problem formulation:

- The environmental setting of a site is characterized in terms of the habitats and biota known or likely to be present.

- The types and concentrations of chemicals that are present in ecologically relevant media are characterized.

- A conceptual model is developed for the site that describes potential sources, potential transport pathways, potential exposure pathways and routes, and potential receptors.

- Assessment endpoints, measurement endpoints, and risk hypothesis are selected to evaluate those receptors for which complete and potentially significant exposure pathways are likely to exist.

These components of the problem formulation are developed for Site 9 in this section. In addition, the fate, transport, and toxicological properties of the chemicals present at a site are also considered during the problem formulation process (see Sections 3.4.2 and 3.4.3).

5.1.1 Environmental Setting

Site 9 covers an area of approximately 7,000 square feet and is located adjacent to the northwest corner of Building CAD 16 as shown on Figure 5-1. Originally the storage area surface consisted of exposed soil enclosed by an earthen containment wall. Some time after 1980 the area was graded and covered with gravel to an unknown depth. Site 9 is bordered by Building CAD 16 to the east, by chain-link fence to the south and west, and by an asphalt/concrete storage lot to the north. Surface water drainage from Site 9 appears to flows north over the asphalt lot and immediately into a storm drain flowing east towards the culverts emptying into the Site 4 area.

Limited grassy cover now grows within the graveled area and there is no contiguous drinking water source available. As such, Site 9 presently offers meager habitat value for terrestrial biota only. Osprey nests have been observed on electrical poles above Site 9 but it is unlikely that either avian or mammalian upper level consumers would use this area directly for feeding. Lower level consumers (e.g., insectivores, herbivores) would be more likely to use the area for foraging.

Based on current assumptions relating to the stormwater linkages between Sites 9 and 4 (described in Section 2.1), and the lack of an identifiable PCB source within the Site 4 area, PCB risks associated with Site 4 surface soils, sediment, and surface water were assumed to be linked directly to Site 9. This approach addresses the migration of PCBs offsite in general and the potential for risks to both aquatic and terrestrial consumers.

5.1.2 Site History and Available Analytical Data

Between six and thirty electrical transformers, some of which contained PCBs, were reportedly stored at Site 9 between 1973 and 1980. Information regarding the number of leaking transformers or the volume of PCB oil stored or spilled is not known. Transformers were no longer stored at the site after 1980. (NEESA, 1984)

The Initial Assessment Study recommended additional study due to the potential for PCB contamination. The Confirmation Study (Dames and Moore, 1986) included collection of 13 soil samples from Site 9 for analysis of PCBs and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)(Dames and Moore, 1986). A sampling summary is available in Table 3-4 and locations are shown on Figure 5-2. Aroclor-1260 was the only PCB congener detected (eight of 13 samples). TCDD was not detected in any samples. Detected concentrations of Aroclor-1260 ranged from 21 ug/kg to 321 ug/kg. The highest concentrations of PCBs were located to the west of Site 9, not in-line with the apparent surface water migration and flow away from the site. No additional sampling was recommended due to the low levels of the detections (as compared to the lowest action level under the Toxic Substance Control Act [TSCA] of 1.0 ppm). These are the only data available for use in the Site 9 SERA.

A Draft Final No Further Remedial Action Document (NFRAP) Decision Document was submitted for Site 9 in December 1999 (Baker, 1999). The document was reviewed by the

Appendix C: Project Source Data – Site Specific

There are no Site Specific References for the Marine Pistol and Rifle Range.

Please refer to Appendix B for General References.

