3.7 Hazardous Materials and Waste Management

This section describes:

- The hazardous material (HM) NSWCDD uses in RDT&E operations and how such materials are handled and disposed of as part of the HM and hazardous waste (HW) management program at NSF Dahlgren.
- The process NSF Dahlgren is conducting to clean up old disposal areas and spills under the Navy's Environmental Restoration Program (ERP).
- The management of munitions, environmental compliance, and the assessment of potential munitions constituents (MCs) on the PRTR and EEA operational range complexes.

The terms "hazardous material," "hazardous waste," and "hazardous substance" have specific legal definitions in various federal regulations. The term "hazardous material" as used in this document identifies those contaminants (chemicals, substances, or compounds) that have been determined to present potential risks to health, safety, or the environment when they occur at certain concentrations, and that are managed under one or more applicable regulatory programs.

3.7.1 Legal Framework

NSF Dahlgren and NSWCDD adhere to USEPA and other federal and state laws and regulations governing HM and HW. The following federal and state statutes and their implementing regulations are relevant to the management and control of HM and HW at Dahlgren:

- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
- Superfund Amendments and Reauthorization Act (SARA) of 1986 to CERCLA
- Resource Conservation and Recovery Act of 1976 (RCRA)
- Hazardous and Solid Waste Amendments (HSWA) to RCRA, 1984
- Toxic Substances Control Act of 1978 (TSCA)
- Clean Water Act (CWA)
- Occupational Safety and Health Administration (OSHA) Regulations
- US Department of Transportation (USDOT) Hazardous Materials Regulations
- Virginia Hazardous Waste Regulations
- Maryland Hazardous Waste Regulations (Potomac River only)
- Military Munitions Rule (MR) of 1997

Through CERCLA, SARA, RCRA, and TSCA, USEPA promulgates and enforces regulations regarding past and present HM and HW management. These regulations establish the mandatory procedures and requirements for compliance and must be followed by federal facilities that use, accumulate, transport, treat, store, or dispose of hazardous wastes or materials. RCRA allows for each state to establish and enforce its own HW management program, provided that the state's requirements are no less stringent than USEPA's. The USEPA will grant primacy – the authority to implement and enforce regulations – to each state that can demonstrate to USEPA that it can statutorily implement and fund a program equivalent in scope and coverage to the RCRA regulations. The Commonwealth of Virginia (implemented by the Virginia Department of Environmental Quality [VDEQ]) and the State of Maryland (implemented by the Maryland Department of the Environment [MDE]) have been granted such primacy.

CERCLA – commonly known as Superfund – as amended by SARA, establishes requirements for identifying and cleaning up unused, closed, and abandoned hazardous waste sites. In response to CERCLA and to RCRA, DoD instituted an ERP to identify, assess, characterize, and clean up or control contamination from past HW or explosive hazardous waste (EHW) disposal operations and hazardous-materials spills at DoD facilities. The Navy implements the ERP at NSF Dahlgren, with USEPA and VDEQ providing regulatory oversight. The ERP is described in Section 3.7.4.

Because RCRA-defined HW is also considered USDOT HM, HM, and HW must be handled, prepared, and transported in accordance with USDOT HM regulations. These regulations have been developed by the USDOT to provide for the safe transport of HM in commerce. The USDOT HM regulations are contained in CFR Title 49 §§ 100-185.

OSHA regulates the safety and health of workers in the US by establishing worker-protection standards that employers must follow. OSHA has promulgated standards to protect workers engaged in HW operations and emergency-response activities. These standards are found in CFR Title 29 § 1910.

The CWA, further described in Section 3.10, is the cornerstone of surface water quality protection in the US. Its broad goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can provide for "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." The CWA addresses both "point source" facilities, such as wastewater treatment plants and industrial facilities, and "non-point source" stormwater runoff. Stormwater discharged into streams and rivers through conveyances such as storm sewers, which, if deemed point sources under the CWA, are subject to regulation. The discharge of treated effluent from wastewater treatment plants is also subject to regulation.

USEPA's MR defines when munitions (ordnance) become waste and are subject to RCRA regulations, and how these waste munitions will be managed, including safe storage and transportation. The Navy implements the MR through its Munitions Rule Implementation Policy, which defines when used or unused munitions (ordnance) are considered EHW. Under the MR, military munitions are not considered EHW when the intended use is for training or for RDT&E activities, or if materials are recovered and destroyed on-range during range clearance operations, repaired, or otherwise subjected to materials recovery. Under the MR definition of wastes, spent ordnance remaining on NSWCDD's land and water ranges is considered to have been used for the intended purpose of RDT&E activities, and therefore, is not subject to HW regulations.

3.7.2 Hazardous Materials and Waste at Dahlgren

NSF Dahlgren is a large-quantity HW generator, with NSWCDD being one of the largest contributors of HW. In the course of conducting RDT&E activities, NSWCDD uses and disposes of a variety of materials that may be considered hazardous by USEPA:

- Corrosive solutions
- Waste paint-related materials
- Lead-contaminated floor mats and rags
- Spent halogenated and non-halogenated solvents
- Waste photographic process chemicals
- Solvents
- Petroleum products, such as used lubricating oils
- Ordnance and explosive materials
- Ash from open burning of ordnance materials
- Contaminated soil
- Spent and expired laboratory chemicals

3.7.3 Hazardous Material and Waste Management Program

NSF Dahlgren and NSWCDD have in place a number of programs, plans, and processes to safely use, transport, handle, store, and dispose of HM and HW, as described below.

3.7.3.1 Hazardous Waste Management Plans

Under RCRA (40 CFR § 264.50) and VDEQ (Virginia Administrative Code [VAC] Title 9 Board 20 Chapter 60 Section 550 [9 VAC 20-60-550]) regulations, owners and operators of all HW accumulation areas must develop and implement contingency plans designed to minimize hazards to human health and the environment from fires, explosions, or any unplanned, sudden or non-sudden release of hazardous materials to the air, soil, or surface water. These planning documents include: a Hazardous Waste Contingency Plan, a Hazardous Waste Management Plan, a Military Munitions Implementation Plan, Accumulation Area Requirements, and Satellite Accumulation Point Requirements.

3.7.3.2 Hazardous Waste Storage Management

The HW generator is the first link in the “cradle to grave” management enforced by RCRA regulations. A generator is the entity that first creates a HW or a facility that first makes a waste subject to RCRA regulation. Generators are classified based on the amount of HW generated in any one-month period. NSF Dahlgren is a Large Quantity Generator, which means the facility generates at least 2,200 pounds of nonacute or more than 2.2 pounds of acute HW per calendar month.

According to RCRA regulations, HW can be stored at a “satellite accumulation point” or a “less-than-90-day accumulation area.” The difference between a satellite accumulation point and a less-than-90-day accumulation area are the volume and length of time HW may be accumulated. At a satellite accumulation point, up to 55 gallons of HW, or 1 quart of acute HW, may be accumulated for an unlimited amount of time. A satellite accumulation point must be at or near the point of HW generation, and under control of the operator of the process generating the HW.

At a less-than-90-day accumulation area, any amount of HW can be collected and stored in containers for up to 90 days without a permit. The 90-day limit for the container begins as soon as the first drop of HW is added to the container.

All HW that needs to be removed from a satellite accumulation area must be turned over to the NSF Dahlgren less-than-90-day accumulation area, Building 1425. HW is stored at Building 1425 and prepared for transportation to an off-site permitted treatment, storage, and disposal facility (TSDF).

NSWCDD makes an effort to inspect satellite accumulation points weekly as a best management practice (BMP). NSWCDD also encourages personnel to use smaller containers and turn them in more frequently, which helps prevent spills due to deterioration of containers. Less-than-90-day accumulation areas are maintained in good condition, and containers are inspected weekly to ensure the structure and containers are in good condition. Examples of HW stored at satellite accumulation areas include, but are not limited to, lead-contaminated waste, solvents, oxidizers, flammables, bases, mercury, and acids. The locations of these satellite accumulation areas can be established and disestablished frequently, depending on changes in processes and operations. For this reason, NSF Dahlgren maintains a current list of all facility satellite accumulation areas and the NSWCDD Safety & Environmental Office maintains a list of all NSWCDD satellite accumulation areas.

All EHW is stored at Buildings 9481, 9482, 9483, 9484, 408A, 353C, 951, and 952. Unlike HW storage locations, the locations of these EHW storage areas do not change with processes and operations. Building 408A is designated a less-than-90 day EHW storage site which can only accept on-site generated waste. Buildings 951, 952, and 353C are permitted magazines which can also receive on-site or off-site generated EHW. EHW can be stored up to 1 year in these magazines. Buildings 9481 9482, 9483, and 9484 are designated as “conditional exempt” under the MR. These buildings can used to store on-site and off-site generated EHW for an unlimited amount of time. However, as a BMP, the NSWCDD Safety & Environmental Office monitors the amount of time EHW items have been in storage and requests justification for continued storage if an item has not been treated within six months.

3.7.3.3 Petroleum Storage Program

NSF Dahlgren manages underground storage tank (UST), aboveground storage tank (AST), and petroleum-oil-lubricant storage regulatory requirements. Applicable regulations for the storage tanks include state and federal petroleum-storage UST regulations, the Oil Pollution Prevention Regulation of 1973, the Oil Pollution Act of 1990, and OSHA requirements. The regulations are incorporated into the NSF Dahlgren Tank Management Plan (NSWCDL, 2003). The Tank Management Plan is updated by NSF Dahlgren to incorporate any changes in the petroleum regulations or permitted petroleum storage locations at the facility.

NSF Dahlgren's USTs are approved by the Underwriters Laboratory. The USTs are designed to meet Virginia UST regulatory requirements (9 VAC 25-580) and federal UST regulatory requirements (40 CFR § 280) for leak detection, secondary containment, and corrosion protection. A UST removal and replacement project, completed in the summer of 1992, replaced aging USTs and several heating-oil tanks to meet Virginia and federal UST regulatory requirements. NSF Dahlgren performs release-detection monitoring by groundwater monitoring on older USTs, interstitial monitoring by liquid-level sensing on newly installed – 1991 or later – USTs, and by visual inspection of ASTs and petroleum-product storage locations.

ASTs are visually monitored by personnel and the spill-prevention control and countermeasures Plan Coordinator on a regular basis. Regulated ASTs are tested for competency and certified to be free of leaks (NAVSEA, 2010). The ASTs and liquid drum storage areas have secondary spill-containment features that have the capacity to prevent an accidental release of the liquid volume from the AST or drums to the environment. Drums with solid waste are stored without direct ground contact (i.e., on pallets or platforms).

Virginia and USEPA regulators inspect the location and construction of regulated USTs and ASTs to insure compliance with state and federal petroleum-storage regulations. Inspectors from the USEPA Office of Enforcement, Compliance, and Environmental Justice and VDEQ performed the most recent inspection in May of 2008. During the May 2008 inspection, the Office of Enforcement, Compliance, and Environmental Justice inspector noted infractions of RCRA rules regarding release-detection monitoring systems. These infractions were noted and corrective action taken by NSF Dahlgren (USEPA, 2008).

Petroleum products are delivered to NSF Dahlgren via vendor-provided transport and equipment. No. 2 fuel oil, gasoline, diesel fuel, and kerosene are transferred directly from the vendor transport to the appropriate UST or AST. Lubricating oils, hydraulic oils, transmission fluids, motor oils, and greases are delivered in 55-gallon drums, 5-gallon containers, or consumer-size packages. When vessels are fueled at the docks of the Yardcraft area, personnel are prepared to utilize emergency containment booms to prevent a potential spill from spreading away from the immediate dock area (NAVSEA, 2010).

An NSF Dahlgren spill-prevention control and countermeasures plan containing information relevant to the Spill Contingency Plan is in place for NSWCDD facilities and was last updated on September 29, 2009.

3.7.3.4 Pollution Prevention Plans

The Navy and NSF Dahlgren Defense Reutilization and Marketing Office manage material that can be reused or recycled. NSF Dahlgren implements a waste-minimization plan aimed at reducing the use of, controlling, and managing hazardous materials. All operations and storage are conducted in accordance with applicable federal, state, and Navy regulations.

NSF Dahlgren also implements a Stormwater Pollution Prevention Plan (SWP3) for their industrial areas that requires monitoring of runoff from potential pollution areas within the ranges, including outfalls associated with gun mount operations and outfalls associated with open burning and open detonation (OB/OD) operations. These outfalls are monitored quarterly or annually for petroleum hydrocarbons, copper, and/or total suspended solids. In addition, stormwater is analyzed yearly for metals, pesticides, base neutral extractables, volatiles, acid extractables, and miscellaneous constituents in the outfall associated with OB/OD operations.

The SWP3 requires the implementation of both structural and non-structural controls to reduce the impact of stormwater runoff to the maximum extent practicable. The SWP3 is currently in the process of being updated (NAVSEA, 2010).

3.7.4 Environmental Restoration Program (ERP)

Prior to the 1970s, common nationwide disposal practices were very different from today's disposal methods, which are based on enhanced knowledge of contaminants and associated risks to human health and the environment. Disposal in the past involved placing waste, both solid and liquid, into unlined landfills. At Dahlgren, debris, ordnance, scrap metal, petroleum-based liquids, electrical equipment with components containing polychlorinated biphenyls (PCBs), and even entire airplane parts were at one time disposed of in this way.

Petroleum materials may also have been inadvertently released into the environment by leaky USTs, and from oil-water separators, vehicle maintenance and repair activities, and ordnance-testing activities. As a result of past practices, environmental contaminants have been found in areas of NSF Dahlgren – either in soil, surface water, or sediments (NAVFAC and NSA South Potomac, 2008).

In response to past practices – and in conformity with CERCLA and SARA – DoD developed the Installation Restoration Program – now called the ERP – to identify, assess, characterize, and clean up or control contamination from past HW or EHW disposal operations and HM spills at DoD facilities. The Navy implements the ERP at NSF Dahlgren, with USEPA and VDEQ providing regulatory oversight.

The Navy conducted a preliminary assessment/site inspection at Dahlgren in the mid-1980s. USEPA then evaluated the Dahlgren site using a hazard-ranking system (HRS). The HRS is the principal mechanism used by USEPA to place an uncontrolled waste site on the National Priority List (NPL). The HRS is a national, numerically-based screening system that uses information from initial investigations to assess the relative potential of a site to pose a threat to human health or the environment. A national ranking of 28.5 or higher results in a site's being placed on the NPL. Sites are listed on the NPL upon completion of HRS screening and public solicitation of comments. The Dahlgren HRS evaluation led to its being added to the NPL on October 14, 1992 (NAVFAC and NSA South Potomac, 2008).

Following listing on the NPL, clean-up of HW sites became a major focus at Dahlgren. Seventy-five sites were initially identified. Sites ranged from large landfills to areas where a few gallons of oil had been spilled on the ground. A series of studies revealed that relatively little contamination of shallow groundwater had occurred as the result of the outdated disposal methods. The smallest sites were cleaned up immediately. Misidentified sites requiring no remediation were removed from the list. In 1994, the 68 remaining sites became the focus of the Installation Restoration Program (now the ERP).

The Navy, USEPA, and VDEQ signed a Federal Facility Agreement on September 30, 1994, which established the procedural framework and schedule for remedial investigation studies at NSF Dahlgren. The Navy, USEPA, and VDEQ formed a partnering team in 1995 to meet every month to six weeks to prioritize, discuss, and implement cleanup activities at Dahlgren. The public was involved to review progress throughout the process.

The Federal Facility Agreement categorized each of Dahlgren's 68 sites as either requiring further characterization – termed Appendix A Sites – or requiring additional documentation or sampling before a "no further action" determination is warranted – termed Appendix B sites. The Appendix A sites were further organized into six categories: ERP, Priority 1, Priority 2, Priority 3, Priority 4, and the Gambo Creek Ecological Assessment (NAVFAC and NSA South Potomac, 2008). Tables 3.7-1 and 3.7-2 list the Appendix A and Appendix B sites, respectively. The status of each site is shown in the tables.

3.7.5 Operational Range Waste Management

As described under the MR definition of wastes, spent ordnance remaining on NSWCDD's land and water ranges is considered to have been used for the intended purpose of RDT&E activities, and therefore, is not subject to HW regulations. Operational ranges with these types of waste are managed under several military directives, policies, and programs described below that require military bases to remove fired munitions from land ranges. Historic sites with these types of waste are managed under the NSF Dahlgren ERP described in the previous section. Military directives, policies, and programs include:

- DoD Directive 3200.15, Sustainment of Ranges and Operating Areas
- DoD Instruction 3200.16, Operational Range Clearance
- DoD Directive 4715.11, Environmental and Explosives Safety Management on Operational Ranges Within the United States
- Navy Range Sustainment Program
- Department of the Navy Operational Range Clearance Policy for Navy Ranges

DoD Directive 3200.15 establishes the policy that ranges must be managed and operated to support their long-term viability to meet the national defense mission. It also establishes responsibilities for the preparation of range sustainment programs within DoD components. A crucial part of range sustainment is the routine removal of military munitions. DoD Instruction 3200.16 provides procedures for all operational ranges requiring appropriate range clearance of used or fired military munitions, munitions debris, and range-related debris that may impair or inhibit the continued use of an operational range.

Furthermore, DoD Directive 4715.11 directs the heads of DoD components to establish procedures for regular range clearance operations to permit the sustainable use of operational ranges for their intended purpose. These procedures need to determine the frequency and degree of range clearance operations, and consider the safety hazards of clearance and the quantities and types of munitions expended on that range. The Navy's response to DoD Directive 4715.11 is their Range Sustainment Program and the Operational Range Clearance Policy for Navy Ranges. Issued in 2004, this Navy policy is designed to ensure that Navy ranges are operated in an environmentally responsible manner that is protective of the public, while sustaining the highest levels of readiness to meet the Navy's mission requirements (NSWCDL, 2003).

Table 3.7-1
Appendix A Sites

Site Number	Site Name	Current Regulatory Status
ERP Sites		
Site 2	Fenced Ordnance Burial Area	ROD-Remedial Action Completed; Long-term Monitoring Underway
Site 3	Ordnance Burn Structure	ROD-Removal Action Completed; No Further Action
Site 9	Disposal/Burn Area	ROD-Remedial Action Completed; Long-term Monitoring Underway
Site 10	Hideaway Pond	ROD-Long Term Monitoring Underway
Site 12	Chemical Burn Area	During the excavation of the former burn pit (started in December 2008), several canisters/bottles were discovered. Material in these containers could not be identified, the excavation site was closed, and a Chemical Safety Submission is required. Remedial action has been completed.
Site 17	1400 Area Landfill	ROD-Remedial Action Completed; Long-term Monitoring Underway; Wetland Monitoring Underway; Methane Mitigation Trench Planning
Site 19	Transformer Draining Area	ROD-Removal Action Completed; No Further Action
Site 25	Pesticide Rinse Area	ROD-Remedial Action Completed; Wetland Monitoring Underway
Site 29	Battery Service Area	ROD-Removal Action Completed; No Further Action
Site 44	Rocket Motor Pit	ROD-Removal Action Completed; No Further Action
Site 58	Building 1350 Landfill	ROD-Remedial Action Completed
Priority 1 Sites		
Site 6	Terminal Range Airplane Park	ROD-Remedial Action Completed; Wetland Monitoring Underway
Site 21	Gun Barrel Decoppering Area	Removal Action Completed; Decision Document- No Further Action
Site 22	Gun Barrel Degreasing Area	Removal Action Completed; Decision Document- No Further Action
Site 31	Airplane Park Dump, EEA	ROD-Removal Action Completed; No Further Action
Site 32	Fast Cook-off Pit/Pond, EEA	ROD-RI/FS Completed; No Further Action
Site 45	July 28, 1992 Landfill B	Removal Action Completed; Decision Document - No Further Action
Site 46	July 28, 1992 Landfill A	ROD-Remedial Action Completed; Wetland Monitoring Underway
Site 50	Fill Area Northeast EEA	Removal Action Completed; Decision Document-No Further Action; Wetland Monitoring Underway
Site 51	Battery Locker Acid Drain Area	SSP Completed-No Further Action
Site 53	OWS 207 300	Removal Action Completed; Decision Document-No Further Action
Site 55	Cooling Pond	ROD-RI/FS Completed; No Further Action
Priority 2 Sites		
Site 13	Gambo Creek Truck Wash Area	Removal Action Completed; Decision Document-No Further Action
Site 20	Former Electroplating Waste UST	Remedial work started in March 2008 and was completed in March 2010.
Site 23	Building 480 Lot (PCB Storage)	FFS Completed; ROD Completed; Soil Remediation Action Complete
Site 37	Lead Contamination Area	ROD Amendment Completed; Remedial Action Completed; Wetlands Planting Completed

Table 3.7-1 (Continued)
Appendix A Sites

Site Number	Site Name	Current Regulatory Status
Priority 2 Sites (Cont'd)		
Site 56	Gun Barrel Degreasing, Rail Way Spur	SSP Completed; Decision Document-No further Action
Site 57	Shell House Dump	SSP Underway; Draft EE/CA completed and withdrawn as additional sampling indicated that there was not an unacceptable risk related to the soils.
Priority 3 Sites		
Site 4	Case Storage Area	EE/CA Completed; Explosive Safety Submission Completed; Removal Action restarted in April 2009, and field work was completed in fall 2010.
Site 14	Evaporation Pond	EE/CA Completed; Explosive safety completed in June 2009; Record of Decision completed in 2011.
Site 15	Scrap Area	EE/CA Completed; Explosive Safety Submission Completed; Removal Action restarted in April 2009 and Field Work finished in 2011.
Site 38	Building 1349 Pest Control Area	SSP Completed; Decision Document-No Further Action
Site 40	Building 120B Defense Reutilization and Marketing Office Lot	SSP Completed; Decision Document-No Further Action
Site 43	Higley Road Land App Area	Removal Action Completed; Decision Document-No Further Action
Site 61a	Gambo Creek Ash Dump	Remedial work is still ongoing with an unknown completion date.
Site 62	Building 396	ROD-RI/FS Completed; Removal Action Completed
Priority 4 Sites		
Site 1	Old Bombing Range	Decision Document - Action is deferred until the range is closed or transferred
Site 5	Projectile Disposal Area	Decision Document - Action is deferred until the range is closed or transferred
Site 36	Depleted Uranium Mound, EEA	ROD-Removal Action Completed; No Further Action
Site 47a	WWI Munitions Mound	EE/CA completed; Removal Action Completed; Decision Document-No Further Action
Site 47b	Explosive Ordnance Disposal Scrap Area	EE/CA completed; Removal Action Completed; Decision Document-No Further Action
Site 49	Depleted Uranium Gun Butt	ROD-Removal Action Completed; No Further Action

Notes: EE/CA = Engineering Evaluation/Cost Assessment; FS = Feasibility Study
RI/FS = Remedial Investigation/Feasibility Study; FFS = Focused Feasibility Study
ROD = Record of Decision; WWI = World War I
SSP = Site Screening Process; OWS = Oil and Water Separator
Sources: NAVFAC and NSA South Potomac, 2008; USEPA, 2011.

Table 3.7-2
Appendix B Sites

Site Number	Site Name	Current Status
SWMU 3	Building 194AA (Concrete Pad)	Closed Out
SWMU 15	Building 120B Contractor Staging Area	Closed Out
SWMU 20/Site 41	Compost Area	Closed Out
SWMU 23	Building 456 Oil Waste Drum	Closed Out
SWMU 27	Tank 280 Contractor Staging	Closed Out
SWMU 57/Site 60	Building 445 Star Gauge Dock	Closed Out
SWMU 62	Paint Can Crusher	Closed Out
SWMU 64	Building 448 Sand Blast Area	Closed Out
SWMU 67	Building 448 Tar Tank Area	Closed Out
SWMU 70	Building 152 TCA AA	Closed Out
SWMU 77	Building 1329 Wash Area	Closed Out
SWMU 78	Building 1121 Waste Oil UST	Closed Out
SWMU 82	Electroplating Line and WWT	Closed Out
SWMU 101	Building 155 Auto Shop UST	Closed Out
SWMU 115	Building 1282 Auto Hobby Storage	Closed Out
SWMU 119	Building 1282 Auto Hobby Tank	Closed Out
SWMU 125/Site 52	OWS 107-350 (Yardcraft Area)	Closed Out
SWMU 127	OWS (1121-300, 115-350, 402-30,000, and 486-1000)	Closed Out
SWMU 128/Site 54	OWS 1121-Old	Closed Out
SWMU 119	Building 1282 Auto Hobby	Closed Out
SWMU 130	Yardcraft Oil Storage Area	Closed Out
SWMU 131/Site 28	Gambo Creek Compost Area	Closed Out
AOC A	Otto Fuel Spill	Closed Out
AOC O	Building 1369 Pesticide Spill Area	Closed Out
AOC X	Classified Documents Incinerator	Closed Out
AOC X7/Site 39	Open Storage Area Main Battery	Closed Out
AOC Z	Terminal Range Building	Closed Out
Other Units C3	Scar at Phalanx Test Area	Closed Out
Other Units C6	Former Radio Testing Area	Closed Out
Additional Areas X6	South Hanger Tank Area	Closed Out
Site 59	Octagon Pad Dump, EEA	Closed Out
Building 126	Former Powder Magazine	Closed Out
Site 61b	Gambo Creek Disposal Area	Closed Out
Site 63	Building 198 Neutralization Tank	Final EE/CA for OU-28 in December 2009 with the removal action, completed in June 2011.

Notes: AOC = Area of Concern SWMU = Solid Waste Management Unit
Source: NAVFAC and NSA South Potomac, 2008: USEPA, 2011.

The NSWCDD Range Management Plan (RMP) establishes the procedures, necessary actions, and action proponents for comprehensive management of munitions and range residue. The RMP ensures that all range wastes are managed as required by applicable federal, state, and local laws, as well by as DoD directives. Under the RMP, surface or partially buried ordnance and debris are removed in accordance with the CNO's Operational Range Clearance Policy for Navy Ranges. Range maintenance and clearance activities can consist of target repair, munitions sweeps, range residue clearance, grading of selected impact areas, and maintaining signs, roads, and fences. An area is considered adequately cleared if all visible ordnance and target debris are removed (NSWCDL, 2003). In addition to RMP practices, specific post- operation cleanup procedures are set out in a standard operating procedure (SOP) prepared for each RDT&E operation and documented at the conclusion of the operation.

Under the MR, used or fired military munitions are considered a waste when: transported off-range for storage, reclamation, treatment, or disposal; recovered, collected, and disposed of by burial or land-filling either on or off a range (burial of munitions is now strictly prohibited); or fired off-range and not promptly rendered safe or retrieved. These types of waste are currently treated at the NSWCDD thermal treatment sites, also referred to as open burning/open detonation (OB/OD) sites (NSWCDL, 2003). The OB/OD sites are regulated through a VDEQ RCRA Subpart X Permit.

The NSWCDD mission includes EHW storage, and thermal treatment of EHW from on-site and off-site sources and of non-transportable ordnance from on-site. The amount of EHW generated, stored, and treated from on-site or offsite activities varies considerably. The total weight of EHW thermally treated by means of OB/OD by NSWCDD in 2007 was 8,597 lbs by OB and 10,277 lbs by OD. The NSWCDD RCRA Subpart X Permit[1] specifies the requirements, procedures, and conditions that must be followed to thermally treat EHW through open burning or open detonation. The RCRA Subpart X Permit also places limits on the EHW capacity for individual events and on a cumulative basis for each year.

NSWCDD structures 951, 952, and 353C are RCRA-permitted EHW storage magazines. EHW generated from on-site or off-site may be stored in these magazines while awaiting on-site thermal treatment. Building structure 408A has been designated as a less-than-90-day accumulation area for EHW. NSWCDD structures 9481, 9482, 9483 and 9484 are conditionally-exempt storage for EHW. This means that EHW from on-site or off-site may be stored in these structures until treated by NSWCDD (NSWCDL, 2003).

3.7.6 Range Sustainability Environmental Program Assessment

The Navy's Range Sustainability Environmental Program Assessment (RSEPA) is a process developed to provide a consistent approach for assessing and addressing the environmental condition of the Navy's operational land ranges. To address the requirements of the Range

[1] RCRA miscellaneous units are a unique category of hazardous waste management units, covered under 40 CFR Part 264, Subpart X. Units covered under Subpart X do not fit neatly within the definition of the more typical waste management units described in Part 264 (containers, tanks, incinerators, etc.). To be permitted, Subpart X units must meet environmental performance standards, while other Part 264 units must meet specific technology standards.

Sustainability Environmental Program, a Range Condition Assessment (RCA) for NSWCDD land-based operational ranges at NSF Dahlgren was completed in 2010 (NAVSEA, 2010).

The RCA evaluated all land-based ranges where munitions operations are conducted, including the AA Fuze Range, Machine Gun Range, Main Range, Missile Test Range, and Terminal Range on the PRTR Complex, and the Harris and Churchill Ranges on the EEA Range Complex. The types and quantities of munitions used on the land ranges are described in Chapters 1 and 2 of this EIS. The RCA evaluation found RDT&E operations at the land ranges to be in overall compliance with applicable environmental regulations and program requirements (NAVSEA, 2010). The following recommendations for HM and HW resulted from the On-Site Visit Information and Collection Review (Phase III) (NAVSEA, 2010):

- **Water and Wastewater Compliance –** NSF Dahlgren is currently updating the Industrial Wastewater Stormwater Pollution Prevention Plan Operations and Maintenance Manual to meet Virginia Pollutant Discharge Elimination System permit conditions. Wastewater that is generated at Mainside is treated by a permitted Federally Owned Treatment Works that has recently undergone upgrades. The treated water is discharged into Upper Machodoc Creek.
- **Munitions / Munitions Constituents / Solid Waste / Hazardous Materials / Hazardous Waste Compliance –** Munitions from past range operations will be removed if they become exposed due to erosion or other processes. Once exposed, these munitions meet the definition of solid waste in the MR (40 CFR §§§ 266.202(a)(1)(iii), 266.202(c)(2), and 266.202(d)) and are managed accordingly. To mitigate potential risks and deficiencies in compliance, mitigation measures including ordnance sweeps and stabilization measures are implemented as described above. Operational Range Clearance BMPs are followed to reduce potential risks to human health and/or the environment.

  As a result of past hurricanes and severe storms, most notably Hurricane Isabel in 2003, a previously unknown area of buried munitions and debris along the eastern shoreline of the Missile Test Range at the Old Plate Battery Test Area has been exposed. These munitions, exposed from erosion or other processes, meet the definition of solid waste in the MR (40 CFR §§§ 266.202(a)(1)(iii), 266.202(c)(2), and 266.202(d)) and present the potential for a deficiency in compliance with the SWP3 if munitions or debris is not managed in accordance with the applicable regulations (NAVSEA, 2010). To mitigate potential risks to human health and the environment and a deficiency in compliance, qualified ordnance teams sweep this area periodically as well as after storm events. If munitions become exposed from erosion, they are removed by the teams or qualified government or contractor personnel and treated at the OB/OD facility. In addition, actions have been taken to stabilize the Old Plate Battery Test Area of the Missile Test Range and to prevent unauthorized access (NAVSEA, 2010).
- **Emergency Planning and Community Right-to-Know Act –** No deficiencies were noted in the RCA report**.**
- **Range Environmental and Explosives Safety Management –** Munitions from past range operations are handled per the Operational Range Clearance Plan and are removed by qualified ordnance personnel and treated at the permitted OB/OD unit if munitions become exposed due to erosion or other processes. Exposed munitions are subject to regulation as solid waste and mitigation measures including ordnance sweeps and

stabilization measures are implemented. No deficiencies were noted for Range Environmental and Explosives Safety Management.

- **Installation Restoration/Munitions Response –** NSF Dahlgren/NAVFAC is the point of contact responsible for unresolved munitions, munitions and explosives of concern, unexploded ordnance (UXO), and discarded military munitions within and outside operational ranges. Through the ERP, NSF Dahlgren has identified, characterized, and remediated contamination from past HW or EHW disposal operations and HM spills at the facility. The Navy implements the ERP at NSF Dahlgren, with USEPA and VDEQ providing regulatory oversight. No deficiencies in the ERP were noted in the RCA report**.**
- **Storage Tank and Petroleum, Oils, and Lubricants Management –** No deficiencies were noted**.**
- **Safe Drinking Water –** The Operations and Maintenance Plan for the public drinking water needs to be updated to reflect current water distribution maps and well locations.
- **Munitions Constituents –** Perchlorate, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) detected in the groundwater of the Columbia aquifer at the OB/OD on the EEA are being investigated in coordination with NSWCDD and the VDEQ. Groundwater protection standards have been established at the OB/OD unit by VDEQ. Self-imposed perchlorate evaluations are ongoing and are summarized in Table 3.7-3. The RCA report concluded that monitoring is currently in compliance with the permit requirements and that shallow groundwater contamination does not have the potential to migrate off-range. Therefore, no deficiencies in compliance were noted for the OB/OD unit (NAVSEA, 2010).

The RCA concluded that the Navy is already investigating, and in most cases has already addressed, areas where there is a potential for an off-range release of MCs from land-based operational areas through the ERP and Subpart X permitting requirements. Further, the RCA concluded that there is no need to investigate any areas for potential off-range releases beyond planned investigations (NAVSEA, 2010).

Table 3.7-3
Summary of Perchlorate Detections

Media	Concentrations (µg/L)			Number of Samples	Number of Detects
	Minimum	Maximum	Average[a]		
Groundwater (OB/OD)	ND	2,700	237.9	118	92*
Groundwater (EEA)	ND	1.0	0.29	7	2
Groundwater (other)	ND	20	2.01	104	32
Surface Water	ND	230	11.5	28	11
Sediment	ND	120	b	25	1
Soil	ND	1,200	b	111	9
Drinking Water	ND	ND	ND	4	0

Notes:
[a] Non-detects (NDs) were included at half the detection limit in the calculated average.
[b] Average not calculated because of predominance of non-detections and wide range of detection limits.
* 27 of 92 detects exceeded the groundwater protection standard of perchlorate of 24 µg/L.
µg/L = micrograms per liter.
Source: NAVSEA, 2010.

3.7.7 Munitions Constituents in PRTR Sediment and Water

To support the analysis of environmental impacts in this EIS, NSWCDD estimated the concentrations of MCs in sediment and water in the water range part of the PRTR Complex. The concentrations were derived for use in screening potential effects on human health (Section 4.8) and ecological receptors (Sections 4.11, 4.12, and 4.13). Appendix F of this report discusses the methodologies that were used.

3.7.7.1 PRTR Gun Firing (Munitions) Data

Many types of ordnance have been tested on the PRTR since 1918, including small-, medium-, and large caliber guns up to 16”, aircraft bombs and guns (until 1957), rockets (ended in the 1970s), mortars, grenades, mines, depth charges, and torpedoes (although underwater explosives have not been tested since the 1970s). However, most of the information on historical ordnance use is based on anecdotal accounts, and the quantities for most types of munitions used are not readily available. Therefore, the quantitative analysis focused on gun-firing data recorded in firing logs that NSWCDD possesses. Firing-log data included the caliber of gun fired, the number of rounds fired, and the location of the target area. These data were used to estimate the quantities of MCs associated with ordnance fired into the PRTR.

As recorded in the firing logs, from 1918 to 2007 the Navy tested 291,971 inert rounds and 51,844 live rounds on the PRTR for a total of 343,815 large-caliber rounds. Inert rounds accounted for 84.9 percent of the total and live rounds accounted for 15.1 percent of the total. Over the 90 years, an average of 3,820 rounds – comprising an estimated 3,244 inert rounds and 576 live rounds – were tested each year. Most of the rounds (99.7 percent) were fired into the MDZ, with a small number of rounds (0.3 percent) into the LDZ.

The PRTR between the Main Range Gun Firing Line (0 yd) and 25,000 yds in the MDZ accounts for 341,706 rounds, or 99.4 percent of all munitions fired on the PRTR and recorded in the log books (Figure 3.7-1, Distribution of Large-caliber Projectiles in the Potomac River Test Range). For the evaluation performed in Appendix F, this area was called the “diffuse zone.” Within this area, the zone from 11,000 to 13,000 yds – called the “dense zone” for evaluation purposes – has the highest density of rounds. This zone has a surface area of approximately 2.3 sq NM and contains approximately 159,580 rounds, yielding a density of 69,686 rounds per sq NM.

3.7.7.2 Munitions Constituents (MCs)

The raw firing activity data obtained were sorted, compiled, and cross-referenced with information on MCs that was obtained from the Munitions Items Disposition Action System (MIDAS) database to determine the type and quantity of MCs in the PRTR. The MIDAS database contains detailed technical data for a wide range of munitions, including the weight and material specifications for individual munitions. These specifications were used to determine the constituents associated with each munitions type. The total weight for each MC associated with each munitions type was calculated by multiplying the number of times a munitions type was fired by the weight of the MC in each munition of that type. Summing those data across munitions types provided the total amount of each constituent associated with live and inert firings.

Distribution of Large-caliber Projectiles in the Middle Danger Zone and Lower Danger Zone

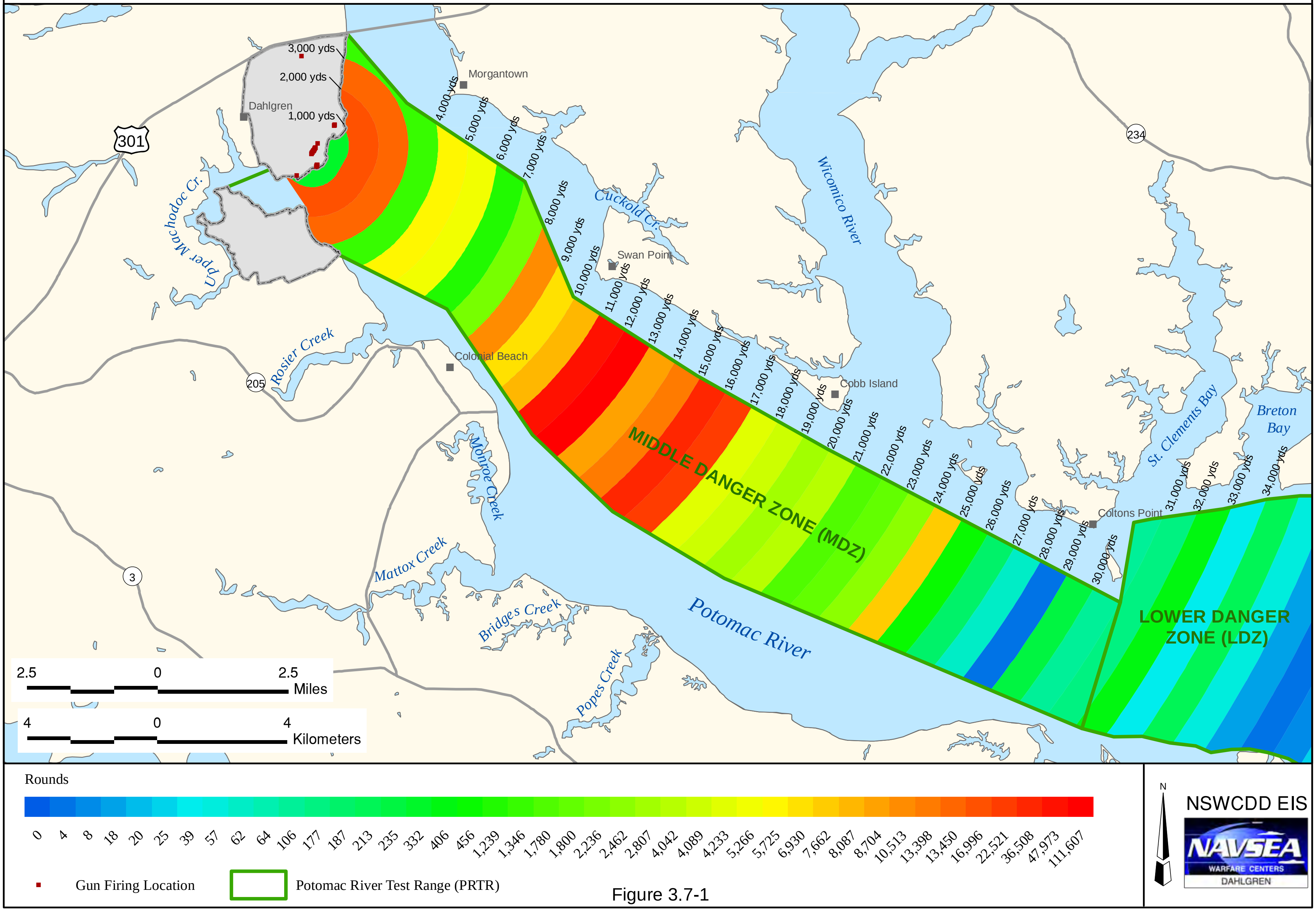

Figure 3.7-1

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

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Based on the MIDAS records, 110 MCs are associated with the 57 different munitions types tested at the PRTR. A total of approximately 33 million lbs of constituents are associated with the 343,815 total rounds fired into the PRTR, as recorded in the log books. The MCs comprising the majority of the total weight are metals in the projectile casing that is common to both live and inert rounds. The predominant constituent is iron, contributing 31 million lbs or 93.2 percent of the total constituent weight. The second largest contributor is copper at 958,087 lbs, followed by manganese at 463,239 lbs; they contribute 2.9 percent and 1.4 percent of the total amount of constituent weight, respectively. Combined, iron, copper, and manganese account for 97.5 percent of the total constituent weight of munitions over the 90 years of testing.

Ammonium picrate (Explosive D), RDX, and 2,4,6-trinitrotouluene (TNT) were the most common explosives used in testing at the PRTR and are among the top ten constituents by weight associated with live munitions.

As there is potential at the PRTR for human and ecological receptors to be exposed to these MCs in the Potomac River, range-specific screening-level risk assessments (RSSRAs) were performed. A subset of MCs was selected as munitions constituents of potential concern (MCOPCs) based on their total mass (cumulative over the last 90 years), toxicity of constituents, and Navy guidance.

The ecological and human health RSSRAs employed conservative (i.e., stringent/protective) assumptions to evaluate existing data and determine whether additional analysis is necessary; protective measures are warranted; or the range poses acceptable risks. Predicted concentrations of MCOPCs in Potomac River water and sediments were also based on conservative modeling assumptions and did not apply any dilution or burial factors for water or sediment concentrations, respectively.

The RSSRAs evaluated MCOPCs by comparing modeled concentrations in water, sediment, and fish tissues to risk-based screening concentrations. The results of the human health and ecological RSSRAs, discussed in Sections 4.8, 4.11, 4.12, and 4.13, indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude – hundreds to billions of times – below concentrations that could cause adverse effects to human health or the environment.

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3.8 Health and Safety

Outdoor RDT&E activities involve the use of explosives, lasers, EM energy, and chemicals. Because of the risks associated with these activities, protecting the health and safety of the public and of NSF Dahlgren personnel must be, and is, an integral part of NSWCDD's mission. NSWCDD RTD&E activities comply with all applicable federal and state, DoD-, Navy-, and installation-level occupational safety and environmental requirements to ensure that these activities are conducted with no or minimal risks to persons or the environment, both on and off the installation and PRTR.

NSWCDD fosters a safety culture that encourages all managers and employees to take responsibility for their safety and that of others and to report any concerns they may have, so that corrective action may be taken without delay. Safety programs and procedures are constantly reviewed and updated to ensure their continuing validity and appropriateness. Personnel are thoroughly trained in the development and implementation of safety procedures. Thanks to this commitment to safety, there have been no fatalities attributable to NSWCDD's RDT&E activities in more than 40 years. In addition, based on review of records for the past 10 years, there have been no illnesses or injuries attributable to outdoor activities.

The Occupational Safety and Health Policy established the following guiding principles to provide every employee with a safe and healthful workplace (NSWCDD, 2011):

- Integrate safety awareness and Operational Risk Management into all aspects of workplace activities and business decisions.
- Continuously improve workplace safety and health through process improvements and eliminating potential hazards to reduce injuries.
- Educate employees with controls and equipment that are essential to sage mission accomplishment.
- Ensure compliance with relevant regulatory standards and laws.
- Foster communication and encourage participation throughout all organizational levels to achieve and maintain a safe and healthful workplace.

This section describes the safety measures NSWCDD employs to protect human health. Section 3.8.1 describes the general safety measures that cover all of NSWCDD's activities. Sections 3.8.2, 3.8.3, 3.8.4, and 3.8.5 describe safety measures specific to ordnance activities, activities requiring EM energy, laser activities, and chemical/biological defense activities, respectively.

3.8.1 Safety Measures for All Activities

Safety-related measures used by NSWCDD to protect human health can be divided into three main types:

- Safety Zones – The establishment and maintenance of safety zones, that is, of areas with special access and land use restrictions designed to protect persons and property from the risks associated with certain facilities and activities. Safety zones typically are only in effect when an operation is taking place.

- Safety Procedures – The development and implementation of safety procedures and methods designed to ensure that specific tests and other RDT&E activities are conducted in as safe a manner as possible, with minimal risk of harm to persons and the environment.
- Protective Equipment – The use of protective equipment by NSWCDD personnel when they are performing hazardous activities, particularly involving the use of explosives, chemicals, and EM energy.

These measures are described below.

3.8.1.1 Safety Zones

PRTR Danger Zones

Danger zones are defined in 33 CFR Part 334. Per the regulations, a danger zone is a "defined water area (or areas) used for target practice, bombing, rocket firing, or other especially hazardous operations, normally for the armed forces. The danger zones may be closed to the public on a full-time or intermittent basis, as stated in the regulations." (33 CFR § 334.2(a)).

The boundaries of the PRTR's UDZ, MDZ, and LDZ (see Figure 1-3) are defined in 33 CFR § 334.230. Specific regulations applicable to the PRTR (33 CFR § 334.230 (a) (2)) include:

(i) Firing normally takes place between the hours of 8 am and 5 pm daily except Saturdays, Sundays, and national holidays, with infrequent night firing between 4 pm and 10:30 pm[2]. During a national emergency, firing will take place between the hours of 6 am and 10:30 pm daily except Sundays.

(ii) When firing is in progress, no person, fishing, or oystering vessels shall operate within the danger zone affected unless so authorized by the Naval Surface Warfare Center's patrol boats. Oystering and fishing boats or other craft may cross the river in the danger zone only after they have reported to the patrol boat and received instructions as to when and where to cross. Deep-draft vessels using dredged channels and propelled by mechanical power at a speed greater than five miles per hour may proceed directly through the danger zones without restriction except when especially notified to the contrary. Unless instructed to the contrary by the patrol boat, small craft navigating up or down the Potomac River during firing hours shall proceed outside of the northeastern boundary of the Middle Danger Zone. All craft desiring to enter the Middle Danger Zone when proceeding in or out of Upper Machodoc Creek during firing hours will be instructed by the patrol boat; for those craft which desire to proceed in or out of Upper Machodoc Creek on a course

Range Control Boat

[2] Although 33 CFR Part 334 allows firing between 4 pm and 10:30 pm, in practice NSWCDD only fires or detonates ordnance Monday through Friday between 8 am and 5 pm.

between the western shore of the Potomac River and a line from the Main Dock of the Naval Surface Weapons Center to Line of Fire Buoy P, clearance will be granted to proceed upon request directed to the patrol boat.

Watercraft and deep-draft vessels are encouraged to communicate with NSWCDD's Range Operations Center (ROC) via marine radio in order to minimize delays. NSWCDD's rigorous implementation of these regulations ensures that activities on the PRTR are conducted safely and with minimal impacts to river users. During activities on the river that could endanger watercraft, a red flag is flown at the Yardcraft piers, near the mouth of Upper Machodoc Creek. Range boats – painted international orange with a white hull and normally stationed near Lower Cedar Point, Maryland; near Swan Point, Maryland; off Colonial Beach, Virginia; and at the mouth of Upper Machodoc Creek – patrol the operational danger zone to ensure that no watercraft are present. To that end, the boats fly red flags warning watercraft not to enter the danger zone without having obtained permission from the nearest range patrol boat or from the ROC, which can be contacted by marine radio. If needed, range boats use a siren as a signal for a passing watercraft to come alongside for information and instructions on how to proceed, or they contact it by marine radio. Depending on the type of operation, traffic can frequently be safely rerouted around the operational area. Deep-draft vessels may be made to hold for a maximum of one hour, but more typically one-half hour, when necessary. To minimize potential inconvenience, advanced notice of scheduled activities and danger-zone restrictions are provided on NSWCDD's website or via a toll-free number. Monitoring equipment, such as the cameras used to record projectile/water impact locations during ordnance activities, is also used for PRTR surveillance during periods of restricted access.

Airfield Safety Zones and Special Use Airspace

Air safety regulations define two- and three-dimensional areas around active runways that must remain clear of obstructions to minimize the risk of accident during takeoffs and landings. For Navy airfields, the size and shape of the safety areas are defined in NAVFAC P-80.3 *Facility Planning Factor Criteria for Navy & Marine Corps Shore Installations*, Appendix F *Airfield Safety Clearances*. The airfield's only functional runway (18/36) currently is not authorized for landings/takeoffs by fixed-wing aircraft. Therefore, only helicopters use it at present. For a helicopter (visual flight rules), the primary surface is 300 feet wide and the length of the runway plus 75 feet at each end.

Range Operations Center (ROC)

The ROC is responsible for controlling test operations on all ranges. The ROC monitors and controls all test sites with patrol boats, air surveillance radar, video surveillance, communications, and other functions required to ensure safe operations. To ensure effective communication in case of emergency, the ROC is always staffed when any of the ranges are being used, when PRTR danger zones are in use, when any airspace is reserved for firing, or when aircraft under NSWCDD's control are conducting tests in or near restricted airspace.

While the air safety area just mentioned is designed to minimize potential hazards to and from helicopters using the NSF Dahlgren airfield, the Special Use Airspace (SUA) associated with the installation's PRTR was established to ensure that non-participating aircraft are not put at risk while activities involving projectiles or flying equipment are being conducted. The dimensions of NSWCDD's SUA are described in Section 1.4.4 and shown in Figure 1-6. Normal restricted airspace operating hours are Monday through Friday from 8 am to 5 pm, excluding holidays.

Activities outside these times require publication of a Notice to Airmen (NOTAM) 48 hours in advance. When not using the SUA for activities, NSWCDD releases the airspace to the control of the Federal Aviation Administration (FAA)'s Potomac Terminal Radar Approach Control (TRACON) for normal use. Closures are coordinated with TRACON. Both visual surveillance and radar are used to make sure the area is clear before proceeding with the planned activities.

Explosive Safety Quantity Distance Arcs

Explosive Safety Quantity Distance (ESQD) arcs are circular perimeters defined around potential explosive sites to minimize the harm an unplanned detonation could cause to persons or buildings. The radius of each ESQD arc is determined based on the NEW of the material at the potential explosive site, as well as on the type of operation. The applicable criteria are contained in NAVSEA OP5: *Ammunition and Explosives Ashore Safety Regulations for Handling, Storage, Production, Renovation, & Shipping* and are defined based on the safety standards established by the DoD Explosives Safety Board. ESQD requirements apply during development; manufacturing; test and maintenance; storage, loading, and off-loading of vehicles; disposal; and all related handling activities.

Existing ESQD arcs at NSF Dahlgren are shown in Figure 3.8-1 (Safety Footprints). On Mainside, ESQD arcs surround the five munitions storage areas (see Figure 3.1-2). Other arcs have been established for the transfer of ordnance by truck in the magazine storage areas and by barge at the piers. Arcs are also present around explosive ranges where outdoor detonations occur, such as at the Explosive Ordnance Disposal (EOD) area and the EEA.

While ESQD arcs represent a significant constraint on development within NSF Dahlgren, they do not substantially affect the local community, being for the most part contained within the confines of the installation. However, as seen in Figure 3.8-1, some of the arcs extend over the waters of Upper Machodoc Creek outside the footprint of the PRTR. When activities involving these arcs extend into the waters of the creek, range boats are deployed to monitor boat traffic within the arcs.

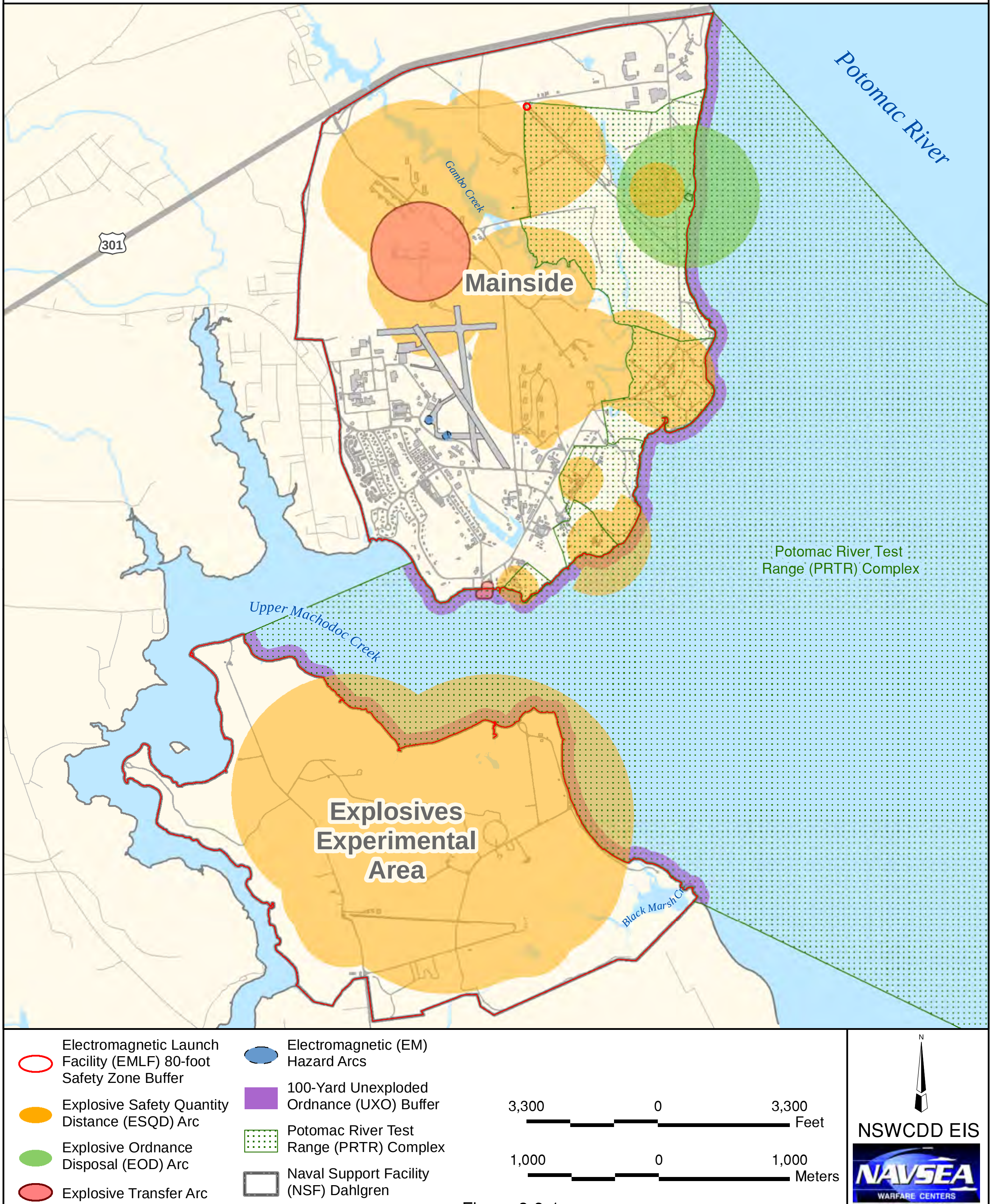
Electromagnetic (EM) Hazard Arcs

An EM hazard occurs when transmitting equipment produces an electronic field sufficient to trigger ordnance (HERO), ignite fuels (HERF), cause harm to persons (HERP), or interfere with electronic equipment (EMI) (described in Section 1.5.2.1). Consequently, arcs are defined around sites producing EM energy to ensure that personnel and sensitive materials are not within range of these potential adverse effects. Two such arcs have been defined in the ground plane area in the Mission Area (Figure 3.8-1). EM arcs vary for the MOATS, NOTES, and ground plane facilities based on individual test scenarios as defined by the risk hazard assessment (RHA) within the standard operating procedure (SOP) or general operating procedure (GOP) (discussed immediately below). NSWCDD coordinates with the Navy and Marine Corps Spectrum Center on all aspects of EM spectrum management.

3.8.1.2 Safety Procedures: RHAs, SOPs and GOP/OPSs

For every new operation that has the potential to be hazardous, an RHA is prepared to determine and document the hazards and ways to mitigate them. If the RHA indicates that a proposed

Safety Footprints



Source: NSWCDD GIS (2008 - 2011)

Figure 3.8-1

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operation could be hazardous, then SOPs or GOPs are developed for the operation based on the RHA. The development and rigorous implementation of RHAs, SOPs, or GOPs with associated operation procedures supplements (OPSs) are at the heart of NSWCDD's safety approach for hazardous operations. SOPs and GOPs are similar in form and content. The main difference is that an SOP pertains to a specific, stand-alone operation, whereas a GOP/OPS is a set of unchanging procedures for a given, multi-use facility or piece of equipment (the GOP) combined with a particular set of procedures for a specific use of this facility or equipment (the OPS). An example of GOP/OPS would be a GOP for the operation of an X-ray facility and an OPS for X-raying a particular rocket motor. Neither the GOP nor the OPS is a stand-alone document; one must always be accompanied by the other.

Policy and guidance on preparing and using SOP/GOP/OPS for energetic material operations or other hazardous operations conducted by NSWCDD is contained in NSWCDL Instruction 8023.2, *Operating Procedures Policy, Guidance, and Format for Energetic Material Operations*, consistent with OPNAVINST 8020.14/Marine Corps Order P8020.11, *Department of the Navy Explosives Safety Policy*; NOSSA 8023.11A, *Standard Operating Procedures Development, Implementation, and Maintenance for Ammunition and Explosives*; NAVSEA OP 5, Vol. 1, *Ammunition and Explosives Ashore-Safety Regulations for Handling, Storing, Production, Renovation, and Shipping*; OPNAVINST 3500.39A/Marine Corps Order 3500.27, *Operational Risk Management*; and other applicable DoD and Navy regulations and instructions, such as the Navy Safety and Occupational Health Program Manual OPNAVINST 5100.23G and NSWCDL 5100.1D and 5100.1M.

Preparation

Preparation of the SOP/GOP/OPS for an operation is the responsibility of the unit organizing and performing the operation. Working with the designated preparer, a technical editor reviews and edits the document for clarity, consistency, and conformance with approved format. Typically, an SOP/GOP/OPS contains the following sections:

- Signature pages (see "Review" and "Implementation" below).
- A general description of the proposed operation.
- A statement of responsibilities, listing what persons will be in charge of what actions.
- A description of the operational location.
- A description of personnel and material limits, which establishes the staff and physical parameters within which the test will take place (this may include definition of a buffer zone; specific meteorological conditions; types of materials needed and their potential interactions, with supporting documentation; etc.).
- A list of safety requirements (which may include the wearing of appropriate personal protective equipment [PPE], a description of conditions under which the test should be cancelled or aborted, specific instructions on how to turn on, operate, and turn off equipment, etc.).
- Emergency response and contingency plans, listing the procedures to follow and assistance/rescue personnel to call in case of accident or emergency, such as a spill, explosive mishap, medical emergency, etc., with names and contact information.

- A description of applicable environmental protection procedures consistent with federal, state, DoD, and Navy regulations.
- Security requirements, establishing the appropriate level of security based on the level of confidentiality of the test.
- A Hazard Control Brief, which is based on the RHA that must be performed as part of every SOP (see text boxes).
- An equipment list, itemizing required safety equipment as well as needed tools and materials.
- A step-by-step description of the procedures to follow before, during, and after the test, with highlighted *Warning* (for personnel) and *Caution* (for equipment) boxes for essential information, as needed.
- Appendices supporting the previous sections, as needed.

An OPS is generally a shorter document that complements the associated GOP with information and measures that are specific to the operation under consideration. Typically, these additions include assembly/disassembly procedures, special handling of equipment or tools, and specific step-by-step instructions, among others.

Review, Validation, and Approval

Review of the SOP/GOP/OPS is an essential step in the process. It ensures that the documents meet all applicable requirements and are complete, accurate, and effective. After completion of the initial draft, the SOP/GOP/OPS is forwarded to the Range Safety Director (RSD) for review by the Operations Safety Committee (OSC). OSC members review the documents, recommend changes, and, in conjunction with NSWCDD's environmental staff, and if applicable, NSF Dahlgren's environmental staff, determine whether measures can be taken that would lessen impacts to the environment without compromising the purpose of the operation. Following this review, the technical editor revises the SOP/GOP/OPS and prepares it for the next steps in the review and approval process, beginning with validation.

Operations Safety Committee Composition

- The Range Safety Director.
- Personnel responsible for the technical requirements and execution of the process.
- Representatives of the Explosives Safety Program Office.

Validation is a key step in the review/approval process. The validation process can take the form either of a paper document or a test run. Validation of the SOP/GOP/OPS ensures that the SOP/GOP/OPS:

- Is effective in making the operation safe.
- Is sufficiently detailed to be used as a stand-alone document.
- Is clear, logical, and consistent.
- Is efficient and conducive of use by the performing personnel.
- Considers environmental issues and is designed to have the least impact practicable.

Policies from NSWCDL Instruction 8023.2, *Operating Procedures Policy, Guidance, and Format for Energetic Material Operations*

Operations involving the processing, movement, or handling of energetic materials shall not take place without approved and documented procedures prepared in accordance with the provisions of this Instruction.

All energetic material operations shall be conducted in a safe manner.

Each operation shall comply with the technical requirements, explosive safety standards, personnel qualification and certification requirements, Navy Occupational Safety and Health standards, federal, state, and local environmental protection requirements, Environmental Management System (EMS) intent and classification and physical security directives.

All personnel shall be responsible for producing quality operations and products in a safe and environmentally responsible manner.

Operating procedures shall clearly identify and minimize existing or potential hazards inherent in the processing of ordnance or ordnance components, and include emergency response, evacuation, and contingency plans, as required.

Prior to the commencement of any operations covered by this Instruction, performing organizations shall ensure that approved operating procedures are available and personnel involved in hazardous operations are qualified and certified, in accordance with NSWCDLINST 8020.1A, *Ordnance Certification Program*.

All operating procedures for energetic material operations shall be approved and released by the Commander, NSWCDD or the approved department manager, who shall be designated in writing.

SOPs must reflect current procedures. Personnel responsible for the technical requirements and execution of the process must ensure that operating procedures are changed and reviewed as necessary to reflect changes.

Personnel involved in a particular operation shall take part in the preparation of operating procedures for that operation.

The preparation of operating procedures shall be delegated to the lowest level consistent with the spirit and intent of this Instruction and technical capability.

A Risk Hazard Assessment (RHA) shall be completed. All hazardous operations shall be thoroughly analyzed for hazards. Hazards shall then be eliminated, controlled, and/or mitigated to a degree that shall result in the establishment of an acceptable level of safety for the process. RHAs shall be conducted in accordance with the Range Operation Policy Statement (ROPS), 05196, and Risk Hazard Assessment Requirements and Template.

Risk Hazard Assessment

A Risk Hazard Assessment (RHA) is prepared to determine the risks of a proposed operation. If hazards are identified, then SOP/GOP/OPSs are prepared, consistent with OPNAVINST 3500.39A/Marine Corps Order 3500.27, *Operational Risk Assessment*. The purpose of an RHA is to carefully examine what could cause harm to people or material during an operation and decide what precautions are needed to mitigate the risk so nobody is injured or becomes ill and no material is damaged. The RHA is then used to generate the SOP/GOP/OPS.

Conducting an RHA involves the following steps:

1. **Identify each component of each task** for the operation under consideration
2. **Determine hazards for each process step**: a hazard is an agent of injury or a condition that could expose a person to danger or harm. Examples of hazards include: working at height, sharp objects, protruding objects, slippery walking surfaces, hot materials, chemicals, energy sources, etc.
3. **Determine mishap-triggering events**: these are the human errors, system faults, or environmental conditions that may cause a mishap. Examples include ergonomic events such as lifting, reaching, or bending; exposures to hazardous materials or energy; or improperly sequenced sub-steps.
4. **Determine potential mishaps**: a mishap is any unplanned or unexpected event causing injury, death, material loss or damage, or an explosion whether damage occurs or not.
5. **Determine risk levels for each process step before mitigation**: the risk level reflects the severity of the potential mishap associated with the step and the probability that the mishap will occur.
6. **Determine appropriate hazard mitigation**: This may consist of engineering controls (e.g., reducing the amount of energy used, substituting materials, using remote controls) and/or administrative controls (e.g., using PPE, using warnings and cautions).
7. **Determine risk levels after mitigation**.

All RHAs are reviewed by the Operations Safety Committee (OSC) and are provided to all personnel who are required to review and approve the corresponding SOP/GOP/OPS.

Source: NSWCDL, 2005b. Range Operation Policy Statement (ROPS) 05196, *Guidance and Template for Risk Hazard Assessment.*

If the SOP/GOP/OPS is for a new or changed process, validation consists of a mock execution of the process – a little like a "dress rehearsal." The validation is conducted by a Validation Team, consisting, at a minimum, of the RSD, the preparer of the SOP/GOP/OPS, a representative of the Explosives Safety Program Office, and a representative of the performing organization. Other personnel may be added, as appropriate. After reviewing the SOP/GOP/OPS, the team observes the procedures being performed using inert materials if possible (if necessary, use of energetic material is allowed, but must be approved). Team members' comments and recommendations are incorporated into the document. The validation process may be repeated until the team is satisfied that the procedures are feasible, correct, and effective. For SOPs/GOPs/OPSs that are revisions or updates of existing, approved documents, validation consists of a line-by-line comparison of the new document with the old one.

Once validation is complete, the Validation Team leader signs the SOP/GOP/OPS and returns it to the preparer for final revisions prior to final review and approval.

The validated SOP/GOP/OPS, along with the validation record, is then forwarded for final approval and release signatures by 1) the performing organization; 2) the Division Head; 3) other activities as applicable; 4) the NSWCDD Safety and Environmental Director in consultation with NSF personnel, as applicable; and 5) the Explosives Safety Officer. Final approval and release authority lies with the NSWCDD Commander or a Department Manager designated by the Commander to that effect. The signature page is the first page of each SOP/GOP/OPS. A sample is shown in Figure 3.8-2 (Sample SOP/GOP/OPS Signature Page).

Once approved, an SOP/GOP/OPS is valid for four years. After four years, the document is considered expired and must undergo a complete review and approval process prior to reissue. Because SOPs/GOPs/OPSs must at all times reflect the most current procedures and techniques, they are subject to continual review and revision, with associated approval requirements commensurate with the scale of the revision. Additional reviews must occur when an action has been inactive for more than six months; if there has been a change or revision to a source document; or if a mishap has occurred. Initiation of any change is the responsibility of the performing organization. Once an SOP/GOP/OPS has been updated, copies of the older version are systematically collected and destroyed. These requirements ensure that SOPs/GOPs/OPSs are always up-to-date and reflective of actual conditions.

Implementation

The measures contained in an SOP/GOP/OPS are implemented every time the operation covered by the document is performed. Prior to the operation, personnel who will be directly involved are provided with the SOP/GOP/OPS and must sign and date a statement certifying they have read and understood the document and have received and understood the corresponding Hazard Control Brief. Within the same time frame, non-performing personnel (i.e., personnel not directly involved in the operation but present in the area) are given the Hazard Control Brief and must sign a statement that they have received and understood the brief. Certifications and signatures are an integral part of each SOP/GOP/OPS and are placed at the very beginning of the document, after the signature page; operations do not begin until all needed certifications and signatures are obtained. The operation is always performed in full compliance with the measures, procedures, warnings, cautions, and step-by-step instructions contained in the SOP/GOP/OPS.

3.8.1.3 Personal Protective Equipment (PPE)

As specified in the SOP/GOP for each operation, to reduce exposure hazards to acceptable levels, personnel may be required to use PPE if they are going to be near the site at which a hazardous operation is taking place. Health and safety concerns decrease rapidly as personnel move away from the operational sites to the point where PPE is no longer required. PPE may include one or more of the following: protective suits, coveralls, hoods, goggles, gloves, boots, respiratory equipment, eye protection, or ear protection.

In developing the SOP/GOP, NSWCDD relies on the RHA process to calculate the duration of exposure, type of exposure, materials being handled, proximity to the test site, and hazards of the exposure to determine the type of PPE required. Personnel receive training in the use of PPE, and use is monitored in line with the SOP/GOP for each operation. The types of PPE specified for a particular test follow USEPA and US Department of Labor (USDOL), Occupational Safety and Health Administration (OSHA) guidance (OSHA, 2003).

3.8.2 Ordnance Activities Safety

Activities involving the use, transport, and storage of ordnance are inherently hazardous; consequently, NSWCDD takes great care to avoid injuries and property damage from ordnance on- and off-base. As discussed in the previous section, detailed policy and guidance for use of ordnance and other energetic material activities is contained in both general DoD and Navy policy and guidance and in instructions developed specifically for NSWCDD, as well as in range and airspace control measures. In addition to the SOPs and GOPs/OPSs described in Section 3.8.1.2 and the range- and airspace-control measures detailed in Section 3.8.1.1, additional safety-control measures are also implemented, as described below.

3.8.2.1 Gun Firing Control Measures

The gun-firing system constitutes one of the primary safety devices for firing projectiles. Electrical or electrically-controlled mechanical devices initiate nearly all gun firings, detonations, and ignitions of ammunition remotely, allowing personnel to be located at a safe distance from the ordnance being fired or detonated. Because NSWCDD tests new weapons and weapon systems components, which do not necessarily act as designed, this is an important safeguard for personnel. NSWCDD's extensive use of instruments to measure and record the outcome of tests also allows personnel to be located well away from RDT&E activities.

The use of firing cut-outs on all NSWCDD's guns provides protection against a gun's firing in the wrong direction or at the wrong angle. Firing cut-outs limit the operational bearing and elevation of a gun's range of motion. On a ship, they keep missiles, guns, and other munitions from firing into the ship's structure. They ensure that guns always fire in the right direction and never accidentally swing away from it. Thus, the area within which the projectile may fall can be precisely determined.

NSWCDD has measures in place to reduce shrapnel and the potential injuries to personnel and property that flying shards of metal could cause when ordnance is detonated. Most detonations are conducted on the EEA[3], which is remote from the rest of the base, has a low density of buildings and personnel, and has access control. To reduce potential shrapnel and noise, some explosives over 200 pounds (lbs) NEW are buried under 6 to 8 ft of soil before detonation[4]. Cameras and other instruments record detonations, allowing personnel to view them from a safe, remote location.

[3] A few detonations take place on the Explosive Ordnance Disposal Training Range, located within the Missile Test Range.

[4] This applies to open detonations for treatment of explosive hazardous waste, but does not apply to such operations as fast cook-off or arena tests.

Sample SOP/GOP/OPS Signature Page

Outdoor Laser SOP#XSL-OS-005-07

NAVAL SURFACE WARFARE CENTER
DAHLGREN SITE
DAHLGREN, VA 22448-5100

Subj: *STANDARD OPERATING PROCEDURES FOR OUTDOOR HIGH ENERGY LASER TESTING*

Prepared and Approved by: ______________________ ____________

Name, Q22 *(Organization Code)* — Date
Laser Safety Specialist

Reviewed and Approved by: ______________________ ____________

Name, Q22 — Date
Test Director

______________________ ____________

Name — Date
Lead Engineer

______________________ ____________

Name, Q22 — Date
Branch Head

______________________ ____________

Name, Q20 — Date
Directed Energy Technology Office

______________________ ____________

Name, G604 — Date
Dahlgren Range Safety Director

Validated by: ______________________ ____________

Validation Team Leader — Date
Code

Approved by:

______________________ ____________

Name, XDC8 — Date
Safety and Environmental Manager

______________________ ____________

Name, XDC8 — Date
Laser System Safety Officer

______________________ ____________

Name, Q20 — Date
Division Head

Approved and Released by:

______________________ ____________

Name, Q Dept — Date
Department Head

THIS DOCUMENT SHALL NOT BE REPRODUCED WITHOUT WRITTEN APPROVAL FROM THE RANGE SAFETY DIRECTOR.

NSWCDD EIS

Source: NSWCDD 2008

Figure 3.8-2

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3.8.2.2 Unexploded Ordnance

A hazard associated with certain RDT&E activities results from unexploded ordnance (UXO). UXO includes all types of explosive or live ordnance that have completely or partially failed to detonate or explode on impact at a target and, therefore, still contain explosives that make them hazardous. Over the years, RDT&E activities at NSF Dahlgren have generated four main types of UXO: naval gun projectiles, small explosives such as grenades, aircraft bombs, and small rockets.

UXO may be present in some areas of NSF Dahlgren, as shown in Figure 3.8-3 (UXO-Impacted Areas). The sediments at the bottom of the Potomac River within the PRTR, most particularly the MDZ, also contain UXO. Because of the difficulties and risks associated with the recovery and disposal of UXO, the preferred option is to leave it undisturbed unless it presents an immediate risk to humans or the environment or must otherwise be disturbed for a different use.

On-installation hazardous UXO areas are clearly marked and access is restricted or controlled, thus minimizing the risks of accidental exposure for personnel who work at NSF Dahlgren. UXO within the installation poses no risk to neighbors.

Within the PRTR, live projectiles that do not detonate at the target area continue into the water and are propelled about eight feet into the muddy and sandy sediments on the river bottom. River users are very unlikely to ever come in contact with most in-river UXO because it remains buried in sediment. Occasionally, during violent storms or hurricanes, embedded UXO may be dislodged as the sediments shift and may drift to reemerge along the shores of the river or settle in shallow waters, where boaters or other river users may accidentally find it. NSWCDD has qualified emergency response ordnance personnel for such occasions. Ordnance personnel collect the UXO and treat it on base at the open detonation area within the EEA.

The installation has prepared and published widely-available fact sheets on what to do if UXO or possible UXO is found. The standard procedure for any potentially explosive item that is discovered is to treat the item as UXO. Finders are urged never to touch or otherwise disturb the item and are provided a telephone number to call to alert the installation, which will then send qualified ordnance personnel to recover the UXO safely. Both on and off the installation, the detection, identification, field evaluation, neutralization, recovery, evacuation, and treatment of UXO is conducted exclusively by highly-trained ordnance personnel.

(In addition to safety concerns, UXO raises environmental concerns due to the potential presence of pollutants that may leach into the environment; this aspect of the UXO issue is addressed in Sections 3.11 and 3.13.)

3.8.3 Electromagnetic Energy Activities Safety

NSWCDD's higher-power EM energy-emitting devices evaluated in this EIS operate in the frequency range of 300 kilohertz (kHz) to more than 300 gigahertz (GHz) and at average powers ranging from 10 watts (W) to 500 megawatts (MW). As shown in Figure 1-2, these frequencies are in the lower end of the EM spectrum, primarily in the radio frequency (RF) range. Microwaves and radio waves are nonionizing radiation – radiation (energy transmitted by waves) in which the energy is insufficient to strip electrons from atoms.

SOPs/GOPs are developed for each operation using EM energy-emitters. SOPs identify and incorporate safe operating parameters with respect to personnel (HERP), ordnance (HERO), fuels (HERF), and EMI with electronic equipment. EMI operating parameters are generally more stringent than HERP, HERO, or HERF operating parameters due to the high sensitivity of the electronics equipment and computers used to monitor the experiments.

Examples of safe distances for continuous exposure to the strongest emitters used at outdoor test facilities are provided in Table 3.8-1. Safety zones for pulsed emitters are generally smaller than for continuous wave emitters, but depend on the pulse characteristics (radiated power per pulse, beam width, repetition rate, pulse width, and radiated energy).

Table 3.8-1
Examples of Safe Distances for Continuous Exposure to EM

Emitter (Status or Make)	Frequency (MHz)	Power (Maximum)	Safety Distances for Continuous Exposure		
			HERO	HERP	EMI
Large Experimental Dipole Radiator (R&D)	18-100	12.5 KW	N/A	15 m	360 m
Medium Experimental Dipole Radiator (R&D)	20-100	12.5 KW	N/A	15 m	360 m
RADAN	200-800	40 W	N/A	2 m	48 m

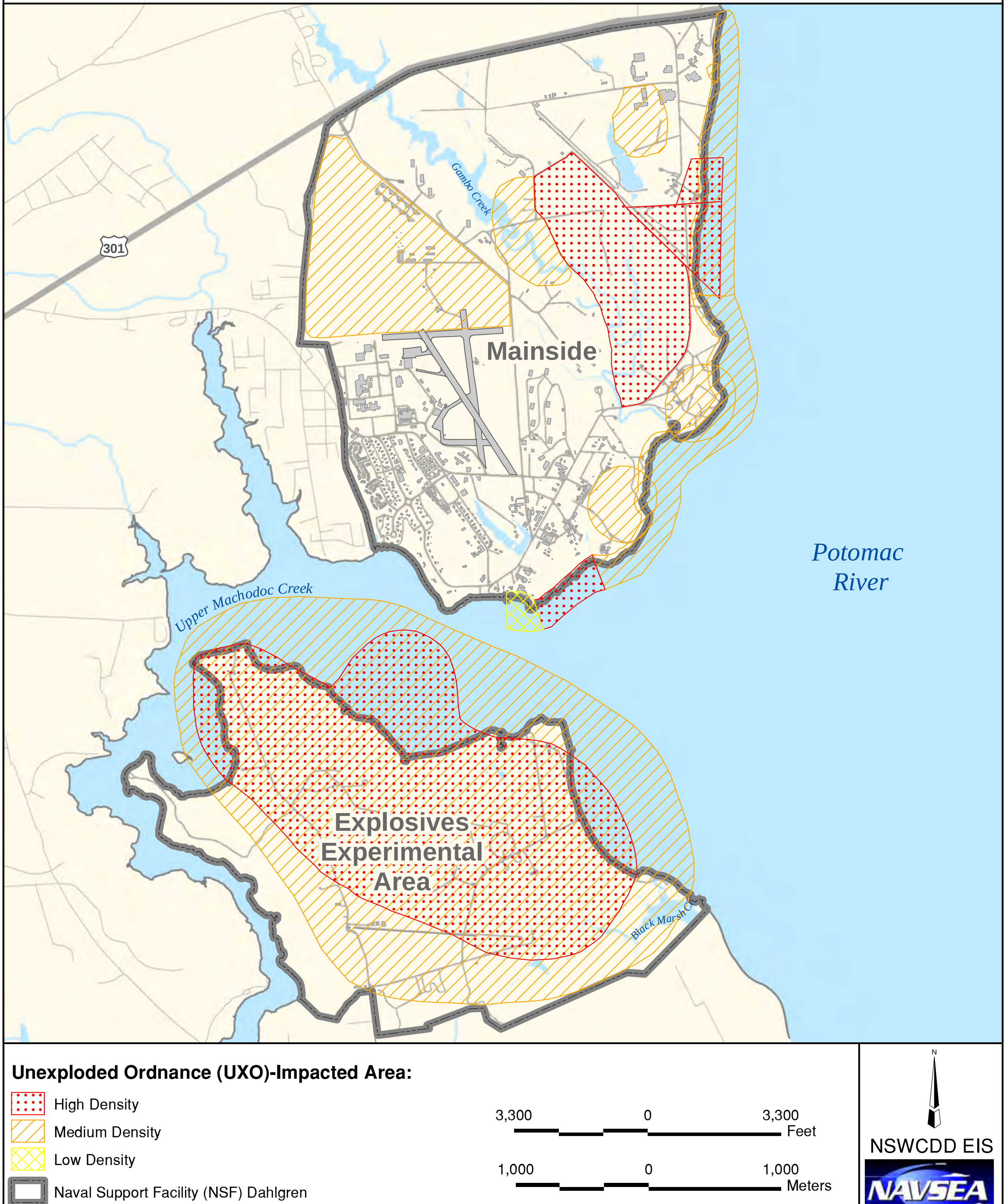
Notes:
N/A = not available; however, HERO safety zones are determined for each emitter in SOPs.
Source: NSWCDL, 2005a.

SOPs are established and maintained in accordance with OPNAVINST 5100.23G, *Navy Safety & Occupational Health Program Manual* and NSWCDLINST 5100.1D. In addition, the operation of all radiofrequency, microwave, or similar millimeter-wave systems must comply with DoD 6055.11, *Protection of DoD Personnel from Exposure to Radiofrequency Radiation and Military Exempt Lasers* to ensure the protection of the workers at the site. Specific policies for EM emissions control at NSWCDD can be found in the NSWCDLINST 5104.3(series), "*Control of Electromagnetic Emissions with Respect to Energetic Operations within NSWCDL.*"

For HERP, a safety zone is calculated for each test, depending on the power and frequency of the emission, and personnel exposure time limits within that zone are determined. Personnel are only allowed within the safety zone near the facility when the facility is emitting EM energy for the exposure time calculated for the test; beyond the calculated duration, personnel are required to don PPE for protection. Base personnel (and off-base neighbors) located beyond the safety zone are not affected by the emissions.

To estimate permissible HERP EM exposure, the rate at which energy is absorbed in body tissues, called the specific absorption rate (SAR), is generally used. The SAR varies based on distance from the source – whether exposure is within the near field or far field. The near field is the region where the distance from a radiating antenna is less than the wavelength of the radiated EM field. In this area, the electric and magnetic fields' power does not decrease with the square of the distance from the source. In contrast, in the far field the power decreases with the square of the distance from the source.

Unexploded Ordnance - Impacted Areas



Source: NSWCDD GIS (2008 - 2011)

Figure 3.8-3

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The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields up to 300 GHz (ICNIRP, 1998). Exposure restrictions to EM energy are based on short-term, immediate health effects, including stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EM fields (ICNIRP, 1998). There are two categories of guidance – basic restrictions and reference levels – as described below.

- **Basic restrictions** are restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects. Depending upon the frequency of the field, the physical quantities used to specify these restrictions are current density (J), SAR, and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.
- **Reference levels** are provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded, as most of the quantities used to establish basic restrictions cannot be easily measured. Some reference levels come from basic restrictions using measurement and/or computational techniques, such as electric field strength (E), magnetic field strength (H), magnetic flux density (B), power density (S), and currents flowing through the limbs. Others reference levels are based on perception and adverse indirect effects of exposure to EM fields, such as contact current and, for pulsed fields, specific energy absorption.

If a reference level is not exceeded, then the relevant basic restriction will not be exceeded. However, a measured or calculated value above the reference level does not always indicate an exceedance of the associated basic restriction. Whenever a reference level is exceeded, it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary (ICNIRP, 1998).

The standards for lower frequencies (3 kHz to 5 megahertz [MHz]) are intended to minimize risks associated with electrostimulation (shocks and burns), while higher frequency standards (100 kHz to 300 GHz) are for protection against effects associated with heating. Absorption of EM energy by the human body changes with frequency. Above 10 GHz, basic restrictions on SAR are provided to prevent whole-body heat stress and excessive localized tissue heating. Between 10 to 300 GHz, basic restrictions are provided on power density (S) to prevent excessive heating in tissue at or near the body surface (ICNIRP, 1998). It should be noted that there is insufficient information on the biological and health effects of EM exposure of human populations and experimental animals to provide a rigorous basis for establishing safety factors over the whole frequency range and for all frequency modulations (ICNIRP, 1998).

Navy permissible exposure limits (PELs), equivalent to basic restrictions, are specified for locations that are defined as either controlled or uncontrolled environments (US Navy, 2011). *Controlled environments* are areas where exposure may be incurred by personnel who are aware of the potential for RF or other types of EM exposure. All tests performed at NSWCDD are conducted in a controlled environment. The EM exposure limits for controlled environments represent scientifically-derived values to limit absorption of RF energy in the body and to restrict the magnitude of EM currents induced in the body and are the equivalent of personnel exposure standards for all individuals (US Navy, 2011). Exposure standards for controlled environments must be adhered to by anyone entering those areas regardless of whether or not they are personnel directly involved with the research and testing being conducted (US Navy, 2011). Levels of EM energy below the exposure limits are considered insufficient to cause adverse effects on health, even under repeated or long-term exposure conditions.

In *uncontrolled environments* where access is not restricted or controlled, lower permissible exposure levels have been adopted to maintain lower exposure levels outside of well-defined areas. The Institute of Electrical and Electronics Engineers' (IEEE, 1999) RF standards limit whole- body-averaged SAR exposure to 0.4 and 0.08 watts per kilogram (W/kg) for controlled and uncontrolled environments, respectively. The exposure limit for controlled environments is considered to be protective, as it based on a whole-body average and the threshold for effects on the most sensitive tissues is greater than this value (ICNIRP, 1998). These levels are also used as basic restrictions by ICNIRP under the categories of occupational and general public exposure, respectively, for EM frequencies from 100 kHz to 10 GHz (ICNIRP, 1998). For frequencies between 10 and 300 GHz, occupational and general public exposure levels should be restricted to 50 and 10 W/m^2, respectively.

Table 3.8-2 summarizes the ICNIRP (1998) reference levels for controlled and uncontrolled exposure, which can be used to estimate EM exposure by measurement of alternative variables for practical exposure assessment purposes, as discussed previously.

Table 3.8-2
Reference Levels for Exposure to Time-Varying Electric and Magnetic Fields

Frequency Range (Hz)	E-field Strength (V/m)	H-field Strength (A/m)	B-field Strength (µT)	Equivalent Plane Wave Power Density (S_{eq}) W/m^2
Controlled Exposure (Occupational)				
0.82-65 kHz	610	24.4	30.7	--
0.065-1 MHz	610	1.6/*f*	2.0/*f*	--
1-10 MHz	610/*f*	1.6/*f*	2.0/*f*	--
10-400 MHz	61	0.16	0.2	10
400-2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	*f*/40
2-300 GHz	137	0.36	0.45	50
Uncontrolled Exposure (General Public)				
3-150 kHz	87	5	6.25	--
0.15-1 MHz	87	0.73/*f*	0.92/*f*	--
1-10 MHz	$87/f^{1/2}$	0.73/*f*	0.92/*f*	--
10-400 MHz	28	0.73	0.092	2
400-2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	*f*/200
2-300 GHz	61	0.16	0.20	10

Notes:
Hz = Hertz (alternating electricity); V/m = volts per meter (electric field strength)
A/m = amperes per meter (magnetic field strength); µT = microTesla (magnetic flux density)
S_{eq} = equivalent plane wave power density; W/m^2 = watts per square meter (electric); *f*= frequency
Source: ICNIRP, 1998.

Exposure limits for magnetic fields are also provided in the IEEE and are provided in their *Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3-kHz to 300 GHz* (IEEE, 1999).

3.8.4 Laser Operations Safety

High-energy (HE) laser RDT&E will focus on directing increasing levels of power at various types of targets. Existing HE lasers do not perform well in the marine environment, a shortcoming that becomes more pronounced during inclement weather such as fog and rain. Therefore, it is important to test different types of HE lasers using different frequencies and power levels in a variety of weather conditions.

The military has been conducting long-range outdoor laser activities since the 1980s; outdoor laser activities have been taking place at NSF Dahlgren since the 1990s. As a result, the health and safety issues associated with the technology have been extensively studied and procedures have been developed and well-tested to ensure safety.

Before HE lasers are operated outdoors at NSF Dahlgren, the planned activities must comply with OPNAVINST 5100.27/Marine Corps Order 5104.1A *Navy Laser Hazards Control Program.* This OPNAVINST incorporated the industry standard, American National Standards Institute (ANSI) Z136.1, *Safe Use of Lasers*, into its requirements. In addition to OPNAVINST 5100.27, NSWCDD develops RHAs and detailed SOPs for each operation involving the use of HE lasers outdoors. These identify and implement controls to ensure the safety of installation personnel and the public and establish the procedures for review, authorization, and operation of NSWCDD's outdoor HE lasers.

Additionally, the Navy's Laser Safety Review Board (LSRB) provides a systems-safety review of all Navy lasers that are used in combat, in combat training, or are classified in the interest of national security, as well as all HE lasers capable of exceeding Class 3a levels (see Table 2-1). Guidance relating to laser safety on military ranges is contained in MIL-HDBK-828A, *Department of Defense Handbook: Laser Safety on Ranges and in Other Outdoor Areas*, and ANSI Z136.6 (2007). *Safe Use of Lasers Outdoors* also contains guidance and recommended practices.

The LSRB is composed of the Bureau of Medicine and Surgery, which serves as the Administrative Lead Agency, Marine Corps Headquarters, the Naval Safety Center, the Lead Technical Navy Laboratory for lasers, and all systems commands, such as Naval Air Systems Command and Naval Sea Systems Command. The Lead Technical Navy Laboratory for the Navy is NSWCDD, based on its expertise in lasers and laser safety. NSWCDD's head of the Lead Technical Navy Laboratory also is a sitting member on a number of ANSI Z136 subcommittees focused on the safe use of lasers. All high energy laser outdoor activities must be approved by the Navy's LSRB and NSWCDD's Laser System Safety Officer.

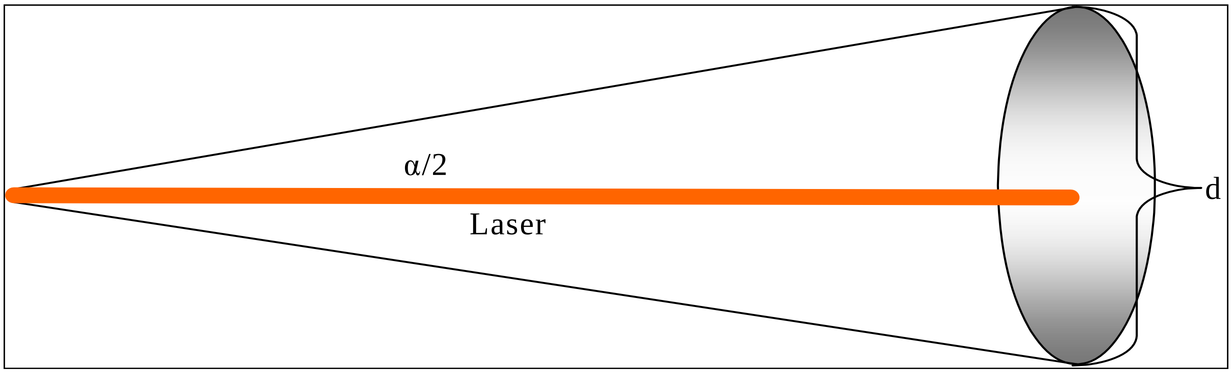
All laser activities must follow a comprehensive SOP/RHA process that includes validation of the process. The purpose of an RHA is to carefully examine what could cause harm to people or material during an operation and decide on what actions are needed to mitigate the risk to an acceptable level so as to minimize the risk of anyone being injured or becoming ill as well as the risk of damage to material. Steps associated with an RHA are listed in the text box in Section 3.8.1.2.

3.8.4.1 General Laser-Control Measures

General laser-control measures have been established for the protection of personnel, the public, and the environment, including: laser safety analysis as part of the RHA process, SOPs, safety buffer zones, remote viewing and operation, range-control measures (barriers and warning systems), interlock controls, and target backstops. These measures include engineering, administrative, and procedural controls that are currently used by NSWCDD and would apply to the Proposed Action. Some of the key control measures are described below, but additional controls may also be used, depending on the testing needs.

- **Laser Safety Analysis**. A prerequisite prior to each outdoor test is a laser safety analysis that quantifies potential ocular and skin hazards and provides recommendations for avoiding hazards. Written approval from the LSRB for the test is required.
- **Test Plan**. As required by ANSI Z136.1 and ANSI Z136.6 standards, as well as the Navy's own laser protection standard, each laser system and designated laser Class 3 or 4 firing must have a test plan developed and approved. The test plan designates the individual(s) responsible for the safe operation of the laser system, the specific control measures employed to minimize unintended exposures, the conditions under which the laser system may be operated, the appropriate personal protective equipment for operators, and the specific nominal ocular hazard distance (NOHD) and nominal hazard zone (NHZ). Each test plan for outdoor activities must be submitted to NSWCDD's Laser System Safety Officer for approval; only after approval may the laser test be conducted. Test plans require laser safety training as well as medical surveillance for the operators to ensure their health and safety.
- **Laser Safety Buffer Zone (Laser Hazard Cone)**. Range control measures include use of safety zones, from which personnel and wildlife are excluded during activities. In accordance with laser range operational procedures, horizontal and vertical buffer zones are established prior to lasing activities. The laser safety buffer zone (or laser hazard cone), shown in Figure 3.8-4 (Laser Safety Buffer Zone) is the combined area of the calculated NOHD and the NHZ. The NOHD is the distance along the axis of the direct laser beam to the human eye beyond which the maximum permissible exposure (MPE) of the laser is not exceeded. The NHZ is the area where direct, reflected, or scattered laser emissions exceed established MPE limits during normal operations. MPEs are set at levels below known hazardous levels. For instance, the MPE for NOHD is based on a power density – the power of the laser beam at a given distance from its source (since its energy dissipates over distance) – of only 10 percent of the power necessary to potentially cause permanent eye damage.
- **Administrative Controls**. Access to the laser operational area is restricted to authorized and properly-trained personnel, which reduces the possibility of inadvertent exposure to laser radiation. Prior to any outdoor lasing activities, and in accordance with laser SOPs, the operational area is swept to clear all unauthorized personnel as well as all materials with reflective surfaces to minimize reflective hazards. Spotters are positioned to look for wildlife. Laser activities are stopped if wildlife gets close to the operational buffer zone. Signage indicating a laser controlled area is posted in accordance with ANSI Z136.1 specifications for the operation of Class 4 lasers. Additional administrative controls are outlined in ANSI Z136.1, *Safe Use of Lasers*, which has been adopted by the DoD as the governing standard for laser safety.

Figure 3.8-4
Laser Safety Buffer Zone



- **Barriers and Warning Systems**. Barriers are erected before activities to exclude personnel from the laser controlled area. Various types of warning systems, such as warning lights (flashing siren and light), audible sirens, and alarms, are initiated prior to operations to alert personnel of the pending laser operation.
- **Remote Operation**. Personnel may operate laser systems from remote locations when safety procedures require that personnel be a safe distance from the operating laser systems. The laser system is connected to a computer system, allowing the operators and technicians to monitor its operation and measurement instruments in a safe manner. The NOHD and NHZ are determined for each laser system to ensure that the operators, as well as other personnel and the general public, are located beyond the distances where skin or ocular hazards are present, including those attributable to both the diffuse reflection and specular reflection (as from a highly reflective surface, such as a mirror) of laser energy.
- **Laser Safety Interlock Controls**. Safety interlocks work through an instantaneous feedback loop to cut off the power to an emitting laser if a single mechanical or electrical component fails or if the laser beam strays from the anticipated beam path. For example, lower-power beams are initially used to validate that the center of the intended target is being illuminated when fired upon. Validation is accomplished by calorimeter sensors placed around the intended aim point of the target. The sensors detect the position of the narrow laser beam by fractions of an inch relative to the center of the aim point. The laser beam is then intentionally made to drift off target to check the sensors. If the laser beam veers off the intended path, the beam will heat up the calorimeter sensors, which will in turn send a signal that the laser is off-target and instantaneously turn off the power to the laser. Another safety interlock example is a system that must be engaged to allow power to flow to the laser system, such as a magnetic connection between a closed door and the door frame leading into the area where the laser system is operated. If this door is opened, then electrical power is disconnected from the system and the laser system cannot operate.
- **Laser Backstops.** A laser beam is composed of light, which, if it encounters no obstacle, can continue traveling in a straight line to infinity. To prevent any chance of a laser beam's traveling farther than required, NSWCDD uses a backstop made of a material that

captures most of the light energy that might otherwise pass by the target or be reflected by it. The size of the backstop used is dependent on a number of variables, including the energy of the laser being tested. To minimize reflected laser energy at the target/backstop, all materials and objects associated with the target – for example, a stand holding it in place – are painted with or composed of light-absorbing materials so that light is not reflected out of the target area.

3.8.4.2 Non-Beam Control Measures

Potential non-beam hazards associated with the use of HE lasers, along with the health and safety measures in place to minimize these hazards, are described below.

- **Electrical Accidents.** Operators of the laser systems have many controls in place, including electrical interlocks, ground fault circuit interrupters, proper grounding, and SOPs outlining how to operate the system to minimize the possibility of electrical shock accidents.
- **Fire Hazard.** The irradiation of targets by an HE laser beam can cause the target to catch on fire; however, the target boards and rotoplane target boards (windmill-like devices) are constructed of flame-retardant materials, as defined by the National Fire Protection Association (NFPA), to minimize the potential fire hazard. Furthermore, the control of the beam path and target area minimizes the potential for any fires to spread beyond the immediate target area or range boundary.
- **Laser-generated Air Contaminants (LGACs).** Air contaminants may be generated when certain Class 4 laser beams interact with matter such as plastics, composites, metals, and tissues (ANSI, 2007). For this reason, target areas are cleared of debris prior to operations. NSWCDD ensures that appropriate industrial hygiene characterizations of exposure to LGACs take place in accordance with 29 CFR § 1910.1000, *Air Contaminants* and Air Force Office of Safety and Health Standard 48-8, *Controlling Exposures to Hazardous Material*s, and limits the exposure of personnel to LGACs.
- **Collateral Electromagnetic Radiation.** Potential collateral EM radiation, or broad-band black-body radiation (i.e., ultraviolet or blue light), produced as a result of air breakdown at the laser/target interface does not present an immediate hazard to personnel, because no personnel will be close to the target impact area. Once lasing activities stop, all collateral radiation (if any) ceases and no residual collateral radiation remains.

3.8.5 Chemical and Biological Simulant Activities Safety

As described in Chapter 2, chemical and biological agent detectors enable early warning of threats to provide protection for military personnel and civilians. The exposure of military personnel or the public to even small amounts of real contaminants, such as nerve or blistering agents, or harmful biological organisms, such as anthrax, is not legal in most countries in the world, including the US. The 1993 Chemical Weapons Convention bans the use of chemical weapons; unlike the 1925 Geneva Protocol, it also bans their development, production, stockpiling, and transfer and it requires that all existing stocks of chemical weapons be destroyed within 10 years. The US signed the Chemical Weapons Convention on January 13, 1993 and ratified it on April 25, 1997. Therefore, DoD scientists have searched for relatively harmless compounds (simulants) that can simulate the effects of dangerous chemical and biological agents without irritating or injuring personnel involved in testing detectors or harming the environment.