Appendix D: Ordnance Technical Data Sheets

SMALL-ARMS AMMUNITION

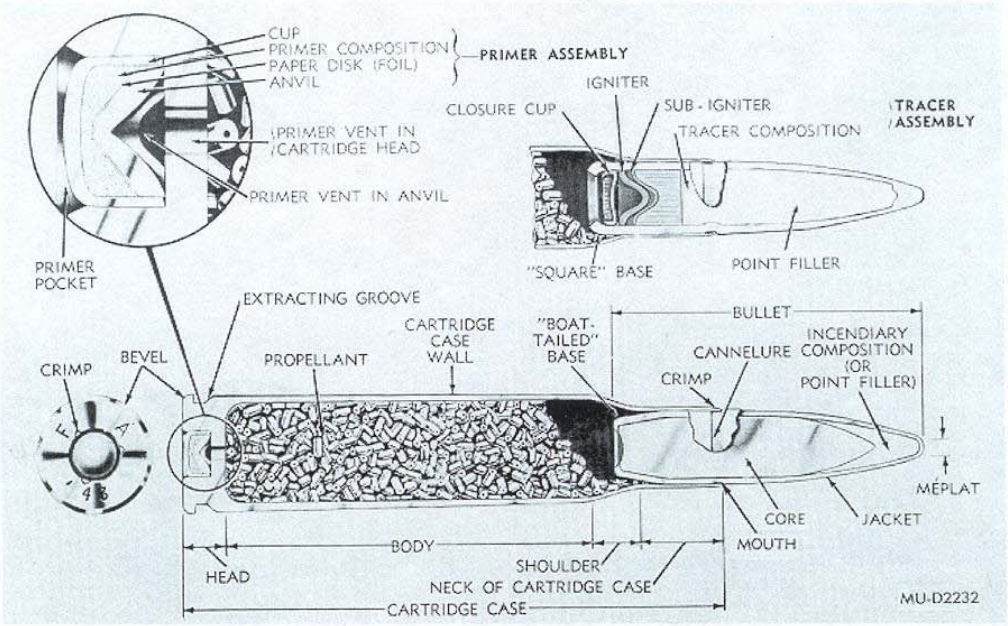

Figure 1. Typical cartridge (sectional)

General. Small-arms ammunition, as used herein, describes a cartridge or families of cartridges intended for use in various types of hand-held or mounted weapons through 30 millimeter. Within a caliber designation, these weapons may include one or more of the following: rifles (except recoilless), carbines, pistols, revolvers, machineguns and shotguns. For purposes of this publication, small-arms ammunition may be grouped as cartridges intended primarily for combat or training purposes (API, HEI, tracer or ball); for training purposes only (blank or dummy); or for special purposes (rifle grenade or spotter-tracer). Refer to TM 9-1306-200 for more detailed information on small-arms ammunition.

Cartridges. In general, a small-arms cartridge is identified as an assembly of a cartridge case, primer, a quantity of propellant within the cartridge case, and a bullet or projectile. Blank and rifle grenade cartridges are sealed with paper closure disks in lieu of bullets. Dummy cartridges are composed of a cartridge case and a bullet. Some dummy cartridges contain inert granular materials to simulate the weight and balance of live cartridges. A typical cartridge and the terminology of its components are shown in figure 1.

Case. Although steel, aluminum, zinc and plastic materials have been used experimentally, brass, a composition of 70 percent copper and 30 percent zinc, is the most commonly used material for cartridge cases. Steel, as well as brass, is an approved material for caliber .45 cartridge cases. Brass, paper and plastic are used for 12 gage shotshell bodies. Aluminum is used for military-type .410 gage shotshell bodies. Configurations of cartridges and bullets are illustrated in figures 2 through 11.

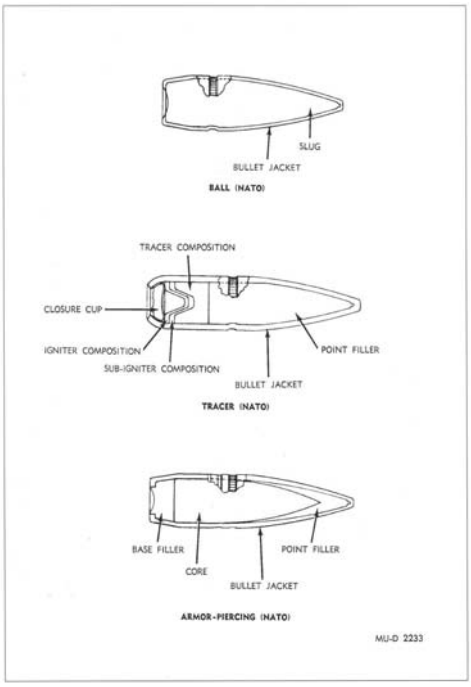

Figure 2. 7.62 mm bullets (sectional)

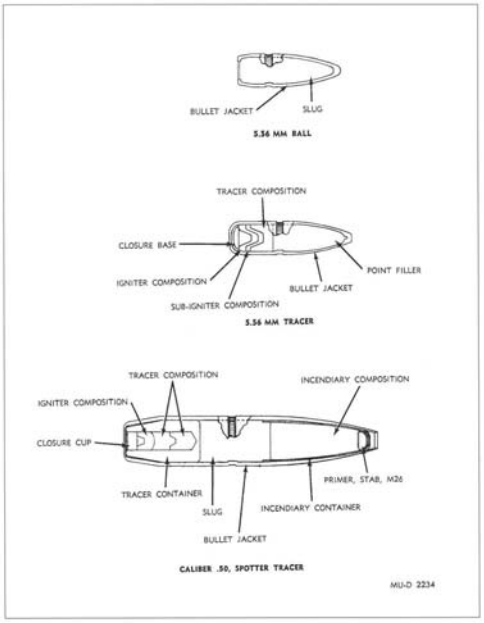

Figure 3. 5.56mm and caliber .50 spotter tracer bullets (sectioned)