Substitute materials must have one or more characteristics – size, density, and/or aerosol behavior – similar to those of real chemical agents so they can effectively mimic them, and they must also carry minimum risk to human health and the environment so that they can be used safely in outdoor tests. After evaluating simulant materials, NSWCDD's research group recommends proposed test simulants to the Safety and Environmental Office for approval. The criteria for selection include:

- **Potential safety and environmental issues related to the simulants' use**. The simulants selected are relatively benign (i.e., low toxicity or effects potential) from a human health, safety, and environmental perspective. Many simulants are present naturally in the environment. Exposure levels during activities would be well below concentrations associated with any adverse effects. The degradation products of the chemical simulants are also considered to be harmless.
- **The spectral location of the absorbance peaks.** The spectral absorbance peaks for the chemicals should be within a certain range of the spectral absorbance peaks of the warfare agents they are intended to mimic, in order to assess the capacity of infrared sensor detectors to absorb spectral peaks within these ranges.

Because of the need for early detection of chemical agents, testing is designed to detect simulants at very low levels – levels well below quantities that could present risks to human health and the environment. Vapor releases would take place within the boundaries of the ranges and Mission Area so that vapor clouds would disperse before reaching the boundaries of the ranges or Mission Area, as determined by modeling and by monitoring weather conditions just prior to the test. Simulant vapor tests are designed to minimize deposition on land and water areas.

As described in Section 2.5.4, chemical simulants approved for use in NSWCDD's past indoor or outdoor RDT&E activities include methyl salicylate (MeS), polyethylene glycol (PEG 200), sulfur hexafluoride (SF_6), triethyl phosphate (TEP), glacial acetic acid (GAA), dipropylene glycol methyl ether (DPGME), dimethyl methylphosphonate (DMMP), diethyl malonate (DEM), diethyl phthalate (DEP), dimethyl adipate (DMA), and diethyl ethyl phosphonate (DEEP). PEG 200, MeS, $SF_{6,}$ TEP, and GAA have been used as simulants outdoors by NSWCDD, while the remaining six simulants (DPGME, DMMP, DEM, DEP, DMA, and DEEP) have only been used indoors. Future outdoor tests might use any of these simulants, or other ones with similar or lower toxicities. Prior to use, all simulants would be reviewed and approved by the NSWCDD Safety and Environmental Office in consultation with NSF Dahlgren personnel, as applicable, and would be approved only after considering toxicity data relative to the intended quantity and concentration of the simulant to be used.

3.8.5.1 Chemical Simulants

Some physical properties of the eleven previously-approved chemical simulants used by NSWCDD are summarized in Table 3.8-3. Most of these benign chemical compounds are commonly found in household products and in industry, as outlined in Table 3.8-4. The lowest published lethal dose or concentration for each of these simulants is provided in Table 3.8-5. A general description of each simulant, inclusive of toxicity data, is provided below. These descriptions are based on studies that are often performed with very high concentrations of a compound over an extended period of time. In contrast, NSWCDD's activities would involve the use of much lower chemical concentrations, with an approximate frequency of one to two test periods of about two weeks per year, each with a maximum of 20 releases. Toxicity data are presented here to provide a better understanding of each compound rather than as a basis for comparative exposures. Chapter 4 provides estimates of the concentrations of each compound that would be released during activities, associated exposure concentrations, and comparisons to safety limits.

The three gases listed, SF_6, 1,1,1,2-tetrafluoroethane (R-134), and 1,1-difluoroethane (R-152a), could be used for the calibration of sensors. The use of SF_6 is being phased out because of its high global warming potential (USEPA, 2006). Only R-134 and R-152 were used in most of the tests performed in July 2009 (NSWCDL, 2009b) and are included in the SOP prepared for those tests (NSWCDL, 2009a).

Methyl Salicylate (MeS)

MeS is a colorless or pale yellow liquid with a strong characteristic wintergreen odor. It is used as a simulant for blistering agents such as sulfur mustard agents (Seitzinger et al., 1990). It occurs naturally in plants, where it probably developed as an anti-herbivore defense. Some of the plants that produce it are in the wintergreen family (Pyrolaceae), providing it with its common name, oil of wintergreen. Other plants that produce MeS include various species of *Gaultheria* (Ericaceae family) – for example, the eastern teaberry (*Gaultheria procumbens*) – and some birches (Betulaceae family), such as the sweet birch (*Betula lenta)*. A recent study by Karl et al. (2008) found that levels of methyl salicylate emissions in forest plants increased dramatically when the plants, which were already stressed by a local drought, experienced unseasonably cool nighttime temperatures followed by large daytime temperature increases. Instruments mounted on towers about 100 ft above the ground measured up to 0.025 milligrams (mg) of methyl salicylate rising from each square ft of forest per hour. The study speculated that the methyl salicylate stimulates plants to begin a process analogous to an immune response in an animal and may also alert neighboring plants to threats.

MeS has been commonly used as an ingredient in liniments or balms applied to the skin to relieve pain associated with lumbago, sciatica, and rheumatic conditions by people of many cultures, including those of China and pre-Columbian North America.

Table 3.8-3
Physical Properties of Chemical Simulants

Simulant Name	Physical State @ 20 °C	Odor	Mol. Weight[1] (g/mole)	Boiling Point °C	Melting Point °C	Specific Gravity[2]	Vapor Density (g/cm^3)[3]	Solubility in Water
Methyl Salicylate (MeS) $HOC_6H_4COOCH_3$	Liquid	Strong	152.14	223	-8.6	1.184	5.24	Slightly soluble
Polyethylene glycol (PEG 200) $(C_2H_4O)nH_2O$	Liquid	Slight	190-210	250	-50	1.125	↓with increase in MW (1.12-1.13)	Soluble
Dimethyl Methylphosphonate (DMMP) $C_3H_9O_3P$	Liquid	Slight	124.08	181	62	1.15-1.174	NA	Soluble
Diethyl Malonate (DEM) $C_7H_{12}0_4$	Liquid	Aromatic-like	160.17	199	-50	1.055	5.52	Partially soluble
Triethyl Phosphate (TEP) $C_6H_{15}O_4P$	Liquid	Ester-like	182.16	215	-56	1.072	6.28	Soluble
Glacial Acetic Acid, (GAA) $C_2H_4O_2$	Liquid	Strong	60.05	118	16.06	1.049	2.07	Partially soluble
Sulfur Hexafluoride (SF_6)	Gas	None	146.05	-63.9	-50.8	NA	5.10	Low solubility
1,1,1,2-Tetrafluoroethane (R-134) $C_2H_2F_4$	Gas/cryogenic liquid	Ether-like	102.03	-26	-101	NA	3.50	Insoluble
1,1-Difluoroethane (R-152a) $F_2HC\text{-}CH_3$	Gas	Slight ether-like	66.05	-25	-117	0.95	NA	Slightly soluble
Diethyl phthalate (DEP) $C_{12}H_{14}O_4$	Liquid	Slight aromatic-like	222.4	295	-40	1.12	7.66	Very low solubility
Dimethyl adipate (DMA) $C_8H_{14}O_4$	Liquid	Mild	174.2	115	10.3	1.063	NA	Slightly soluble
Dipropylene glycol methyl ether (DPGME) $C_7H_{16}O_3$	Liquid	Mild ether-like	148.2	190	-80	0.951	5.11	Soluble
Diethyl ethyl phosphonate (DEEP) $C_6H_{15}O_3P$	Liquid	Mild	166.16	198	180-181	1.0259	NA	Slightly soluble

Notes:
1. Mol. Weight = molecular weight
2. Specific gravity of water = 1
3. Vapor density of air =1

Sources:
Toxicology Data Network (2008) and NOAA (2009).

Table 3.8-4
Common Household and Industrial Uses of Chemical Simulants

Methyl Salicylate (MeS) (Oil of Wintergreen): Used in household products such as Ben Gay, tiger balm, Listerine, toilet cleaners (Clinging Bowl, Lime A Way), Bioganic lawn and garden spray, Nilodor pet products (shampoo, cleaner, cat box additive), and Four Paws pet dental liquid tartar remover for dogs.
Polyethylene glycol (PEG 200): Used as basis of laxatives (e.g. GoLYTELY, GlycoLax, Fortrans, TriLyte, Colyte. MiraLax or GlycoLax). It is the basis of many skin creams and sexual lubricants, frequently combined with glycerin. Whole bowel irrigation (polyethylene glycol with added electrolytes) is used for bowel preparation before surgery or colonoscopy and drug overdoses. It is also used in a number of toothpastes as a dispersant, is under investigation for use in body armor and tattoos to monitor diabetes, and is commonly used in the laboratory for a variety of purposes.
Dimethyl methylphosphonate (DMMP): Major uses are industrial in heavy metal extraction and solvent separation; pre-ignition additive for gasoline; defoamer; plasticizer & stabilizer; textile conditioner & antistatic substance; additive in solvents & low temp hydraulic fluids.
Diethyl Malonate (DEM): Occurs naturally in grapes and strawberries as a colorless liquid with an apple-like odor, and is used in perfumes. It is also used to synthesize other compounds, such as barbiturates, artificial flavorings, Vitamin B1, and Vitamin B6.
Triethyl Phosphate (TEP): Primarily used as an industrial catalyst, a polymer resin modifier, and a plasticizer (e.g., for unsaturated polyesters). Secondarily used as a solvent, flame retardant, an intermediate for pesticides and other chemicals, and a stabilizer for peroxides.
Glacial Acetic Acid (GAA): This is the compound that gives vinegar its sour taste and pungent smell. Used in household products such as sealants, waterproofing, adhesives (silicone adhesive sealant clear, Loctite Stick With It; Radio Shack Silicone Adhesive Sealant, Dow Corning Aquarium Sealant, Nikwax Polar Proof Wash-In Waterproofing), window and floor cleaners (Earth Friendly window kleener and floor kleener; Pledge Grab It Vinegar Wet Floor Wipes), personal care (Grecian Formula 16, Liquid with Conditioner). It is also used industrially in the production of soft drink bottles, photographic film, and wood glue, as well as synthetic fibers and fabrics.
Sulfur Hexafluoride (SF_6): Used in industry as a gaseous insulating material (electrical equipment, radar wave guides) and semiconductors (dry/plasma etching). There is also limited use in special applications ranging from medical applications to space research.
1,1,1,2-Tetrafluoroethane (R-134): Primarily used as a high-temperature refrigerant for domestic refrigeration and automobile air conditioners. Other uses include plastic foam blowing, cleaning solvent, propellant for the delivery of pharmaceuticals, gas dusters (usually used to clean or dust delicate or sensitive items such as electronic components and computer equipment), and removing the moisture from compressed air. Production currently exceeds 1 million pounds annually in the US.
1,1-Difluoroethane (R-152a): Used as a refrigerant, an aerosol propellant, and in electronic cleaning products.
Diethyl phthalate (DEP): A plasticizer that is widely used in tools, automotive parts, toothbrushes, food packaging, cosmetics and insecticides.
Dimethyl adipate (DMA): Used commonly in paint-stripping formulations for home maintenance (Klean Strip Easy Liquid Sander, Parr Paint and Resin Removing Hand Cleaner, Parks Pro Stripper II Liquid Paint Stripper, Parr Painters Clean Hand Cleaner) and also in auto products (Sprayway Industrial Strength Cleaner Wipes). DBE blends are also used in the coating industry to clean up polyurethane adhesives, polyurethane foams, and unsaturated polyester resins. It is also used as a chemical intermediate and as a plasticizer in the production of paper and cellulose resins.
Dipropylene glycol methyl ether (DPGME): Used in the manufacture of a wide variety of industrial and commercial products, including household maintenance products such as paints, varnishes, inks, and cleaners (Parks Adhesive Remover, Parks Aluminum Siding Cleaner, DIF Wallpaper Stripper, Custom Grout Colorant, Aqua Mix Protective Gloss Finis, AFM Safecoat Polyureseal BP Gloss, AFM Safecoat MexeSeal Interior, Exterior, Sherwin-Williams Wood Classics Interior Waterborne Polyurethane Varnish, Gloss, Sherwin-Williams Armorseal Tread Plex Water Based Acrylic Floor Coating, StoneTech Stone and Tile Cleaner, Ready-to-Use, Wet Look Grout Sealer, Fletco Elite Diamond Finish Gloss, Parks Pro Liquid Paint Stripper, Zinsser Shieldz Prewallcovering Primer, Custom Epoxy Haze Remover & Degreaser, Sherwin-Williams Woodscapes House Stain Exterior Polyurethane Semi-Transparent, StoneTech Stone and Tile Cleaner Wipes). It is also used as component of pet care and pesticide products (Enforcer Flea Spray for Homes, Ortho Dursban Ready-Spray Outdoor Flea & Tick Killer, Ortho Dursban Lawn Insect Spray 1, Nilodor Air Freshener-Floral, and Nilodor Kennel Wash).
Diethyl ethyl phosphonate (DEEP): Used as a gasoline additive; also used in heavy-metal extraction, as a defoamer, plasticizer and antistatic substance.
Sources: Household Products Database, National Library of Medicine, 2010; Hazardous Substances Data Bank [HSBD], 2008a,2008b, 2008c, 2008d, 2008e, 2009; Wikipedia, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2008g; Chemicalland21, 2008; USCPSC, 1994; Oxford University, 2008a.

Table 3.8-5
Lowest Published Toxicity of Chemical Simulants Approved for Use Previously by NSWCDD

Simulant Name	Exposure Route	Toxicity*		Species
Methyl salicylate (MeS)	Ingestion	LD50	700-1,500 mg/kg	Guinea Pig
Polyethylene glycol (PEG 200)	Ingestion	LD50	1,400 mg/kg	Rabbit
Dimethyl methylphosphonate (DMMP)	Ingestion	LD50	8,210 mg/kg	Rat
Diethyl malonate (DEM)	Ingestion	LD50	14.9 ml/kg	Rat
Triethyl phosphate (TEP)	Inhalation	LD50	28,000 ppm/6H (28,000 ppm)	Rat
Glacial acetic acid (GAA)	Inhalation	LC50	5,360 ppm/1H	Mouse
Sulfur Hexafluoride (SF_6)[1]	Intravenous	LD50	5,790 mg/kg	Rabbit
1,1,1,2-Tetrafluoroethane (R-134)	Inhalation	LC50	1,500 g/kg	Rat
1,1-Difluoroethane (R-152a)	Inhalation	NOAEL	67,485 mg/m^3 (25,000 ppm)	Rat
Diethyl phthalate (DEP)	Ingestion	LD50	1,000 mg/kg	Rabbit
Dimethyl adipate (DMA)	Intraperitoneal	LD50	1.8 ml/kg	Rat
Dipropylene glycol methyl ether (DPGME)	Ingestion	LD50	5.4 ml/kg	Rat
Diethyl ethyl phosphonate (DEEP)	Ingestion	LD50	2,330 mg/kg	Rat

Notes: LCLo – lowest published lethal concentration
LD50 – lethal dose resulting in 50 percent mortality
NOAEL – no-observed-adverse-effect level
[1]- Non-toxic in small amounts; otherwise like other dense odorless gases it may present a risk of suffocation.
NA – Not Available
Source: HSDB, 2008a, 2008b, 2008c, 2008d, 2008e, 2009, 2011a, 2011b.

In very small quantities, MeS is used as a flavoring in products, including chewing gum, baked goods, syrups, candy, non-alcoholic beverages (birch beer, for example) and ice cream (Hazardous Substances Data Bank [HSDB], 2008a). It is also used as a fragrance to mask other odors in products such as toilet cleaners and pesticides.

MeS has a half-life of about 1.4 days due to its reaction with photochemically-produced hydroxyl radicals (Meylan and Howard, 1993). It is slightly soluble in water, with lowest solubility of 0.11 percent at an acid concentration of 62 percent acid and increasing in solubility at concentrations both above and below this value (Rubel, 1989).

MeS belongs to the salicylate group of analgesics (painkillers) that are derivatives of salicylic acid (such as aspirin). Salicylates are considered to be relatively safe drugs, but normal doses can cause gastrointestinal disturbances in sensitive patients and large doses can be toxic or fatal, especially to children (Columbia Encyclopedia, 2011). One teaspoon or 5 milliliters (ml) of MeS contains 7,000 mg of salicylate, equivalent to 21 aspirin tablets, and a dose as low as 4 ml (4.7 grams [g]) may be fatal in children (Gilman et al., 1990). The lethal dose of MeS for children is 10 ml, and, for adults, 30 ml, which is equivalent to a dose of about 0.5 grams per kilogram (g/kg), assuming an average weight of 132 lbs (Clayton and Clayton, 1982).

Ingestion of salicylates at high doses produces toxic symptoms such as tinnitus (ringing in the ears), nausea, and vomiting (HSDB, 2008a). The lethal single dose of MeS administered orally required to kill 50 percent of the test animals exposed, known as the LD50 (see text box), ranges from 890 milligrams per kilogram (mg/kg) for rats to 2,800 mg/kg for rabbits (Clayton and Clayton, 1982). The LD50 for dermal exposure is 70,000 mg/kg for guinea pigs (Clayton and Clayton, 1982). The biological half-life for MeS is 2 to 3 hours when given in low doses, about 12 hours at doses used for anti-inflammatory purposes, and up to 15 to 30 hours at high therapeutic doses or when there is intoxication (Gilman et al., 1990).

Toxicological Terms

LD50/Lethal Dose: The dose of a toxicant (generally oral or dermal) that will kill 50 percent of the test organisms within a designated period. The lower the LD50, the more toxic the compound. For example, the LD50 of salt (sodium chloride) for rats is 3,000 mg/kg (milligram per kilogram or parts per million [ppm]).

LC50/Lethal Concentration: Median lethal concentration (e.g., in air) needed to kill half of a group of experimental organisms in a given time.

Biological half-life: The time an organism takes to eliminate one half the amount of a compound.

No observed adverse effect level (NOAEL): Exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations.

Lowest observed adverse effect level (LOAEL): The lowest level of a stressor that causes statistically and biologically significant differences in test samples as compared to other samples subjected to no stressor.

Sources: USEPA, 2010; Oxford University, 2008b.

Phillips and Wentsel (1993) examined the acute toxicity of MeS on cucumbers (*Cucumis sativus*) and the red wriggler earthworm (*Eisenia foetida*). They grew cucumbers in soil with six concentrations of MeS – 0 (control), 50, 100, 200, 350, and 500 mg/kg. Sublethal effects on cucumbers were observed at the 350 and 500 mg/kg levels, but the survival rate was 100 percent at all concentrations. Earthworms were exposed to the same six MeS concentrations in soil as were cucumbers. As concentrations of MeS increased, earthworms showed an increasing weight loss and mortality rate. Weight loss was seen beginning at the 100 mg/kg dose level. Earthworm survival rates were 100 percent at the 0 to 200 mg/kg levels, 87 percent at 350 mg/kg, and 0 percent at the 500 mg/kg level, with acute toxicity beginning between 350 and 500 mg/kg.

Occupational Exposure Terms

Time-weighted average (TWA): Average exposure for one individual over a given working period. Typically, 8 hours (hr)/day, 40 hr/week (wk).

Permissible exposure limit (PEL): Established by OSHA. The concentration in air of a substance to which nearly all workers may be repeatedly exposed 8 hrs/day, 40 hr/wk, for 30 years with no adverse effects.

Short-term exposure limit (STEL): A 15-minute TWA exposure that should not be exceeded at any time during the workday. Exposures at these levels are allowed up to 4 times per day with at least 60 minutes between exposures.

Source: American Industrial Hygiene Association, 1999.

Polyethylene glycol (PEG 200)

Polyethylene glycol (PEG) occurs as a clear liquid or as a white semi-solid to solid with a slightly sweet (mild) odor, depending on its molecular weight and ambient temperature. It can be used as one of the components of a chemical simulant for a G-agent (nerve agent) or H-agent (blistering agent) due to its physicochemical properties (US Patent Office, 2003). It is the most commercially important type of polyether (a compound with more than one ether group). Low-molecular PEG is a clear liquid that has many uses, including as a textile auxiliary (chemicals added to protect or increase the flexibility of fibers), as the basis of a number of laxatives, skin creams, tablets, and lubricants, as a dispersant in toothpastes, as a thickener (e.g., in hydraulic fluids), and as a binding substance in making molds for ceramics, casting and powder metallurgy, and to create very high osmotic pressures (tens of atmospheres) in water systems in biochemistry experiments (ChemIndustry, 2008). Other uses include attaching PEG to various protein medications to allow for a slowed clearance of the carried protein from the blood, permitting a longer-acting medicinal effect with reduced toxicity (Caliceti and Veronese, 2003). PEG has been shown to be a strong inhibitor of colon cancer in rats (e.g., Corpet et al., 2000).

Dimethyl Methylphosphonate (DMMP)

Dimethyl methylphosphonate (DMMP) is a colorless gas with a distinct odor. It is used as a simulant for anticholinesterase (nerve) agent (e.g., sarin gas) training exercises and for the calibration of detectors. DMMP is primarily used in industrial settings with applications such as heavy metal extraction; solvent separation; gasoline pre-ignition additive; plasticizer and stabilizer; flame retardant; and as a viscosity depressant in polyester and epoxy resins, among many other applications (Table 3.8-4). The US produces about 0.2 to 2 million lbs of DMMP per year (NTP, 1987). Trade names include Fran TF 2000, Fyron DMMP, Metaran, NSC 62240, and Reoflam DMMP. The estimated half-life in soil ranges from 0.2 to 60 days, with an average of 12.4 days (HSDB, 2008b). The atmospheric vapor phase half-life for DMMP is estimated to be 1.6 months (GEMS, 2007). DMMP is considered for use as a G-agent – the first and oldest series of nerve gases, developed in the 1930s – simulant due to its physicochemical properties (Bartelt-Hunt et al., 2008).

The National Toxicology Program (NTP) performed a series of DMMP toxicity studies on mice and rats consisting of single-administration, 15-day, and 13-week studies to obtain toxicity data, to establish dose levels for two-year studies, and to identify target tissues (NTP, 1987). DMMP was administered orally in corn oil by gavage (force-feeding). In the single-dose studies, rats and mice were given one of six doses – either 0, 1,250, 2,500, 5,000, 10,000, or 15,000 mg/kg DMMP – equivalent to up to 6,810 mg/kg body weight. No compound-related deaths were seen in male or female rats or male mice, but two high-dose female mice died. The acute oral LD50 value is estimated to be greater than 3,000 mg/kg for rats and greater than 6,000 mg/kg for mice (NTP, 1987).

The 15-day study consisted of rats and mice receiving doses of 0, 1,250, 2,500, 5,000, 10,000, or 15,000 mg/kg DMMP per day. Compound-related deaths occurred in the three highest-dose groups of rats and the two highest-dose groups of mice (NTP, 1987).

In the 13-week study, DMMP was given at doses of 0, 250, 500, 1,000, 2,000, or 8,000 mg/kg. Compound-related deaths occurred at 2,000, 4,000, and 8,000 mg/kg in rats and at 4,000 and 8,000 mg/kg in mice (NTP, 1987). Decreased weight gain was seen at doses of 2,000 mg/kg and higher. Reproductive effects were seen in rats dosed with concentrations of up to 2,000 mg/kg DMMP for a 13-week period. Undosed female rats and mice mated with dosed individuals showed an increase in the number of fetal resorptions (NTP, 1987). Histopathologic changes were seen in the kidney and testes of male rats, and decreases in sperm count and sperm motility occurred in male rats but not in male mice. Toxic effects to the reproductive system of male rats and mice were reversible after a 13- to 14-week recovery period (NTP, 1987).

In the two-year studies, rats were dosed with 0, 500, or 1,000 mg/kg DMMP per day and mice were dosed with 0, 1,000, or 2,000 mg/kg per day (NTP, 1987). All animals were dosed five days per week for 103 weeks. There was some evidence of carcinogenic activity, renal toxicity, and decreased survival of male rats fed 1,000 mg/kg DMMP, but no evidence of carcinogenic activity for female rats given doses of 500 or 1,000 mg/kg (NTP, 1987). Renal toxicity and decreased survival occurred in dosed male rats at dose levels of 500 and 1,000 mg/kg (NTP, 1987).

Diethyl Malonate (DEM)

Diethyl malonate is a naturally occurring compound found in grapes and strawberries. It is a colorless liquid with an apple-like odor. DEM is also used to synthesize other compounds, particularly flavors and fragrances (Table 3.8-4). DEM is considered for use as a G-agent simulant due to its physicochemical properties (Bartelt-Hunt et al., 2008).

In a study designed to provide baseline data on the toxicity of DEM to plants, soil microorganisms, and earthworms, it was determined that DEM deposited on soil and leaf surfaces was rapidly lost through volatilization processes, with a half-life of 1 to 3 hours for the short-residence-time component and 16 to 242 hours for the long-residence-time component (Cataldo et al., 1990). Earthworms exposed to soil doses with 0.0107 and 0.0207 mg per m^2 had survival rates of 86 percent and 66 percent, respectively. At higher dose levels, the activity or mobility of the earthworms was affected in more than half the individuals exposed.

Mammalian toxicity information indicates that DEM causes slight irritation to rabbit skin and severe burning to rabbit eyes, but no skin sensitization or skin irritation was induced in human volunteers treated with dilute solutions (BIBRA, 1996). Toxicity information on DEM is limited, but tests on laboratory animals show low acute oral and dermal toxicity (BIBRA, 1996).

Triethyl Phosphate (TEP)

Triethyl phosphate is a colorless liquid with a slight, pleasant or sweetish odor (Lewis, 2001 as cited in HSDB 2008c) that is soluble in most organic solvents, alcohol, and ether, and is completely miscible in water (Lewis, 1999 as cited in HSDB 2008c). It is used primarily in industry, but is also used as a flame retardant (Table 3.8-3). Consumer exposure to triethyl phosphate via inhalation during its use as a flame retardant in plastic materials was calculated to be approximately 0.001 mg/m^3 (NIOSH, 1983 as cited in HSDB 2008c). TEP is considered for use as a G-agent (e.g., Sarin) simulant due to its physicochemical properties (Bartelt-Hunt et al., 2008).

The LD50 for oral ingestion was determined to be 1,600 mg/kg in rats and rabbits and more than 1,500 mg/kg in mice (Bingham et al., 2001 as cited in HSDB 2008c). The dermal LD50 was ascertained to be greater than 21,400 mg/kg in guinea pigs (United Nations Environmental Program [UNEP], 1998) and greater than 20,000 mg/kg in rabbits (Bingham et al., 2001 as cited in HSDB 2008c). Exposure of rats via inhalation resulted in an LD50 greater than 8,817 mg/m^3 for a 4-hour exposure with a no-observed-adverse-effect level (NOAEL) of 1,400 mg/m^3 (UNEP, 1998).

In subchronic studies on rats, TEP was determined to have low toxicity with no serious damage in oral doses up to 6,700 mg/kg body weight. The NOAEL in the most relevant tests was 1,000 mg/kg body weight per day (UNEP, 1998). When reproductive effects in rats were examined, a NOAEL of 335 mg/kg body weight per day was determined, based on effects on litter size (UNEP, 1998).

In a 14-day toxicity test on the red wiggler earthworm (*Eisenia foetida*), the only noticeable effect from the *highest* exposure concentration of 1,000 mg/kg was a slight hardening of the earthworms at the end of the study (UNEP, 1998). Studies were also conducted to determine the phytotoxicity of TEP using sorghum-sudangrass (*Sorghum bicolor*), tomato (*Lycopersicon lycopersicum*), and glossy privet (*Ligustrum lucidum*). Triethyl phosphate was applied to sod and foliar tissue at rates of 0, 4, 400, and 40,000 mg/m^2 and was also applied in a thickened formulation at an application rate of 40,000 mg/m^2 on both soil and foliar tissue. Toxicity was observed only at the highest application rate of 40,000 mg/m^2 and the absence of phytotoxicity symptoms indicated no adverse effects to plants at application rates of 400 mg/m^2 or lower (Sikora et al., 1994).

In aquatic systems, LD50s ranged from more than 100 to 2,140 mg/kg for fish and from more than 100 to 2,705 mg per liter (mg/L) for invertebrates in tests ranging from 48 to 96 hours (UNEP, 1998). In a subchronic 21-day test, the concentration at which half the test individuals showed effects, known as the Effective Concentration 50 (EC50), for the water flea *Daphnia magna* was 729 mg/L (Verschueren, 2001). The bioconcentration potential of TEP in aquatic organisms is considered to be low (HSDB, 2008c).

TEP is considered to be moderately toxic, with a probable oral lethal dose to humans of between 500 to 5,000 mg/kg, which equates to between 1 ounce [oz] and 16 oz for a 150-pound individual (Gosselin et al., 1984).

Glacial Acetic Acid (GAA)

Glacial acetic acid is a colorless liquid that gives vinegar its sour taste and pungent smell. It is highly soluble in water. It is a weak acid that is used both in industry and in the house (Table 3.8-4). Acetic acid-producing bacteria are ubiquitous throughout the world and have been widely used throughout history. In the third century BC, the Greek philosopher Theophrastos described using vinegar on metals to produce pigments. The worldwide production of acetic acid is estimated at 5 million tons per year, about half of which is produced in the US. Glacial acetic acid is an excellent polar protic solvent – a solvent with a dissociable H^+ – and pure acetic acid is used in the production of terephthalic acid, the raw material for polyethylene terephthalate (PET), which is widely used to make drink, food, and other containers. It is used as a simulant for the second series of nerve agents, the V-agents.

The National Institute for Occupational Safety and Health (NIOSH) estimated in a survey performed from 1981 to 1983 that more than 900,000 workers are potentially exposed to acetic acid in the US (NIOSH, 1983 as cited in HSDB 2008d). Occupational exposure may occur through inhalation and dermal contact at workplaces where acetic acid is produced or used. Acetic acid occurs throughout the environment and is a normal metabolite in animals, hence people are continually exposed to low concentrations of it through the ingestion of food and the inhalation of air (HSDB, 2008d). Acetic acid is absorbed from the gastrointestinal tract and through the lungs and is almost completely oxidized by tissues (World Health Organization [WHO], 1967).

As an acid, a splash of vinegar (4 to 10 percent acetic acid solution) in the human eye causes immediate pain and redness, sometimes with injury of the corneal epithelium (Mackison et al., 1981 as cited in HSDB 2008d). Repeated or prolonged contact with the skin may cause dermatitis. Acetic acid vapor is irritating to the eyes and nose, causing tears and reddening (hyperemia) (HSDB 2008d).

Individuals with chronic respiratory, skin, or eye disease are at increased risk from acetic acid exposure (Mackison et al., 1981 as cited in HSDB 2008d). Application of a 10-percent acetic acid solution to intact or abraded skin patches did not produce any effect in guinea pigs or rabbits, but concentration of 50 percent produced mild injuries, from 50 to 80 percent produced moderate to severe burns, and above 80 percent produced severe burns (Bingham et al., 2001 as cited in HSDB 2008d). Ingestion of acetic acid may also irritate the gastrointestinal tract, resulting in digestive disorders, including pyrosis (heartburn) and constipation.

LD50s for ingestion of GAA range from 1,200 mg/kg for rabbits over a 6-day exposure period to 4,960 mg/kg for mice (WHO, 1967). The LD50 for dermal exposure of rabbits was determined to be 1,060 mg/kg (Lewis, 1999 as cited in HSDB, 2008d). LC50s for inhalation exposure are between 5,620 mg/L for mice 11,400 mg/L for rats (USEPA, 2003).

High concentrations of acetic acid are harmful to aquatic life due to decreased pH levels that are toxic to oxidizing bacteria, inhibiting oxygen demand (Environment Canada, 1981). The survival rate of mosquito fish (*Gambusia affinis*) exposed to acetic acid at concentrations of up to 100 mg/L for 96 hours was 100 percent, but at concentrations of 320 mg/L and higher the survival rate fell to 0 percent within 24 hours (USEPA, 2003). The LC50 for fathead minnows (*Pimephales promelas*) was greater than 315 mg/L for a 1-hour exposure, but decreased to 88 mg/L for a 96-hour exposure (Verschueren, 2001).

Sulfur Hexafluoride (SF_6)

Sulfur hexafluoride is a colorless, odorless gas. It is soluble in potassium hydroxide and alcohol, but has a low solubility in water. It is primarily used in industry as a gaseous electrical insulating material and for the production of semiconductors (dry/plasma etching) (Table 3.8-4).

As with other gases, direct exposure to large concentrations could cause asphyxiation as a result of the displacement of oxygen (ACGIH, 1994). However, ordinarily SF_6 does not exist in a pure state (Sittig, 2002). The degeneration products of SF_6 (e.g., sulfur tetrafluoride) can be toxic, causing nose and ear irritation, nausea and vomiting, coughing, shortening of the breath, tightness of the chest, and pulmonary edema. Sulfur hexafluoride (known as Sonovue) is used (via injection) in echocardiography, but is contraindicated for patients with hypersensitivity to sulfur hexafluoride or pre-existing cardiac conditions and is not recommended for pregnant or lactating women, as its safety and effectiveness has not been established (European Medicines Agency, 2004).

Acute exposure of 50 rats to an 80 percent SF_6 atmosphere for periods from 16 to 24 hours showed no effects and the acute toxicity potential of SF_6 is probably very low (HSDB, 2011a).

The estimated bioconcentration factor (BCF) suggests the potential for bioconcentration in aquatic organisms is low (HSDB, 2011a).

1,1,1,2-Tetraflouroethane (R-134)

1,1,1,2-Tetraflouroethane (R-134) is an inert colorless, odorless gas used primarily as a high-temperature refrigerant for refrigeration and automobile air conditioners (Table 3.8-4). Trade names include tetrafluoroethane, R-134a, Genetron 134a, Freon 134a and HFC-134a. It began to be used in the 1990s to replace dichlorodifluorometane (Freon-12), which was banned in the US and other countries in 1994 because of its ozone depleting properties.

R-134 exhibits relatively low toxicity in animals (WHO/International Program on Chemical Safety [IPCS], 1998), with a four-hour (acute toxicity) lethal concentration of 567,000 ppm (2.36 × 106 mg/m^3) reported for rats and no effects observed at 81,000 ppm (337,770 mg/m^3) (WHO/IPCS, 1998). At concentrations in excess of 200,000 ppm (834,000 mg/m^3), exposure to 1,1,1,2-tetrafluoroethane depressed the central nervous system of rats (WHO/IPCS, 1998).

A study examining delayed fetal development in rats following chronic exposure to R-134 found delayed fetal development following exposure of females to 50,000 ppm (208,500 mg/m^3), but no effects were seen at exposure at 10,000 ppm (41 700 mg/m^3) (Hodge et al., 1980 as cited in WHO/IPCS, 1998). No exposure-related neoplastic (abnormal growth) or non-neoplastic effects were observed in two-year inhalation studies (one-hour daily nose-only exposure) at R-134 concentrations up to 50,000 ppm (208,500 mg/m^3) in rats and up to 75,000 ppm (312,750 mg/m^3) in mice (Alexander et al., 1995a) or in a similarly designed one-year study in which dogs were exposed to 120,000 ppm (500,400 mg/m^3) (Alexander et al., 1995b).

In aquatic systems, R-134 has shown low toxicity for the few organisms it has been tested on. It also has a low estimated half-life for volatilization from a river of about three hours (HSDB, 2008e). The low toxicity and high volatility indicate negligible risk to aquatic organisms (WHO/IPCS, 1998). In addition, low estimated bioconcentration indicates that 1,1,1,2-tetrafluoroethane will not bioconcentrate in fish and aquatic organisms (Lyman et al., 1982 as cited in HSDB, 2008e).

A health-based occupational exposure limit for 1,1,1,2-tetrafluoroethane of 1,000 ppm (4,170 mg/m^3) (eight hour time-weighted average) is in effect within the US and the United Kingdom UK based on the NOAEL of 10,000 ppm (41,700 mg/m^3) determined for the Hodge et al. (1980) chronic study on rats divided by an uncertainty factor of 10 (WHO/IPCS, 1998; American Industrial Hygiene Association, 1999).

1,1-Difluoroethane (R-152a)

1,1-Diflouroethane (R-152a) is an inert colorless, odorless gas used primarily as a high-temperature refrigerant for refrigeration and air conditioners and as an aerosol propellant (Table 3.8-4). It is also known as Freon 152a, Genetron 152, and HCFC-152a. R-152a is recommended as an alternative refrigerant to R-134, as it has a lower global warming potential (USEPA, 2008).

A two-year inhalation study on rats was used to evaluate the toxicity of R-152a, where rats were exposed to 0, 2,000, 10,000, or 25,000 ppm 1,1- difluoroethane (equal to 0, 5399, 26,994, or 67,485 mg/m^3, respectively) (McAlack and Schneider, 1982 as cited in Integrated Risk Information System [IRIS], 2009). The 25,000 ppm concentration was designated as a chronic NOAEL, as no significant respiratory, mortality, metabolic, or other effects were observed.

Exposure to higher concentrations of R-152a in an acute study indicates that is practically nontoxic. Male albino rats exposed to 74,000, 100,000, or 200,000 ppm R-152a for two hours

(Limperos and Zapp, 1951 as cited in IRIS 2009) showed no mortality and the most pronounced effect of acute or sub-acute exposures to R-152a was reversible central nervous system depression observed at high concentrations (100,000 ppm or greater). This central nervous system effect was not observed at any of the concentrations tested in the critical study of chronic duration. The findings of other studies where rats were exposed to up to 100,000 ppm of R-152a were consistent with the Limperos and Zapp (1951) study (IRIS, 2009).

Diethyl Phthalate (DEP)

Diethyl phthalate (DEP) is an odorless oily liquid that is commonly used in plastic products, such as toothbrushes, automobile parts, tools, toys, and food packaging in order to make them more flexible, as well as in cosmetics, insecticides, and aspirin (Table 3.8-4; Agency for Toxic Substances and Disease Registry [ATSDR], 1995). Because it is not a part of the chain of chemicals (polymers) that makes up the plastics, it can be released fairly easily from these products. It has a similar octanol-water coefficient[5] (K_{ow}) to VX (S-[2-(di-isopropylamino)ethyl]-O-ethyl methylphosphonothioate), an extremely toxic substance that is used a nerve agent (V-agent) (Bartelt-Hunt et al., 2008).

DEP has caused death in animals when given in very high oral doses, but brief ingestion of lower doses caused no harmful effects (ATSDR, 1995). Based on a study by Brown et al. (1978), the USEPA derived a NOAEL for DEP of 1 percent of the diet (750 mg/kg-day) and a LOAEL of 5 percent of the diet (3,160 mg/kg-day) (IRIS, 2008). In the Brown et al. study, groups of rats were fed diets containing 0, 0.2, 1.0, or 5.0 percent DEP for 16 weeks. There was significantly less weight gain and associated food consumption in both male and female rats fed 5 percent DEP and in females fed 1 percent DEP. No changes in behavior or other clinical signs of toxicity were observed. The livers and kidneys of animals fed 5 percent DEP were larger than normal, but not from any harmful effect that could be directly attributed to DEP (ATSDR, 1995). DEP is not known to cause cancer in humans or animals (ATSDR, 1995; IRIS, 2008).

Dimethyl Adipate (DMA)

Dimethyl adipate (DMA) is a colorless liquid. Its blends are used in the coating industry to clean up polyurethane adhesives, polyurethane foams, and unsaturated polyester resins (Table 3.8-3). DMA is part of a dibasic ester (DBE) blend that is used as a major ingredient in several paint strippers. The DMA content in DBE blends varies from about 15 to 90 percent. The other components of the DBE blends are dimethyl glutarate and dimethyl succinate. The most popular DBE blends used in paint stripping formulations contain about 90 percent DMA, with most of the final DBE content in consumer paint strippers ranging from about 20 to 50 percent (NTP, 1994). DMA is also used as a chemical intermediate and as a plasticizer in the production of paper and cellulose resins (USCPSC, 1994). It is a potential simulant of the blister agent mustard gas (Bartelt-Hunt et al., 2008), based on its Henry's Law constant[6] (K_h).

There are reports of blurred vision from the use of DBE-based paint strippers. These effects occurred when the product was used under conditions of low ventilation and the mixtures used

[5] The octanol-water partition coefficient is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature.
[6] Henry's Law states that the mass of a gas which will dissolve into a solution is directly proportional to the partial pressure of that gas above the solution.

contained less than 20 percent DMA and higher percentages of the more volatile dimethyl glutarate and dimethyl succinate (USCPSC, 1994).

DMA is regarded as showing little acute or chronic toxicity. There are no apparent dermal irritant or sensitizing effects, but if it is hot or heated it may cause transient irritation of nose or throat (Clayton and Clayton, 1982). Subchronic inhalation studies using rats investigated toxicity of DBE aerosol-vapor mixture using concentrations of 160, 390, and 1,000 mg/m^3 and lower concentrations of 20, 76, and 390 mg/m^3. Rats were exposed for six hours a day, five days a week, for approximately 90 days. Mild olfactory degeneration was found at 90 days of exposure in female and male rats exposed to 20 mg/m^3 and above and 76 mg/m^3 and above, respectively (Kelly et al., 1986). The incidence, severity, and extent of the lesions increased with DBE concentration and duration of exposure. Other adverse effects that occurred as a result of subchronic DBE exposure included a dose-dependent decrease in liver weight beginning at 160 $mg/m^{3.}$ Serum sodium levels were slightly decreased at 76 mg $/m^-$ and above, while a decrease in body weight was noted in rats exposed to the highest DBE concentration (1,000 mg/m^3).

A single-generation reproductive effects study was conducted on male and female rats exposed to DBE concentrations up to 1,000 mg/m^3 for six hours a day, five days a week for 90 days, followed by daily exposure during mating, gestation, and lactation. The total study period was approximately 150 days. It was concluded that reproduction in rats was not altered by repeated inhalation exposure of to up to 1.0 mg/m^3 DBE – a concentration that produced both body weight and histological effects in parental rats (Kelly et al., 1998).

Dipropylene glycol methyl ether (DPGME)

Dipropylene glycol methyl ether (DPGME) is a clear liquid with an ethereal (ether-like; pungent) odor. It is used in many home-maintenance products (Table 3.8-4) and also in some pet products and pesticides (Household Products Database, 2010). It is a potential simulant of G (nerve)-agents (Bartelt-Hunt et al., 2008).

DPGME causes narcosis in animals at very high concentrations. Rats exposed for 7 hours to 500 ppm showed signs of mild narcosis but recovered rapidly (UNEP, 2001). The acute oral LD(50)s in rats and dogs are 5,135 mg/kg and 7,500 mg/kg, respectively and the dermal LD(50) in rabbits is 9,500 mg/kg (UNEP, 2001). Direct eye contact or eye exposure to a high ambient concentration results in slight and transient eye irritation, but does not cause permanent damage (UNEP, 2001).

The current OSHA-PEL for dipropylene glycol methyl ether is 100 ppm of air (600 mg/m^3) as an 8-hour time-weighted average (TWA) concentration (OSHA, 2011). NIOSH also has a short-term exposure limit (STEL) of 150 ppm (900 mg/m^3) (OSHA, 2011). Exposures at the STEL concentration should not be repeated more than four times a day and should be separated by intervals of at least 60 minutes. These exposure limits are the same as those recommended by American Conference of Governmental Industrial Hygienists (ACGIH, 1994 as cited in OSHA, 2011).

Diethyl ethyl phosphonate (DEEP)

Diethyl ethyl phosphonate (DEEP) is a colorless liquid that is used as a gasoline additive. It is also used in heavy-metal extraction, as a defoamer, as a plasticizer, and as an antistatic compound (Oxford University, 2008a). It is used as a simulant for G-agents (nerve agents) (Bartelt-Hunt et al., 2008).

DEEP has been classified as “not hazardous” according to European Union Directive 67/548/EEC, relating to the classification, packaging, and labeling of dangerous substances (as amended) – one of the main European Union laws concerning chemical safety. Toxicity values for oral exposure are an LD50 of 2,330 mg/kg in rats and an LD50 of 2,500 mg/kg in mice (Oxford University, 2008a). Blumbach et al. (2000) examined relative kidney weights of rats that received oral doses of 50 or 100 mg/kg DEEP per day for five days. Male rats showed increased kidney weights after both dose regimens, but female rats showed no changes relative to controls. The increases were likely due to binding to α_{2u}-globulin, a male rat-specific protein that is not found in female rats, or in either sex of mice, and is therefore unlikely to occur in humans.

3.8.5.2 Biological Simulants

RDT&E activities using biological simulants are included in Alternatives 1 and 2. NSWCDD would only use Biosafety Level (BSL)-1 organisms as biological simulants. BSL-1 is the basic level of protection and is appropriate for working with microorganisms that are not known to adversely affect normal healthy humans (Centers for Disease Control and Prevention [CDC] and National Institutes of Health [NIH], 2007). BSLs range from the lowest level of 1 (BSL-1) where precautions are minimal, often consisting of gloves and some sort of facial protection to the highest level of 4 (BSL-4) that require the use of a positive pressure personnel suit with a segregated air supply, a biolab with electronically secured multiple airlocks to prevent both doors opening at the same time, multiple showers, a vacuum room, an ultraviolet light room, and other safety precautions designed to destroy all traces of the biohazard.

BSL-1 organisms representing potential threats from fungi, bacteria, viruses, and toxins could be used in future RDT&E of biological detectors. Potential species include the bacteria *Bacillus atrophaeus* (formerly known as *Bacillus globigii*), *Bacillus subtilis, Bacillus thuringiensis, Pantoea agglomerans* (formerly known as *Erwinia herbicola*), and *Deinococcus radiodurans;* the fungus *Aspergillus niger*; the protein ovalbumin; the MS2 bacteriophage; and/or BSL-1 organisms similar to them. Each of these types of simulants is discussed below.

Spore-Forming Bacteria: Bacillus atrophaeus, Bacillus subtilis, and Bacillus thuringiensis

Bacillus species produce an endospore, which is a dormant, tough, non-reproductive structure that allows the bacteria to survive through periods of environmental stress such as extreme heat and desiccation (USEPA, 1997). Under most conditions *Bacillus* are not biologically active but exist in endospore form. The endospores are ubiquitous in soil and rocks and are easily dispersed by wind and water (Moeller et al., 2004). *Bacillus* species are also commonly found in dust, air, water, and wet surfaces throughout the world (Center for Research Information [CRI], 2004). They generally occur at population levels of 10 to 100 per gram of soil (Alexander, 1977). However, concentrations of *Bacillus* occurring naturally in the desert have been measured at 100,000 spores per gram of surface soil (US Army, Dugway Proving Ground, 2003). Benign species of *Bacillus* are used to simulate the toxic spore-forming bacterium, *Bacillus anthracis*, commonly known as anthrax. *Bacillus atrophaeus* has been used for over 70 years in this role and is the most frequently used simulant for anthrax (Borden Institute et al., 1997; Edgewood Chemical Biological Center, 2004; Greenberg et al., 2010).

Bacillus subtilis and similar *Bacillus* species are common in the environment and are uncommon causes of disease to healthy individuals (DoD, 2003a, b). *B. subtilis* is one of the most widely-used bacteria for the production of enzymes and specialty chemicals (USEPA, 1997). Industrial uses of *B. subtilis* include the production of amylase, protease (e.g., cleaning aids in detergents), inosine, ribosides, and amino acids (USEPA, 1997). *B. subtilis* is not a human pathogen but has on several occasions been isolated from human infections (USEPA, 1997). Infections were only found in patients in compromised immune states, indicating that there must be immunosuppression of the host followed by inoculation in high numbers for infection to occur, and would not cause disease in normal healthy humans. USEPA concluded in a risk assessment (USEPA, 1997) that *B. subtilis:*

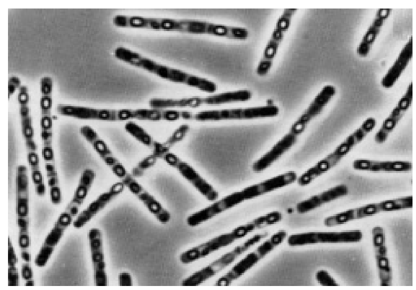
> …is not a human pathogen, nor is it toxigenic like some other members of the genus. The virulence characteristics of the microorganism are low. According to Edberg (1991) either the number of microorganisms challenging the individual must be very high or the immune status of the individual very low in order for infection with *B. subtilis* to occur.

Identification of Bacteria

A *strain* is a subset of a bacterial species differing from other bacteria of the same species by some minor but identifiable difference. One strain of a species is designated as the *type strain*. It is usually one of the first strains studied and is often more fully characterized than other strains, although it does not have to be the most representative member. Only those strains very similar to the *type strain* are included in a species.

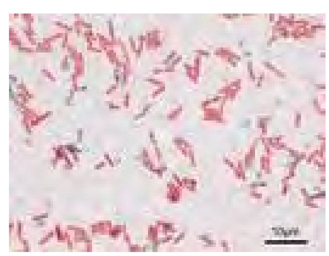
Source: Abedon, 1998.

B. subtilis is also not known to be an animal or plant pathogen (USEPA, 1997). These benign bacteria would be used to simulate the release of toxic bacteria, such as *B. anthracis* (anthrax), which have similar spores and dispersal characteristics (Carrera et al., 2007).



Bacillus thuringiensis
(1000x magnification)

B. atrophaeus produces its own toxins and can sicken people whose immune systems have been compromised, but not healthy individuals. Human infection by *B. atrophaeus* primarily results from deep incisions in the skin, such as penetrating injuries, surgical procedures, and catheters and intravenous lines, and/or a debilitated health state (CRI, 2004); therefore it is often encountered as a nosocomial (acquired or occurring in a hospital) pathogen. *B. atrophaeus* is also a cause of food poisoning, resulting in diarrhea and vomiting, but fatalities are rare (CRI, 2004). It can contaminate cooked meat, cooked vegetables, milk, infant formulae, and is a significant contaminant of bread (CRI, 2004). It has also been isolated from recycled-paper products, which, if used for packaging foodstuffs, could result in contamination and possible food poisoning (CRI, 2004). Infections are usually treated with antibiotics (Blue et al., 1995). Cases of long-term persistence or recurrence or of extended latency have not been found (CRI, 2004).



Bacillus subtilis
(spores are green)

B. thuringiensis is a naturally occurring bacterial disease of insects and is used as an active ingredient in some insecticides (Cranshaw, 2006). Several strains of *B. thuringiensis* can infect and kill Lepidoptera (moths, butterflies, and caterpillars) by producing proteins that react with the cells of the gut lining of susceptible insects and paralyze the digestive system (Cranshaw, 2006). Infected insects generally die from starvation, which can take several days. The most commonly used strain of *B. thuringiensis* (*kurstaki* strain) kills only leaf- and needle-feeding caterpillars. Recently, strains have been developed that control certain types of fly larvae (*israelensis* strain), and these strains are used against larvae of mosquitoes, black flies and fungus gnats. Other strains have been developed with activity against some leaf beetles, such as the Colorado potato beetle and elm leaf beetle (*san diego* strain, *tenebrionis* strain) (Cranshaw, 2006). Among the various strains, insecticidal activity is specific to the target insect group and *B. thuringiensis* is considered safe to people and nontarget species. Some formulations are considered safe to be used on food crops (Cranshaw, 2006).

Because the *Bacillus* species proposed for use are ubiquitous in the environment, the releases expected from activities will not significantly increase populations in the environment.

Pantoea agglomerans

Non- Spore-Forming Bacteria: Pantoea agglomerans and Deinococcus radiodurans

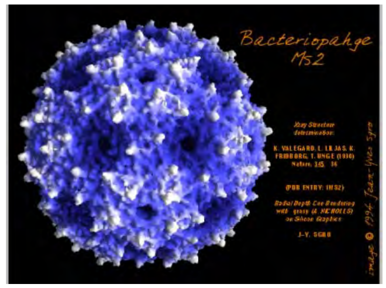
Pantoea agglomerans is a gram-negative, rod-shaped bacterium that is associated with plants. *P. agglomerans* is used as a simulant for pathogenic gram-negative species, such as *Yersinia pestis* – the cause of the bubonic plague – and *Francisella tularensis* – the cause of tularemia or rabbit fever. *P. agglomerans* is nonpathogenic and has beneficial uses. For example, it is used for biological control of the fire blight bacteria (*Erwinia amylovora*) that infects pear and apple trees and makes affected areas appear blackened, shrunken, and cracked, as though scorched by fire (USEPA, 2006). No adverse human health effects associated with *P. agglomerans* have been observed through data reports submitted to USEPA or public literature. Based on available data and its low toxicological significance, USEPA classifies *P. agglomerans* (strain E325) as having the lowest toxicity level, toxicity category IV (USEPA, 2006). Toxicity categories for pesticide products range from toxicity category I, for products that are considered highly toxic and/or severely irritating to toxicity category IV, for products that are practically non-toxic and non-irritant.

Deinococcus radiodurans

Deinococcus radiodurans is a gram-positive extremophilic bacterium – an organism that thrives in physically or geochemically extreme conditions. It is one of the most radioresistant (resistant to radiation) organisms known and it can survive conditions that include cold, dehydration, vacuum, and acid (DeWeerdt, 2002). Exposure to ionizing radiation can result in numerous DNA double-strand breaks, but *D. radiodurans* may compensate for extensive DNA damage through adaptations that allow cells to avoid detrimental effects of DNA strand breaks and increase the efficiency of the DNA-repair proteins (Cox and Battista, 2005). They could also be assisted by the accumulation of manganese complexes, which can provide an irradiated cell with sufficient enzymatic activity needed to repair DNA and survive (Daly, 2009). Due to its unique properties, the use of *D. radiodurans* for detoxifying mixed radioactive wastes containing ionic mercury and other metals is being examined (e.g., Brim et al., 2000). While *D. radiodurans* is quite hardy, it is a relatively weak competitor. It is not considered a human pathogen and a *Deinococcus*-related bacterium has been found living inside the human stomach (Bik et al., 2006).

Ovalbumin

Ovalbumin is a glycoprotein (a conjugated protein having a carbohydrate as the nonprotein component). It is the main protein found in egg white and is used as a key reference protein for immunization and biochemical studies. It can also be used to simulate protein toxins, such as ricin – a protein extracted from the castor bean (*Ricinus communis*) – and botulinum toxin – a potent neurotoxic protein produced by the bacterium *Clostridium botulinum* (Aberdeen Proving Ground, 2002). Ovalbumin is commonly consumed in food products and used as a medium to grow vaccines. Individuals with ovalbumin (egg) allergies should avoid exposure to it.



Bacteriophage MS2

Bacteriophage MS2

Bacteriophage MS2 (family *Leviviridae*) is a small, icosahedral, bacteriophage of *Escherichia coli,* a bacterium that is commonly found in the intestine of warm-blooded animals, including humans. A bacteriophage is a virus that infects bacteria. MS2 are ubiquitous and are found in places populated by their bacterial hosts such as soil or the intestines of animals.

The small size of MS2, its simple structure, its RNA genome, and harmlessness to humans, animals, plants, and other higher organisms make it a useful simulant for deadly small RNA viruses, such as Ebola virus (*Ebolavirus*), Marburg virus (*Marburgvirus*), and smallpox (*Variola major* and *Variola minor*) (O'Connell et al., 2006). MS2 is used in place of pathogenic viruses in a wide variety of studies that range from the testing of compounds for disinfecting surfaces to studying the environmental transport and fate of pathogenic viruses in groundwater (O'Connell et al., 2006).

Aspergillus niger

Aspergillus niger

The fungus *Aspergillus niger* is one of the most common species of the genus *Aspergillus*. It causes a disease called black mold on certain fruits and vegetables such as grapes, onions, and peanuts, and is a common contaminant of food. It is ubiquitous in soil and is commonly reported in indoor environments. It is widely used in biotechnology and has been in use for many decades to produce extracellular (food) enzymes and citric acid (Schuster et al., 2002).

A. niger is less likely to cause human disease than some other *Aspergillus* species, but, if large amounts of spores are inhaled, a serious lung disease, aspergillosis, can occur. Since *Aspergillus* is so common in the environment, most people breathe in *Aspergillus* spores every day (CDC, 2008). The spores do not harm people with healthy immune systems, but individuals with compromised immune systems breathing in many spores (such as in a very dusty environment) may become infected. Aspergillosis may occur among horticultural workers that inhale peat dust, which can be rich in *Aspergillus* spores. *A. niger* is also a cause of otomycosis, a fungal infection of the outer ear that occurs in tropical areas.

The EPA's *Aspergillus niger Final Risk Assessment*, dated February 1997, states in the Summary of Risk Integration section that: "*Aspergillus niger* is worldwide in distribution and has been isolated from numerous habitats. Humans are continually exposed to *A. niger* spores and vegetative forms on foodstuffs and in the air. The vast majority of strains of *A. niger*, especially those used in industrial fermentation, have a history of safe use. While there are sporadic reports to the contrary, most isolates have not been documented to be serious pathogens of humans, animals or plants. Specific strains may produce certain mycotoxins or may elicit allergic responses among workers. Those limited instances of adverse effects seem to be associated with a limited number of strains. With proper characterization of industrial strains, use of those with potential for such effects can be avoided. Schuster et al. (2002) also concluded in a review that with appropriate safety precautions, *A. niger* is a safe production organism.

3.9 Geology, Topography, Soils, and Sediments

3.9.1 Geology

NSF Dahlgren is located within the Coastal Plain physiographic province, which extends along the Atlantic Ocean from Cape Cod, Massachusetts to Florida and along the Gulf Coast to Texas. The Coastal Plain province consists of an eastward-thickening sedimentary wedge of unconsolidated sediments, including silt, clay, and sand, with some gravel and lignite. The sediments range in geologic age from the Cretaceous to the Quaternary periods. There are approximately 1,500 ft of Coastal Plain unconsolidated sediment beneath NSF Dahlgren (Meng and Harsh, 1988). The unconsolidated sediments are underlain by crystalline basement rock. The geologic age and lithologic units in the vicinity of NSF Dahlgren are summarized in Table 3.9-1. The geology of NSF Dahlgren and the PRTR area are illustrated in Figure 3.9-1 (Geology - NSF Dahlgren) and Figure 3.9-2 (Geology - PRTR).

Table 3.9-1
Generalized Lithologic Units in the Vicinity of NSF Dahlgren

<table>
<tr><th colspan="2">Geologic Age</th><th rowspan="2">Stratigraphic Formation</th></tr>
<tr><th>Period</th><th>Epoch</th></tr>
<tr><td rowspan="2">Quaternary</td><td>Holocene</td><td>Holocene deposits</td></tr>
<tr><td>Pleistocene</td><td>Tabb Formation</td></tr>
<tr><td rowspan="6">Tertiary</td><td>Miocene</td><td>Calvert Formation *</td></tr>
<tr><td rowspan="3">Eocene</td><td>Chickahominy Formation *</td></tr>
<tr><td>Piney Point Formation *</td></tr>
<tr><td>Nanjemoy Formation</td></tr>
<tr><td rowspan="2">Paleocene</td><td>Marlboro Clay</td></tr>
<tr><td>Aquia Formation</td></tr>
<tr><td rowspan="2">Cretaceous</td><td>Late Cretaceous</td><td rowspan="2">Potomac Group</td></tr>
<tr><td>Early Cretaceous</td></tr>
<tr><td colspan="3">Note: Absent in portions of the NSF Dahlgren vicinity.
Source: Meng and Harsh, 1988.</td></tr>
</table>

Surficial sediments at NSF Dahlgren are Quaternary-age deposits derived from Holocene deposits and the Tabb Formation, and Tertiary-age deposits derived from the Calvert Formation, Chickahominy Formation, and Piney Point Formation sediments. The surficial deposits vary in thickness due to erosion and deposition over time. The Calvert, Chickahominy, and Piney Point formations may be absent in portions of the installation. The Nanjemoy Formation underlies the surficial sediments. This formation is approximately 148 ft thick and is composed of alternating quartz and glauconite sands, clays, and calcitic units of shell and cavernous shell limestone of the Tertiary Period. The Marlboro Clay in turn underlies the Nanjemoy Formation. The Marlboro Clay is a 20- to 30-foot-thick clay, alternating pinkish-orange and dark gray in color. The Aquia Formation underlies the Marlboro Clay and consists of distinctive dark green to gray-green, argillaceous, glauconitic, well-sorted sand with indurated shell beds. The thickness of the Aquia Formation ranges up to 100 ft. Finally, the Cretaceous Period Potomac Group underlies the Aquia Formation; it is approximately 1,000 ft thick and is the oldest and deepest formation, resting on the crystalline basement rock (NSF Dahlgren, 2007).

3.9.2 Topography

Figures 3.9-3 (Topography - NSF Dahlgren) and 3.9-4 (Topography - PRTR) illustrate the existing topography of NSF Dahlgren and the PRTR, respectively. In Virginia, the Coastal Plain physiographic province is characterized by low relief, with elevations ranging from sea level in coastal areas to 400 ft above mean sea level (MSL) in the western portions of the province. The Chesapeake Bay and Potomac River are prominent features of the Coastal Plain in the vicinity of NSF Dahlgren and the PRTR area.

NSF Dahlgren's topography is generally low and flat, with elevations ranging from MSL near the Potomac River and its tributaries to 28 ft above MSL in the northwestern part of Mainside and the southwestern parts of the EEA. The broad, low-lying area within which NSF Dahlgren is located is interpreted to be an earlier shore of the Potomac River, where alluvial deposition has produced the present flat topography. Most of the area's slopes are gradual. However, steep slopes are found along sections of streams within the installation and along the Potomac River shoreline (NSF Dahlgren, 2007).

3.9.3 Soils

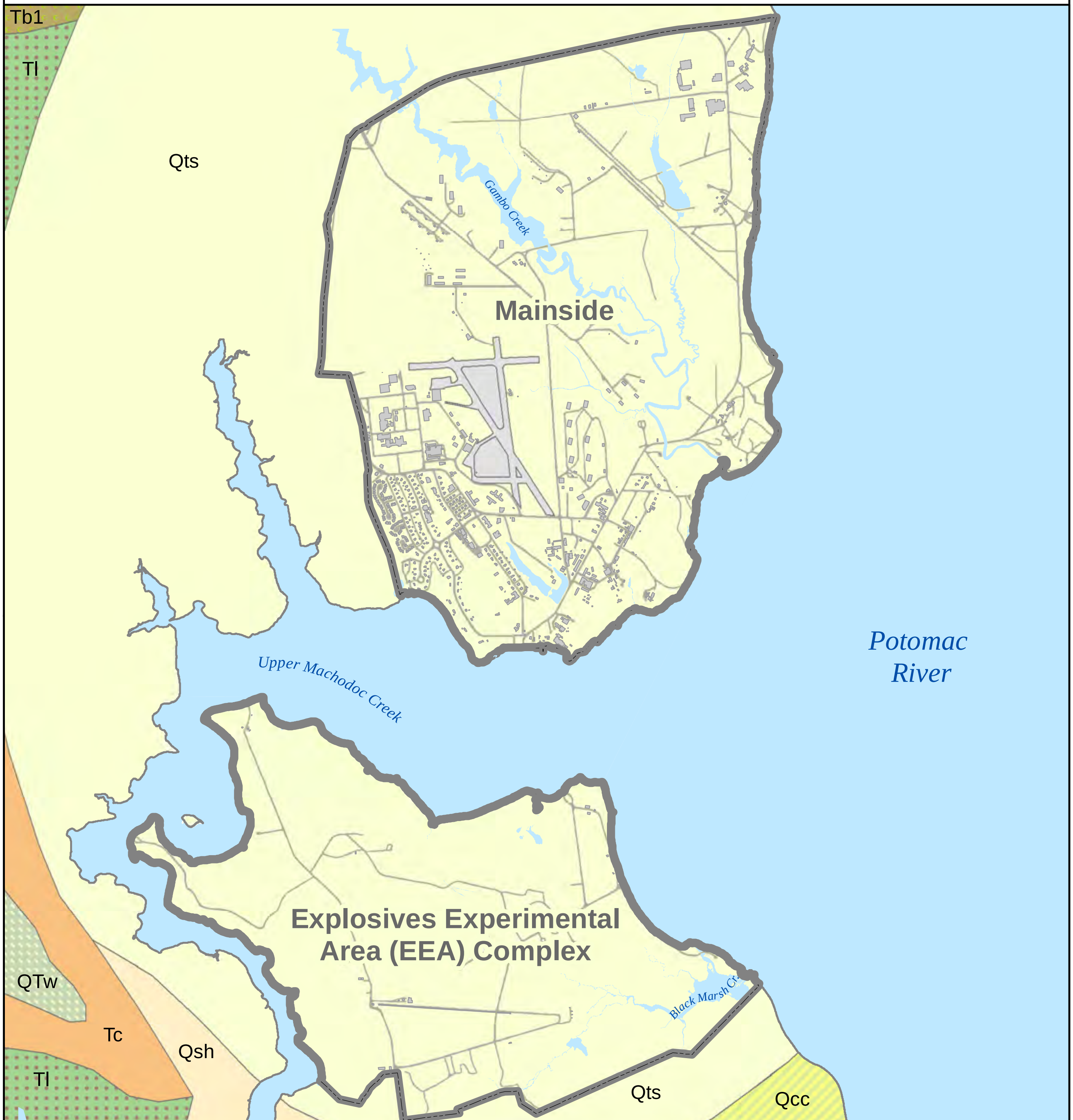
3.9.3.1 NSF Dahlgren Soils

The Soil Conservation Service (SCS) – now the Natural Resources Conservation Service (NRCS) – has surveyed King George County soils, including those on NSF Dahlgren (SCS, 1974). The survey described and delineated twenty named soil types within the installation, as shown in Figure 3.9-5 (Soils - Mainside) and Figure 3.9-6 (Soils - EEA). A brief description of each soil type is provided in Table 3.9-2.

The primary soil type found at NSF Dahlgren consists of the Tetotum-Bladen-Bertie soil association. This soil association is characterized by deep, moderately well-drained to poorly drained soils with clay loam, sandy clay loam, or clay subsoil in broad, low-lying areas (SCS, 1974).

The NRCS National Hydric Soil List identifies three hydric soil types that occur at NSF Dahlgren: Bladen loam, Fallingston very fine sandy loam, and Pooler loam. Hydric soils typically support hydrophytic vegetation and occur in wetland areas. Bladen loam is found throughout large sections of the installation. This soil has a clayey texture and is common where a seasonally high water table remains near the surface for long periods of time. Fallingston very fine sandy loam is also found throughout NSF Dahlgren. The texture of this soil ranges from very fine sandy loam to sandy clay loam; it is common where the high water table is at the surface or within a depth of 1.5 ft during wet periods. Pooler loam is found only within the western portions of the EEA. This soil's texture ranges from heavy clay loam to very fine sandy loam; the seasonal high water table is usually at a depth of 1 to 1.5 ft below ground in winter and spring.

Geology - NSF Dahlgren



Tertiary
- Tb1, gravel, sand
- Tc, sand, silt
- Tl, sand, silt

Quarternary
- Qcc, sand, silt
- Qsh, gravel, sand
- Qts, Tabb Formation, sand

Tertiary-Quarternary
- QTw, undifferentiated, gravel, sand

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD GIS (2008 - 2011), Geology: 2005, Integrated Geologic Map Databases for the United States: Delaware, Maryland, New York, Pennsylvania, and Virginia: U.S. Geological Survey Open-File Report 2005-1325, U.S. Geological Survey, Reston, VA.

Figure 3.9-1

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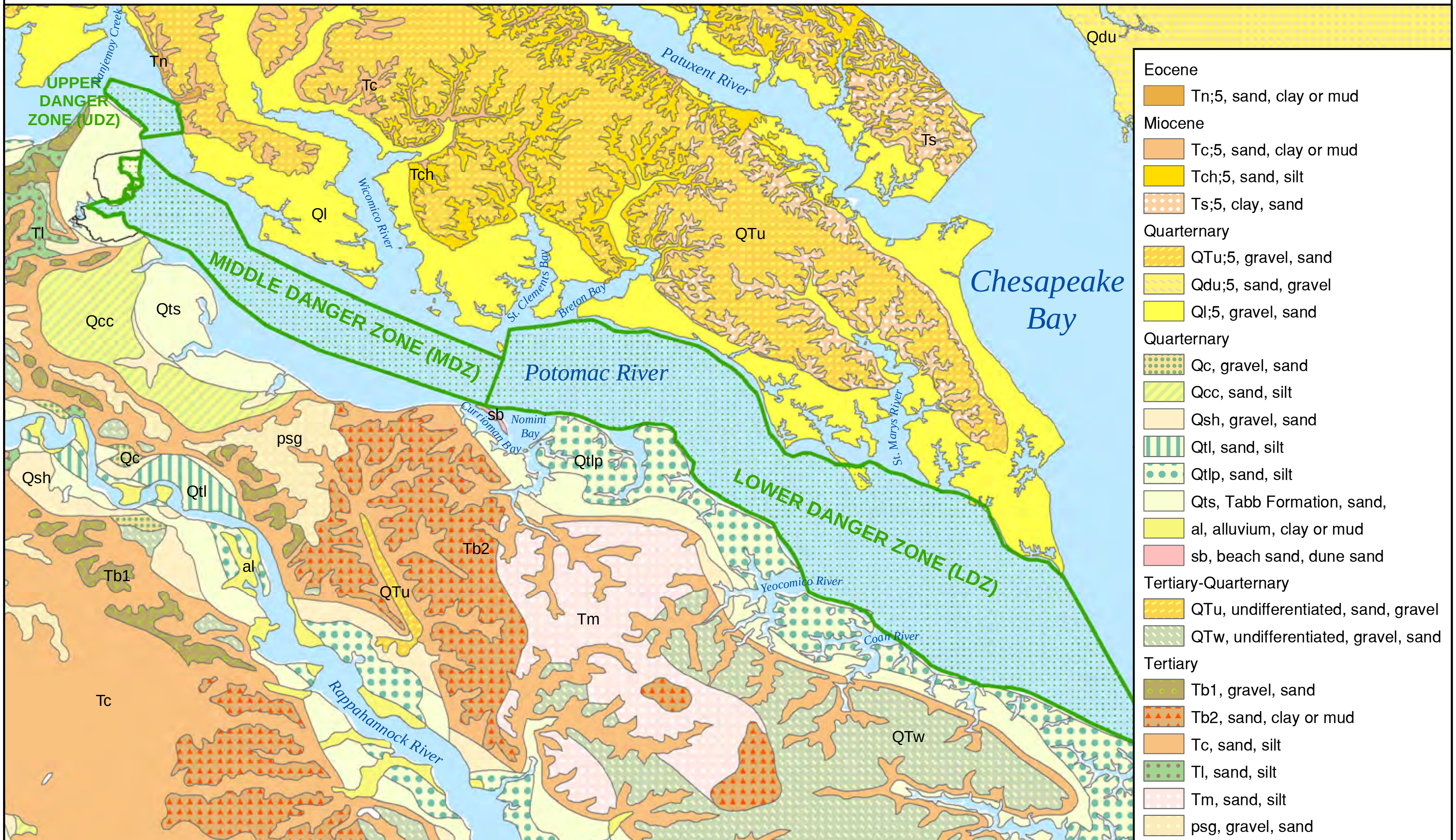
Geology - PRTR



Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

7 0 7 Miles

11 0 11 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD GIS (2008 - 2011), Geology: 2005, Integrated Geologic Map Databases for the United States: Delaware, Maryland, New York, Pennsylvania, and Virginia: U.S. Geological Survey Open-File Report 2005-1325, U.S. Geological Survey, Reston, VA.

Figure 3.9-2

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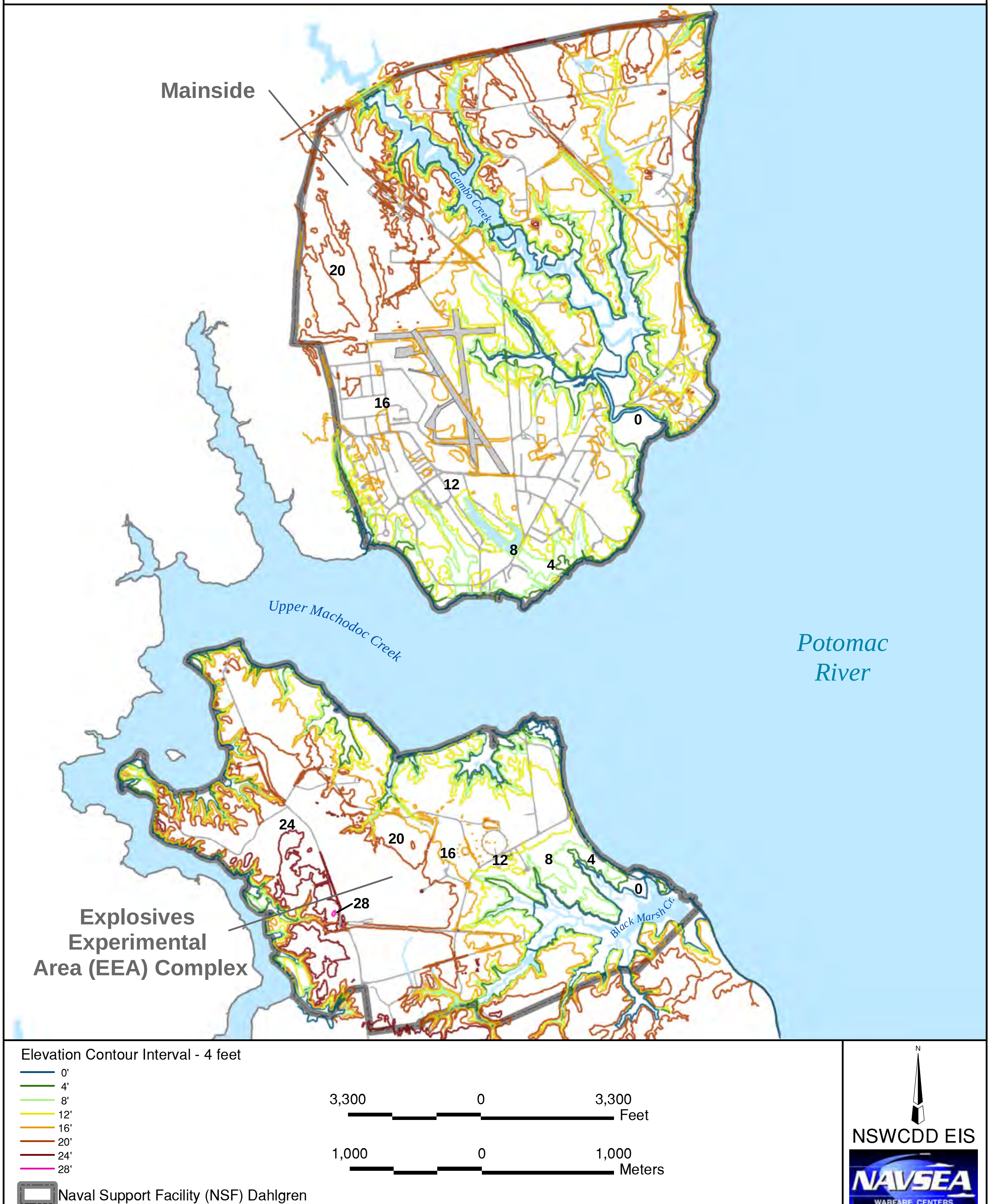
Topography - NSF Dahlgren



NSWCDD EIS

Figure 3.9-3

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Topography - PRTR

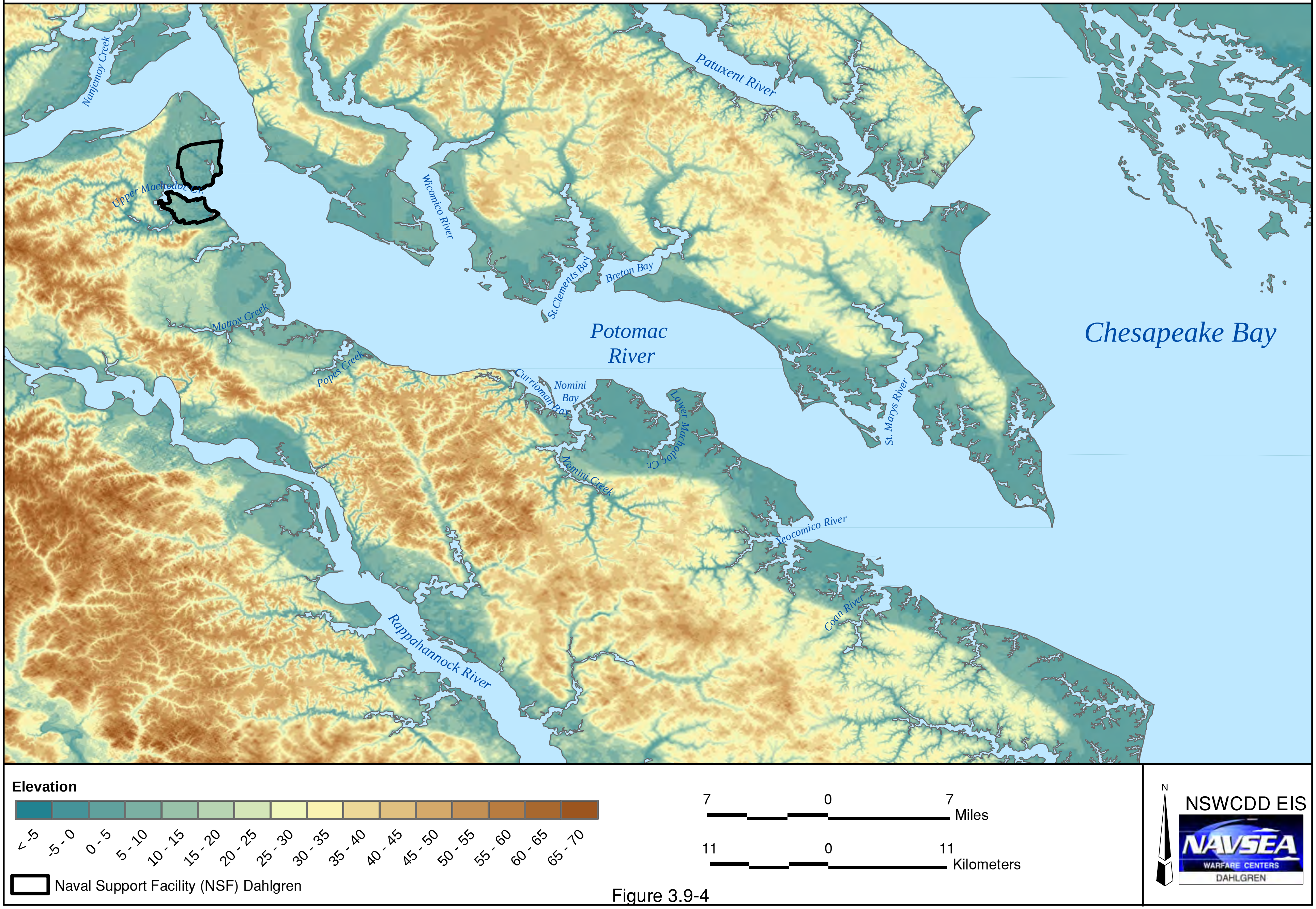

Figure 3.9-4

Source: USGS 30 meter National Elevation Data U.S. Geological Survey, 2007.

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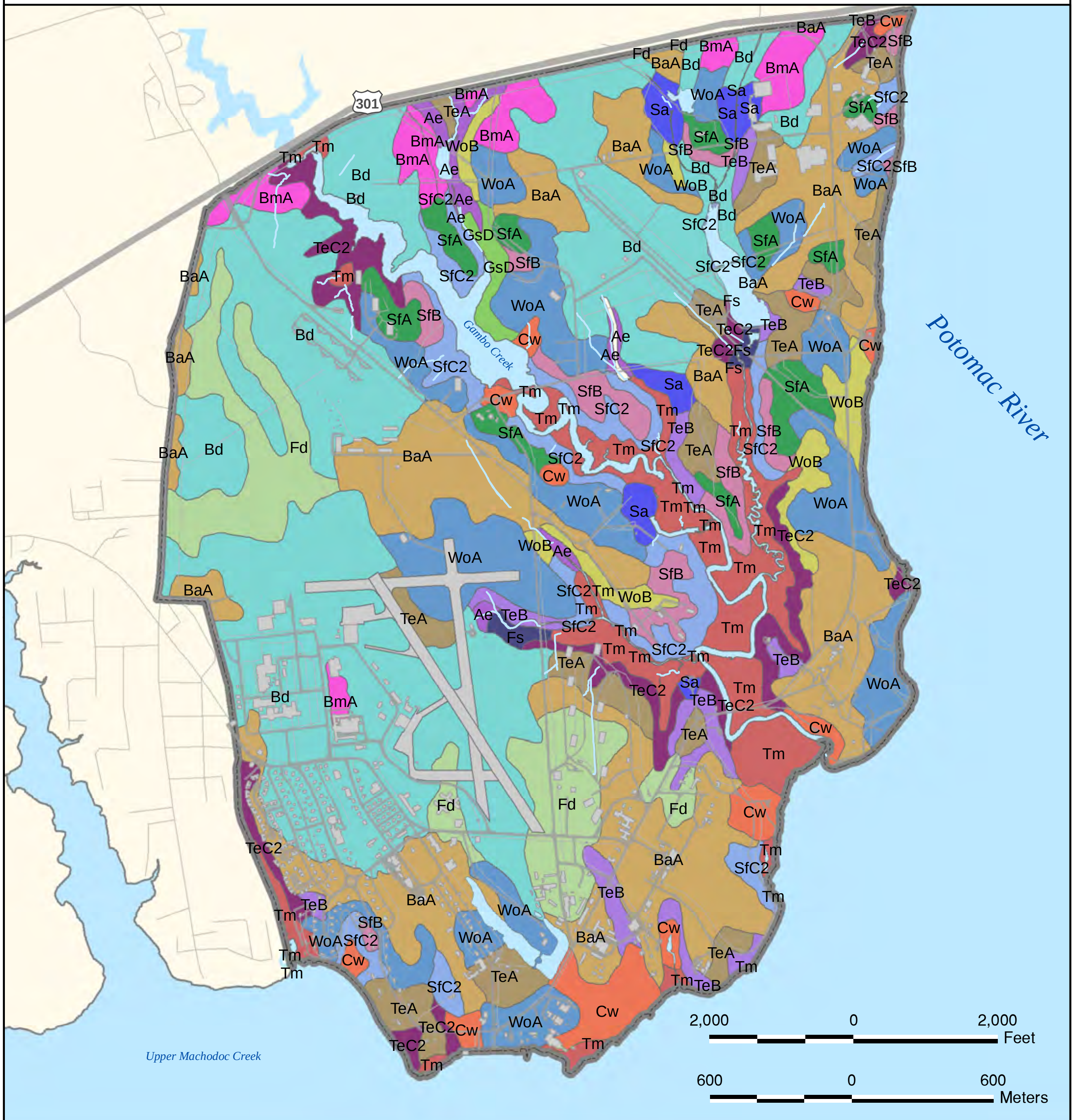
Soils - Mainside



- Ae, Alluvial land, Severe flooding
- BaA, Bertie very fine sandy loam, Severe seasonal high water table
- Bd, Bladen loam, Severe seasonal high water table shrink-swell potential
- BmA, Bourne fine sandy loam, Severe seasonal high water table
- Cw, Cut and fill land, Soil material removed or reworked by machinery
- Fd, Fallsington very fine sand loam, Severe seasonal high water table
- Fs, Fresh water swamp, Severe wetness
- GsD, Galestown-Sassafras complex, Moderate slope building limitations
- Sa, Sand and gravel pits, Mined area or dump containing waste material
- SfA, Sassafras fine sandy loam, Moderate slope 0-2%
- SfB, Sassafras fine sandy loam, Moderate slope 2-6%
- SfC2, Sassafras fine sandy loam, Moderate slope 6-10%
- TeA, Tetotum fine sandy loam, Severe seasonal high water table
- TeB, Tetotum fine sandy loam, Severe seasonal high water table
- TeC2, Tetotum fine sandy loam, Severe seasonal high water table
- Tm, Tidal marsh, Severe wetness
- WoA, Woodstown fine sandy loam, Severe seasonal high water table
- WoB, Woodstown fine sandy loam, Severe seasonal high water table

Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

N

NSWCDD EIS

Figure 3.9-5

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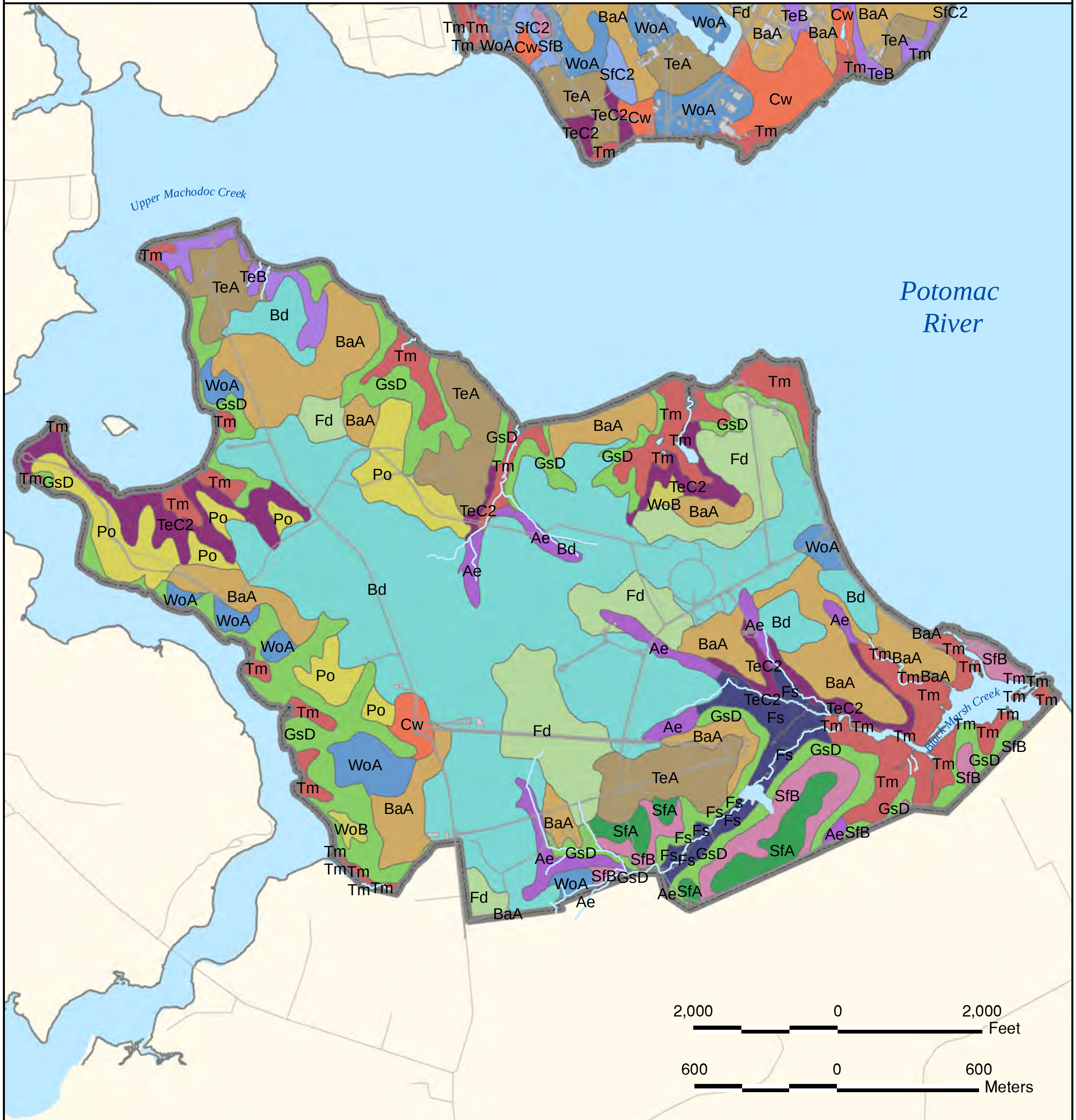
Soils - EEA



- Ae, Alluvial land, Severe flooding
- BaA, Bertie very fine sandy loam, Severe seasonal high water table
- Bd, Bladen loam, Severe seasonal high water table shrink-swell potential
- Cw, Cut and fill land, Soil material removed or reworked by machinery
- Fd, Fallsington very fine sandy loam, Severe seasonal high water table
- Fs, Fresh water swamp, Severe wetness
- GsD, Galestown-Sassafras complex, Moderate slope building limitations
- Po, Pooler loam, Severe seasonal high water table shrink-swell potential
- SfA, Sassafras fine sandy loam, Moderate slope 0-2%
- SfB, Sassafras fine sandy loam, Moderate slope 2-6%
- SfC2, Sassafras fine sandy loam, Moderate slope 6-10%
- TeA, Tetotum fine sandy loam, Severe seasonal high water table
- TeB, Tetotum fine sandy loam, Severe seasonal high water table
- TeC2, Tetotum fine sandy loam, Severe seasonal high water table
- Tm, Tidal marsh, Severe wetness
- WoA, Woodstown fine sandy loam, Severe seasonal high water table
- WoB, Woodstown fine sandy loam, Severe seasonal high water table

Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

Figure 3.9-6

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

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Table 3.9-2
NSF Dahlgren Soils

Soil Symbol	Soil Name	Soil Description
Ae	Alluvial Land, wet	A nearly level–to-gently sloping soil found along drainageways and small streams. Textures range from loamy sand to sandy loam and loam. The soil is strongly-to-very strongly acid. It is low in natural fertility and organic-matter content. Permeability is moderate to rapid. A seasonal high water table is at the surface for many months. It is subject to seepage and flooding from uplands.
BaA	Bertie very fine sandy loam, 0-3% slopes	A deep, somewhat poorly drained, nearly level-to- very gently sloping soil in low areas. Soil textures range from fine sandy loam to sandy clay loam and clay loam. It is strongly-to-extremely acid. It is low in organic-matter content and natural fertility. Permeability is moderate. A seasonal high water table is 1.5 ft in winter and in spring.
Bd	Bladen loam, 0-2% slopes	A deep, poorly drained, nearly level soil. Textures range from loam clay to clay. Permeability is slow. It is very strongly acid and low in natural fertility and organic matter content. A seasonal high water table remains near the surface for long periods.
BmA	Bourne fine sandy loam, 0-2% slopes	A moderately well-drained, nearly level-to-sloping soil on uplands. There is a moderate-to-strong fragipan at a depth of about 18 to 24 inches. The soil is strongly-to-very strongly acid. It is low in natural fertility and organic-matter content. Subsoil above the fragipan is moderately permeable, but the fragipan is slowly-to-very slowly permeable. A parched water table occurs above the fragipan during wet periods.
BmB	Bourne fine sandy loam, 2-6% slopes	Similar to BmA above, but has steeper slopes.
Cw	Cut and Fill	Cut-and-fill land consists of areas where soil has been removed or reworked by machinery. Texture ranges from loamy sand to clay loam and clay, but some areas are very gravelly. Sediment production is medium to high. Runoff is rapid, and permeability is moderate to slow.
Fd	Fallingston very fine sandy loam, 0-2% slopes	A deep, poorly drained, nearly level soil on lowlands. Texture ranges from very fine sandy loam to sandy clay loam. It has a very strongly acid-to-extremely acid subsoil, and is low in organic-matter content and natural fertility. The subsoil has moderate permeability. Available moisture capacity is moderate. It has a seasonal high water table at the surface or within a depth of 1.5 ft during wet periods.
Fs	Fresh water swamp	Low-lying areas consisting of mixed alluvium that is waterlogged or covered by fresh water, except during extended dry periods. These areas consist of layers of sandy loam, fine sandy loam, loam, and silt loam. A mat of partly-decayed organic material is on the surface in many areas. The surface layer commonly is gray to dark gray. The lower layers are strongly glued.
GsD	Galestown-Sassafras complex, 6-15% slope	This complex consists of deep, well-to-somewhat excessively drained soils on uplands. Texture ranges from loamy fine sand to fine sand. It is very strongly acid and is low in natural fertility and organic-matter content. Galestown soils make up about 45% of the complex, with Sassafras representing about 30%. Permeability is rapid, and available moisture capacity is low. Runoff is medium, and erosion is a moderate hazard if the soil is exposed.
Po	Pooler loam, thin solum variant	A deep, somewhat poorly drained, nearly level soil. Textures range from heavy clay loam to very fine sandy loam. It has a strongly acid-to-very strongly acid subsoil. It is low in natural fertility and organic- matter content. Permeability is slow in the subsoil, and available moisture capacity is moderate. The seasonal high water table is at a depth of 1 to 1.5 ft in winter and in spring.

Table 3.9-2 (Continued)
NSF Dahlgren Soils

Soil Symbol	Soil Name	Soil Description
Sa	Sand and Gravel Pits	The soil material of this type is generally coarse. Runoff is slow, and permeability is moderately rapid. These soils commonly have a thin cover of weeds, brush, and small trees. Thin strands of grass cover fine-textured materials.
SfA	Sassafras fine sandy loam, 0-2% slopes	A deep, well-drained soil on nearly level slopes. Texture ranges from fine sandy loam near the surface to sandy clay loam, loamy fine sands, and fine sands at lower substrata. Permeability is moderate in the subsoil, and available moisture capacity is moderate.
SfB	Sassafras fine sandy loam, 2-6% slopes	The same as SfA above, except that the slopes are increased. Its runoff is medium. Erosion has a moderate hazard rate if this soil is clean-tilled or exposed.
SfC2	Sassafras fine sandy loam, 6-10% slopes	The same as SfB above, but with increased slopes. Runoff is medium on this soil. Erosion is a very severe hazard if this soil is clean-tilled or exposed.
TeA	Tetotum fine sandy loam, 0-2% slopes	A deep, moderately well-drained soil on nearly level slopes. Texture ranges from fine sandy loam near the surface to sandy clay loam to mottled clay loam at lower layers. The subsoil is moderately permeable. Available moisture capacity is moderate. A seasonal high water table is at a depth of 1.5 to 2.5 ft during winter and spring.
TeB	Tetotum fine sandy loam, 2-6% slopes	The same as TeA above, except that slopes have increased. Runoff is slow to medium, and erosion is a moderate hazard if it is clean-tilled or exposed.
TeC2	Tetotum fine sandy loam, 6-10% slopes	The same as TeB above, except that slopes have increased. This creates a severe erosion hazard if the soil is clean-tilled or exposed.
Tm	Tidal Marsh	Broad, low areas of mixed alluvium that are covered periodically by tidal water. Textures range from coarse to medium materials. There are various layers of sandy, loamy, clayey, and muck materials. Subsurface is commonly glued. Tidal marsh is constantly waterlogged. Such areas play an important role in wildlife ecology.
WoA	Woodstown fine sandy loam, 0-2% slopes	A deep, moderately well-drained soil on nearly level to gentle slopes. It has a medium acid-to-very strongly acid subsoil. The subsoil is moderately permeable, and available moisture capacity is moderate. There is a seasonally-high water table at a depth of 1.5 to 2.5 ft, which makes artificial drainage beneficial for farm use.
WoB	Woodstown fine sandy loam, 2-6% slopes	The same as WoA above, except that the slope has increased. Runoff is slow to medium, and erosion is a moderate hazard if the soil is clean- tilled or exposed.
Source: SCS, 1974.		

As noted in Table 3.9-2, soil erosion is a moderate to severe hazard at NSF Dahlgren when certain soils are tilled or exposed. Some soils have steep slopes or other characteristics – e.g., a seasonal high water table – that restrict potential uses. Such soils include Alluvial land, Bertie very fine sandy loam, Galestown-Sassafras Complex, Tidal Marsh, and the Woodstown fine sandy loam. Erosion hazards, steep slopes, or other soil restrictions are shown in Figure 3.9-7 (Soil Restrictions - Mainside) and Figure 3.9-8 (Soil Restrictions - EEA).