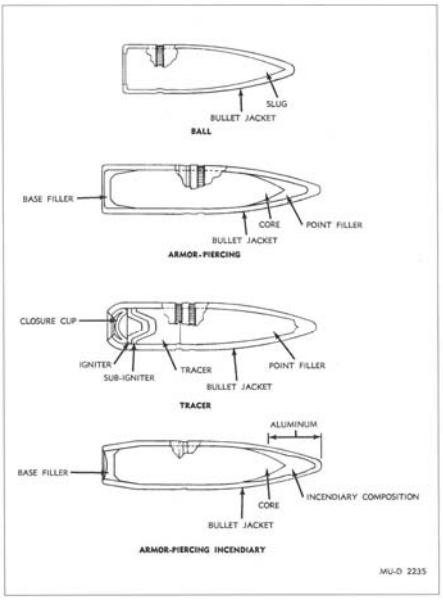

Figure 4. Caliber .30 bullets (sectional)

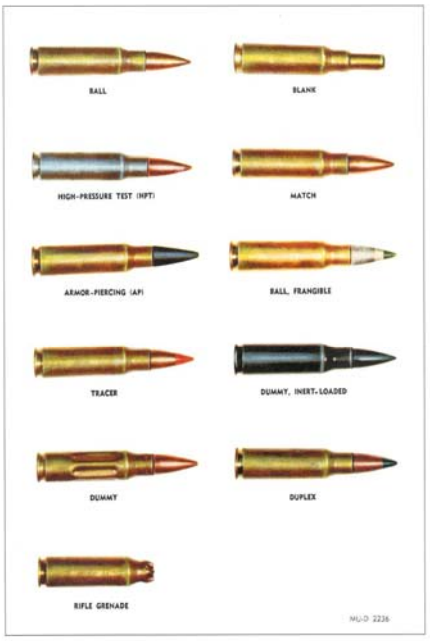

Figure 5. 7.62mm cartridges

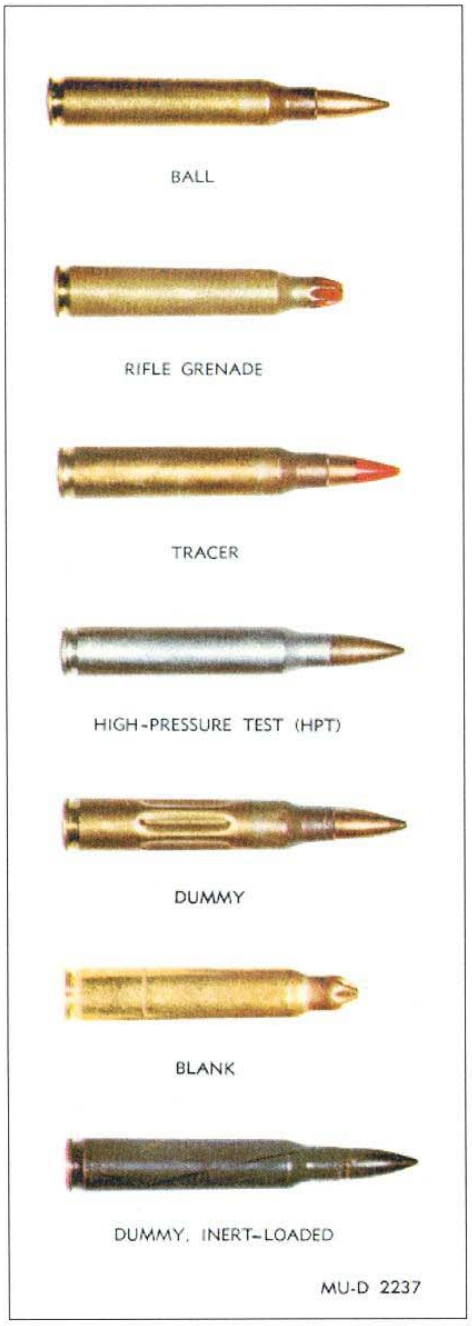

Figure 6. 5.56mm cartridges

Propellant. Cartridges are loaded with varying weights of propellant. This is to impart sufficient velocity (within safe pressures) to the projectile to obtain the required ballistic performance. These propellants are either of the single-base (nitrocellulose) or double-base (nitrocellulose and nitroglycerine) type. The propellant grain configuration may be cylindrical with a single, lengthwise perforation, spheroid (ball) or flake. Most propellants are coated with a deterrent (to assist in controlling the rate of combustion) and with a final coating of graphite (to facilitate flow of propellant and eliminate static electricity in loading cartridges).