Soil Restrictions - Mainside

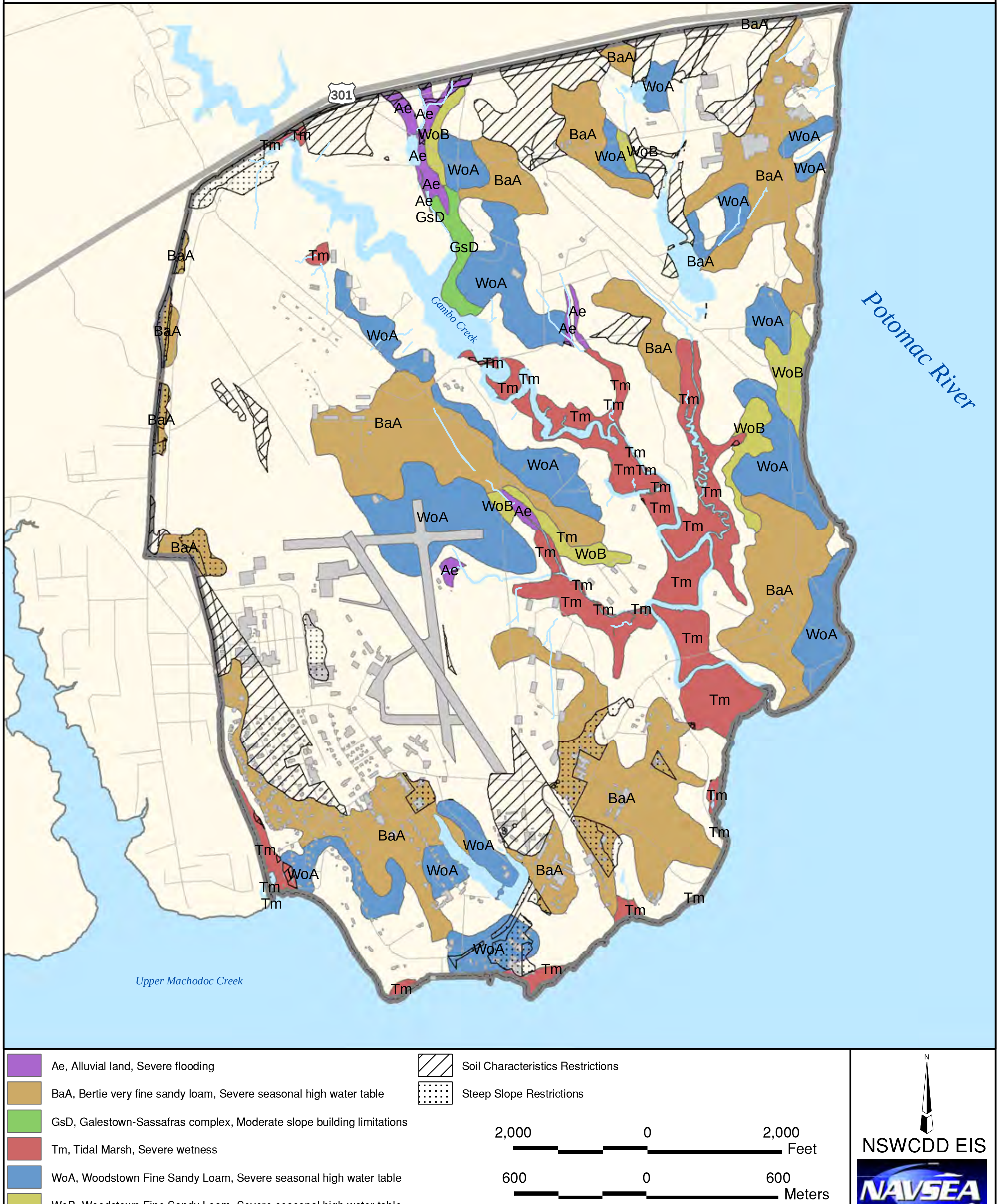

Figure 3.9-7

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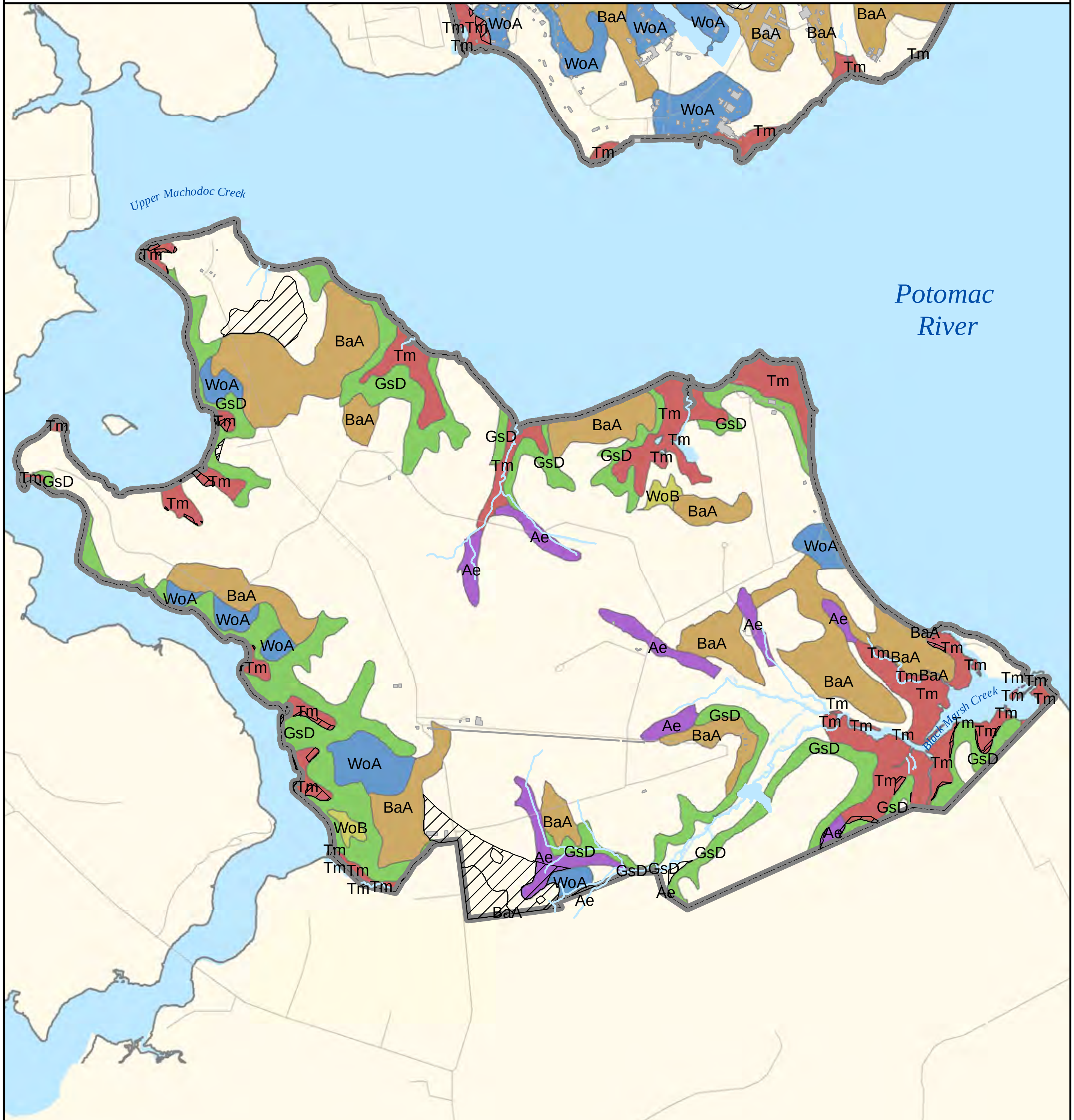
Soil Restrictions - EEA



Ae, Alluvial land, Severe flooding

BaA, Bertie very fine sandy loam, Severe seasonal high water table

GsD, Galestown-Sassafras complex, Moderate slope building limitations

Tm, Tidal marsh, Severe wetness

WoA, Woodstown fine sandy loam, Severe seasonal high water table

WoB, Woodstown fine sandy loam, Severe seasonal high water table

Soil Characteristics Restrictions

2,000 0 2,000 Feet

600 0 600 Meters

N

NSWCDD EIS

Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

Figure 3.9-8

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3.9.3.2 Potomac River Shore Erosion

NSF Dahlgren Shoreline Erosion

NSF Dahlgren is located on the western shore of the Potomac River and is bisected by Upper Machodoc Creek; it is traversed by Gambo Creek and other tributaries to the Potomac. Over the years, the installation's shorelines have experienced significant erosion from strong storms. The hydrology of the Potomac River in this area further aggravates the erosion problem. At NSF Dahlgren, the river varies from less than 2 mi to approximately 5.7 mi wide with extensive shallow areas less than 10 feet deep near the installation. The width of the river provides a long fetch, which allows wave energy to build up when strong winds are present. In addition, soil stratification in the region allows groundwater seepage into subsurface soils along shoreline embankments, which tends to undermine the layers above. This seepage, in conjunction with the undermining action of the waves, is a cause of erosion and bank failure. Increased boat traffic, multi-directional currents, and overland storm flow also contribute to increasing the erosion rate (Naval District Washington [NDW], 2007).

In 1998, NSWCDD contracted with the US Department of Agriculture's Natural Resources Conservation Service to assist in development of a Shoreline Management Plan to address shoreline erosion. The purpose of the Shoreline Management Plan was to inventory the existing shoreline conditions at the installation, identify areas with erosion problems, and provide recommendations to correct the erosion problems, where required.

The Shoreline Management Plan estimated that volume-erosion rates along NSF Dahlgren shorelines are contributing sediment to the Chesapeake Bay at a rate that is 4 to 6 times greater per unit than the rate of sediment contributed by the Potomac River watershed as a whole (NSWCDL, 1999). As expected, higher banks contribute the majority of the sediment. On Mainside, only 26 percent of the shoreline has banks higher than 10 feet, however, 54 percent of the sediment is contributed to the river from them. On the EEA, nearly 48 percent of eroded sediment comes from the 18 percent of the shoreline with banks higher than 10 feet. The annual recession rate of shorelines at NSWCDD estimated in the Shoreline Management Plan range from 0.5 to 1.5 feet per year.

Based on the Shoreline Management Plan prioritization of areas with erosion problems, NSF Dahlgren proposed to construct a combination of sills and/or shoreline revetments at five sites (Site A, Site C, Site EOD, Site B994, and Site B1490) along the west bank of the Potomac River to protect facilities and infrastructure from shoreline erosion and bank failure (NSF Dahlgren, 2007). Due to budget restraints, the application of shoreline erosion reduction measures is being conducted in a priority order. NSF Dahlgren has completed shoreline erosion control measures at three of the sites (Site C, Site B994, and Site B1490) to stem the erosion. The projects included the construction of 1,500 feet of revetments and sills and the creation of wetland habitat to reduce erosion and sedimentation and enhance water quality in the vicinity of the Potomac River.

Currently, NSF Dahlgren proposes to construct shoreline stabilization and restoration structures and to consider employing living shoreline techniques along approximately 11,730 feet of the installation's shoreline on the Potomac River and Upper Machodoc Creek (NSF Dahlgren and Naval Facilities Engineering Command, Washington, 2012). The shoreline stabilization and restoration measures would be implemented in four phases, by priority, for 12 shoreline reaches.

Shoreline Erosion along the Tidal Potomac River and Estuary

In 1977, the US Geological Survey (USGS) began a five-year inter-disciplinary study of the tidal Potomac River and estuary which also included evaluation of shoreline erosion rates. Findings were published by USGS in 1985 (USGS, 1985) and are described below.

The USGS study measured erosion rates by comparing digitized historical shoreline maps and modern maps and stereopairs of aerial photographs taken at different points in time, with the aid of an interactive computer-graphics system and a digitizing stereo-plotter. Cartographic comparisons encompassed 90 percent of the tidal Potomac River and spanned periods of 38 to 109 years, with most measurements spanning at least 84 years. Photogrammetric comparisons encompassed 49 percent of the study reach and spanned 16 to 40 years. Field monitoring of erosion rates and processes at two sites, Swan Point, Maryland, and Mason Neck, Virginia, spanned periods of 10 to 18 months.

The USGS found that in the study area shoreline bank erosion was accelerated by wind-driven waves which break down and remove accumulated debris in the shore zone and abrade and undercut the base of the bank. Slope processes, including surficial erosion and mass movement, play an important role in mobilizing and delivering debris to the base of the bank. These processes are most active at sites with high bank relief and at sites marked by seepage or zones of concentrated ground-water flow from the face of the bank. Seasonal patterns of temperature and precipitation influence the level of activity of slope processes, and local patterns of sediment transport and beach elevations affect the frequency of wave attack and the amount of under-cutting at the base of the bank. The cycle of slope erosion has a variable time scale, and the time period for completion of a cycle initiated by basal erosion increases with height and complexity of the slope

USGS field measurements at monitoring sites at Swan Point, Maryland, and Mason Neck, Virginia, indicate that short-term (10- to 18-month) recession and volume-erosion rates along a shoreline less than 3,280 ft long may vary greatly and that local factors, such as the capacity of the beach to buffer wave impact, presence or absence of obstructions that modify patterns of sediment transport, and trees at the top of the bank, may be primarily responsible for these variations. Although such variations are not likely to persist over a period of decades, they illustrate the importance of longer-term measurements and synoptic measurement for estimating average erosion rates and sediment loads.

USGS estimated that average recession rates, the horizontal distance that a shoreline recedes in a year, along the estuary (all of the PRTR is in the estuary) were 1.4 to 1.7 ft per year along the Virginia shore and 1.0 to 1.3 ft per year along the Maryland shore. Average recession rates of shoreline in the tidal river and transition zone upriver from the PRTR were close to 0.49 ft per year.

USGS estimated that average volume-erosion rates, a measure of the quantity of material eroded from a bank in a year, along the estuary were 13.5 to 20.1 cubic ft per foot of shoreline per year (Virginia shore) and 6.0 to 7.9 cubic ft per foot of shoreline per year (Maryland shore). Estimated average volume-erosion rates along the shores of the tidal river and transition zone upriver from the PRTR were 0.55 to 0.74 cubic ft per foot of shoreline per year.

Weighted average volume-erosion rates along the Virginia shore of the estuary were 20.1 cubic ft per foot of shoreline per year; comparable volume-erosion rates along the Maryland shore of the estuary were 7.9 cubic ft per foot of shoreline per year. Average rates along the tidal river and transition zone were 6.2 cubic ft per foot of shoreline per year.

The maximum average volume-erosion rates for an individual reach, 89 cubic ft per foot of shoreline per year, were measured along the Nomini Cliffs in Westmoreland County (adjacent to the PRTR MDZ), where maximum ground surface elevations were 154 ft above MSL. The most complicated set of erosional processes occurs on high bluffs with complex stratigraphy such as Nomini Cliffs. Erosion processes occurring on the Nomini Cliffs are affected by the presence of multiple seepage zones, discontinuous ironstone ledges, sheet joints, and tectonic joints. Large landslips occur on the upper 10 to 20 meters of the cliffs above seepage zones marking perched water tables. Channels incised in the face of the slope form permanent drainage systems for transportation of water and sediment. Along some sections of these bluffs, pinnacles have been carved in the upper part of the slope by rill and gully erosion (USGS, 1985).

3.9.4 Sediments

This section describes the physical distribution and characteristics of sediments within NSF Dahlgren and the PRTR based on available information. Further information on sediments is provided in Section 3.10 of this EIS, which discusses water and sediment quality. Figure 3.9-9, Sediments - PRTR, illustrates the sediment types found along the Potomac River.

The terraced lowlands surrounding tributaries within NSF Dahlgren and the PRTR are comprised of “lowland deposits” consisting of coarse (sandy) and fine (clayey or silty) sediments with cobbles and boulders. These deposits commonly contain reworked glauconite, varicolored silts and clays, brown-to-dark gray lignitic silty clay, and remnants of marine fauna (Maryland Geological Survey [MGS], 2008).

The bottom of the PRTR is covered by sediments that may have been carried into the river by tributaries, eroded from the Potomac River shoreline, transported downriver from upstream locations, transported from the Chesapeake Bay, introduced from the atmosphere, or generated by biological activity (USGS, 2003).

The sediments are composed of different proportions of sand-, silt-, and clay-sized particles. Larger in size, sands are generally located along the shallow margins of a waterbody, adjacent to the shoreline, and on shelves around peninsulas. Sands typically accumulate in higher-energy environments. Stronger waves and currents near shore typically remove, or prevent the deposition of, finer-grained sediments, leaving sands behind. In contrast, silts and clays – “mud” – generally occur in low-energy environments and in slow-moving tributaries or river channels.

The silts and clays represent the deposition of fine material from suspension in lower-energy environments, where sand-sized particles cannot be carried (USGS, 2003). Mixed sediments may be deposited by alternating high- and low-energy events, which produce inter-layered sands and silty clays that are later mixed by biological activity. They may represent underwater exposures of pre-Holocene sediments deposited under different conditions. Human activities, such as dredging and the overboard placement of dredged material, may also generate mixed sediments (USGS, 2003).

3.9.5 Seismic Activity

Most of the world's earthquakes occur near plate boundaries of the earth's crust. Since places like the California coast are on a boundary between two plates, they have many more earthquakes than places like Virginia and Maryland, which are near the center of the North American plate. Nevertheless, earthquakes still occur in this region, and Virginia has had more than 160 earthquakes since 1977, of which 16 percent were felt. This equates to an average of one earthquake occurring every month, with two felt each year (Virginia Tech Seismological Observatory, 2011b).

Recently, on August 23, 2011, an earthquake with a magnitude of 5.8 occurred near Louisa and Mineral, Virginia, approximately 56 mi west-southwest of NSF Dahlgren (USGS, 2011b, c, d; Virginia Tech Seismological Observatory, 2011c). The shallow earthquake caused moderate shaking and was felt from Florida to Ontario to Missouri. There were hundreds of aftershocks (USGS, 2011b). Moderately heavy damage occurred in Louisa County southwest of Mineral, and widespread light to moderate damage occurred from central Virginia to southern Maryland, including the Washington, DC area (USGS, 2011b, 2011d). The USGS Earthquake Hazard Program received 74 reports of the earthquake from persons in Dahlgren, Virginia, where the intensity was estimated as 5.6 on the Modified Mercalli Intensity scale, indicating that the earthquake was felt by nearly everyone and damage was minimal (USGS, 2010, 2011a). The August 23, 2011 earthquake was almost as strong as the strongest recorded earthquake in Virginia, a magnitude 5.9 earthquake that occurred in May 1897, in Giles County (USGS, 2006, 2011c).

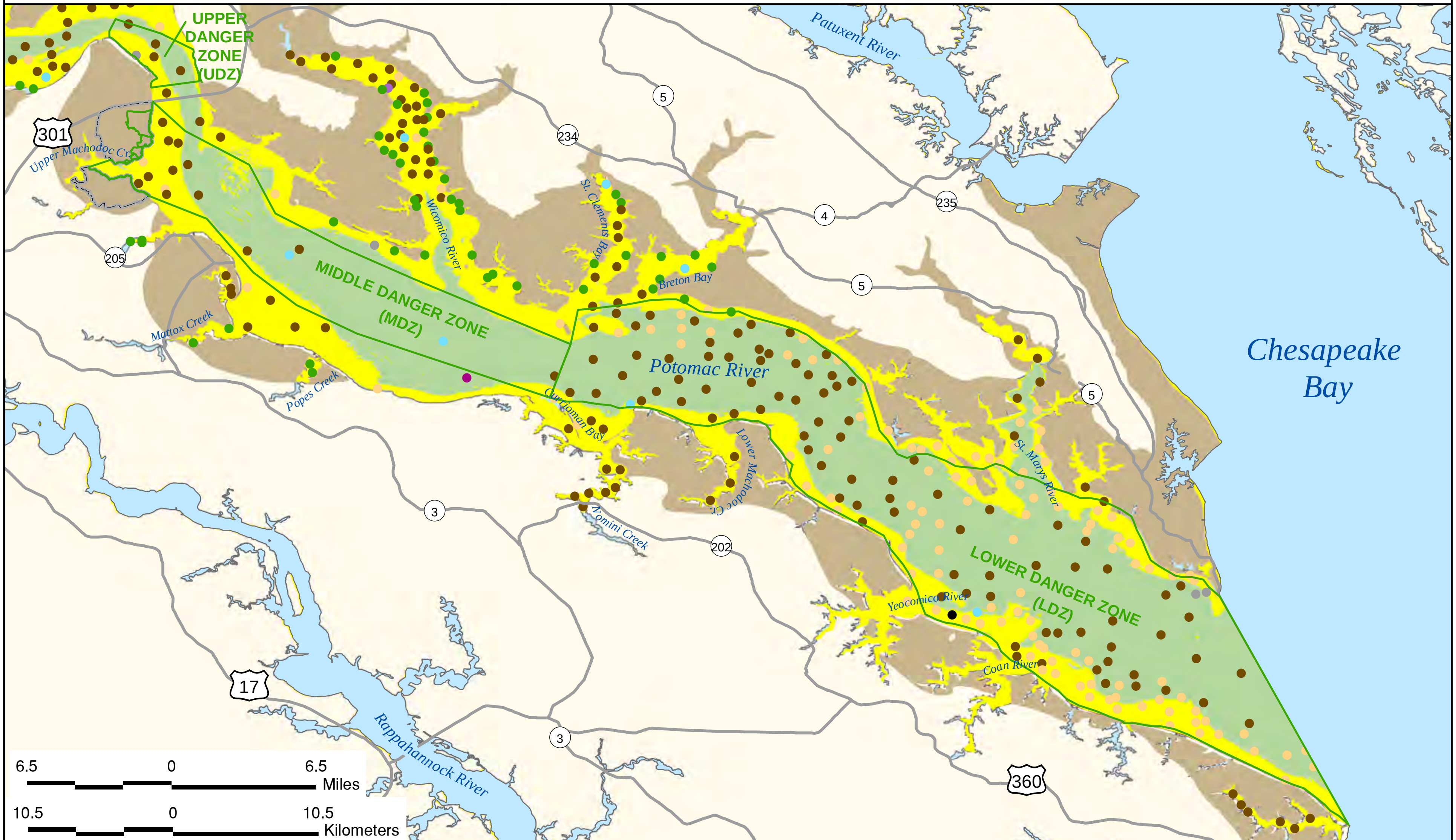
The 2011 earthquake occurred within the Central Virginia Seismic Zone, a previously recognized seismic zone (USGS, 2011b, d). The zone is laced with mapped geological faults, as well as numerous, undetected smaller or deeply-buried faults (Virginia Tech Seismological Observatory, 2011a). The Central Virginia Seismic Zone has produced small and moderate earthquakes since at least 1774 (USGS, 2006; Virginia Tech Seismological Observatory, 2011a). As of 2006, the largest known damaging earthquake in the zone occurred in 1875, with a magnitude of 4.8 (USGS, 2006).

The earthquake hazard in the United States has been estimated in a variety of ways. Chief among them is the production of risk maps. These maps were created to provide design values to assist engineers in designing buildings, bridges, highways, and utilities that will withstand shaking from earthquakes in the United States. Such maps also prove useful in establishing building codes and insurance rates in areas of high risk. These seismic risk maps are based either on relative risk or the probability of a certain seismic event at a particular time and place.

The USGS National Seismic Hazard Map is a risk map that shows the distribution of earthquake shaking levels that have a certain probability of occurring in the United States. Based on this seismic hazard map, NSF Dahlgren is located in a very low seismic hazard area – 2 to 4 percent probability – as compared to high seismic hazard areas – 32 percent or greater probability – such as California (USGS, 2002).

The Maryland Geological Survey (MGS) produced Maryland seismic hazard maps based on the USGS national database. Perhaps the most significant finding of Maryland's seismic hazard maps is the categorization of all but the northeastern corner of Maryland as a region of negligible seismicity, with very low probability of collapse of structure (MGS, 1998).

Sediments - PRTR



Clay	Mud	Sand
SAV	Oysters	Shells
Gravel	Rock /Rocky	

Source: National Oceanic and Atmospheric Administration (NOAA) electronic navigational chart, 2007.

Silty Clay

Approximate Shoreward limit of "mud"

Source: Knebel et al., 1981

Figure 3.9-9

"Lowland Deposits" consisting of coarse (sandy) and fine (clayey or silty) sediments with cobbles and boulders.

Source: Draft Physiographic Map of Maryland, Maryland Geologic Survey (MGS), 2008.

NSF Dahlgren

Potomac River Test Range (PRTR) Complex

Source: NSWCDD GIS (08 -11); Danger Zones defined in CFR 33, Part 33.230.

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The seismic hazard map was widely used for many years, because it was the best risk map available. However, this type of risk map has certain drawbacks. For one thing, there is no justification for assuming that events larger than those observed historically will not occur in the future. It is also known that ground-motion attenuation – the dying out of the earthquake shock waves – with distance is far less in Virginia and Maryland than in the western states. In other words, an earthquake east of the Rocky Mountains affects an area about ten times as large as a West Coast earthquake of the same magnitude (USGS, 2006).

A more recent seismic risk assessment method is the probabilistic map. This map shows the expected maximum horizontal ground acceleration as a percentage of g (the acceleration due to gravity, or 32.2 ft/sec^2) in the United States. These ground accelerations, which are one measure of ground shaking, have a 2, 5, or 10 percent probability of being exceeded in 50 years. Structural damage in poorly-constructed buildings begins to occur at about 16-18 percent g in probabilistic assessment (USGS, 2006).

According to probabilistic ground motion mapping for peak ground acceleration, the NSF Dahlgren geographic area has a very low chance of experiencing a damaging earthquake within the next 50 years. A structure built on firm rock has 2 percent probability (1-in-50 odds) of undergoing ground shaking of between 5 and 10 percent g or higher in the next 50 years (USGS, 2008). By comparison, areas within the Central Virginia Seismic Zone, where the August 23, 2011 earthquake occurred, have a 2 percent probability of undergoing ground shaking of between 12 and 15 percent g or higher.

As these probabilities were calculated by the USGS for the 2008 National Seismic Hazard Maps update, seismic data from the 2011 magnitude 5.8 earthquake were not considered. The USGS currently is updating the National Seismic Hazard Maps for release in 2014 (Gade, pers. comm., November 14, 2011). The USGS will assess the data from the August 23, 2011 earthquake and will incorporate the resulting findings, as well as other new findings on earthquake ground shaking, faults, seismicity, and geodesy, in the 2014 update.

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3.10 Water Resources

3.10.1 Surface Water

Figure 3.10-1, Surface Water Resources – NSF Dahlgren, shows surface water resources on and in the vicinity of Dahlgren. Figure 3.10-2, Surface Water Resources - PRTR, shows the tributaries to the Potomac River in the vicinity of the PRTR. Major surface water features at NSF Dahlgren and the PRTR Complex include the Potomac River and Upper Machodoc Creek. In the vicinity of NSF Dahlgren and the PRTR, the Potomac River flows northwest to southeast from Mathias Point, Virginia to the river mouth. Upper Machodoc Creek flows west to east along the southern boundary of Mainside, dividing NSF Dahlgren into two areas, Mainside to the north and the EEA Complex on Pumpkin Neck to the south. NSF Dahlgren has approximately 4 mi of shoreline on the Potomac River and about 6 mi of shoreline on Upper Machodoc Creek (NSWCDD, 2001).

Gambo Creek flows from northwest to southeast through Mainside, dividing it into approximately equal tracts. On Pumpkin Neck, Black Marsh Creek flows from west to east across the southeastern portion of the EEA Complex. Small, unnamed tributaries to the Potomac River, Upper Machodoc Creek, and Gambo Creek flow through NSF Dahlgren as well. Several ponds are present on the installation, including Beaver Pond and Lespedeza Pond on Mainside. In addition, two manmade freshwater impoundments – Hideaway Pond and Cooling Pond – are located within Mainside.

Williams Creek and Deep Creek flow into Upper Machodoc Creek west of Mainside. On the Virginia side, several creeks and rivers – including Rosier Creek and Mattox Creek – flow into the Potomac River south of the NSF Dahlgren boundary, adjacent to the MDZ and LDZ. Across the river, on the Maryland side, the major tributaries to the Potomac River, east of the PRTR, are the Port Tobacco, Wicomico, and St. Marys Rivers. Two smaller tidal creeks – Piccowaxen Creek and Cuckold Creek – enter the Potomac River across from NSF Dahlgren.

3.10.1.1 Jurisdictions and Standards

From Washington, DC to the river mouth – including the vicinity of NSF Dahlgren and the PRTR – the State of Maryland has jurisdiction over the Potomac River to the low water mark of the shore on the right bank (the bank on the Virginia side) of the river. The river in the vicinity of the PRTR is designated as Use II waters under the Maryland Water Quality Regulations (Code of Maryland Regulations [COMAR] Title 26 Subtitle 08 Chapter 02 Regulation 02 [26.08.02.02]), indicating that it is suitable for support of estuarine and marine aquatic life and shellfish harvesting. On the Maryland side of the river in the vicinity of the PRTR, the tributaries to the Potomac River likewise are designated as Use II waters.

Maryland has various numeric criteria for the protection of aquatic life and human health that set the minimum water quality to meet the designated uses. Criteria are published for temperature, dissolved oxygen (DO), turbidity, bacteria, and toxics. The numeric criteria for Use II waters include the following:

- **Temperature**: The maximum temperature outside the mixing zone (the area contiguous to a discharge) may not exceed 90˚F or the ambient temperature of the surface waters, whichever is greater.
- **pH**: Normal pH values may not be less than 6.5 or greater than 8.5.

Under the Virginia Water Quality Standards (9 VAC 25-260), all state waters, including wetlands, are designated for the following uses:

- Recreational uses (e.g., swimming and boating)
- Propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them
- Wildlife
- Production of edible and marketable natural resources (e.g., fish and shellfish)

On the Virginia side of the Potomac River, in the vicinity of the PRTR, the tidal portions of tributaries to the river are designated Class II waters. The tidal tributaries that enter the Potomac River in the vicinity of the PRTR upstream from Buoy 33 near NSF Dahlgren – approximately 1.3 nautical miles (NM) downstream of the Harry Nice Bridge – are designated further as transition-zone waters. (Figure 3.10-2 shows the location of Buoy 33.) Those tributaries that enter the river downstream of Buoy 33 are designated estuarine waters. For the Chesapeake Bay and its tidal tributaries, including the Potomac River and its tributaries, Virginia requires that Class II waters meet a standard of pH 6.0 to 9.0.

Maryland and Virginia have adopted the five tidal-water designated uses – migratory fish spawning and nursery, shallow-water, open-water fish and shellfish, deep-water seasonal fish and shellfish, and deep-channel seasonal refuge – proposed by the Chesapeake Bay Program (CBP) for the Chesapeake Bay and its tidal tributaries (CBP, 2003). All five designated uses occur in portions of the Potomac River and its tidal tributaries in the vicinity of NSF Dahlgren and the PRTR. Table 3.10-1 summarizes the boundaries of the tidal-water designated uses and their vertical and horizontal extents in the vicinity of the PRTR.

The two states have adopted common numeric criteria for DO concentrations in the Chesapeake Bay and its tidal tributaries that are consistent with the DO criteria recommended by the CBP (COMAR 26.08.02.02, 9 VAC 25-260). Table 3.10-2 presents the DO criteria.

The designated uses for waterbodies are protected by the application of states' numerical and narrative water quality criteria. The Maryland Department of the Environment (MDE) and the Virginia Department of Environmental Quality (VDEQ) administer the Federal Water Pollution Control Act – commonly referred to as the Clean Water Act (CWA) – and implement regulatory and planning programs to reduce the input of pollutants to the waters of the states. The long-term goal of these programs, in part, is to ensure that all streams, rivers, and bays support their designated uses. The states establish total maximum daily loads (TMDLs) as a tool for achieving this goal and implementing state water quality standards.

Surface Water Resources - NSF Dahlgren

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.10-1

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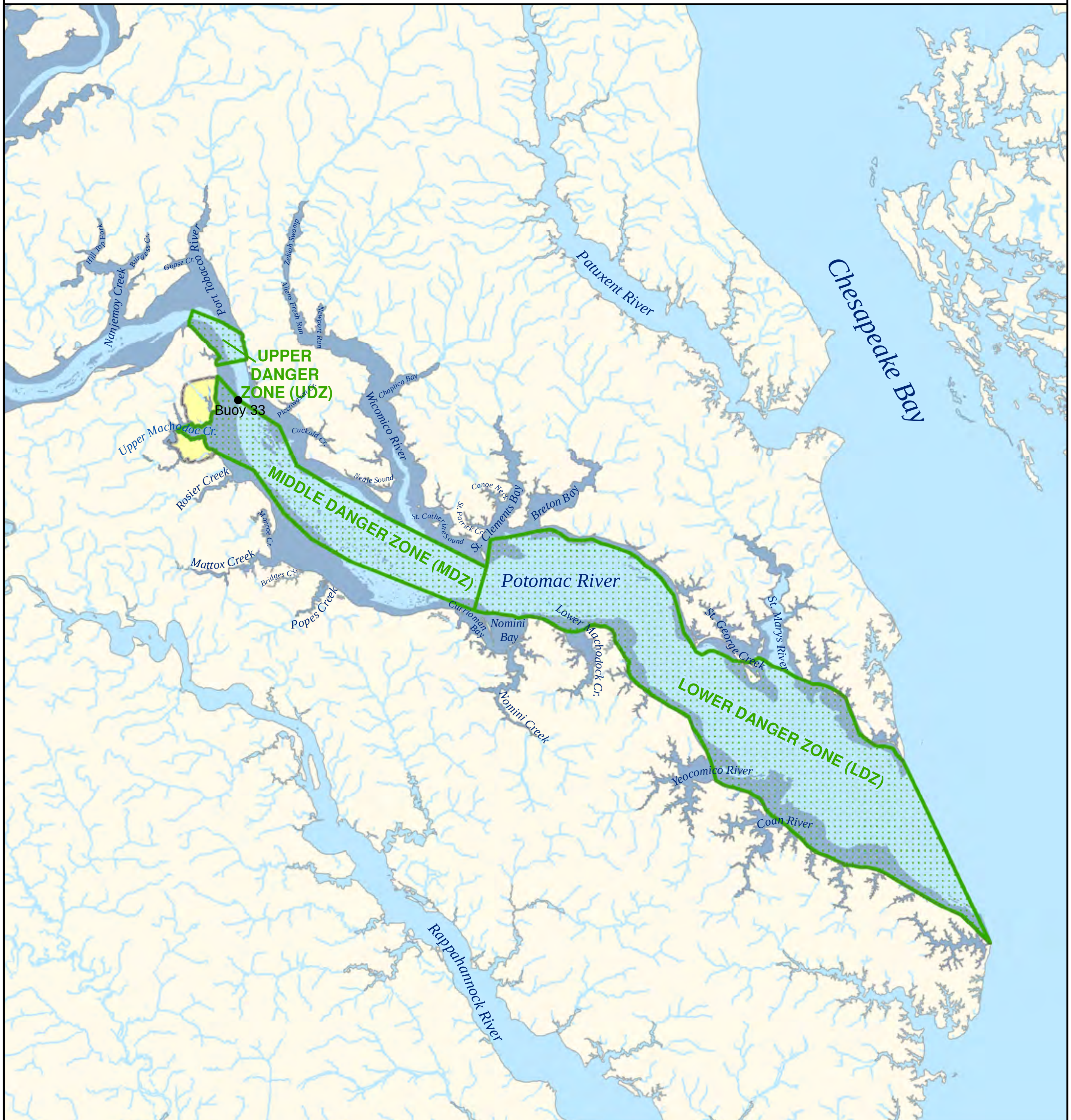
Surface Water Resources - PRTR



Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR)

Surface Water

Stream

8 0 8 Miles

13 0 13 Kilometers

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Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.10-2

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Table 3.10-1
Boundaries and Extents of Tidal Water Designated Uses

Migratory Fish Spawning and Nursery Designated Use
Boundaries: The use extends horizontally from the intertidal zone (mean low water) across the body of water to the adjacent intertidal zone, and down through the water column to the bottom water-sediment interface. *Extent in the vicinity of the PRTR*: The Potomac River and its tidal tributaries upstream of and including the Wicomico River; and St. Clements Bay, Breton Bay, and St. Marys River.
Shallow-Water Bay Grass Designated Use
Boundaries: The use covers tidally-influenced waters from the intertidal zone to a CBP segment-specific depth contour. The use applies during the bay grass growing season: April 1 through October 31 for the Potomac River and its tributaries in the vicinity of the PRTR. *Extent in the vicinity of the PRTR*: The Potomac River and its tidal tributaries from the intertidal zone to the 3.3-ft depth contour in Nanjemoy Creek and the Port Tobacco River (upstream of the UDZ), the 6.6-ft contour upstream of the UDZ to approximately the middle of the UDZ, and the 1.6-ft contour from the middle of the UDZ to the mouth of the Potomac River.
Open-Water Fish and Shellfish Designated Use
Boundaries: From June 1 through September 30, the use includes tidally-influenced waters extending horizontally from the shoreline measured at mean low water, to the adjacent shoreline, and extending through the water column to the bottom water-sediment interface. If the presence of a pycnocline[1] prevents oxygen replenishment, the use extends only as far as the upper boundary of the pycnocline. From October 1 through May 31, the use includes all tidally-influenced waters extending horizontally from the shoreline, measured at mean low water, to the adjacent shoreline, and down into the water column to the bottom water-sediment interface. *Extent in the vicinity of the PRTR*: The Potomac River and its tidal tributaries.
Deep-Water Seasonal Fish and Shellfish Designated Use
Boundaries: Tidally-influenced waters located between the measured depths of the upper and lower boundaries of the pycnocline, where a measured pycnocline is present and presents a barrier to oxygen replenishment from June 1 through September 30. In some areas, the use extends from the upper boundary of the pycnocline down to the bottom water-sediment interface, where a lower boundary of the pycnocline is not calculated due to the depth of the water column. *Extent in the vicinity of the PRTR*: The Potomac River.
Deep-Channel Seasonal Refuge Designated Use
Boundaries: Tidally-influenced waters at depths greater than the measured lower boundary of the pycnocline in isolated deep channels. The use is defined laterally by bathymetry of the trough, and vertically by the lower boundary of the pycnocline above and the bottom water-sediment interface below. *Extent in the vicinity of the PRTR*: The Potomac River – notably, the waters of the lower Potomac River trench.
Note: 1. The pycnocline is the zone between waters with different densities; e.g., a zone separating shallow, fresher water from deep, more saline water. **Source:** Based on CBP, 2003; USEPA, 2004.

Table 3.10-2
Tidal Water Designated Uses Dissolved Oxygen (DO) Criteria

Designated Use	Criteria [1,2]	Temporal Application
Migratory Fish Spawning and Nursery [3]	▪ 7-day mean ≥6 milligrams per liter (mg/l) ▪ Instantaneous minimum ≥ 5 mg/l	February 1 to May 31
Shallow-Water Bay Grass	▪ 30-day mean ≥5.5 mg/l in low salinity (tidal fresh waters, salinity ≤0.5 ppt) ▪ 30-day mean ≥5 mg/l in high salinity (>0.5 ppt) ▪ 7-day mean ≥4 mg/l ▪ Instantaneous minimum ≥3.2 mg/l [4]	Year-round
Open-Water Fish and Shellfish	▪ 30-day mean ≥5.5 mg/l in low salinity (tidal fresh waters, salinity ≤0.5 ppt) ▪ 30-day mean ≥5 mg/l in high salinity (>0.5 ppt) ▪ 7-day mean ≥4 mg/l ▪ Instantaneous minimum ≥3.2 mg/l [4]	Year-round
Deep-Water Seasonal Fish and Shellfish [5]	▪ 30-day mean ≥3 mg/l ▪ 1-day mean ≥2.3 mg/l ▪ Instantaneous minimum ≥1.7 mg/l	June 1 to September 30
Deep-Channel Seasonal Refuge [5]	▪ Instantaneous minimum ≥1 mg/l	June 1 to September 30

Notes:
1. ≥ indicates greater than or equal to; > indicates greater than; ≤ indicates less than or equal to.
2. ppt indicates parts per thousand.
3. Open-water fish and shellfish criteria apply from June 1 to January 31.
4. At temperatures considered stressful to shortnose sturgeon (Acipenser brevirostrum) (>84 degree Fahrenheit [˚F]), DO concentrations above an instantaneous minimum of 4.3 mg/l will protect survival of this listed sturgeon species.
5. Open-water fish and shellfish criteria apply from October 1 to May 31.

Source: CBP, 2003; COMAR 26.08.02.02; 9 VAC 25-260.

Section 303(d) of the CWA requires that states (as well as territories and authorized tribes) develop lists of impaired waters – waters that do not meet water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology (USEPA, 2008b). The act requires that the states establish priority rankings for waters on the lists and develop TMDLs for these waters. Table 3.10-3 lists the TMDLs that Maryland and Virginia are developing for impaired waters of the Lower Potomac River and the creeks in the immediate vicinity of NSF Dahlgren.

A TMDL specifies the maximum amount of the pollutant that the waterbody can receive and still meet water quality standards, and allocates pollutant loadings among point and nonpoint pollutant sources (USEPA, 2011). The USEPA must approve or disapprove the TMDL.

3.10.1.2 Potomac River

Physical Characteristics

The Potomac River basin encompasses 14,670 sq mi in four states – West Virginia, Pennsylvania, Virginia, and Maryland – and the District of Columbia (Interstate Commission on the Potomac River Basin [ICPRB], 2007). Forests cover the majority (57.6 percent) of the basin land area, and agriculture, water and wetlands, and developed land cover 31.8, 5.0, and 4.8 percent of the land area, respectively (ICPRB, 2007).

Table 3.10-3
Lower Potomac River and NSF Dahlgren Vicinity Total Maximum Daily Loads (TMDLs)

Water	Cause for Listing
Maryland	
Oligohaline Lower Potomac River	▪ Total nitrogen ▪ Total phosphorus ▪ Total suspended solids
Mesohaline Lower Potomac River	▪ Total nitrogen ▪ Total phosphorus ▪ Total suspended solids
Virginia	
Deep Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ Aquatic plants (macrophytes)
Gambo Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ Aquatic plants (macrophytes)
Upper Machodoc Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ Enterococcus ▪ Polychlorinated biphenyls (PCBs) in fish tissue ▪ Aquatic plants (macrophytes)
Williams Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ pH ▪ Aquatic plants (macrophytes)
Note: Oligohaline indicates 0.5 to 5 ppt; mesohaline indicates 5.0 to 18 ppt. **Source:** MDE and Maryland Department of Natural Resources (MDNR), 2008; VDEQ and Virginia Department of Conservation and Recreation (VDCR), 2008.	

The Lower Potomac River basin drains 1,756 sq mi (Irani, pers. comm., October 14, 2011). Approximately 26 percent of the basin is open water and 10 percent is wetlands. The most extensive land use is forest, covering almost 38 percent of the basin, with agriculture covering 16 percent and urban land covering 4 percent (Irani, pers. comm., October 14, 2011). Impervious surfaces account for over 4 percent of the land area in the Lower Potomac River basin (Irani, pers. comm., October 14, 2011).

The Potomac River flows over 383 mi from Fairfax Stone, West Virginia to the river mouth at Point Lookout, Maryland (ICPRB, 2007). The length of the tidal reach of the river is 114 mi (Landwehr et al., 1999). The Potomac River flows into the Chesapeake Bay about 43 NM south of NSF Dahlgren. Within the PRTR portion of the Potomac River, the river ranges in width from approximately 1.2 NM at a narrow section within the PRTR Upper Danger Zone to more than 6 NM at the river's mouth.

The bathymetry of the PRTR portion of the Potomac River is illustrated in Figure 3.10-3, PRTR Bathymetry. The lower Potomac River trench extends from Ragged Point to the mouth of the river (USEPA, 2003). The depth of the trench averages from 49 to 82 ft and a 33- to 49-ft-deep shelf extends from the sides of the trench (USEPA, 2003). There is no sill across the mouth of the Potomac River.

The PRTR portion of the Potomac River is tidal and it is an estuary – i.e., a partially enclosed body of water that has a free connection to the open sea and where saltwater from the sea mixes with freshwater from rivers, streams, and creeks (National Oceanic and Atmospheric Administration [NOAA], 2011a). This portion of the Potomac River exhibits features that are characteristic of a partially mixed estuary – specifically, strong tidal currents, moderate vertical stratification, and considerable longitudinal variation in salinity (Wilson, 1977). Moderate vertical stratification is characterized by the occurrence of two basic water layers – a less-saline, upper water provided by the river, and a deeper marine water – separated by a zone of mixing (Thurman, 1994). Within the PRTR, the mean salinity of the Potomac ranges from approximately 4 to 8 parts per thousand (ppt) in the vicinity of NSF Dahlgren, between the UDZ and the MDZ, to approximately 11 to 16 ppt around the downstream end of the LDZ, near the mouth of the Potomac (based on Maryland Department of Natural Resources [MDNR], 2010).

Tidal-height data obtained from temporary tide gauges established between NSF Dahlgren and Lewisetta, Virginia, encompassing both the MDZ and the LDZ, indicate that the PRTR portion of the Potomac River has a semidiurnal tide period of 12.4 hours (Wilson, 1977). According to Wilson (1977), the tidal range decreases from about 2.17 ft at Dahlgren, Virginia to about 1.57 ft at Lewisetta, and the high tide at Dahlgren occurs approximately 1.8 hours after that at Lewisetta. A permanent tide gauge (NOAA Station 8635750) was installed in July 1990 in Lewisetta (Figure 3.10-4, Water Quality and Benthic Monitoring Stations). The mean tidal range at the Lewisetta station is 1.24 ft and the diurnal range is 1.50 ft (NOAA, 2011b).

Mean tidal range is the difference in height between mean high water and mean low water. Mean high water is the average of all the high-water heights and mean low water is the average of all the low-water heights observed over a 19-year period.

Diurnal range, or great diurnal range, is the difference in height between mean higher high water and mean lower low water. Higher high water is the higher of two high waters and lower low water is the lower of two low waters occurring during a tidal day. The mean higher high water is the average of the higher high water heights observed over a 19-year period. The mean lower low water is the average of the lower low water heights observed over a 19-year period.

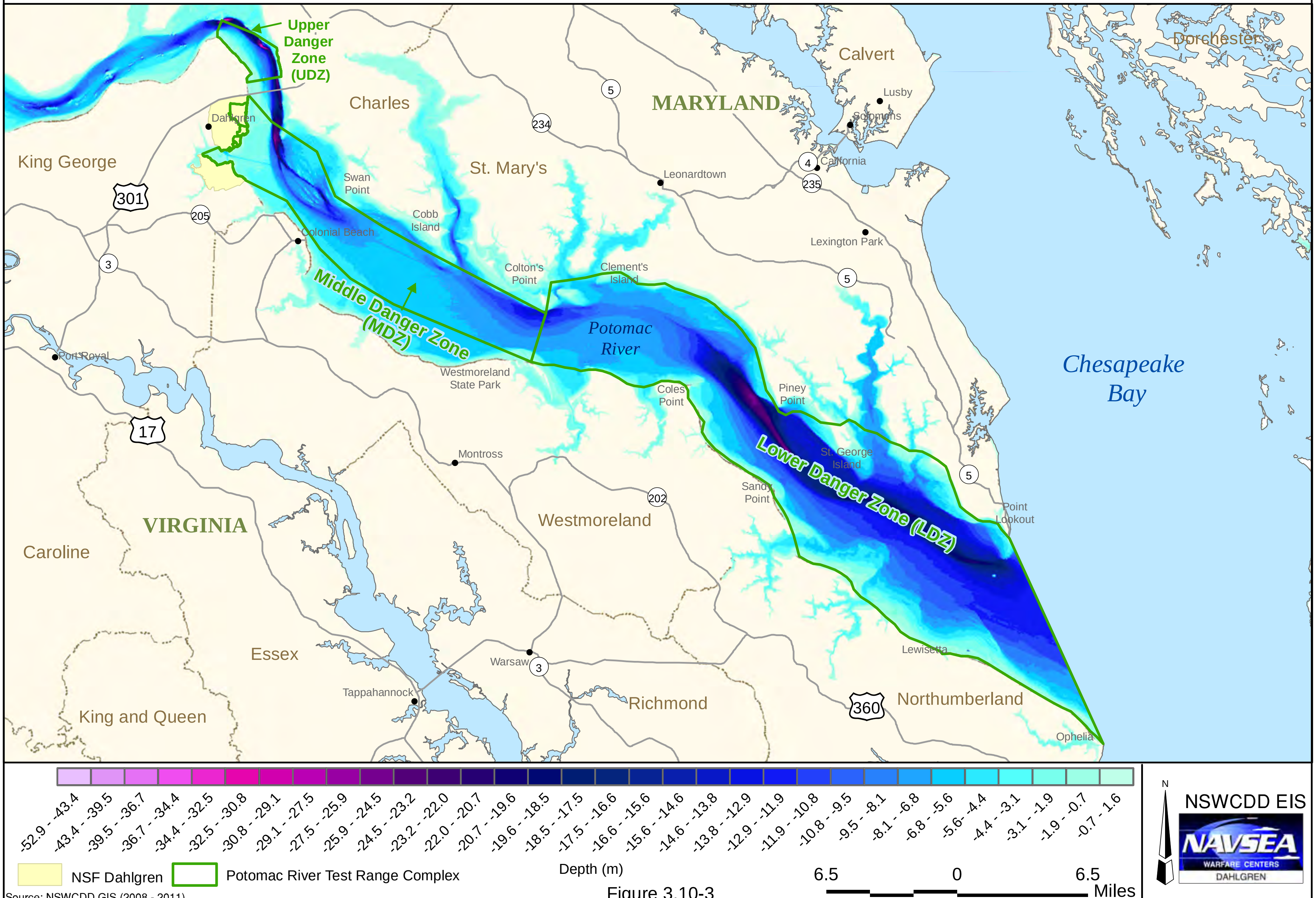
Source: Based on Thurman, 1994; NOAA, 2000.

Because of the constriction in the Potomac River channel cross section upstream of NSF Dahlgren at the Nice Bridge (between the UDZ and the MDZ), current velocities there are higher than downstream (Wilson, 1977). Current phases at Dahlgren lag those near Lewisetta by 1.5 to 2 hours (Wilson, 1977). In the vicinity of the MDZ, the river makes a bend to the south and widens considerably. As this occurs, the water velocity decreases drastically.

Water Quality

The MDNR has routinely sampled water quality year round in the Chesapeake Bay and the Potomac River (as well as other tidal tributaries to the Chesapeake) since 1985 (MDNR, 2010). Five MDNR monitoring stations are located in the vicinity of NSF Dahlgren and the PRTR, as shown on Figure 3.10-4. The MDNR collects data 12 to 20 times a year at the four Potomac River stations (RET2.2, RET2.4, LE2.2, and LE2.3) and 16 times a year at Station CB5.3 in the Chesapeake Bay, near the mouth of the Potomac.

PRTR Bathymetry



Source: NSWCDD GIS (2008 - 2011)

Figure 3.10-3

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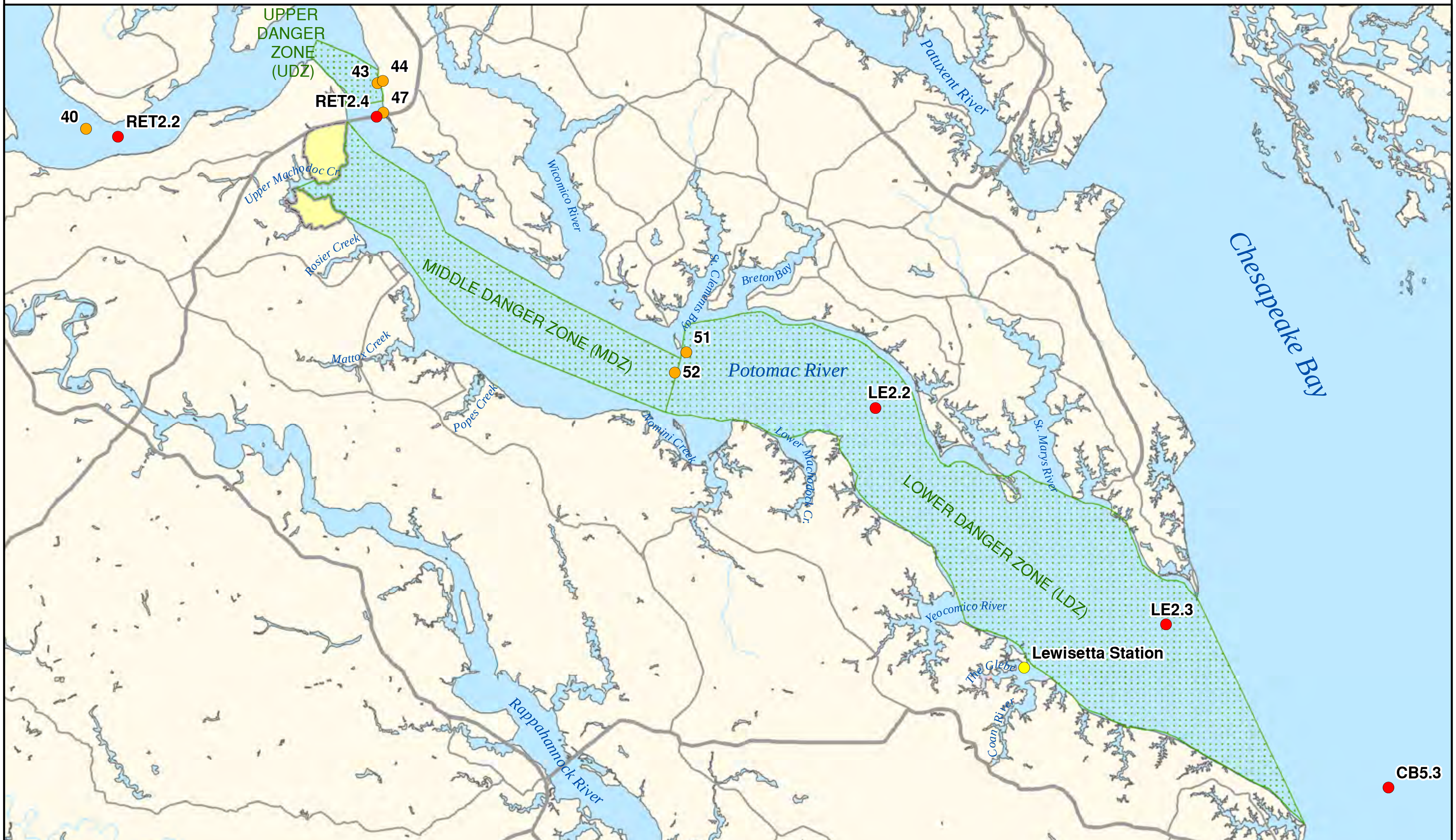
Water Quality and Benthic Monitoring Stations



Lewisetta, VA Station – NOAA Station 8635750

Maryland Department of Natural Resources (MDNR) Fixed Water Quality Monitoring Station

MDNR Fixed Benthic Monitoring Sites

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR) Complex

Surface Water

6.5 0 6.5 Miles

10.5 0 10.5 Kilometers

N

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Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.10-4

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Salinity

Figure 3.10-5, Potomac River Salinity Levels (1985-2006), depicts surface water salinity levels in the Lower Potomac River. The figure shows the seasonal average salinity levels for the spring and the fall, based on monthly average salinities at the MDNR monitoring stations. Table 3.10-4 shows the monthly surface water salinity at the MDNR stations.

Salinity Modifier	Salinity Range (ppt)
Hyperhaline	greater than 40
Euhaline	30.0 to 40
Mixohaline (Brackish)	0.5 to 30
Polyhaline	18.0 to 30
Mesohaline	5.0 to 18
Oligohaline	0.5 to 5
Fresh	less than 0.5

Source: Cowardin et al., 1979.

At all five stations, the mean salinity for each month is within the mixohaline or brackish range – between 0.5 and 30 ppt. Salinity levels increase in a downstream direction. At Station RET2.2, 8 NM upstream of the PRTR, mean salinities for each month are within the oligohaline range – 0.5 to 5 ppt. Between the UDZ and the MDZ, salinities vary between the oligohaline range and the mesohaline range – 5.0 to 18 ppt. In the LDZ and in the Chesapeake Bay, near the mouth of the Potomac River, mean salinities are within the mesohaline range.

Table 3.10-4
Surface Water Salinity (ppt)

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	2.76	2.64	1.52	0.96	0.92	1.55	3.04	3.75	3.88	4.04	3.68	3.31
	Max	7.43	8.50	6.81	3.99	4.09	3.70	6.34	8.21	6.49	7.46	7.81	7.81
RET2.4	Min	0.00	0.32	0.00	0.04	0.34	0.49	1.98	2.37	1.09	2.74	1.51	0.26
	Mean	6.97	6.56	4.66	3.82	3.65	4.84	6.84	7.61	7.96	8.36	8.05	7.52
	Max	13.33	13.99	8.76	10.98	7.71	8.32	10.11	11.57	11.41	11.44	13.06	13.39
LE2.2	Min	5.10	4.00	2.98	3.36	3.10	4.20	7.26	6.11	7.12	7.01	7.26	5.02
	Mean	12.23	11.10	9.45	8.60	7.82	8.58	10.48	11.75	12.91	13.30	13.23	13.08
	Max	18.26	18.55	18.28	16.66	12.47	12.63	13.83	15.07	16.41	16.46	17.04	18.07
LE2.3	Min	7.74	9.40	7.18	6.71	6.06	7.30	9.11	9.28	10.37	7.87	9.59	8.25
	Mean	14.07	14.43	12.75	11.30	10.80	11.08	12.71	14.00	14.91	16.08	15.68	15.49
	Max	18.90	20.29	19.73	16.06	15.34	14.59	15.81	17.11	17.38	19.52	19.04	20.08
CB5.3	Min	7.81	8.89	8.73	7.34	7.50	8.12	10.04	10.47	11.87	11.02	10.95	9.91
	Mean	15.02	15.29	13.56	12.62	12.16	12.79	13.60	15.06	15.93	17.17	16.57	16.67
	Max	19.87	21.27	20.08	17.79	16.02	16.26	16.69	18.48	18.41	21.48	20.57	20.85

Notes: 1. Salinities are in parts per thousand (ppt).
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.

Source: Based on MDNR, 2010.

At all five stations, salinity levels are seasonal, varying through the year depending on rainfall, and freshwater runoff and river flows. The relationship between river flows and salinity is strongest at the most upstream station – RET2.2 – and weakens downstream. The highest mean salinity levels occur in October. During the 1985 to 2009 period of record, polyhaline (18.0 to 30 ppt) water was recorded from October through March at Station LE2.3 in the LDZ, and from August through March in the Chesapeake Bay. Salinity levels decline from February through May, when snowmelt and increased seasonal rainfall produce elevated freshwater discharges from streams and groundwater. The lowest mean salinity levels occur in May. Between the UDZ and the MDZ (at Station RET2.4), fresh water was recorded during the months of December through June, as evidenced by minimum salinities within the 0 to 0.5 ppt range. Salinity levels increase from the spring through the summer, when river flows are lowest.

Temperature

Table 3.10-5 shows the monthly surface water temperature at the monitoring stations. Temperatures are typically similar across the five monitoring stations, with only a 0.4- to 3.1-degree Fahrenheit (˚F) range of variation in monthly mean temperatures between the warmest station and the coolest station. The largest temperature variations between upstream and downstream stations occur from March through June, when the upstream stations are warmer, and from October to December, when the upstream stations are cooler. The mean temperatures at the five monitoring stations are most similar in September.

Table 3.10-5
Surface Water Temperature (˚F)

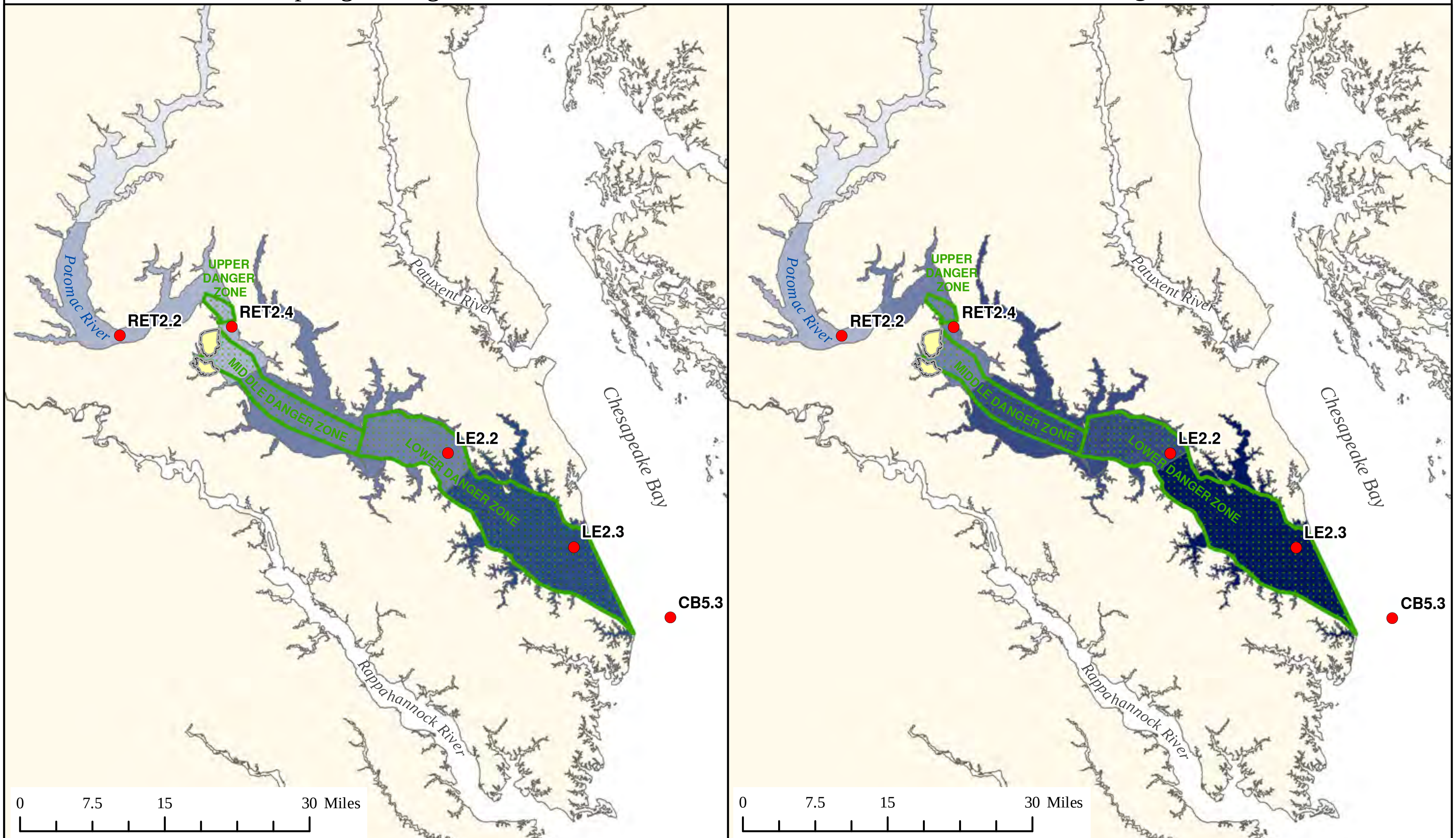
Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	33.62	33.62	37.04	50.81	60.44	68.90	79.16	77.99	71.69	57.02	46.40	37.22
	Mean	38.34	38.51	44.87	55.53	65.74	75.84	81.29	80.97	75.59	63.94	53.28	44.13
	Max	46.58	43.52	50.90	61.16	72.32	80.06	84.11	85.10	79.25	71.60	59.36	53.42
RET2.4	Min	34.70	33.44	36.50	48.56	60.71	67.64	78.26	77.72	72.86	57.20	47.84	39.02
	Mean	38.94	38.30	44.01	54.50	65.00	74.62	80.50	80.89	75.83	64.62	54.33	45.09
	Max	46.40	42.44	49.73	59.45	71.24	78.89	83.21	84.92	79.07	72.05	60.26	53.78
LE2.2	Min	35.06	35.96	36.86	50.54	60.71	68.18	77.18	76.46	72.41	60.35	48.74	39.02
	Mean	40.23	39.47	44.41	54.43	64.60	74.93	79.96	79.82	75.47	64.67	54.67	45.72
	Max	48.02	43.52	50.54	59.45	71.06	78.89	82.94	83.93	78.80	70.61	61.88	53.96
LE2.3	Min	33.98	31.82	36.32	49.37	59.18	64.76	77.18	77.54	71.24	60.26	50.90	40.64
	Mean	39.78	37.72	42.89	53.16	63.63	73.64	79.70	80.05	75.63	66.65	55.64	46.91
	Max	45.86	42.44	47.12	57.38	69.80	78.80	81.95	83.48	81.32	71.78	60.62	54.32
CB5.3	Min	34.34	31.46	36.68	49.46	58.64	63.32	77.27	76.82	71.60	61.34	50.90	40.64
	Mean	39.97	37.86	42.74	52.62	63.08	73.21	79.49	79.73	75.76	66.48	55.53	47.18
	Max	46.58	42.80	46.22	56.30	68.54	78.53	81.77	83.30	81.14	70.16	59.54	54.50

Notes: 1. Temperatures are in degrees Fahrenheit (˚F).
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.
Source: Based on MDNR, 2010.

Over the year, the lowest mean temperatures occur in January and February and the highest mean temperatures occur in July and August. Station RET2.2 has the largest annual range between the minimum and maximum mean monthly temperatures – 43.0˚F. Station LE2.2 has the smallest annual variation in mean monthly temperatures, with a range of 40.5˚F. The low range in annual mean temperatures at LE2.2 results from comparatively high mean temperatures in January and February. Station LE2.2 is the warmest station in January, when downstream Stations CB5.3 and LE2.3 are the second and third warmest, respectively. Station LE2.2 also is the warmest station in February, when upstream Stations RET2.2 and RET2.4 are the second and third warmest.

Potomac River Salinity Levels (1985-2006)

Spring Average | Fall Average



- MDNR Fixed Water Quality Monitoring Station
- Naval Support Facility (NSF) Dahlgren
- Potomac River Test Range (PRTR)
- Tidal Fresh < 0.5 parts per thousand (ppt)
- Oligohaline 0.5 to 5.0 ppt
- Low Mesohaline 5.0 to 9.3 ppt
- Medium Mesohaline 9.3 to 13.7 ppt
- High Mesohaline 13.7 to 18 ppt

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011); Based on Landwehr et al., 1999 and Maryland Department of Natural Resources (MDNR), 2007a.

Figure 3.10-5

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The high mean temperatures at Station LE2.2 in January and February may result from discharges from the Morgantown Generating Station – located across the Potomac River from NSF Dahlgren – of water that is warmer than the receiving river water during the winter. The generating station uses a once-through cooling system, circulating on average 1.0 million gallons of river water per minute (Mirant Mid-Atlantic, LLC, 2006). The system employs a 1,833-ft-long discharge canal to cool water from the condenser and mix the discharge with river water (Maryland Power Plant Research Program, 2001).

Dissolved Oxygen

Table 3.10-6 shows the monthly bottom-water DO concentrations – i.e., the amount of oxygen dissolved in the water – at the MDNR monitoring stations. During all 12 months of the year except one, the highest mean DO concentrations occur at Station RET2.2, upstream of the PRTR. The highest mean DO concentration in March occurs at Station LE2.3 – in the LDZ near the mouth of the Potomac River – with Stations RET2.2 and LE2.2 having the second highest concentrations. From November through February, mean DO concentrations generally decrease in a downstream direction, with the highest concentrations at Station RET2.2 and the lowest concentrations at Station CB5.3 in the Chesapeake Bay. During the five-month period between May and September, however, the lowest mean DO concentrations occur in the LDZ at Stations LE2.2 and LE2.3.

Table 3.10-6
Bottom Water Dissolved Oxygen (mg/l)

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	10.00	9.90	7.25	7.35	5.45	3.30	3.55	4.25	4.60	5.25	7.40	8.60
	Mean	11.46	12.23	10.53	8.97	7.25	5.63	5.50	5.63	6.23	7.20	9.14	10.33
	Max	13.20	14.10	12.60	10.05	8.55	9.10	7.55	7.90	7.15	8.65	10.60	12.70
RET2.4	Min	7.80	7.60	6.10	4.85	1.95	0.35	1.70	1.45	2.02	4.25	4.97	7.50
	Mean	10.93	11.09	9.64	7.72	4.73	2.57	2.68	3.29	4.84	6.24	8.19	9.57
	Max	12.70	14.30	12.00	9.80	7.15	3.85	4.75	4.75	6.50	7.90	10.30	12.20
LE2.2	Min	8.60	8.80	8.10	4.40	0.09	0.05	0.05	0.00	0.03	2.55	5.00	6.90
	Mean	10.27	11.12	10.54	7.22	3.13	0.75	0.47	0.72	2.50	5.35	7.72	9.08
	Max	14.00	16.10	12.85	9.55	7.30	2.60	2.90	3.45	6.20	7.45	9.60	10.80
LE2.3	Min	8.90	9.00	8.10	5.45	0.90	0.10	0.07	0.08	0.10	2.60	5.80	7.80
	Mean	10.34	10.86	10.66	8.05	3.99	1.46	0.37	0.79	3.22	5.89	7.88	9.42
	Max	11.70	12.14	12.50	11.40	6.85	7.30	1.33	3.31	6.13	8.20	9.50	11.50
CB5.3	Min	8.10	9.20	8.60	4.80	2.15	0.90	0.25	0.50	0.50	3.10	4.70	6.50
	Mean	9.78	10.53	9.98	7.57	4.74	2.61	1.12	1.63	3.48	5.54	7.27	8.65
	Max	11.10	11.80	11.50	9.55	6.82	6.10	2.20	2.90	5.70	7.90	8.90	10.50

Notes: 1. Dissolved oxygen concentrations are in milligrams per liter (mg/l).
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.
Source: Based on MDNR, 2010.

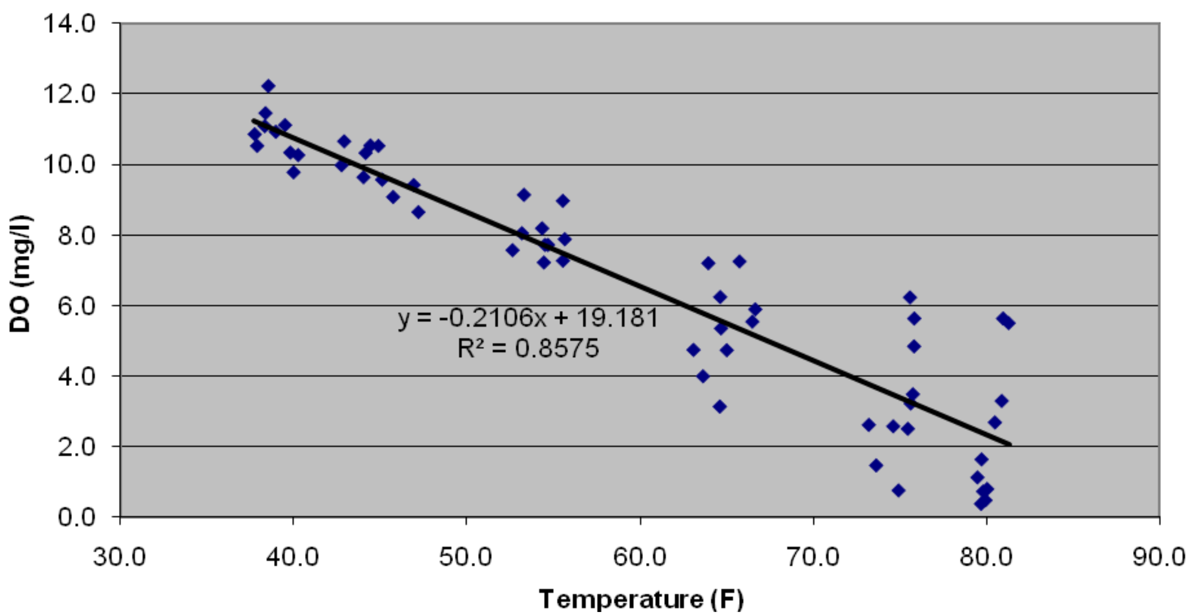
The mean DO concentrations for the months from May through September and for the two monitoring stations in the LDZ are more variable than the concentrations for the remaining months of the year and for the other stations. From May through September, there is a 3.7- to 5.1-mg/l range of variation in monthly mean DO concentrations between the station with the highest concentration and the station with the lowest concentration. From October through April the ranges of variation are lower, with values between 1.0 and 1.9 mg/l. Over the course of a year, the ranges of variation for Stations LE2.2 and LE2.3 are 10.7 and 10.5 mg/l, respectively; whereas for the other stations the ranges of variation are between 6.7 and 9.4 mg/l.

DO concentrations are influenced by temperature and salinity, as the solubility of oxygen in water decreases with increasing temperature and salinity (NOAA, 2011a). Over the year, the highest mean DO concentrations in the vicinity of the PRTR occur in February, the month with the lowest mean surface water temperatures at four of the five stations. At Station RET2.2 the lowest mean surface water temperature occurs one month earlier, in January. The lowest mean DO concentrations occur in July (with the exception of Station RET2.4 which has its lowest mean DO occurring in June), and the highest mean surface water temperatures occurring in July and August.

Analysis of the surface water temperature and bottom water DO data for the five monitoring stations in the vicinity of the PRTR indicated a high correlation ($r^2 = 0.8575$) between the two parameters, as shown in Figure 3.10-6 (Temperature-DO Scatter-plot Diagram). The correlation is strongest at lower surface water temperatures (indicated by the clustering of data points) and weaker at higher temperatures. A similar analysis of surface water salinity and DO concentrations indicated a negligible correlation ($r^2 = 0.0293$) between these parameters[7].

> **r^2** is the square of the Pearson product-moment correlation coefficient. The r^2 value can be interpreted as the proportion of the variance in y attributable to the variance in x.

Figure 3.10-6
Temperature-DO Scatter-plot Diagram



[7] The 'high' and 'negligible' degrees of correlation are based on Table 6.3 in Schmidt, Marty J., 1975, *Understanding and Using Statistics: Basic Concepts*.

From May through September, the mean monthly DO concentrations for Stations RET2.4, LE2.2, LE2.3, and CB5.3 are all below 5 mg/l, with only Station RET2.2 maintaining mean monthly concentrations above this threshold. DO concentrations below 5 mg/l can stress some aquatic organisms in the river, such as some fish species, especially if exposed to these conditions for prolonged periods (MDNR, 2010). Although some bottom-dwelling organisms, such as worms, can survive at DO concentrations as low as 1 mg/l, many organisms will not survive exposure to concentrations below 1 mg/l for more than a few hours (MDNR, 2010). The June mean DO concentration for Station LE2.2 is below the 1-mg/l threshold, as are the July and August mean concentrations for both Station LE2.2 and Station LE2.3.

It is likely that low DO conditions are a natural feature of the lower Potomac River trench (USEPA, 2003), which extends from near Station LE2.2 to the mouth of the river, near Station LE2.3. The Potomac River trench is not connected to the mainstem Chesapeake Bay trench. Strong water-column stratification effectively isolates the trench waters from the surface waters, preventing the mixing of surface and bottom waters. Given the large size of the Potomac River basin, large amounts of organic matter potentially are transported from upriver to the waters of the trench. Decomposition of this organic matter could depress oxygen levels that are not readily replenished due to the presence of a pycnocline (the zone between waters with different densities). The high mean DO concentration in the LDZ, at Stations LE2.2 and LE2.3, in March – the month with the highest freshwater discharges – may result from high river flows rejuvenating the below-pycnocline waters of the Potomac River trench.

Turbidity

Water turbidity is a state of reduced clarity of the water caused by the presence of suspended matter. The greater the amount of total suspended solids (TSS) in the water, the higher the turbidity and the less light penetrates through the water. Increased turbidity can lead to reduced growth of submerged aquatic vegetation (SAV), reduced fish health, and, typically in association with dredging operations, burial of benthic organisms.

Excessive algal growth, runoff, shoreline erosion, pollution, resuspension of bottom sediments, and the mixing of fresh and salt water can increase turbidity. River discharge and turbidity data for the five monitoring stations in the vicinity of the PRTR were analyzed to determine the relationship between the two parameters in the Lower Potomac River. As river discharge data for the Potomac River were not available for a gage in the vicinity of the PRTR, data from the United States Geological Survey (USGS) monitoring station near Washington, DC (Station 01646502) were used in the analysis. The analysis indicated high correlation between discharge and turbidity for Station RET2.2 ($r^2 = 0.6966$) and moderate to high correlation for Station RET2.4 ($r^2 = 0.5422$); whereas, the analysis indicated negligible correlations between the two parameters for the three downstream stations – LE2.2, LE2.3, and CB5.3.

Secchi depth is measured using a Secchi disk, a circular plate that is divided into quarters, painted alternately black and white. The disk is lowered into the water and the Secchi depth, the depth at which the disk is no longer visible, is recorded. Low Secchi depth indicates high turbidity.

Table 3.10-7 shows the monthly turbidity – measured as Secchi depth – of the water at the MDNR monitoring stations. Throughout the year, mean water turbidity generally decreases in a downstream direction, with the highest turbidity (or lowest clarity) at Station RET2.2, and the lowest turbidity at Stations LE2.3 and CB5.3.

Table 3.10-7
Water Clarity or Turbidity (Secchi Depth) (m)

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	0.10	0.20	0.20	0.25	0.25	0.35	0.35	0.45	0.15	0.30	0.05	0.10
	Mean	0.43	0.53	0.43	0.40	0.42	0.53	0.65	0.66	0.74	0.76	0.59	0.49
	Max	0.80	1.20	0.70	0.65	0.60	0.85	0.95	1.05	1.10	1.40	1.80	0.90
RET2.4	Min	0.10	0.30	0.30	0.20	0.40	0.35	0.50	0.60	0.35	0.50	0.21	0.20
	Mean	0.69	0.74	0.60	0.47	0.57	0.65	0.77	0.84	0.93	1.08	1.06	0.79
	Max	1.50	1.30	1.00	0.85	0.80	1.15	1.15	1.10	1.35	1.70	2.60	1.20
LE2.2	Min	1.00	0.70	0.70	0.40	0.35	0.60	0.70	0.95	0.95	0.95	1.10	0.50
	Mean	1.54	1.58	1.32	1.02	1.07	1.11	1.25	1.33	1.33	1.58	1.70	1.47
	Max	2.60	3.40	2.30	1.80	2.70	1.95	2.00	1.70	1.70	2.10	3.40	2.80
LE2.3	Min	1.10	1.40	1.10	0.85	1.00	1.00	0.85	1.20	1.00	1.30	1.30	1.10
	Mean	2.00	2.08	1.84	1.54	1.66	1.45	1.44	1.62	1.68	1.89	2.18	2.24
	Max	2.80	3.10	3.00	2.40	2.90	2.20	1.85	2.30	2.30	2.50	3.80	6.00
CB5.3	Min	1.50	1.00	0.80	0.70	1.00	0.85	0.90	1.20	1.30	1.00	1.20	1.20
	Mean	2.05	2.00	1.80	1.64	1.63	1.45	1.48	1.68	1.76	1.82	2.17	2.14
	Max	3.00	3.20	2.70	2.75	2.95	2.30	2.10	2.60	2.70	2.50	3.80	3.80

Notes: 1. As a measure of water clarity or turbidity, Secchi depths are in m.
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.

Source: Based on MDNR, 2010.

At all five stations, turbidity is seasonal. The highest mean turbidity levels occur in April for the three upstream stations and in June or July for the downstream stations. For Stations RET2.2 and RET2.4, the lowest turbidity levels occur in October; whereas for the three stations downstream of RET2.4, the lowest turbidity levels occur in November or December.

pH

Table 3.10-8 shows the monthly surface water pH at the monitoring stations. pH is variable across the five monitoring stations, with a 0.29 to 0.89 range of variation in monthly mean pH between stations. The largest variations between upstream and downstream stations occur in the spring and summer. The mean pH values at the five monitoring stations are most similar during the winter.

pH – potential of hydrogen – is a measure of the acidity or alkalinity of a solution. The pH scale ranges from 0 to 14. A pH of 7 is neutral; below 7 is acidic and above 7 is alkaline or basic. The pH of water determines the amount that can be dissolved in the water (solubility) and the amount that can be utilized by aquatic life (biological availability) of chemical constituents, such as nutrients and heavy metals.

Buffering capacity is the ability of a solution to resist changes in pH. As a result of buffering, the pH in an estuary tends to remain fairly constant because the chemical components of seawater resist large changes in pH.

In the vicinity of the PRTR, pH generally increases in a downstream direction, as shown by Figure 3.10-7 (Mean Surface Water pH). Throughout the year, pH at the two upstream stations (RET2.2 and RET2.4) tends to be lower than that at the three downstream stations (LE2.2, LE2.3, and CB5.3). Counter to this tendency toward increasing pH downstream, Station LE2.2, in the upper portion of the LDZ, has the highest mean pH for eight months through the year. The annual range of variation of pH at the stations generally decreases in a downstream direction, likely as a result of buffering by seawater. However, Station RET2.4, between the UDZ and the MDZ, has the largest annual range of variation. The high mean monthly pH values for Station LE2.2 and the large range of variation at Station RET2.4 may result from discharges from the Morgantown Generating Station.

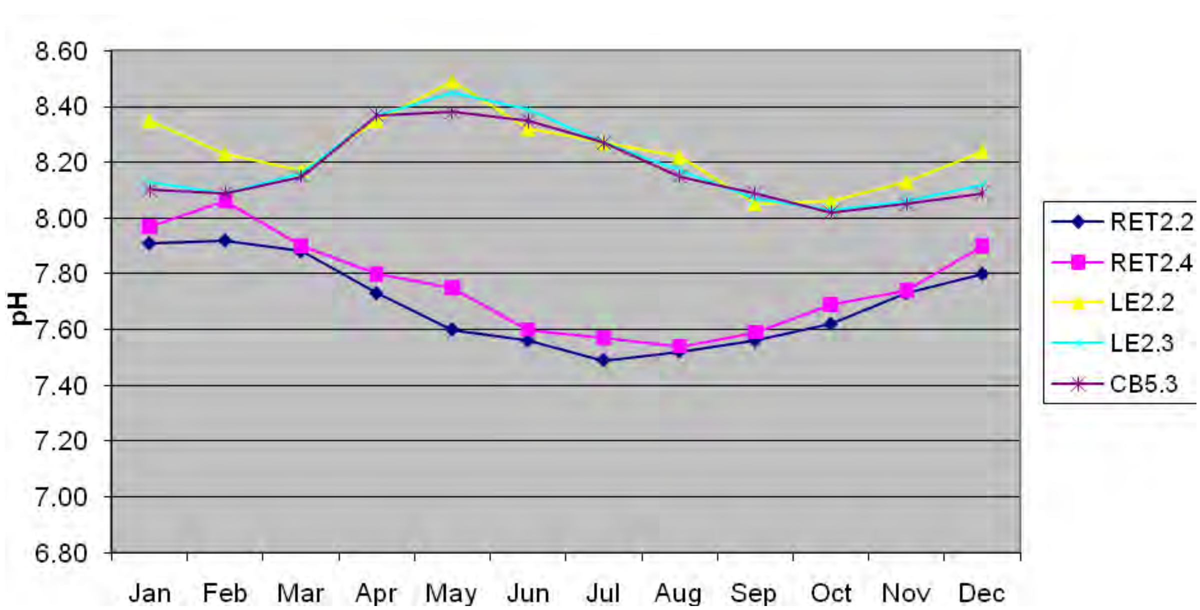
Table 3.10-8
Surface Water pH

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	7.40	7.50	7.60	7.45	7.05	6.95	7.10	7.07	6.80	6.90	6.80	6.90
	Mean	7.91	7.92	7.88	7.73	7.60	7.56	7.49	7.52	7.56	7.62	7.73	7.80
	Max	8.30	8.30	8.35	8.05	7.90	8.00	7.70	8.30	8.60	7.90	8.20	8.20
RET2.4	Min	7.60	7.70	7.50	7.40	7.30	7.40	7.15	7.20	7.15	7.45	7.00	6.90
	Mean	7.97	8.06	7.90	7.80	7.75	7.60	7.57	7.54	7.59	7.69	7.74	7.90
	Max	8.40	8.50	8.40	8.30	8.20	7.85	7.75	7.95	7.90	7.95	8.10	8.40
LE2.2	Min	7.80	7.80	7.65	7.55	8.05	8.05	7.75	7.80	7.60	7.60	7.60	7.80
	Mean	8.35	8.23	8.17	8.35	8.49	8.32	8.27	8.22	8.05	8.06	8.13	8.24
	Max	9.40	8.70	8.85	9.00	9.00	8.60	8.65	8.75	8.35	8.45	8.60	8.70
LE2.3	Min	7.71	7.50	7.79	7.95	8.10	7.95	8.05	7.66	7.71	7.90	7.69	7.80
	Mean	8.13	8.09	8.16	8.37	8.45	8.39	8.27	8.17	8.07	8.03	8.06	8.12
	Max	8.70	8.40	8.44	8.84	8.80	8.60	8.45	8.60	8.30	8.50	8.30	8.40
CB5.3	Min	7.67	7.50	7.79	7.90	7.95	7.97	8.01	7.69	7.67	7.90	7.73	7.80
	Mean	8.10	8.09	8.15	8.37	8.38	8.35	8.27	8.15	8.09	8.02	8.05	8.09
	Max	8.60	8.40	8.50	8.78	8.75	8.60	8.60	8.55	8.40	8.30	8.30	8.50

Notes: 1. pH denotes 'potential of hydrogen' and is a measure of the acidity or alkalinity of a solution.
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.

Source: Based on MDNR, 2010.

Figure 3.10-7
Mean Surface Water pH



Biological Indicators of Water Quality

The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Biological or biotic integrity is "the capability of supporting and maintaining a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats of the region" (Karr and Dudley, 1981; Karr, 1991; USEPA, 2008b). As the numbers, diversity, and condition of living organisms present provides a direct and effective measure of the biological integrity of a specific waterbody, biological indicators are used to assess water quality. Biological indicators are measures, indices of measures, or models that characterize an ecosystem or one of its critical components (USEPA, 2008b). They are numerical values that are derived from actual measurements, have known statistical properties, and convey useful information for environmental decision making.

An index of biotic integrity (IBI) is used to determine the integrity of a biological community in a given waterbody. IBIs are comprehensive (i.e., they examine the subject community as a whole) and rapid bioassessment techniques that can be applied on a relatively large scale.

> An **index** is a ratio or other number derived from a series of observations and used as an indicator or measure.

In the Chesapeake Bay area, an estuarine benthic IBI (B-IBI) was developed by Weisberg et al. (1997) and Lacouture et al. (2006) developed a phytoplankton IBI (P-IBI). Both of these IBIs were developed for and are in use in the Chesapeake Bay and its tidal tributaries, including the Potomac River. IBIs for SAV (Dennison et al., 1993), zooplankton (Carpenter et al., 2006), and tidal fish (MDNR, 2008) also have been developed for use in the Chesapeake Bay and its tidal tributaries, but have not been implemented or are no longer active. The benthic and phytoplankton IBIs are discussed below. Fish kills are also discussed, as an additional indicator of water quality in the Lower Potomac River.

Benthic Index of Biotic Integrity (B-IBI)

Benthic (or bottom-dwelling) invertebrates are aquatic invertebrates, including insects, crustaceans, mollusks, and worms, that spend the majority of their life associated with the bottom in an aquatic ecosystem. The presence or absence of benthic invertebrates is regulated by several parameters, including organic input (i.e., carbon input), oxygen level, temperature, salinity, current strength, turbidity, substrate type, and inorganic input. Unlike fish and other mobile species, many benthic invertebrates lack mobility and, as such, are more susceptible to stress, such as hypoxia, sedimentation, accumulation of contaminants, and other natural and anthropogenic impacts. Many studies have shown that the structure of benthic assemblages can be directly attributed to a response by the benthos – the organisms that live on or near the seabed or bottom, collectively – to a myriad of anthropogenic or natural impacts to the aquatic ecosystems (Weisberg et al., 1997). As a result of these characteristics, benthic invertebrates are reliable and sensitive indicators of habitat quality and environmental status, stress, and trends (Weisberg et al., 1997; Llansó et al., 2008).

> **Hypoxia/Hypoxic waters** are waters with dissolved oxygen concentrations of less than 2 parts per million, the level generally accepted as the minimum required for most marine life to survive and reproduce.
>
> **Source:** USEPA, 2008b.

Weisberg et al. (1997) developed a B-IBI for the Chesapeake Bay based on communities in ideal conditions, or conditions with little or no impairment. The B-IBI allows for comparison of relative condition between benthic invertebrate communities across habitat types. The Chesapeake Bay Long-Term Benthic Monitoring Program uses the B-IBI to assess the condition of the benthic community at each of its monitoring sites, including those in the Potomac River. The B-IBI is based on a scale of 1 to 5.

Metrics Used to Calculate the Chesapeake Bay B-IBI

- Shannon-Wiener species diversity index
- Total species abundance
- Total species biomass
- Percent abundance of pollution-indicative taxa
- Percent abundance of pollution-sensitive taxa
- Percent biomass of pollution-indicative taxa
- Percent biomass of pollution-sensitive taxa
- Percent abundance of carnivores and omnivores
- Percent abundance of deep-deposit feeders
- Tolerance score
- Tanypodinae-to-Choronomidae percent abundance ratio

Note: Two additional metrics are used only at fixed stations by the Virginia Benthic Monitoring Program, none of which are on the Potomac River.

Source: Llansó, 2002.

The Chesapeake Bay Long-Term Benthic Monitoring Program monitors benthic community conditions at fixed and probability benthic monitoring sites in the Chesapeake Bay and its tidal tributaries (Llansó, 2002; Llansó et al., 2007, 2008). Fixed sites are sampled twice a year, in May and in late August or September, to identify temporal trends in benthic community conditions. Probability sites are sampled once a year, in late August or September, to assess the geographic extent of degraded benthic community conditions. Benthic community condition is classified into four levels based on the B-IBI, as follows (Llansó et al., 2008):

- A score less than or equal to 2.0 is classified as severely degraded habitat
- A score from 2.0 to 2.6 is classified as degraded
- A score greater than 2.6 but less than 3.0 is classified as marginal
- A score of 3.0 or higher is classified as meeting the Chesapeake Bay benthic community restoration goals

Probability-based summer sampling at probability benthic monitoring sites was initiated in 1994, and the sampling intensity in the Potomac River was increased in 1995 and subsequent years (Llansó et al., 2007, 2008). Sampling of probability sites occurs at depths greater than 3.3 ft and up to 39.4 ft (Llansó et al., 2007). The probability sites are not sampled deeper than 39.4 ft because anoxia commonly occurs below that depth and samples are consistently azoic (i.e., without living organisms).

Analysis of the probability-based sampling data indicated that in terms of the condition of the health of the benthic communities, the Potomac River is in poor condition. The following findings are indicative of the condition of the river (Llansó et al., 2008):

For each year from 1995 to 2007, over half – ranging from 56 to 92 percent – of the bottom area of the Potomac River failed to meet the Chesapeake Bay benthic community restoration goals. Each year, 48 to 93 percent of the bottom area that failed to meet the restoration goals was severely degraded.

For the period 1996 through 2007, over 81 percent of sites in the Potomac River that failed to meet the restoration goals failed due to insufficient abundance or biomass of organisms (Llansó et al., 2008). For the same period, 11 percent of the sites that failed to meet the restoration goals failed due to excess abundance or biomass.

In 2007, an estimated 80 percent of the bottom area of the Potomac River failed to meet the restoration goals. Among the 25 Potomac River probability sites sampled in 2007, 13 sites were azoic and 1 additional site was nearly azoic, with only 1 organism sampled.

Six fixed benthic monitoring sites, sampled since 1984, are located in the Lower Potomac River and are shown in Figure 3.10-4. A seventh Potomac River site – Site 36 – is located approximately 4.3 miles south of Washington, DC, near the Woodrow Wilson Bridge, and is not shown in Figure 3.10-4. Site 40, which is shown on Figure 3.10-4, is located upstream of the PRTR, in the vicinity of MDNR Monitoring Station RET2.2. For each of the seven Potomac River fixed sites, Table 3.10-9 shows the water depth at the site, the percentage of silt or clay in the substrate, and the B-IBI scores for four sampling periods.

Table 3.10-9
B-IBI Scores at Fixed Benthic Monitoring Sites

Site	Depth (ft)[1]	Percent Silt/Clay[1]	B-IBI Score				Trend Significance
			1985-1987	2002-2004	2004-2006	2005-2007	
36	≤ 16.4	≥ 40	3.14	2.28	3.22	2.89	NS
40	21-33	≥ 80	2.80	3.01	3.20	3.09	NS
43	≤ 16.4	≤ 30	3.76	3.58	3.58	3.58	NS
44	36-56	≥ 75	2.80	2.56	2.51	1.84	$p < 0.05$
47	≤ 16.4	≤ 30	3.89	3.40	3.89	4.02	NS
51	≤ 16.4	≤ 20	2.43	3.07	2.41	2.33	$p < 0.05$
52	30-43	≥ 60	1.37	1.22	1.04	1.11	NS

Notes: 1. ≥ indicates greater than or equal to; ≤ indicates less than or equal to.
2. NS indicates not significant.
Source: Llansó et al., 2007, 2008.

There is a strong correlation between hypoxia, depth, and sedimentation. Hypoxic events generally are more frequent as depth and sedimentation increase. B-IBI scores for the Potomac River benthic community likewise are correlated with depth and sedimentation, as well as hypoxia. The most severely degraded benthic monitoring sites in the PRTR portion of the Potomac River – and throughout the river – are Sites 44 and 52. As shown in Table 3.10-9, both sites are deep sites with high silt/clay content of the substrate, indicating a depositional environment with high sedimentation. Hypoxia influences benthic community condition at both Site 44 and Site 52 (Llansó et al., 2005). Conversely, the two benthic monitoring sites in the PRTR portion of the Potomac that have consistently met the Chesapeake Bay benthic community restoration goals – Sites 43 and 47 – are comparatively shallow and have low sedimentation (lower percentages of silt/clay). These two sites are less likely to experience hypoxic events than are Sites 44 and 52.

The B-IBI scores within the Potomac River that are marginal or that meet the Chesapeake Bay benthic community restoration goals are relatively low compared to scores within the rest of the Chesapeake Bay watershed. Overall, the Potomac and Patuxent Rivers, and Maryland's western shore, are in the poorest condition, based on B-IBI scores at fixed benthic monitoring sites. Among these three low-scoring areas, the Potomac River had the largest percentage of severely degraded conditions (Llansó et al., 2007).

For the period 1999 through 2003, in the PRTR portion of the Potomac River, the benthic habitats at 71 percent of the fixed sampling sites were degraded (Llansó et al., 2007). Upstream of the PRTR, the habitats at less than 50 percent of the sites were degraded. The high percentage of degraded sites in the PRTR portion of the river is due primarily to anoxic conditions (absence of oxygen) in the deeper – i.e., depths greater than 39 ft – water of the Lower Potomac River (Llansó et al., 2003). The reason anoxia is considered the primary reason for the high percentage of degraded sites in this portion of the river is that there is a strong relationship between B-IBI scores, DO levels, and depth (Llansó et al., 2003). Generally, dissolved oxygen decreases with depth, as do B-IBI scores. This relationship illustrates the enormous impact anoxia has on the benthic invertebrate community.

Significant ($p < 0.05$) trends have been observed at two fixed sampling sites in the PRTR portion of the Potomac River since sampling began – Sites 44 and 51 (Llansó et al., 2008). As shown in Table 3.10-9, the B-IBI score for Site 44 decreased from 2.80 for the initial condition (1985 to 1987) to 1.84 for the current condition (2005 to 2007), changing the rating for the site from marginal to severely degraded. The score for Site 51 also decreased, from 2.43 to 2.33, although the site rating in that case remained the same – degraded.

By contrast, despite their proximity to Site 44 (see Figure 3.10-4), Sites 43 and 47 have consistently met the Chesapeake Bay benthic community restoration goals. The lower scores and declining benthic community condition at Site 44 may result from the greater depth at the site and the site's location in a depositional environment, indicated by the high silt/clay content of the substrate. The site with the worst B-IBI scores throughout the last 22 years is Site 52, with scores consistently below 1.5, indicating a severely degraded benthic community condition. Site 52 is in deep water and is in a depositional area, both factors that likely contribute to the impoverishment of the benthic habitat.

Phytoplankton Index of Biotic Integrity (P-IBI)

A P-IBI based on reference phytoplankton communities – communities showing little or no impairment – was developed in order to characterize Chesapeake Bay and its tidal tributaries (Buchanan et al., 2005; Lacouture et al., 2006). The P-IBI serves as a quantitative scale to assess phytoplankton community status relative to water quality, and uses various metrics to characterize habitat conditions. Impaired areas generally have high DIN and PO_4 concentrations and low Secchi depths (high turbidity).

P-IBI ratings range from 1.0 to 5.0. The index classifies the phytoplankton community status as follows (Buchanan, 2006; Lacouture et al., 2006):

- A score from 1 to less than 2 is classified as Poor
- A score from 2 to less than 2.67 is classified as Poor to Fair
- A score from 2.67 to less than 3.33 is classified as Fair
- A score from 3.33 to less than 4 is classified as Fair to Good
- A score from 4 to 5 is classified as Good

A Good status is the recommended restoration goal for all Chesapeake Bay waters, including tidal tributaries such as the Potomac River, based on its correlation with attainment of the Chesapeake Bay water quality criteria and standards for dissolved oxygen and water clarity (Buchanan, 2006). A Good P-IBI rating is intended to correspond to the best attainable level of phytoplankton community integrity, not the level of integrity found in pristine estuaries (Buchanan, 2006).

Metrics Used to Calculate the Chesapeake Bay P-IBI

- Carbon:chlorophyll *a*
- Surface chlorophyll *a*
- Percent of total biomass composed of cryptophytes
- Cyanophyte biomass
- Diatom biomass
- Dinoflagellate biomass
- Dissolved organic carbon
- *Microcystis aeruginosa* abundance
- Pheophytin
- Picophytoplankton abundance
- *Prorocentrum minimum* abundance
- Total nano-micro phytoplankton biomass

Note: Carbon:chlorophyll a is the ratio of total nano-micro phytoplankton biomass to chlorophyll a in the above-pycnocline layer.

Source: Lacouture et al., 2006.

P-IBI parameters are monitored at two MDNR monitoring stations – Stations RET2.2 and LE2.2 – located in the vicinity of NSF Dahlgren and the PRTR (see Figure 3.10-4). Mean index scores based on data collected from 1985 to 2002 classify the oligohaline portion of the Potomac River – Station RET2.2, above the UDZ – as having a Poor P-IBI in spring (March to May) and a Fair P-IBI in summer (July to September), with average indices of 1.9 and 3.1, respectively (Buchanan, 2006; Lacouture et al., 2006). The mesohaline portion of the Potomac River – Station LE2.2, in the LDZ – was classified as having Fair phytoplankton communities in spring, and Poor to Fair communities in summer, with mean scores of 2.8 and 2.6, respectively (Buchanan, 2006; Lacouture et al., 2006).

Fish Kills

The MDE oversees the investigation of fish-kill incidents throughout the state, including the Lower Potomac River (MDE, 2011). Fish kills result from both natural and human-induced stresses. Based on data provided by the MDE (Luckett, pers. comm., February 9, 2010), 65 fish kills involving 12 or more fish occurred from 1984 through 2009 in the tidal Potomac River in Charles and Saint Mary’s Counties, Maryland – i.e., from upstream of the UDZ to the mouth of the river.

The 65 incidents in the tidal Potomac River killed approximately 442,000 fish and shellfish, predominantly fish (finfish). Of the 65 fish kills, 14 probably were caused by low DO levels or by low DO in combination with other stresses:

- The statewide fish-kill response program designated low DO levels as the probable cause of nine of the incidents, killing approximately 114,000 fish, or about 25.8 percent of all the fish and shellfish killed in the 65 fish kills in the tidal Potomac River.
- Entrapment in combination with low DO was designated as the probable cause of an additional three incidents, and one other incident was attributed to entrapment in combination with low DO and/or a toxic algae bloom; combined, these four incidents killed approximately 11,500 fish, or 2.6 percent of the total.
- Toxic algae combined with low DO were designated as the probable causes of one incident, killing approximately 500 fish, or 0.1 percent of the total.

Review of the MDE data indicates that one species of fish – spot (*Leiostomus xanthurus*) – is particularly susceptible to low DO in the tidal Potomac River. Approximately 100,300 spot probably were killed by low DO resulting from storm-induced inversion during a single incident. The species represented at least 79.6 percent of the fish killed by the 14 low-DO-related incidents, and spot died in 8 of the 14 kills. Other susceptible species include Atlantic croaker (*Micropogonias undulatus*), summer flounder (*Paralichthys dentatus*), white perch (*Morone americana*), Atlantic menhaden (*Brevoortia tyrannus*), and striped bass (*Morone saxatilis*), together representing at least 11.2 percent of the fish killed. Six other species, along with fish of unidentified species, represent the remaining 9.2 percent.