Primer. Small-arms cartridges contain either a percussion or electric primer. The percussion primer consists of a brass or gilding metal cup that contains a pellet of sensitive explosive material secured by a paper disk and a brass anvil. The electric primer consists of an electrode button in contact with the priming composition, a primer cup assembly and insulator. A blow from the firing pin of the weapon on the center of the percussion primer cup base compresses the primer composition between the cup and the anvil. This causes the composition to explode. The function of the electric primer is accomplished by a firing pin with electrical potential, which contacts the electrode button. This allows current to flow through the energy-sensitive priming composition to the grounded primer cup and cartridge case, exploding the priming composition. Holes or vents in the anvil or closure cup allow the flame to pass through the primer vent in the cartridge case and ignite the propellant. Rimfire ammunition, such as the caliber .22 cartridge, does not contain a primer assembly. Instead, the primer composition is spun into the rim of the cartridge case and the propellant is in intimate contact with the composition. On firing, the firing pin strikes the rim of the cartridge case, compressing the primer composition and initiating its explosion.

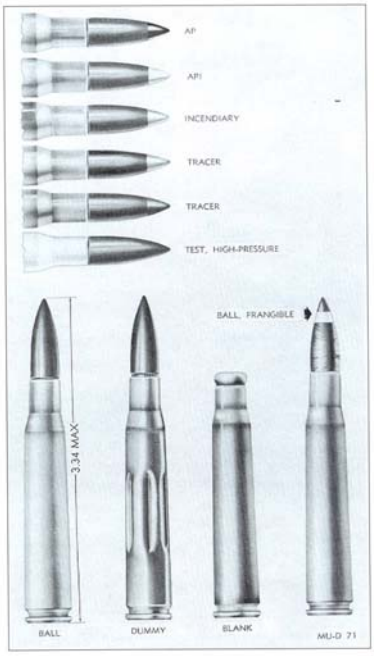

Figure 7. Caliber .30 cartridges

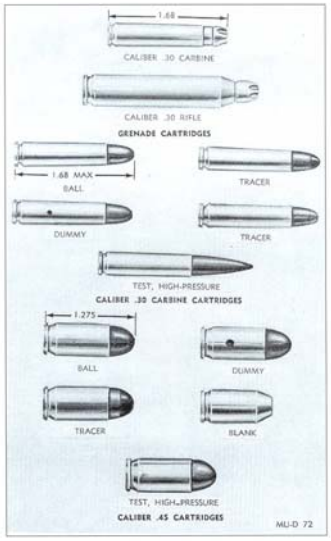

Figure 8. Caliber .30 carbine and caliber .45 cartridges

Bullet. With few exceptions, bullets through caliber .50 are assemblies of a jacket and a lead or steel core. They may contain other components or chemicals which provide the terminal ballistic characteristics of the bullet type. The bullet jacket may be either gliding metal, gliding-metal clad steel, or copper plated steel. Caliber .30 and 7.62mm frangible bullets are molded of powdered lead and a friable plastic which pulverizes into dust upon impact with the target. The pellets used in the shotgun shells are spheres of lead alloys varying from 0.08 inch to 0.33 inch in diameter.

Figure 9. Caliber .50 cartridges

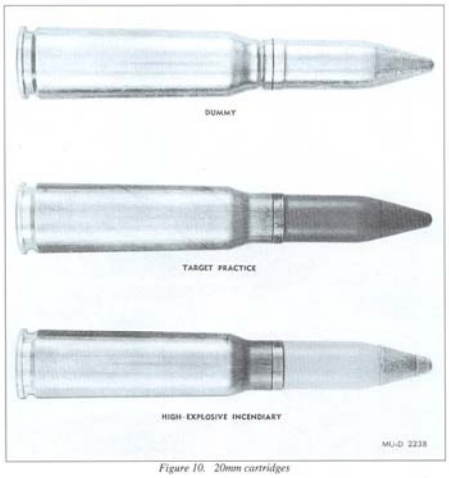

Figure 10. 20mm cartridges

Ball Cartridge. The ball cartridge is intended for use in rifles, carbines, pistols, revolvers and/or machineguns against personnel and unarmored targets. The bullet, as designed for general purpose combat and training requirements, normally consists of a metal jacket and a lead slug. Caliber .50 ball bullet and 7.62-mm, Ball M59 bullet contain soft steel cores.