Recent Potomac River Fish Kills

- A large fish kill occurred from June 2 to June 4, 2006 in the Lower Potomac River, in the vicinity of the MDZ and LDZ. Between 7,000 and 8,000 fish, comprising multiple species, washed ashore on the Virginia side of the river, between Colonial Beach and Coles Point (ICPRB, 2006). Algal toxin from a dinoflagellate bloom or the upwelling of anoxic (i.e., lacking oxygen) bottom waters, likely driven by strong westerly winds, may have been the proximal cause of the fish kill (ICPRB, 2006).
- During the summer of 2006, approximately 30,000 fish (multiple species) died off Cobb Island, on the Maryland side of the Lower Potomac in the vicinity of the MDZ (Pelton, 2007). Low dissolved-oxygen levels were the probable cause of the fish kill.
- In mid-February 2007, approximately 50,000 white perch and some striped bass died and washed ashore on the Maryland side of the river, near Swan Point in the vicinity of the MDZ, and near Tall Timbers in the vicinity of the LDZ (Pelton, 2007; Fahrenthold, 2007). It is likely that thermal shock resulting from severe cold killed the fish that were trapped in shallow water by strong winds and tides (Fahrenthold, 2007).

Several fish kills probably were caused by water quality conditions other than low DO levels. A single, very large fish kill was attributed to entrapment or disease. This incident killed an estimated 200,000 fish and shellfish, or about 45.2 percent of the fish killed in the 65 fish kills in the tidal Potomac River. Approximately 95 percent of the fish were Atlantic menhaden, but the kill also involved striped bass, oyster toadfish (*Opsanus tau*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), and blue crab (*Callinectes sapidus*). Other water-quality-related fish kills included the following:

- Three incidents attributed to cold stress killed over 50,500 fish, of which an estimated 50,250 were white perch; the remaining 250 or so individuals were individuals of five other finfish species.
- One incident attributed to the discharge of chlorine from the Morgantown Generating Plant killed approximately 8,000 gizzard shad (*Dorosoma cepedianum*).
- One incident attributed to toxic algae killed approximately 3,700 fish – predominantly hogchoker (*Trinectes maculatus*), spot, Atlantic silverside (*Menidia menidia*), and white perch, but also individuals of 11 other finfish species.
- One incident attributed to a natural die-off killed approximately 200 Asian clams (*Corbicula fluminea*).

The fish-kill response program designated commercial discards as the probable cause of 27 fish kills and recreational discards as the probable cause of 1 additional kill. Commercial and recreation discards killed approximately 15,000 fish. The causes of the remaining 16 fish kills, involving almost 39,000 fish, are not known.

3.10.1.3 Tributaries

Upper Machodoc Creek is approximately 3,000 ft wide at its mouth and 6 ft deep. Its total length is approximately 17.4 mi and its watershed encompasses approximately 47.2 sq mi. Gambo Creek is tidally influenced as far inland as NSF Dahlgren's northern boundary (NOAA, 1993; NSWCDD, 2001).

The Commonwealth of Virginia has jurisdiction over tributaries to the Potomac River on NSF Dahlgren. Under the Virginia Water Quality Standards (Virginia Regulation [VR] 680-21-00), Upper Machodoc Creek and its tidal tributaries are designated as Class IIa (NSF Dahlgren, 2006). This designation is applied to estuarine waters capable of propagating shellfish. Based on VDEQ water quality data, 0.4 sq mi of Upper Machodoc Creek are in impairment for bacteria (shellfish condemnation) and pH (aquatic life), and 0.8 sq mi were assessed as not supporting the fish consumption use goal due to exceedances of polychlorinated biphenyls (PCBs) in fish tissue (VDEQ, 2008). In addition, 13 to 17 percent of samples taken did not meet DO and fecal coliform criteria (VDEQ, 2008). A portion of the Williams Creek-Upper Machodoc Creek area also did not meet DO, pH, and bacteria goals (VDEQ, 2008).

The other tidal tributaries of the Potomac River on the installation are classified as Class IIb waters, which designates the waters as suitable for bathing and fishing, but taking shellfish is prohibited (NSF Dahlgren, 2006). This designation is applied to estuarine waters with Potomac embayment standards. The VDEQ assessed 0.2 sq mi of Gambo Creek as not supporting the shellfishing use goal in the 2004 water-quality assessment due to bacterial contamination (VDEQ, 2008).

3.10.1.4 Ponds

Both Beaver Pond and Lespedeza Pond are located north of Gambo Creek, in the north-central and northeast portions of Mainside, respectively. Two man-made ponds are also present on Mainside. Hideaway Pond, which is approximately 13 ac in size, is located in the Advanced Concepts Complex area in the northeast section of Mainside. Cooling Pond, which is approximately 10 ac in size, is located in the southern section of Mainside.

NOAA (1993) reported that surface water, sediment, and fish tissue samples were collected in Hideaway Pond and its two tributaries and analyzed for mercury. Mercury was not detected in any of the surface water samples (NOAA, 1993). However, although the detection limit of 0.10 micrograms per liter (μg/l) was below the current recommended criterion maximum concentration (CMC) of 1.4 μg/l, it was above the current recommended criterion continuous concentration (CCC) of 0.77 μg/l (USEPA, 2009). Half of the sediment samples contained mercury concentrations greater than or equal to 0.01 milligrams per kilogram (mg/kg) on a wet weight basis, although these concentrations were not directly comparable to the screening guideline, which is expressed in mg/kg on a dry weight basis (NOAA, 1993). Earlier studies detected mercury at a maximum concentration of 1.9 mg/kg in fish tissues collected from Hideaway Pond (Fred C. Hart

> **CMC** is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.
>
> **CCC** is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.
>
> **Source:** USEPA, 2009.

Associates, Inc., 1983, as cited in NOAA, 1993). This concentration is an order of magnitude above the recommended criterion of 0.3 mg/kg methyl mercury for the protection of human health, based on a total fish consumption rate of 0.0386 lb per day (USEPA, 2009).

3.10.1.5 Stormwater Management

NSF Dahlgren follows three regulatory programs that are intended to protect water resources from degradation caused by stormwater runoff. The programs are the Virginia Stormwater Management Regulations (4 VAC 3-20), the Virginia Erosion and Sediment Control Regulations (4 VAC 50-30), and the Chesapeake Bay Preservation Act and Regulations. Subchapter 3.1.3 describes Virginia’s Coastal Zone Management Program (as well as Maryland’s).

The intent of Virginia's Chesapeake Bay Preservation Act (CBPA), Virginia Code 10.1-2100 et seq., and its implementing Chesapeake Bay Preservation Area Designation and Management Regulations, 9 VAC 10-20-10 et seq., is to protect certain lands, designated as Chesapeake Bay Preservation Areas, which if improperly developed could result in substantial damage to the water quality of the Chesapeake Bay and its tributaries. Chesapeake Bay Preservation Areas are divided into resource protection areas (RPAs) and resource management areas (RMAs).

RPAs include tidal wetlands; nontidal wetlands connected by surface flow and contiguous to tidal wetlands or water bodies with perennial flow, tidal shores, and 100-ft vegetated buffer areas located adjacent to and landward of the above three features, and along both sides of any water bodies with perennial flow (King George County, 2011). Development in RPAs is restricted to water dependent uses and redevelopment. RMAs include all other areas in King George County. Development performance criteria are applied to development within RMAs.

The CBPA is promulgated through county land ordinances; the DoD is a signatory to an agreement supporting the CBPA and partnering to conduct restoration of the Chesapeake Bay. It is Navy policy to comply to the extent possible, consistent with the military mission and budget constraints, with Virginia's Chesapeake Bay Preservation Act and its implementing regulations, maintained in accordance with the Virginia Erosion and Sediment Control Law (Virginia Code section 10.1-560) and the Virginia Stormwater Management Law (Virginia Code section 10.1-603, or an equivalent local program).

The quantity and quality of stormwater leaving the installation is controlled by a stormwater management system. The system consists of water retention ponds, gravity storm mains, laterals, drainage ditches, culverts, inlets, and catch basins. Most of the lines and culverts are reinforced concrete or corrugated metal, ranging in diameter from 4 to 60 inches (NSF Dahlgren, 2006). Natural features such as streams, wetlands, and floodplains also are part of the stormwater management system at NSF Dahlgren (NSWCDL, 1993, as cited in NSF Dahlgren, 2006). A Virginia Pollutant Discharge Elimination System (VPDES) permit covers small quantities of stormwater discharges into receiving water bodies.

3.10.2 Wetlands and Floodplains

3.10.2.1 Wetlands

Regulations

A number of federal laws, regulations, and policies regulate activities in wetlands, namely:

- Section 404 of the Clean Water Act, which directs the United States Army Corps of Engineers (USACE) to require permits for the discharge of dredged and fill material into "waters of the United States," a term that includes rivers, lakes, and most streams and wetlands.
- Executive Order 11990, *Protection of Wetlands*, which requires federal agencies to take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.
- The North American Wetlands Conservation Act, 16 U.S.C. §4408, which requires the restoration, management, and protection of wetlands and habitats for migratory birds on federal lands.
- The Wetlands Resources Act, 16 U.S.C. §3901, which calls for intensifying cooperative efforts among federal, state, and local governments and private interests for the management and conservation of wetlands.

The USACE regulates development in jurisdictional wetlands under Section 404 of the Clean Water Act and regulations contained in 33 CFR, Parts 320-330. For regulatory purposes under the Clean Water Act, the USACE and the USEPA define wetlands as:

> "… those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" (40 CFR § 230.3(t)).

Any action requiring a Section 404 Clean Water Act permit also requires a Section 401 water quality certification from the responsible state authority. Not every activity affecting wetlands requires a Section 404 permit/Section 401 water quality certification. Only those activities involving the discharge of dredged or fill material into a "water of the United States," including most wetlands, require these federal approvals.

The Commonwealth of Virginia regulates wetlands through a number of laws and provisions:

- The Virginia Wetlands Act of 1972 (Title 62.1 of the Code of Virginia), which protects tidal wetlands and regulates wetland development.
- Virginia Water Protection Regulations (VR 680-15-02), which regulate state waters and require a Virginia Water Protection Permit for activities involving wetlands under Section 404 of the Clean Water Act.

- Virginia Acts of Assembly Chapters 1054 (House) and 1032 (Senate), passed in the 2000 session, which amend existing wetland laws to require a Virginia Water Protection Permit for certain activities in non-tidal wetlands.

NSF Dahlgren Wetlands

Figure 3.10-8 (Wetlands - NSF Dahlgren) shows wetland areas at NSF Dahlgren, using National Wetland Inventory (NWI) descriptors. Wetlands at NSF Dahlgren are primarily associated with the Potomac River, Upper Machodoc Creek, Gambo Creek, Black Marsh Creek, and unnamed tributaries to these waterways. Wetlands within NSF Dahlgren are mostly estuarine emergent, palustrine forested, estuarine unconsolidated shore, and estuarine scrub-shrub wetlands. Wetlands outside the installation's boundaries are of similar type and distribution as those found within.

Table 3.10-10 provides a summary of the extent of wetlands on NSF Dahlgren, based predominantly on the estimated coverage of wetlands on the installation and to a lesser extent on field delineations of wetland limits. Estuarine and palustrine wetlands cover approximately 608 ac, or approximately 14 percent of the installation. The 608-ac total includes 90 ac of estuarine subtidal habitat, which is a deepwater habitat. Deepwater habitats are permanently-flooded lands that lie below the deepwater boundary of wetlands (Cowardin et al., 1979).

Table 3.10-10
Wetlands on NSF Dahlgren

Wetland Type	Area (ac)	Percentage of Total Acreage of NSF Dahlgren
Estuarine		
Intertidal	278	6.4
Subtidal	90	2.1
Total Estuarine	368	8.5
Palustrine		
Emergent	18	0.4
Forested (PFO)	183	4.2
Scrub-Shrub (PSS)	9	0.2
Unconsolidated Bottom	30	0.7
Total Palustrine	240	5.6
Total Wetlands	**608**	**14.1**

Note: Numbers may not total exactly due to rounding.
Source: NSF Dahlgren, 2007.

The wetlands on NSF Dahlgren along the Potomac River and Upper Machodoc Creek are predominantly estuarine, intertidal, emergent marsh, along with areas of scrub-shrub wetland and unconsolidated shores. Extensive estuarine wetlands border Gambo Creek. This brackish, intertidal, emergent marsh is dominated by saltmarsh cordgrass (*Spartina alterniflora*), marsh elder (*Iva frutescens)*, and pigweed (*Amaranthus cannabinus*) (NSWCDD, 2001). The wetland is well-buffered by mixed hardwood and pine forests. The downstream section of Black Marsh Creek is bordered by estuarine intertidal emergent marsh and unconsolidated shore. Further upstream, palustrine forested wetlands dominate.

There are approximately 92 ac of forested wetland swales in a designated special interest area (SIA) in the northwestern portion of Mainside. The swales drain toward the north end of the airfield. Tree species in the forested wetlands include red maple (*Acer rubrum)*, black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), white oak (*Quercus alba*), willow oak (*Quercus phellos*), and pin oak (*Quercus palustris*) (NSWCDD, 2001). The shrub layer is sparse to non-existent. The herb layer includes sedges (*Carex* spp.) and *Sphagnum* species (NSWCDD, 2001).

There is an approximately 6.1-ac constructed, non-tidal, seasonally-flooded emergent herbaceous wetland located in the southern section of Mainside. The wetland was constructed in 2001 as mitigation for remediation of the Pesticide Rinse Area (Solid Waste Management Unit 25) (NSF Dahlgren, 2006). The wetland was constructed by widening a narrow drainage way and associated wetlands that drain Cooling Pond, and then diverting flows from the pond across the widened area. The area was planted with wetland vegetation following excavation. The wetland is channelized at its downstream end and drains into tidal wetlands bordering Upper Machodoc Creek. Vegetation in the constructed wetland is characterized by black willow (*Salix nigra*), eastern baccharis (*Baccharis halimifolia*), woolgrass (*Scirpus cyperinus*), common rush (*Juncus effusus*), cattail (*Typha* spp.), strawcolored flatsedge (*Cyperus strigosus*), and common reed (*Phragmites australis*) (NSF Dahlgren, 2006).

3.10.2.2 Floodplains

Executive Order 11988, *Floodplain Management*, sets forth the responsibilities of federal agencies for reducing the risk of flood loss or damage to personal property, minimizing the impacts of flood loss, and restoring the natural and beneficial functions of floodplains. This order was issued in furtherance of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

A floodplain is any land area susceptible to being inundated by floodwaters from any source. A **100-year floodplain** is an area susceptible to being inundated by the base flood – that is, the flood having a one percent chance of being equaled or exceeded in any given year.

Federal Emergency Management Agency (FEMA) National Flood Insurance Program data show that NSF Dahlgren has approximately 391 ac of land that lies within the 100-year floodplain on Mainside and an additional 325 ac on the EEA Complex (Figure 3.10-9, Floodplains - NSF Dahlgren). The majority of the land on the installation that is within the floodplain is located on either side of Gambo Creek and along Black Marsh Creek. Floodplains also are located along the shores of Upper Machodoc Creek and the Potomac River.

3.10.3 Groundwater

3.10.3.1 Hydrogeology

On NSF Dahlgren, approximately 1,500 ft of unconsolidated sediments are present above the bedrock (Meng and Harsh, 1988). Based on Meng and Harsh (1988), Bell et al. (1994), Hammond and Bell (1995), Bell (1996), and Harlow and Bell (1996), these sediments are divided into the following seven hydrogeologic units, from the land surface downward:

Wetlands - NSF Dahlgren

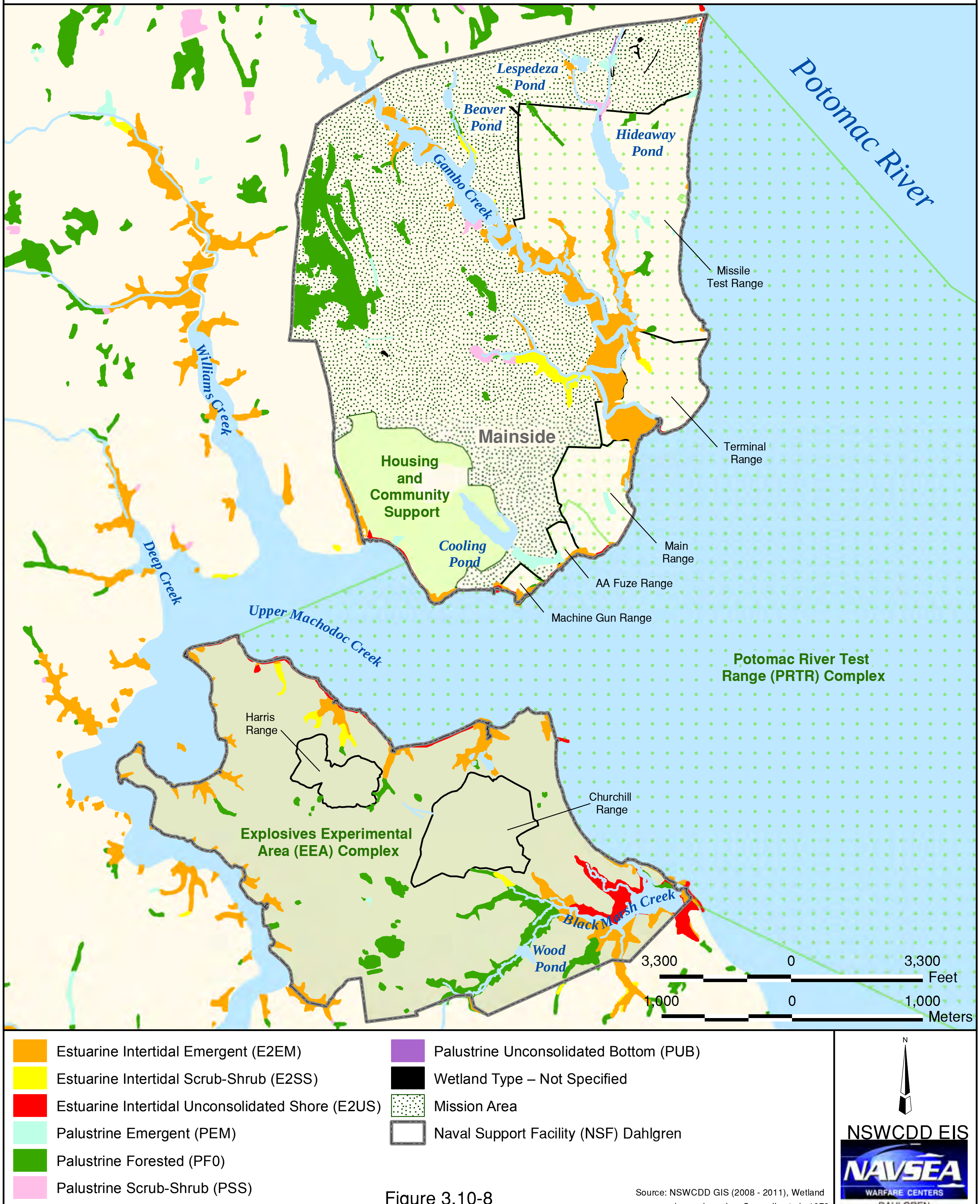


Figure 3.10-8

Source: NSWCDD GIS (2008 - 2011), Wetland classes based on Cowardin et al., 1979.

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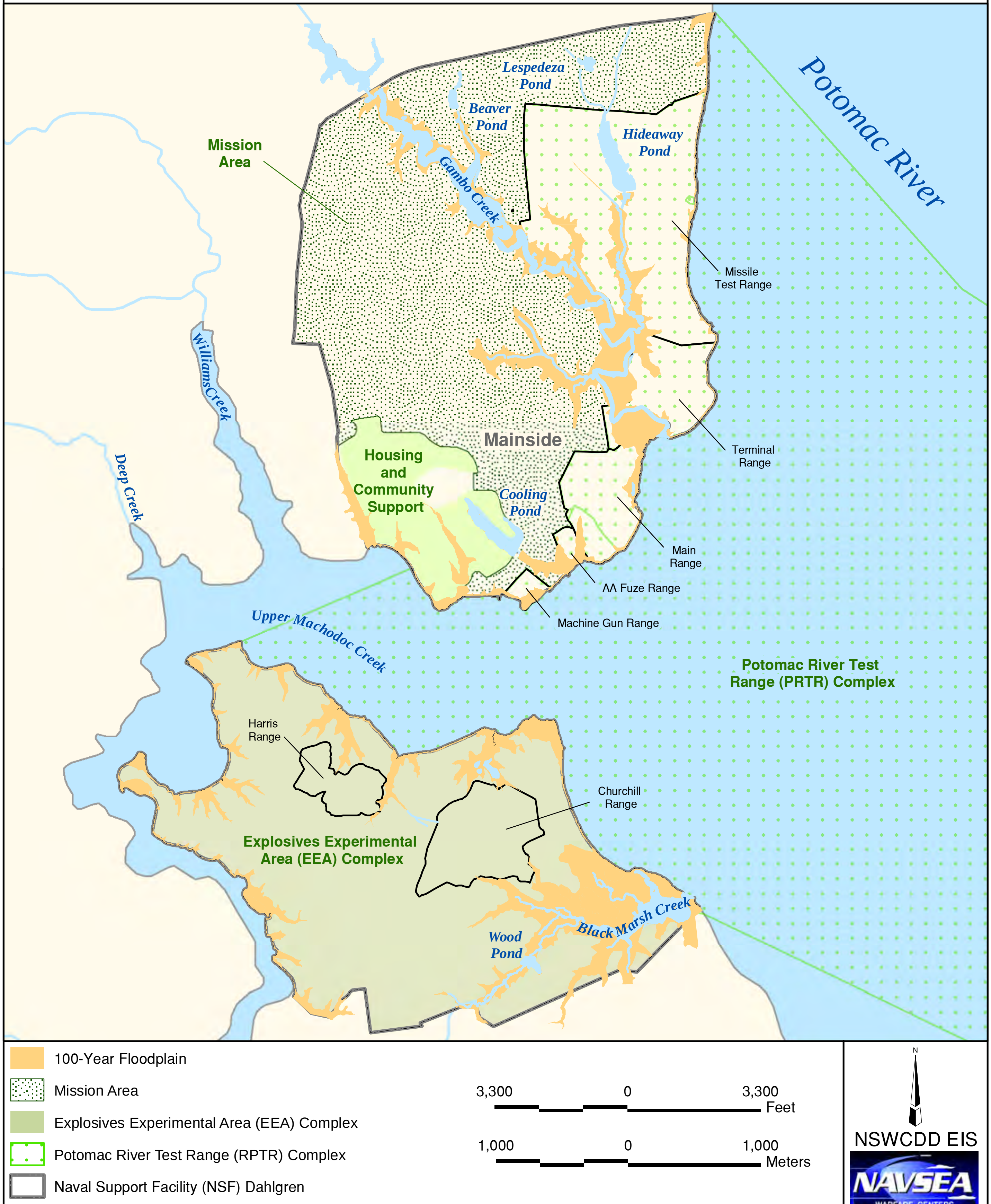
Floodplains - NSF Dahlgren



Source: NSWCDD GIS (2008 - 2011)

Figure 3.10-9

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- Columbia aquifer
- Upper confining unit
- Upper confined aquifer
- Nanjemoy-Marlboro confining unit
- Aquia aquifer
- Potomac confining unit
- Potomac aquifer

The following paragraphs describe the four aquifers that underlie NSF Dahlgren.

Columbia Aquifer

The Columbia aquifer underlies most of Mainside, but is absent in the stream valley of Gambo Creek in the northwestern part of Mainside (Harlow and Bell, 1996). The aquifer is present across the entire EEA Complex, where it varies from less than 8 ft to approximately 34 ft in thickness (Bell, 1996). On Mainside, the Columbia aquifer generally is 5 ft or more in thickness, and is thickest in the northeastern, central, and southeastern parts (Harlow and Bell, 1996).

Throughout most of NSF Dahlgren, the Columbia aquifer is underlain by the upper confining unit (Bell et al., 1994; Hammond and Bell, 1995; Bell, 1996), comprising deposits with relatively low permeability that restrict vertical groundwater movement between the Columbia aquifer and the underlying aquifers (Harlow and Bell, 1996; Agency for Toxic Substances and Disease Registry [ATSDR], 2006). However, the upper confining unit and upper confined aquifer are absent over an east-west trending band across the center of the EEA Complex, and the Columbia aquifer lies directly on the Nanjemoy-Marlboro confining unit (unpublished data on file in the Virginia district office of the USGS, as cited in Hammond and Bell, 1995; Bell, 1996).

The Columbia aquifer is recharged directly by precipitation across most of NSF Dahlgren (Bell, 1996; Harlow and Bell, 1996). Some groundwater enters the Columbia aquifer across portions of the installation boundary (Bell, 1996; ATSDR, 2006) and from the Nanjemoy-Marlboro confining unit, where the unit underlies the aquifer (Bell, 1996). On Mainside, groundwater flows from the northeast and northwest toward the wetlands along Gambo Creek, Upper Machodoc Creek, and the Potomac River (Harlow and Bell, 1996). On the EEA Complex, flow is generally from the western and central portion of the complex toward the Potomac River, Upper Machodoc Creek, Black Marsh, and other surface water features (Bell, 1996). Most water in the Columbia aquifer likely discharges to adjacent surface waterbodies (Harlow and Bell, 1996).

Upper Confined Aquifer

The unnamed, upper confined aquifer was discovered during hydrogeologic studies conducted by the USGS between 1992 and 1995 (Harlow and Bell, 1996). On Mainside, the upper confined aquifer ranges in thickness from 16 to 31 ft, being thickest in the northwestern part (Harlow and Bell, 1996). The aquifer is 0 to 35 ft thick on the EEA Complex (Bell, 1996).

The Nanjemoy-Marlboro confining unit underlies the upper confined aquifer (unpublished data on file in the Virginia District office of the USGS, as cited in Bell et al., 1994; Hammond and

Bell, 1995; Harlow and Bell, 1996) and impedes vertical groundwater flow between the upper confined aquifer and underlying aquifers (Harlow and Bell, 1996).

The upper confined aquifer is probably recharged by a combination of flow across the upper confining unit and the Nanjemoy-Marlboro confining unit (Bell, 1996). Groundwater flow in the upper confined aquifer is approximately northeast to southwest on Mainside (Harlow and Bell, 1996). On the EEA Complex, groundwater in the northern arm of the upper confined aquifer probably flows northward and eastward toward Upper Machodoc Creek and the Potomac River, whereas groundwater in the southern arm generally flows eastward-northeastward toward the Potomac River (Bell, 1996).

Aquia Aquifer

The recharge zone for the Aquia aquifer is approximately 25 miles west of NSF Dahlgren (Brown and Root Environmental, 1996, as cited in ATSDR, 2006). On Mainside, groundwater flow within the Aquia aquifer is approximately northwest to southeast (Harlow and Bell, 1996). The head –the difference in elevation between two points in a body of fluid – distribution observed during the USGS study was consistent with published maps of the Aquia aquifer that indicate a regional decline in water levels caused by withdrawals in Maryland (Harlow and Bell, 1996). Curtin et al. (2005) estimated that, in the vicinity of NSF Dahlgren, the water level of the Aquia aquifer declined approximately 20 ft between 1982 and 2003.

At the time of the USGS hydrogeologic study on Mainside (1995), there were no known withdrawals from the Aquia aquifer within or near Mainside (Harlow and Bell, 1996). However, according to the public health assessment for NSF Dahlgren (ATSDR, 2006), the Aquia aquifer provides water to many light industrial, small municipal, and domestic wells located around NSF Dahlgren.

Potomac Aquifer

The principal producing, confined aquifer underlying NSF Dahlgren is part of the Potomac Formation, which overlies the bedrock basement. This formation comprises three separate confined aquifers – the upper, middle, and lower Potomac aquifers – and associated confining units (Meng and Harsh, 1988). Most industrial and municipal wells in the general vicinity of NSF Dahlgren likely use the middle Potomac aquifer, sometimes in combination with the underlying, lower Potomac aquifer. Only the middle and lower Potomac aquifers underlie NSF Dahlgren (Meng and Harsh, 1988). These two aquifers are referenced collectively here as the Potomac aquifer.

The Potomac aquifer is recharged through a 253-sq-mi area approximately 25 mi west of NSF Dahlgren, along the Fall Line (NSWCDD, 2003). The Potomac aquifer is capable of supplying large quantities of groundwater and is the primary source of drinking water for NSF Dahlgren and the NSF Dahlgren municipal water system (ATSDR, 2006). Deep wells on the installation draw water from the aquifer (NSF Dahlgren, 2006). In the vicinity of NSF Dahlgren, the altitude of the top of the middle Potomac

> The **Fall Line** is a low, east-facing erosional scarp that parallels the Atlantic coastline from New Jersey to the Carolinas. It separates hard Paleozoic metamorphic rocks of the Appalachian Piedmont to the west from the softer, gently dipping Mesozoic and Tertiary sedimentary rocks of the Coastal Plain.
>
> **Source:** USGS, 2000.

aquifer is between approximately 260 and 280 ft below sea level (based on Meng and Harsh, 1988).

The middle Potomac confining unit overlies the Potomac aquifer and is between approximately 20 and 50 ft thick in the vicinity of NSF Dahlgren (based on Meng and Harsh, 1988). Studies indicate that the Potomac aquifer is not completely isolated from the overlying aquifers by a confining layer, and could be vulnerable to contamination from surface sources (Brown and Root Environmental, 1996, as cited in ATSDR, 2006). However, no evidence of contamination has been detected by the NSF Dahlgren drinking-water monitoring program (ATSDR, 2006).

3.10.3.2 Water Quality

Of the three shallow aquifers on Mainside, the mainly unconfined Columbia aquifer is most likely to be contaminated by surface sources (Harlow and Bell, 1996; ATSDR, 2006). During May 1993, water quality samples were collected once from 35 observation wells on Mainside, including 29 wells in the Columbia aquifer (Harlow and Bell, 1996). Water samples also were obtained from three wells in the upper confined aquifer and three wells in the Aquia aquifer. Due to anomalously high pH values measured in water samples from all three wells in the Aquia aquifer, chemical analyses of water from these wells were considered to not be representative (Harlow and Bell, 1996) and are not discussed here.

Dissolved solids and five inorganic constituents were present in water from the Columbia aquifer at concentrations that exceeded the national secondary drinking water standards (NSDWSs) for drinking water established by the USEPA (Harlow and Bell, 1996), as shown in Table 3.10-11. The concentration of dissolved solids exceeded the NSDWS of 500 milligrams per liter in 3 of 29 samples from the Columbia aquifer. An elevated concentration of sodium was present in one water sample, and elevated concentrations of chloride were present in two water samples.

National secondary drinking water standards (NSDWSs) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

Source: USEPA, 2008a.

Elevated concentrations of iron and manganese are the most extensive water-quality problems with regard to inorganic constituents in the Columbia aquifer. The concentration of dissolved iron exceeded the NSDWS in 10 water samples, and the concentration of manganese exceeded the NSDWS in 17 samples. High concentrations of iron and manganese at Mainside probably are the result of anoxic (severely deficient in oxygen) water conditions in parts of the Columbia aquifer (Harlow and Bell, 1996). Groundwater from two of the three wells in the upper confined aquifer on Mainside likewise had iron concentrations exceeding the NSDWS, and water from all three wells exceeded the NSDWS for manganese (Harlow and Bell, 1996). All other constituents measured were below the NSDWSs (Harlow and Bell, 1996).

On the EEA Complex, water-quality samples were collected from 28 wells – 20 wells in the Columbia aquifer, 4 wells in the Nanjemoy-Marlboro confining unit, and 4 wells in the upper confined aquifer – in June 1994 (Bell, 1996). Water in the upper confined aquifer and in some parts of the Columbia aquifer is anoxic and, as shown in Table 3.10-11, has high concentrations of dissolved iron and manganese (Bell, 1996). Concentrations of dissolved iron and manganese exceeded the NSDWS in 9 and 11 of 20 water samples, respectively (Bell, 1996). High concentrations of these constituents indicate local anoxic conditions in the Columbia aquifer.

Table 3.10-11
Columbia Aquifer Water Quality

Constituent	Concentration			NSDWS	Number of Samples Exceeding NSDWS
	Maximum	Median	Minimum		
Mainside					
Aluminum (mg/l)	0.630	0.060	0.010	0.05 to 0.2	ND
Chloride (mg/l)	480	9.2	2.2	250	2
Fluoride (mg/l)	0.20	<0.10	<0.10	2.0	0
Iron (mg/l)	30	0.160	<0.010	0.3	10
Manganese (mg/l)	7	0.095	<0.010	0.05	17
pH (standard units)	6.9	5.3	4.7	6.5 to 8.5	26
Sulfate (mg/l)	85	14	<0.10	250	0
Total dissolved solids (mg/l)	1,190	110	49	500	3
EEA Complex					
Aluminum (mg/l)	1.700	0.020	<0.010	0.05 to 0.2	ND
Chloride (mg/l)	2,100	4.1	1.9	250	1
Fluoride (mg/l)	1.5	0.10	<0.10	2.0	0
Iron (mg/l)	40.000	0.230	0.009	0.3	9
Manganese (mg/l)	0.550	0.059	0.010	0.05	11
pH (standard units)	6.8	5.9	4.2	6.5 to 8.5	18
Sulfate (mg/l)	130	16	0.60	250	0
Total dissolved solids (mg/l)	4,510	106	37	500	1

Notes:
1. Results from 29 analyses were used to calculate all statistics for Mainside water quality. Results from 20 analyses were used to calculate all statistics for EEA Complex water quality, except results from 19 analyses were used to calculate statistics for aluminum.
2. NSDWS indicates National Secondary Drinking Water Standard.
3. mg/l indicates milligrams per liter.
4. ND indicates number of samples exceeding NSDWS was not determined because an NSDWS was not established for aluminum at the time of the study.
5. < indicates less than.

Source: Bell, 1996; Harlow and Bell, 1996; USEPA, 2008a.

3.11 Potomac River Aquatic Biological Resources

Biological resources in and around NSF Dahlgren can be divided into aquatic and terrestrial resources. Aquatic biological resources are concentrated in the Potomac River (Sections 3.11 and 3.12) and ponds, streams, and creeks at NSF Dahlgren (Section 3.13). Terrestrial resources are the land-based wildlife and vegetation resources of NSF Dahlgren and are described in Section 3.13. Rare, threatened, and endangered species that are either present or potentially found at NSF Dahlgren or the PRTR are discussed in Section 3.14.

As discussed in Section 3.10.1.2, the length of the tidal reach of the Potomac River is 114 mi. The river flows into the Chesapeake Bay about 43 NM south of NSF Dahlgren (see Figure 1-1). The PRTR is located within the estuarine portion of the Potomac River and extends from around Mathias Point to the mouth of the river (see Figure 1-2).

Plants and animals that live in the Potomac River are influenced by a number of factors, with salinity being one of the most important factors affecting their distribution and ecology. The tidal Potomac River can be divided into three segments by salinity regimes (see Figure 3.10-5) – tidal fresh, oligohaline, and mesohaline (Landwehr et al., 1999) – that delimit and characterize the segments:

- Tidal fresh – includes the area of the tidal river above Quantico, Virginia. The water is fresh – salinity of less than 0.5 ppt – except in extremely dry years, and the net flow is seaward at all depths.
- Oligohaline – covers the transition zone between Quantico, Virginia, and the Harry Nice Bridge. The salinity is generally low, ranging from 0.5 to 5 ppt, except during drought. Extensive saltwater-freshwater mixing occurs in this segment.
- Mesohaline – extends from the Harry Nice Bridge to the mouth of the river. This segment has moderately brackish water, with salinities typically ranging from 5 to 18 ppt.

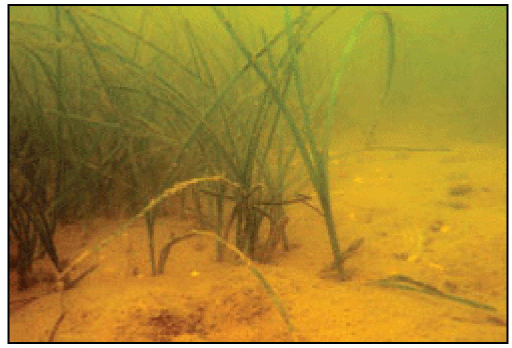
Oligohaline and mesohaline waters, along with the polyhaline waters (18-30 ppt) found in the lower part of the Chesapeake Bay below the mouth of the Potomac River, all fall under the terms "brackish" or "mixohaline" with a salinity range from 0.5 to 30 ppt. Ocean water, by comparison, generally has salinity levels of 30 to 35 ppt. Within the PRTR, the mean salinity of the Potomac ranges from approximately 4 to 8 ppt in the vicinity of NSF Dahlgren, to approximately 11 to 16 ppt around the downstream end of the LDZ (based on MDNR, 2010).

3.11.1 Vegetation

3.11.1.1 Submerged Aquatic Vegetation (SAV)

Submerged aquatic vegetation (SAV) is a critical component of the Potomac River ecosystem, providing important biological and physical functions (Rybicki and Landwehr, 2007). SAV forms an integral part of the food web in the Chesapeake Bay, providing shelter and nursery grounds for shellfish and finfish, as well as providing food for a diversity of waterfowl (Ruhl et al., 1999). In addition, the structure provided by SAV helps to stabilize bottom sediment.

The Chesapeake Bay Program (CBP) has defined the three salinity segments of the lower river as Potomac tidal fresh (POTTF), Potomac oligohaline (POTOH), and Potomac mesohaline (POTMH) (Landwehr et al., 1999). The UDZ is in segment POTOH, and the MDZ and LDZ are in segment POTMH. The tidal fresh segment (POTTF) is upstream of the PRTR and, therefore, is not discussed further in this section.



Submerged aquatic vegetation

Table 3.11-1 lists submerged aquatic plants of the tidal Potomac River, based upon surveys conducted by the USGS (Carter et al., 1983) and the Virginia Institute of Marine Science (VIMS) (e.g., Orth et al., 2004, 2005, 2006, 2007, 2011). Common species of SAV in the Potomac River include wild celery (*Vallisneria americana;* also called American eelgrass or tapegrass), coontail (*Ceratophyllum demersum)*, naiad (*Najas* spp.), and common elodea (*Elodea canadensis)* (Orth and Moore, 1984). Wild celery is one of the most abundant submerged aquatic plants found in the tidal Potomac River (Carter et al., 1983). It prefers fresh and slightly brackish water, with lower growth at salinities above 10 ppt (Doering et al., 2001). The growing season for SAV in the Potomac River extends from April through October (Carter et al., 1998).

Orth and Moore (1984) reviewed information on the historical distribution and abundance of SAV in the area of the Chesapeake Bay, of which the Potomac River is the largest tributary. In general, historical records indicate that SAV has been abundant over the last few hundred years, but they also show changes in abundance and species composition. SAV disappeared from the freshwater tidal Potomac River in the late 1930s (Carter et al., 1985). This decline in SAV was followed by an invasion of the exotic species Eurasian watermilfoil (*Myriophyllum spicatum*), from the late 1950s to the early 1960s. During this time period, there was also a significant expansion in SAV in many creeks on the Virginia side of the Potomac River (Moore et al., 2004).

In the 1960s and 1970s there was a decline of SAV in the Chesapeake Bay (Orth and Moore, 1984). The decline was first seen in local regions in the mid-1960s, but spread to all parts of the bay in the 1970s. The pace and extent of the decline increased after Tropical Storm Agnes in 1972 (Orth and Moore, 1984). These reductions were thought to be linked to high nutrient and sediment loads that decreased water clarity (Carter et al., 1998; Orth and Moore, 1984). In the early 1980s water quality improved with upgrades made to wastewater treatments plants, such as the Blue Plains wastewater treatment facility located above the Woodrow Wilson Bridge in the freshwater tidal section. Improvements in water quality led to the return of many species of SAV in the Potomac River (Carter et al., 1987).

Table 3.11-1
Submerged Aquatic Plants of the Tidal Potomac River

Common Name	Scientific Name
Wild celery	*Vallisneria americana*
Redhead grass	*Potamogeton perfoliatus*
Curly pondweed[1]	*Potamogeton crispus*
Coontail	*Ceratophyllum demersum*
Widgeon grass	*Ruppia maritima*
Sago pondweed	*Potamogeton pectinatus*
Slender pondweed	*Potamogeton pusillus*
Leafy pondweed	*Potamogeton epihydrus*
Eurasian watermilfoil[1]	*Myriophyllum spicatum*
Horned pondweed	*Zannichellia palustris*
Southern naiad	*Najas guadalupensis*
Slender naiad[2]	*Najas gracillima*
Naiad[1]	*Najas minor*
Northern or slender naiad	*Najas flexilis*
Stonewort	*Nitella* sp.
Muskgrass	*Chara* spp.
Common elodea	*Elodea canadensis Michx.*
(Brazilian) waterweed[1,2]	*Egeria densa Planch.*
Water stargrass	*Heteranthera dubia*
Hydrilla[1]	*Hydrilla verticillata*
Water chestnut	*Trapa natans*
Eelgrass	*Zostera marina*

Notes:
1. Invasive (non-native) species.
2. Predicted outside of NSF Dahlgren PTRC MDZ and LDZ study area, but may occur in the UDZ.

Sources: Carter et al. (1983); Orth et al. (2004, 2005, 2006, 2007, 2011); Rybicki et al. (2007).

USGS has monitored the distribution and composition of SAV beds in various segments of the Potomac River since 1978 using methods such as transect sampling (in the years 1978 to 1981, 1985 to 1987, and 2002) and shoreline surveys (from 1983 to 2004) (Rybicki et al., 2007). A USGS survey performed from 1978 to 1981 showed that the tidal river had few submerged aquatic plants, but that the greatest abundance and diversity were found in the transition zone of the estuary (Carter et al., 1985). In 1983, the USGS began a new study of the distribution and abundance of SAV that documented the return of many species of submerged aquatic plants to the tidal river (Carter et al., 1985).

Since the mid-1980s VIMS has estimated the annual SAV coverage for various Chesapeake Bay segments, inclusive of the Potomac River, using a combination of aerial photographs and on-site assessments (e.g., Orth et al., 1989, 1996, 2007, 2011). Using the results of these surveys, the changes in SAV coverage in the Potomac can be followed over time.

Data on SAV coverage from 1978 to 2010 were examined for the POTMH segment, which contains the majority of the PRTR, and for the Dahlgren MD-VA USGS quadrant. The total cover and annual change in cover for these areas are provided in Table 3.11-2.

Table 3.11-2
Changes in SAV Acreage in the Lower Potomac River (POTMH)

Year	SAV Acreage	Change from Previous Year	Dahlgren VA-MD Quad Acreage	Change from Previous Year
Historical[1]	4978	NA	NA	NA
1978	498	NA	183	NA
1984	148	-70%	11	-94%
1985	137	-8%	5	-57%
1986	107	-22%	6	22%
1987	123	15%	35	512%
1989[2]	249	103%	162	357%
1990	269	8%	128	-21%
1991	338	26%	144	13%
1992	239	-29%	84	-42%
1993	272	14%	71	-16%
1994	481	77%	77	9%
1995	591	23%	103	33%
1996	994	68%	139	36%
1997	1648	66%	230	65%
1998	1709	4%	406	77%
1999	2351	38%	453	12%
2000	1045	-56%	148	-67%
2001	1739	66%	236	60%
2002	2619	51%	4	-98%
2003	2484	-5%	16	286%
2004	3401	37%	57	253%
2005	3337	-2%	86	51%
2006	1689	-49%	38	-56%
2007	678	-60%	21	-45%
2008	396	-42%	28	35%
2009	336	-15%	39	36%
2010	207	-38%	54	39%

Source: Orth et al., 2011 except for [1] Moore et al. April 2004
Notes:
NA = Not applicable.
[1] Area not fully mapped.
[2] Area was not mapped in 1988.
Historical estimates of acreage may vary depending on the source.

As seen in this table, the amount of SAV coverage each year can vary substantially. In general, SAV coverage in the POTMH segment increased from 1984 to 2004 and has shown a steady decline to the current time (Orth et al., 2011). The SAV coverage in the USGS Dahlgren, VA-MD quadrangle shows a large percent variation in the annual SAV coverage, but generally reflects the trend of the POTMH river segment.

There have also been changes in SAV species distribution and abundance over time. Common species in the Dahlgren USGS quad area include wild celery, redhead grass, coontail, common elodea, widgeon grass, the invasive species Eurasian watermilfoil, and *Hydrilla verticillata* (hydrilla).

Hydrilla is an invasive species from Southeast Asia that grows rapidly and has the potential to outcompete some native species. It was first seen in the Potomac River in 1982 and within two years was fairly widespread in the upper freshwater tidal portion of the river. Hydrilla can grow very densely in shallow areas, where it interferes with boat traffic. As a consequence, the US Army Corps of Engineers (USACE) and local and state agencies began a harvesting program in 1986 to provide boaters with access through the hydrilla beds to boat moorings and marinas (Rybicki et al., 2007). Monitoring since the 1980s has shown that although hydrilla comprised more than 40 percent of the total abundance of vegetation in the Potomac River, it did not eliminate other species over time, and instead the proportion of native SAV has increased over time (USGS, 2010). The other common invasive species, Eurasian watermilfoil, has a greater presence in the oligohaline portion of the river, from Quantico, Virginia to the Nice Bridge (Rybicki et al., 2007), and is not abundant in areas of the PRTR with higher salinities.

3.11.1.2 Emergent Vegetation

Emergent vegetation is rooted in sediments underwater, but grows above – emerges from – the surface of the water. There are 219 ac of estuarine intertidal emergent wetlands on NSF Dahlgren, along the Potomac River, Upper Machodoc Creek, and other tributaries. These wetlands are dominated by saltmarsh cordgrass, marsh elder, and pigweed (NSWCDD, 2001). The wetlands on NSF Dahlgren are discussed in Section 3.10.2.

3.11.2 Plankton

Plankton refers to organisms that passively float or weakly swim in water. While planktonic organisms may have some locomotory ability and can swim vertically, they generally do not have enough power to counteract currents or turbulence or to control their horizontal movement in fresh or salt water. The majority of planktonic organisms are small, with a maximum size of less than an inch in length (less than two centimeters). There are two principal groups of plankton – phytoplankton (plant plankton) and zooplankton (animal plankton).

Common Phytoplankton *Ceratium lineatum*

3.11.2.1 Phytoplankton

Phytoplankton include microscopic algae such as diatoms (eukaryotic algae), dinoflagellates (unicellular protists), and cyanobacteria (blue-green algae). Phytoplankton species composition and abundance are functions of interactions with environmental conditions including salinity, temperature, light, nutrients, turbulence, and water depth, in addition to other factors such as grazing, competition, and disease (Tango et al., 2005).

The spring bloom of phytoplankton in Chesapeake Bay is dominated by diatoms (Marshall et al., 2005). Spring dominance of diatoms is expected to also occur in the tidal Potomac River. The cell walls of diatoms are made from silica and most diatoms are unicellular. In oligohaline waters the major diatom species include *Skeletonema potamos*, *Skeletonema costatum*, *Cyclotella* spp., and a mixed assemblage of other centric (marine) diatoms less than one inch long. In mesohaline waters the most abundant taxa include *Cerataulina pelagica*, *Skeletonema costatum*, *Cyclotella* spp., *Dactyliosolen fragilissimus*, *Heterocapsa rotundata*, *Prorocentrum minimum*, and *Ceratium furca*. In summer, the phytoplankton community is more diverse, with a greater proportion of chlorophytes (a division of green algae) and cyanobacteria in the lower salinity (fresh and oligohaline) waters and diatoms and dinoflagellates in the higher salinity (mesohaline and polyhaline) waters (Marshall et al., 2006).

Increases in the amount of sediment and nutrients entering the Potomac River can increase algal growth or “blooms” and subsequently affect many other species. About 90 percent of the plankton community in a summer bloom consists of only one or two species, depriving higher trophic levels – organisms higher on the food chain – of valuable nutrition (ICPRB, 2004). Based on these characteristics, phytoplankton is considered a good indicator of water quality. The CBP has been monitoring plankton since the 1980s and has been developing plankton-based indicators of Chesapeake Bay health (ICPRB, 2008), which are described in Section 3.10.1.2.

3.11.2.2 Zooplankton

Rotifer - a common zooplankton species

Zooplankton – animal plankton – provide the intermediate link between primary producers, such as phytoplankton, and secondary consumers, such as macroinvertebrates and fish. In the Potomac River, zooplankton are an important food source for fish, crabs, mussels, and other aquatic animals. Zooplankton include organisms that are entirely planktonic (e.g., copepods, cladocerans, and rotifers) and animals that spend only a portion of their life as plankton (e.g., larvae of benthic invertebrates, benthic chordates, and certain fish). Larval fish (ichthyoplankton) are discussed in Section 3.11.4.

Species of zooplankton are distributed in the Chesapeake Bay based on factors including salinity and food (e.g., phytoplankton) (Reshetiloff, 2004). The Chesapeake Bay Water Quality Monitoring Program included zooplankton sampling from 1984 to 2002 at as many as 36 fixed monitoring stations in the main stem and tidal tributaries of the bay (CRC, 2005). Components of the sampling program included mesozooplankton (zooplankton greater than 202 micrometers [μm] in length), microzooplankton (between 20 and 202 μm long), and gelatinous zooplankton (CRC, 2005).