Tracer Cartridge. By means of a trail of flame and smoke, the tracer cartridge is intended to permit visible observation of the bullet's in-flight path or trajectory and the point of impact. It is used primarily to observe the line of fire. It may also be used to pinpoint enemy targets to ignite flammable materials and for signaling purposes. The tracer element consists of a compressed, flammable, pyrotechnic composition in the base of the bullet. This composition is ignited by the propellant when the cartridge is fired. In flight, the bullet emits a bright flame which is visible to the gunner. Trace burnout occurs at a range between 400 and 1,600 yards, depending upon the caliber of ammunition.

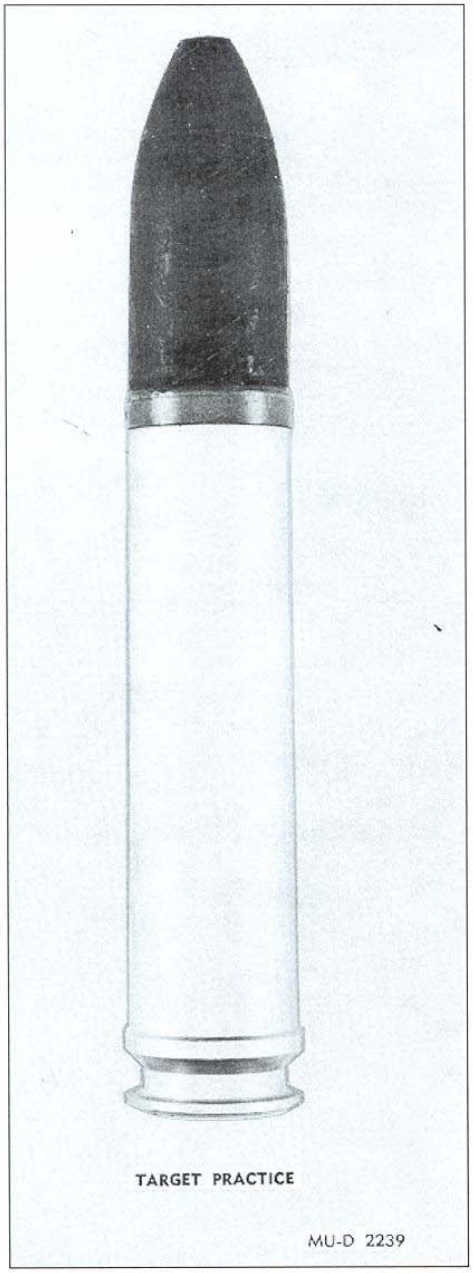

Figure 11. Typical 30mm projectile

Match Cartridge. The match cartridge is used in National and International Match Shooting competitions. The bullet consists of a gliding-metal jacket over a lead slug. The cartridges are identified on the head face with the designation NM (National Match) or Match.

Armor-Piercing Cartridges. The armor-piercing cartridge is intended for use in machine-guns or rifles against personnel and light armored and unarmored targets, concrete shelters, and similar bullet-resisting targets. The bullet consists of a metal jacket and a hardened steel-alloy core. In addition, it may have a base filler and/or a point filler of lead.

Armor-Piercing-Incendiary Cartridge. The armor-piercing-incendiary cartridge is used in rifles or machineguns as a single combination cartridge in lieu of separate armor-piercing and incendiary cartridges. The bullet is similar to the armor-piercing bullet, except that the point filler is incendiary mixture instead of lead. Upon impact with the target, the incendiary mixture burst into flame and ignites flammable material.

Armor-Piercing-Incendiary Tracer Cartridge. The bullet of the armor-piercing-incendiary-tracer cartridge combines the features of the armor-piercing, incendiary, and tracer bullets and may be used to replace those cartridges. The bullet consists of a hard steel core with compressed pyrotechnic mixture in the cavity in the base of the core. The core is covered by a gilding-metal jacket with incendiary mixture between the core point and jacket. This cartridge is for use in caliber .50 weapons only.

Duplex Cartridge. The duplex cartridge contains two special ball type bullets in tandem. The front bullet is positioned partially in the case neck, similarly to a standard ball bullet. The rear bullet, positioned completely within the case, is held in position by a compressed propellant charge. The base of the rear bullet is angled so that in flight, it follows a path slightly dispersed from that of the front bullet.