A Food Availability Index was developed to assess total zooplankton food availability for the larvae of migratory fish. Based on zooplankton data collected from 1999 to 2002, the Potomac River had a borderline minimal/below-minimal Food Availability Index. A comparison of zooplankton data from the beginning of the zooplankton sampling period – from 1984 to 1989 – with the latter part of the program – from 1999 to 2002 – showed decreases in zooplankton at most stations in mesohaline and polyhaline waters, while zooplankton increased in tidal fresh and oligohaline waters. For example, station RET2.2 in the oligohaline area (see Figure 3.10-3 for station location) showed a 33 percent increase in zooplankton, while station LE2.2 in the mesohaline area (see Figure 3.10-3 for station location) showed a 13 percent decrease (CRC, 2005).

Types of Zooplankton

- **Mesozooplankton**: hard-bodied zooplankton greater than 202 µm (based upon net size used in the CBP). This group includes copepods, cladocerans, benthic invertebrate larvae and other meroplankton (organisms that are only planktonic for a portion of their life cycles) (Johnson, 2007).

- **Microzooplankton**: hard-bodied zooplankton between 20 and 200 µm. In the CBP (Johnson, 2009), this group includes copepod nauplii, rotifers and protozoans. Microzooplankton are dominated by ciliated protozoans, rotifers, larval stages of copepods (nauplii), as well as larval stages of various other organisms.

- **Gelatinous Zooplankton**: soft-bodied zooplankton, including cnidarians (true jellyfish, hydromedusae) and ctenophores (comb-jellies). The ctenophore *Mnemiopsis leidyi* and the sea nettle *Chrysaora quinquecirrha* are dominant consumers in the Chesapeake Bay food web.

The Chesapeake Bay Water Quality Monitoring Program determined that the zooplankton status in the Chesapeake Bay area is generally not good, and that current zooplankton food levels for migratory fish larvae are inadequate in most major spawning/nursery areas (CRC, 2005). However, there are improving trends in selected regions of Chesapeake Bay and its tidal tributaries.

3.11.3 Aquatic Invertebrates

Invertebrate organisms are an extremely diverse group, making up over 95 percent of all known species of animals (Ruppert et al., 2003), including oysters, mussels, clams, crabs, sponges, jellyfish, sea anemones, worms, snails, sea slugs, whelks, squid, insects, and many lesser-known creatures. Although zooplankton are invertebrates, they are treated separately, in Section 3.11.2.

Common Aquatic Invertebrates
Midge larvae, snails, worms, and amphipods

In all their forms and diversity, invertebrates represent an important trophic link – a nutritional or energy link in a food web – in aquatic and terrestrial habitats by linking producers (algae and plants), decaying organic matter (hereafter, detritus), and vertebrate predators (fishes, birds, reptiles, and mammals). Many species of invertebrates consume detritus, and are in turn eaten by predators higher in the food web, such as fish, birds, sea turtles, and marine mammals. Detritus is formed by the decomposition of organic matter (decaying plant and animal material) which is facilitated by microorganisms (bacteria and fungi). Aquatic and terrestrial invertebrates graze on microorganisms and detritus, releasing valuable nutrients back into the surrounding environment, nutrients which are also recycled back into the food chain. Moreover, many invertebrates produce large volumes of feces and pseudofeces, which can also increase nutrient availability and nutrition for plants and microorganisms. Without invertebrates, energy transformed by producers, or lost through decomposition, would not be recycled into the higher trophic levels of the food web.

3.11.3.1 Aquatic Invertebrate Habitats in the Lower Potomac River Estuary

Aquatic invertebrates can live in many different habitats in the Potomac River Estuary. The most common habitats utilized by aquatic invertebrates are:

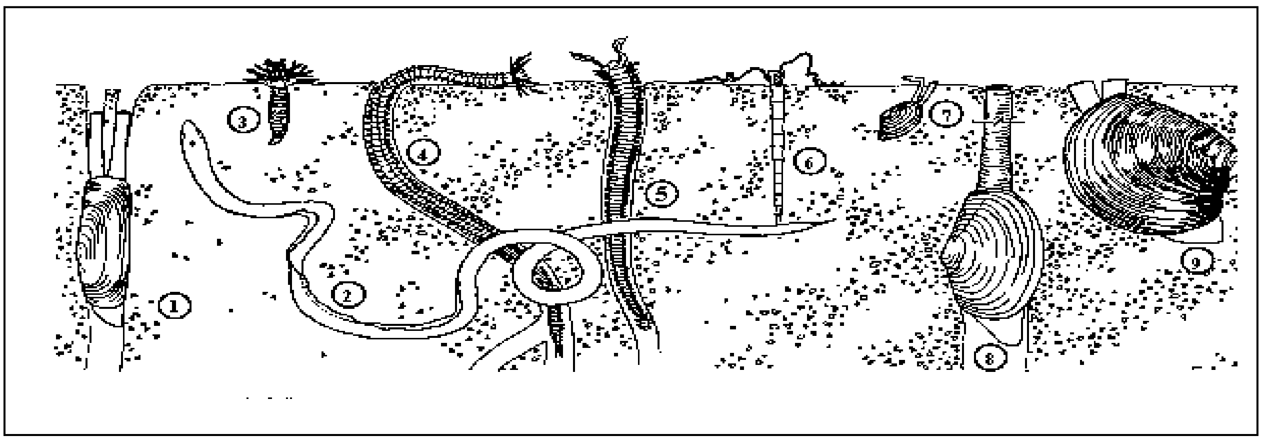
- **Benthic zone**. The bottom of the river forms the benthic zone. Organisms that live in the benthic zone are termed “benthos” or benthic organisms. Many aquatic invertebrates are benthic organisms, spending a majority of their lives living on the bottom of an aquatic ecosystem. The diversity and population size of benthic invertebrate species is controlled by the amount of detritus available, oxygen levels, temperature, salinity, current strength, turbidity, substrate type, and inorganic input.
- **Pelagic zone**. The pelagic zone, or open-water habitat, of the Potomac River Estuary is utilized by only a few groups of invertebrates (e.g., jellyfish, comb jellies, and zooplankton) on a permanent basis. It is underutilized because it usually lacks cover and protection from predators. Some invertebrate species utilize this zone only briefly, right before hatching into their adult form (e.g., aquatic insects). The invertebrates which utilize the pelagic zone the most are the zooplankton communities. Zooplankton can be found in very dense communities in the pelagic waters of the Potomac River Estuary; see Section 3.11.2.
- **Littoral zone**. The shallow edges of the river, which are the areas in the Potomac River Estuary shallow enough for rooted plants to grow, constitute the littoral zone. The habitats that encompass the littoral zone include the watery areas of wetlands, most piers and jetties, seagrass meadows, aquatic emergent plant beds, and oyster bars. In the Potomac River Estuary, the littoral zone is divided into two sections – the intertidal and subtidal zones. The intertidal zone, the zone closest to shore, can be temporarily exposed to air, and usually hosts an abundance of invertebrates. The subtidal zone is also abundant with invertebrate life, but is deeper than the intertidal zone and not often exposed to the air. The intertidal and subtidal zones share many of the same invertebrate groups, though there are some invertebrate species that are specific to each zone.

3.11.3.2 Potomac River Benthic Invertebrate Community Quality

Invertebrates are not only a diverse group that represent an important trophic link but are also important indicators of water and habitat quality, as described in Section 3.10.1.2. As noted in Section 3.10.1.2, the Potomac River benthic community has been rated “poor” overall since the mid-1980s, more so in the mesohaline region that in the tidal freshwater regions. Anoxia is considered the primary culprit for this rating (Llansó et al., 2007).

3.11.3.3 Invertebrate Species Found in the Lower Potomac River Estuary

Table 3.11-3 lists the groups of invertebrates found in the area of the Lower Potomac River Estuary where the PRTR danger zones are located. This list was assembled from data collected as part of the Maryland Department of Natural Resources (MDNR)'s Long-term Benthic Monitoring program (described in Section 3.10.1.2). MDNR has seven fixed long-term monitoring stations in the Potomac River (see Figure 3.10-4) ranging from tidal fresh waters to mesohaline waters. The program also collects random samples on a yearly basis (Llansó et al., 2007). The program samples invertebrate communities on soft mud and sand bottoms but not those on hard rocks or oyster reefs. Therefore, invertebrates that live on hard surfaces, such as Hydroids, some Anthozoans, Bryozoans, certain worms, and some mollusks, are either not well represented or not represented at all in the data collected by this long-term benthic monitoring program (Llansó, pers. comm., April 30, 2008). However, to make this list as complete as possible, the MDNR species list was augmented by data from the National Oceanic and Atmospheric Administration (NOAA)'s Estuarine Living Marine Resources (ELMR) program (Stone et al., 1994; Nelson and Monaco, 2000) and from Lippson & Lippson's (2006) overview of life in the Chesapeake Bay and its tributaries. Nonetheless, this list is probably still not complete, considering the vast diversity of invertebrates in aquatic ecosystems. For example, Tardigrades (or Water Bears) and Rotifer species may have been left out of sample inventories primarily because these organisms are microscopic and can easily be overlooked.



Common Benthic Invertebrates that may be found in the Lower Potomac River Estuary.
Source**:** (Llansó et al., 2007)

1. Stout razor clam *(Tagelus plebeius*)
2. Red ribbon worm (*Micrura leidyi*)
3. Burrowing anemone (*Ceriantheopsis americanus*)
4. Common clam worm (*Neanthes succinea*)
5. Red-gilled mudworm (*Marenzelleria viridis*)
6. Glassy tube worm (*Spiochaetopterus costarum*)
7. Baltic Macoma clam (*Macoma balthica*)
8. Soft-shelled clam (*Mya arenaria*)
9. Hard clam (*Mercenaria mercenaria*)

Table 3.11-3
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Hirudinea (Leeches)	Many species	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, birds, aquatic insects, reptiles, mollusks and mammals	parasitic to mammals, fish, birds, crustaceans, reptiles
Oligochaete (Aquatic Earthworms)	Many species	Littoral, Benthic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, birds, aquatic insects, reptiles, mollusks and other invertebrates	detritus[3], protozoa, algae
Polychaete (Bristle Worms)	*Neanthes succinea; Heteromastus filiformis*	Littoral, Benthic	Brackish, Marine	MDZ, LDZ	fish, starfish, sea urchins, lobsters, skates, crabs, horseshoe crabs, birds	sponges, zooplankton, detritus
Coleoptera (Beetles)	*Dytiscus* spp.; *Gyrinus* spp.; *Cicindela doralis*	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	birds, invertebrates, fish	detritus, protozoa, algae
Collembola (Springtails)	*Anurida maritima* (Seashore springtail)	Littoral, Benthic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish and invertebrates	detritus
Diptera (Flies, Midges)	*Aedes solicitans* (Saltmarsh mosquito larvae); *Chrysops* spp. (Deer Fly Larvae); *Tabanus americanus* (American horse fly larvae); *Chironomus* spp. *and Coelotanypus* spp. (Chironomid family); *Chaoborus* spp. (Chaoborus family)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, worms, large crustaceans, birds	small insect larvae, small crustaceans, zooplankton, mosquito larvae, annelids, fly larvae
Hemiptera (True Bugs)	*Corixa* spp. (Water boatmen); *Gerris* spp. (Water striders)	Littoral	Tidal Fresh, Oligohaline	UDZ	fish, worms, large crustaceans, birds	small crustaceans, aquatic insects, zooplankton, detritus, algae, protozoans, worms, mosquito larvae
Arthropod; Insecta; Odonata (Dragonflies, Damselflies)	*Anax junius* (Green darner); *Libellula puchella* (Twelve-spot skimmer); *Erythrodiplex berenice* (Seaside dragonlet)	Littoral	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, amphibians, large invertebrates, birds	mayfly larvae, small crustaceans, worms, odonata larvae, mollusks, zooplankton small fish, tadpoles
Trichoptera (Caddisflies)	*Oecetis* spp. (Longhorned case maker caddisfly)	Littoral, Pelagic	Tidal Fresh, Oligohaline	UDZ	fish and invertebrates	detritus, small crustaceans, zooplankton, small insect larvae, sponges
Amphipoda (Scuds, Sideswimmers)	*Gammarus* spp. (Scuds); *Ampelisca abdita* (Small four-eyed amphipod); *Leptocheirus plumulosus* (Common burrower amphipod	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, larger invertebrates, worms, birds	detritus, algae, protozoans

Table 3.11-3 (Continued)
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Cladocera (Giant Water Flea)	*Leptodora kindtii* (Giant water flea)	Littoral, Benthic, Pelagic	Tidal Fresh, Oligohaline	UDZ	fish and invertebrates	zooplankton, small invertebrates
Decapoda (Crayfish)	*Orconectes limosus* (Coastal plains river crayfish); *Cambarus diogenes* (Burrowing crayfish)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ	fish, jellyfish, turtles, birds, mammals	clams, decapods, oysters, SAV, detritus, zooplankton, worms
Decapoda (Crab)	*Callinectes sapidus* (Blue crab); *Uca pugnax* (Marsh fiddler crab)*;* *Rhithropanopeus harrisii* (White-fingered mud crab)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, jellyfish, turtles, birds, mammals	clams, decapods, fish, oysters, SAV, detritus, zooplankton, worms
Decapoda (Shrimp)	*Crangon septemspinosa* (Sevenspine Bay shrimp); *Palaemonetes* spp. (Grass shrimps); *Farfantepenaeus aztecus* (Brown shrimp)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, jellyfish, turtles, birds, mammals	detritus, zooplankton
Isopoda (Isopods)	*Cyathura polita* (Slender isopod); *Edotea triloba* (Mounded-back isopod); *Lironeca ovalis* (Fish-gill isopod)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	invertebrates, fish, crustaceans, birds, mammals	detritus, blood from host, zooplankton, algae, protozoans
Mysidacea (Opossum Shrimp)	*Neomysis americana* (Opossum shrimp); *Americamysis* spp. (Americamysis family)	Benthic, Pelagic	Tidal Fresh, Mesohaline		fish and invertebrates	zooplankton, detritus, algae
Sessilia (Barnacles)	*Balanus eburneus* (Ivory barnacle); *Balanus improvisus* (Bay barnacle); *Balanus subalbidus* (White barnacle)	Littoral	Brackish, Marine	UDZ, MDZ, LDZ	Flatworms, sponges, byozoans, Sea Stars, Whelks	zooplankton, algae
Stomatopoda (Mantis Shrimp)	*Squilla empusa* (Mantis shrimp)	Littoral, Benthic	Mesohaline, Polyhaline	MDZ, LDZ	fish, crabs, mantis shrimp	shrimp, fish, crab
Merostomata (Horseshoe Crabs)	*Limulus polyphemus* (Horseshoe crab)	Littoral, Benthic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	birds, fish, turtles	bivalves, annelid worms, small invertebrates
Pycnogonida (Sea Spiders)	*Callipallene brevirostris* (Long-necked sea spider)	Benthic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	N/A	cnidarians, bryozoans, hydroids, sedentary polychaetes
Bryozoa (Bryozoans)	*Pectinatella* spp. (Freshwater Bryozoan); *Bowerbankia gracilis* (Creeping bryozoan); *Conopeum tenuissimum* (Lacy crust bryzoan)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	Sea urchins and fish	bacteria, diatoms, algae
Chaetognatha (Arrow Worms)	*Sagitta* spp. (Arrow worms)	Littoral, Pelagic, Benthic	Polyhaline, Marine	MDZ, LDZ	fish and large invertebrates	zooplankton

Table 3.11-3 (Continued)
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Cephalochordata (Lancelets)	*Branchiostoma caribaeum* (Lancelet)	Benthic, Littoral	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish	detritus, zooplankton, algae
Uchordata (Sea Squirts)	*Molgula manhattensis* (Sea squirt)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish	zooplankton, algae, small crustaceans
Anthozoa (Sea Anemone, Corals)	*Diadumene leucolena* (White anemone); *Edwardsia elegans* (Burrowing anemone); *Haliplanella luciae* (Green-striped anemone); *Leptogorgia virgulata* (Whip coral)	Littoral, Benthic	Brackish, Marine	UDZ, MDZ, LDZ	sea slugs, snails, fish, sea stars	fish, shrimp, isopods, amphipods, plankton
Hydrozoa (Hydroids)	*Cordylophora caspia* (Freshwater hydroid); *Dynamena disticha* (Horn garland hydroid); *Ectopleura crocea* (tube hydroid); *Garveia franciscana* (Rope grass)	Benthic, Littoral, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	Sea slugs	small crustaceans, insect larvae, annelid worms
Scyphozoa (Jellyfish)	*Chrysaora quinquecirrha* (Sea nettle); *Cyanea capillata* (Lion's mane jellyfish); *Craspedacusta sowerbii* (Freshwater jellyfish)	Pelagic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish, sea turtles, mammals, crabs	fish, zooplankton, shrimp, small crustaceans
Ctenophora (Comb Jellies)	*Beroe ovata* (Pink comb jelly); *Mnemiopsis leidyi* (Sea walnut)	Pelagic	Brackish, Marine	UDZ, MDZ, LDZ	sea turtles, fish, sea birds, other comb jellies	plankton
Asteroidea (Sea Stars)	*Asterias forbesi* (Common sea star); *Micropholis atra* (Burrowing brittle star)	Littoral, Benthic	Polyhaline, Marine	MDZ, LDZ	fish, birds	sponges, bryozoans, and mollusks, detritus
Echinoidea (Sand Dollars)	*Echinarachnius* spp.	Littoral, Benthic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish crabs and birds	detritus, plankton
Holothuroidea (Sea Cucumbers)	*Cucumaria pulcherrima* (Pale sea cucumber); *Thyone briares* (Common sea cucumber); *Leptosynapra tenuis* (White synapta)	Littoral, Benthic	Polyhaline, Marine	LDZ	crustaceans, gastropods, turtles, fish, mammals	detritus
Cephalopoda (Squid)	*Lolliguncula brevis* (Brief squid)	Pelagic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish, squid	fish, crustaceans, squid
Gastropoda (Snails, Whelks, Sea Slugs)	Many species	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, birds, crabs, mammals	detritus, algae, protozoans

Table 3.11-3 (Continued)
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Pelycypoda (Bivalves: Oysters)	*Crassostrea virginica* (Eastern oyster)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, echinoderms, crabs, birds, snails, mammals	plankton, detritus
Pelycypoda (Bivalves: Clams)	*Mya arenaria* (Soft-shelled clam); *Gemma gemma* (Gem clam); *Macoma* spp. (Macoma clams); *Corbicula fluminea* (Asian clam)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, echinoderms, crabs, birds, snails, mammals	plankton, detritus
Pelycypoda (Bivalves: Mussels)	*Ischadium recurvum* (Hooked mussel)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, echinoderms, crabs, birds, snails, mammals	plankton, detritus
Polyplacophora (Chitons)	*Chaetopleura apiculata* (Common eastern chiton)	Benthic	Polyhaline, Marine	MDZ, LDZ	starfish, crabs, fish, sea anemones, birds	algae, detritus
Nemertea (Ribbon, Round, or Proboscis Worms)	Many species	Benthic, Littoral, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, crustaceans	detritus, mollusks, worms, small crustaceans, snails
Phoronida (Horseshoe or Phoronid Worms)	*Phoronis* spp. (Horseshoe worms)	Benthic, Littoral	Polyhaline, Marine	MDZ, LDZ	fish	small invertebrates, algae, detritus, plankton
Platyhelminthes (Flatworms)	*Euplana gracilis* (Slender flatworm); *Stylochus ellipticus* (Oyster flatworm)	Benthic, Littoral	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, worms, aquatic insect larvae	detritus, protozoans, small crustaceans, mollusks, barnacles, oysters, worms, algae
Porifera (Sponges)	*Cliona* spp. (Boring sponges); *Halichondria bowerbanki* (Crumb-of-bread sponge); *Haliclona* spp. (Eroded sponges	Benthic, Littoral, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, sea slugs, sea turtles	detritus, plankton

Sources:
Life in the Chesapeake Bay, Lippson and Lippson, 2006.
NOAA's Estuarine Living Marine Resources (ELMR) program, Stone et al., 1994; Nelson and Monaco, 2000.
(MDNR) Long-term Benthic Monitoring and Assessment Component of the Chesapeake Bay Water Quality Monitoring Program, Llansó et al., 2007.

Notes:
1. Lists the names of species most commonly known to occur in the Lower Potomac River Estuary; this list is not inclusive of every species in the estuary.
2. Habitat includes all stages of an organism's life that is associated with the river.
3. Detritus implies not only decaying organic matter but also bacteria and fungi, as these are the microorganisms primarily responsible for decomposition.

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While the invertebrates listed in Table 3.11-3 are ecologically important species, only blue crabs (*Callinectes sapidus)*, Eastern oysters (*Crassostrea virginica)*, and some clam species are economically important. The Chesapeake Bay and the Potomac River support a diverse commercial fishery, with blue crab yielding the largest financial return, at $45 million per year (Fahrenthold, 2007; Potomac River Fisheries Commission [PRFC], 2008). Historically, the Potomac River was a bountiful source of oysters and clams, but the catch has declined greatly. Clam harvesting in the Potomac River is minimal today.

Blue Crab

The blue crab in the Potomac River is both an ecologically and economically important crustacean. Blue crab habitat in the river ranges from tidal freshwater to the mesohaline waters at the mouth of the river. The blue crab utilizes SAV not only as protection from potential predators, but also to prey on other organisms and as a vital nursery for juvenile crabs (Lippson and Lippson, 2006). Blue crabs play a critical role in the healthy function of an ecosystem, for they are prey for economically important species such as striped bass (*Morone saxatilis*) and black and red drum (*Pogonias cromis* and *Sciaenops ocellatus*, respectively). In addition, they are also an important prey item for a myriad of other species, including loggerhead turtles (*Caretta caretta*), Kemp's ridley turtles (*Lepidochelys kempi*), mammals, and many bird species, such as herons and egrets (Lippson and Lippson, 2006). The blue crab is also important because it feeds on clams, fish, and other small invertebrate species. By doing so, the blue crab keeps these populations from exploding and over-reaching their habitat requirements.

Blue Crab
Callinectes sapidus

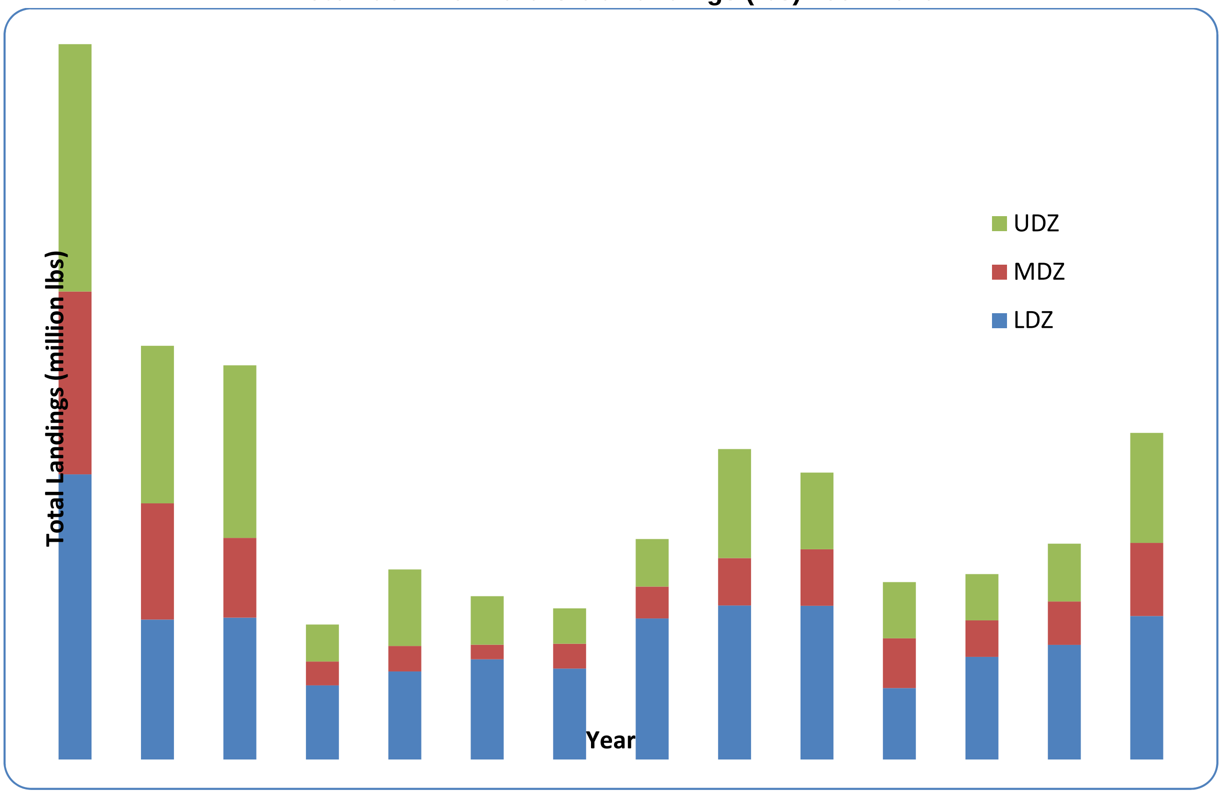
The blue crab population throughout the bay declined sharply in the last two decades, dropping 70 percent from an estimated 852 million in 1993 to 273 million in 2007 (Fahrenthold, 2008). The decline is variously attributed to overfishing; higher water temperatures and nitrogen levels, which contribute to algal blooms/die-offs and consequent low oxygen levels; and a decrease in SAV, which reduces nursery habitat (Fahrenthold, 2007). Figure 3.11-1 (Potomac River Hard Crab Landings (lbs) 1997-2010) illustrates the drop in total blue crab from Possum Point, Virginia to the mouth using landings of hard crabs data from the PRFC. For example, a decline in total annual harvest has been observed in the lower Potomac River (Possum Point, Virginia downstream to the mouth), including the UDZ, MDZ, and LDZ, where approximately 8.9 million pounds were harvested in 1997, but only 2.2 million pounds in 2007 (Cosby, PRFC, pers. comm., March 1, 2010). As a result, the states of Maryland and Virginia in

Hard Crabs

For a blue crab to grow larger, it must periodically shed its smaller shell through a process known as molting – or, more accurately, ecdysis. Early in its molting cycle, the crab begins to form a new, soft shell underneath its existing hard shell. Hard crabs are crabs with hard outer shells.

April 2008 moved to reduce the limit of female blue crabs allowed to be harvested in 2008 by 34 percent (Fahrenthold, 2008). The decrease in limits set by the two states has had a significant impact, as recent studies and landing data show that the crab population has nearly doubled in subsequent years (Fahrenthold, 2010; Cosby, PRFC, pers. comm., March 1, 2011). Current population estimate place the blue crab population at 658 million crabs bay-wide (Farenthold, 2010).

Figure 3.11-1
Potomac River Hard Crab Landings (lbs) 1997-2010



Source: Cosby, PRFC, pers. comm., March 1, 2011.

Eastern Oyster

The native eastern oyster can be found in nearly all coastal waters from Canada to Argentina, including the lower Potomac River. Oysters generally live in benthic and littoral areas, filtering plankton and detritus from the water column. What they do not eat they spit back out as waste, which is valuable to many other detritus consumers. When oysters were at their highest population levels in the 1800’s, the oyster population could filter the entire Chesapeake Bay watershed, including the Potomac River, every three days (Newell, 1988). Today, it is estimated that the current oyster population would take a whole year to filter the same volume of water (Newell et al., 2005).

Oysters permanently cement themselves to a firm substrate. Once well-established, oysters and their shells form reefs that become complex ecosystems, offering a solid structure for other sessile organisms (e.g., barnacles, sea anemones) to attach to, and homes and hiding places for organisms to seek refuge from predation (e.g., blue crabs, oligochaetes, polychaetes). Oyster communities create spawning substrate for some species of fish, stabilize bottom sediments, concentrate food sources for predatory fish species, serve as breakwater and protection from erosion, and clarify the water column through their filtering behavior. Oysters are a food source for certain fish species, echinoderms, crabs, birds, snails, and mammals.

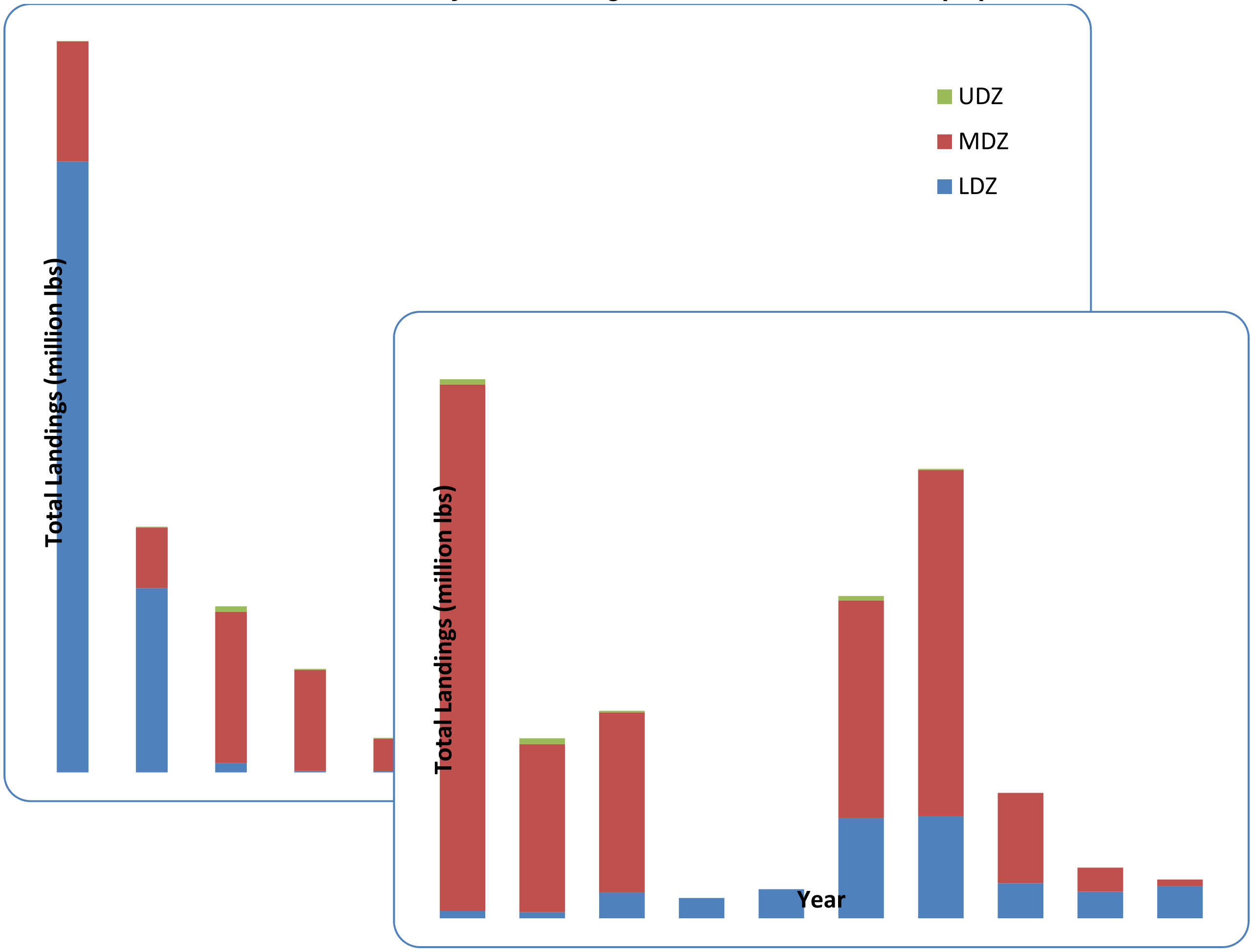
Eastern Oyster
Crassostrea virainica

The oyster population of the Chesapeake Bay and its tributaries has dropped precipitously since the later 1800s, when trade in Chesapeake Bay oysters boomed. By 1991, oyster populations were thought to be only four percent of the historical 19th-century levels (National Research Council and the Committee on Nonnative Oysters in the Chesapeake Bay, 2004). Although oysters are still harvested in the Potomac today, annual harvests continue to decline, as illustrated on Figure 3.11-2 (Potomac River Oyster Landings 1997-1998 to 2009-2010 (bu)). For example, in the 1997-1998 season, approximately 39,547 bushels (bu) were harvested from the Potomac River from Possum Point, Virginia to the mouth of the river, but the 2009-2010 season's harvest of 403 bu represented just 1 percent of the 1997-1998 landings (Cosby, PRFC, pers. comm., March 1, 2011).

The primary causes of oyster decline include overfishing, poor water quality (i.e., increased sedimentation), habitat loss, freshwater intrusion (i.e., decreased salinity levels), and disease. The most common disease in the Chesapeake Bay is Dermo Disease, which is caused by the protozoan parasite *Perkinsus marinus*, (VIMS, 2011). It is likely that the effectiveness and subsequent lethality of these diseases are the result of multiple stressors acting on the oyster population. For example, overfishing, poor water quality (i.e., increased sedimentation), habitat loss, and freshwater intrusion all add stress to the oyster population, decreasing its resistance to disease (Burreson, 1991).

As a result of the oyster decline, the oyster fishery in the Potomac River has been greatly diminished (Figure 3.11-2), and many of the oyster beds are currently off limits due to contamination. Figure 3.11-3 (Potomac River Oyster Bars) shows the boundaries of MDNR's natural oyster bars (NOBs) and historical oyster bars. NOBs are legally-defined locations where oyster bars are found in Maryland waters, which include most of the Potomac River. Since they are legal boundaries that were drawn to encompass potential oyster habitat, they may include some areas that do not support oyster growth. The NOB charts are based on surveys in 1928, 1975 through 1985, and 1994. The historical data show areas where oysters have been known to grow, but are not necessarily included as oyster bars on the current NOB charts (MDNR, 2008).

Figure 3.11-2
Potomac River Oyster Landings 1997-1998 to 2009-2010 (bu)



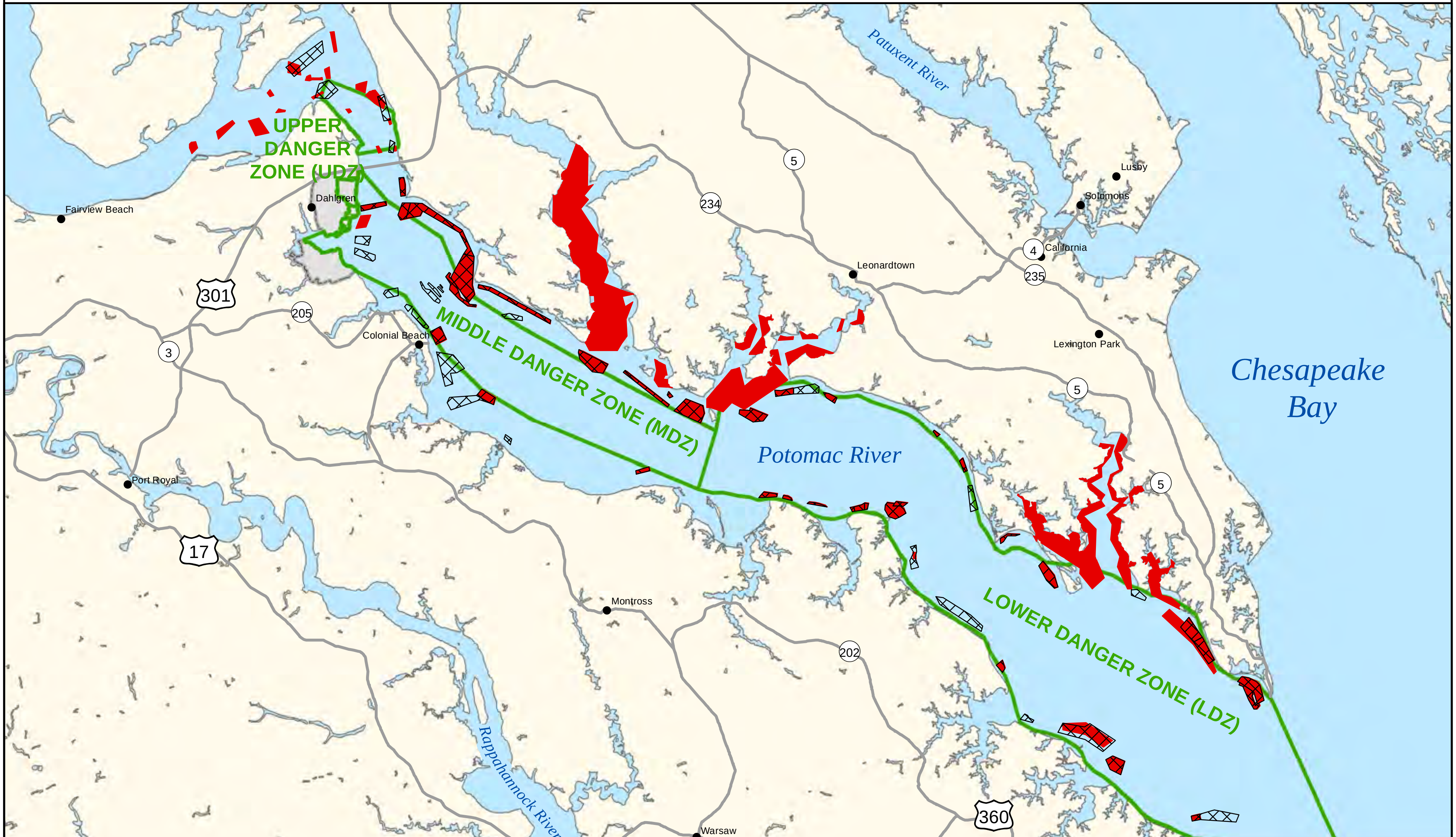
Source: Cosby, PRFC, pers. comm., March 1, 2011.

3.11.4 Fish

3.11.4.1 Distribution and Abundance

The structure of fish communities depends on abiotic (physical) factors, such as salinity, temperature, and dissolved oxygen, and on biotic (biological) factors, such as food availability, competition, predation, and habitat requirements. The PRTR portion of the Potomac River is characterized by strong tidal currents, moderate vertical stratification, and considerable longitudinal variation in salinity (Wilson, 1977). These characteristics underlie its ecological importance in providing adult, migratory, spawning, and nursery habitat for local and regional fish populations.

Potomac River Oyster Bars



MDNR Natural Oyster Bars (NOB) Data

Maryland's Historic Oyster Bottom (1976 - 1983)

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

6 0 6 Miles

10 0 10 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011), Maryland Department of Natural Resources
Disclaimer: The Natural Oyster Bar/lease lines shown are for oyster management purposes only.
For the official boundaries consult the current official Natural Oyster Bar Chart.

Figure 3.11-3

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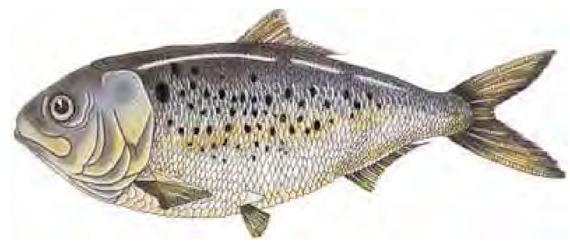
Table 3.11-4 presents a list of the approximately 90 fish species that are expected to occur in the PRTR portion of the Potomac River, ranging in abundance from rare – e.g., shortnose and Atlantic sturgeons, marsh and spotfin killifishes, and code and clown gobies – to highly abundant – e.g., hogchoker, rough and Atlantic silversides, bay anchovy, banded and striped killifishes, mummichog, and white perch. In chronological order, the principal sources of the information in Table 3.11-4 are briefly described below.

- Fish-sampling efforts in 1977 and 1978 identified 31 species within NSF Dahlgren and surrounding waters (NSWCDL, 1979). Seventeen species were captured in the Potomac River, mostly species that inhabit shallow waters near the shore. These included silversides, carp, bay anchovy, killifishes, white perch, striped bass, yellow perch, spot, and northern pipefish.



Atlantic Menhaden – *Brevoortia tyrannus*

- The *Environmental Atlas of the Potomac Estuary* (Lippson et al., 1981) is a compilation of data and information pertaining to the Potomac River Estuary. A review of the atlas, as well as of Lippson & Lippson's *Life in the Chesapeake Bay* (2006), suggests that approximately 70 species of fish are expected to occur in the PRTR portion of the river. The *Atlas* designates the occurrence of 20 of these species as abundant – i.e., common species found in large numbers – in the estuary: hogchoker, rough silverside, Atlantic silverside, alewife, Atlantic menhaden, bay anchovy, mummichog, naked goby, bluefish, striped bass, American eel, tidewater silverside, blueback herring, American shad, gizzard shad, banded killifish, striped killifish, white perch, yellow perch, and spot.
- In conjunction with a SAV study conducted between 1999 and 2002, the Alliance for the Chesapeake Bay and NSF Dahlgren conducted fish sampling at two stations on the Potomac River at NSF Dahlgren and four stations on Upper Machodoc Creek (Alliance for the Chesapeake Bay, Not Dated; NSF Dahlgren, 2007). A total of 24 fish species was collected at the Potomac River stations during these efforts (completed fish collection forms provided by Lou Etgen, Interim Director, Alliance for the Chesapeake Bay, November 17, 2008). The most abundant species collected were white perch and Atlantic silverside, comprising 51.0 and 30.0 percent of the total catch, respectively. Other species that represented at least 1.0 percent of the total catch were bay anchovy, banded killifish, mummichog, striped killifish, and striped bass. Additional species of recreational and commercial importance that were collected included American eel, gizzard shad, yellow perch, bluefish, and spot.
- More-recent studies and consultations – among them, NOAA, February 2008, and Cosby, PRFC, pers. comm., March 1, 2011 – provided information on additional species that are expected to occur, bringing the approximate total number of species to 100.

Table 3.11-4
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Achiridae (American soles)				
Hogchoker	*Trinectes maculatus*	demersal · amphidromous · freshwater, brackish and marine	0 - 75	2, 3, 6, 7, 9, 10
Acipenseridae (sturgeons)				
Shortnose sturgeon	*Acipenser brevirostrum*	demersal · anadromous · freshwater, brackish and marine	NA	2, 9
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	demersal · anadromous · freshwater, brackish and marine	? - 46	2, 6, 9
Anguillidae (freshwater eels)				
American eel	*Anguilla rostrata*	demersal · catadromous · freshwater, brackish and marine	0 - 464	2, 5, 6, 7, 8, 9, 10
Atherinopsidae (neotropical silversides)				
Rough silverside	*Membras martinica*	pelagic · marine	NA	2, 9
Silversides	*Menidia* sp.			1, 3, 6, 10
Tidewater silverside (Inland silverside)	*Menidia beryllina*	pelagic · freshwater, brackish and marine	0 - ?	1, 2, 3, 5, 9, 10
Atlantic silverside	*Menidia menidia*	pelagic · oceanodromous · brackish and marine	0 - ?	1, 2, 3, 5, 7, 9, 10
Batrachoididae (toadfishes)				
Oyster toadfish	*Opsanus tau*	reef-associated · marine	NA	2, 6, 7, 9
Belonidae (needlefishes)				
Atlantic needlefish	*Strongylura marina*	reef-associated · freshwater, brackish and marine	1 - ?	2, 3, 5, 7[c,] 9, 10
Blenniidae (combtooth blennies)				
Striped blenny	*Chasmodes bosquianus*	demersal · brackish and marine	? - 30	2, 9
Feather blenny	*Hypsoblennius hentz*	reef-associated · marine	NA	2, 9
Carangidae (jacks and pompanos)				
Blue runner	*Caranx crysos*	reef-associated · marine	0 - 100	2, 9
Carcharhinidae (Requiem sharks)				
Bull shark	*Carcharhinus leucas*	reef-associated · amphidromous · freshwater, brackish and marine	1 - 152	11
Centrarchidae (sunfishes)				
Sunfish	*Lepomis* sp.			10
Redbreast sunfish	*Lepomis auritus*	demersal · freshwater	NA	3, 10
Bluegill	*Lepomis macrochirus*	benthopelagic · freshwater	NA	5, 7
Largemouth bass	*Micropterus salmoides*	benthopelagic · freshwater	? - 7	5, 7
Black crappie	*Pomoxis nigromaculatus*	benthopelagic · freshwater	NA	1, 4
Clupeidae (herrings, shads, sardines, menhadens)				
	Alosa sp.			1, 3, 5, 7, 10
Blueback herring (blueback shad)	*Alosa aestivalis*	pelagic · anadromous · freshwater, brackish and marine	5 - 55	2, 6, 7, 8[d,] 9
Hickory shad	*Alosa mediocris*	pelagic · anadromous · freshwater, brackish and marine	NA	2, 7, 9
Alewife	*Alosa pseudoharengus*	pelagic · anadromous · freshwater, brackish and marine	5 - 145	2, 6, 7, 9, 10
American shad	*Alosa sapidissima*	pelagic · anadromous · freshwater, brackish and marine	0 - 250	2, 6, 7, 8, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Atlantic menhaden	*Brevoortia tyrannus*	pelagic · oceanodromous · brackish and marine	0 - 50	2, 3, 5, 6, 7, 8, 9
Gizzard shad (American gizzard shad)	*Dorosoma cepedianum*	pelagic · anadromous · freshwater, brackish and marine	? - 33	2, 3, 5, 7, 8, 9, 10
Hickory shad	*Alosa mediocris*	pelagic · anadromous · freshwater, brackish and marine	NA	2, 7, 9
Alewife	*Alosa pseudoharengus*	pelagic · anadromous · freshwater, brackish and marine	5 - 145	2, 6, 7, 9, 10
American shad	*Alosa sapidissima*	pelagic · anadromous · freshwater, brackish and marine	0 - 250	2, 6, 7, 8, 9
Atlantic menhaden	*Brevoortia tyrannus*	pelagic · oceanodromous · brackish and marine	0 - 50	2, 3, 5, 6, 7, 8, 9
Gizzard shad (American gizzard shad)	*Dorosoma cepedianum*	pelagic · anadromous · freshwater, brackish and marine	? - 33	2, 3, 5, 7, 8, 9, 10
Cynoglossidae (tonguefishes)				
Blackcheek tonguefish	*Symphurus plagiusa*	demersal · brackish and marine	0 - 183	2, 7[e], 9
Cyprinidae (minnows and carps)				
Carp (Common carp)	*Cyprinus carpio carpio*	benthopelagic · potamodromous · freshwater and brackish	NA	1, 3, 5, 7, 8
Unidentified shiner	*Notropis* sp.			1
Cyprinodontidae (pupfishes)				
Sheepshead minnow	*Cyprinodon variegates variegatus*	benthopelagic · non-migratory · freshwater, brackish and marine	NA	2, 6, 7, 9
Diodontidae (porcupinefishes [burrfishes])				
Striped burrfish	*Chilomycterus schoepfii*	reef-associated · marine	? - 11	2, 9
Engraulidae (anchovies)				
Striped anchovy (Broad-striped anchovy)	*Anchoa hepsetus*	pelagic · brackish and marine	1 - 70	2, 9
Bay anchovy	*Anchoa mitchilli*	reef-associated · amphidromous · brackish and marine	1 - 36	1, 2, 3, 5, 6, 7, 9, 10
Fundulidae (topminnows and killifishes)				
Killifishes	*Fundulus* spp.			1, 6, 10
Marsh killifish	*Fundulus confluentus*	benthopelagic · non-migratory · freshwater, brackish and marine	NA	2, 9
Banded killifish	*Fundulus diaphanous diaphanus*	benthopelagic · non-migratory · freshwater and brackish	NA	1, 2, 3, 5, 9, 10
Mummichog	*Fundulus heteroclitus heteroclitus*	benthopelagic · non-migratory · freshwater, brackish and marine	NA	1, 2, 3, 5, 7, 9, 10
Spotfin killifish	*Fundulus luciae*	benthopelagic · non-migratory · brackish and marine	NA	2, 9
Striped killifish	*Fundulus majalis*	benthopelagic · non-migratory · brackish and marine	NA	1, 2, 3, 5, 9, 10
Rainwater killifish	*Lucania parva*	pelagic · amphidromous · freshwater, brackish and marine	NA	2, 9
Gasterosteidae (sticklebacks and tubesnouts)				
Fourspine stickleback	*Apeltes quadracus*	benthopelagic · freshwater, brackish and marine	NA	2, 9
Threespine stickleback (Three-spined stickleback)	*Gasterosteus aculeatus aculeatus*	benthopelagic · anadromous · freshwater, brackish and marine	0 - 100	2, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Gobiesocidae (clingfishes and singleslits)				
Skilletfish	*Gobiesox strumosus*	reef-associated · brackish and marine	0 - 33	2, 3, 9, 10
Gobiidae (gobies)				
Gobies	*Gobiosoma* spp.			6
Naked goby	*Gobiosoma bosc*	demersal · brackish and marine	NA	2, 9, 10
Seaboard goby	*Gobiosoma ginsburgi*	demersal · marine	? - 50	2, 9
Code goby	*Gobiosoma robustum*	demersal · brackish and marine	NA	2, 9
Clown goby	*Microgobius gulosus*	demersal · amphidromous · freshwater, brackish and marine	NA	2, 9
Green goby	*Microgobius thalassinus*	demersal · marine	NA	2, 9
Hemiramphidae (halfbeaks)				
Halfbeak (Common halfbeak)	*Hyporhamphus unifasciatus*	reef-associated · oceanodromous · brackish and marine	0 - 5	2, 9
Ictaluridae (North American freshwater catfishes)				
White catfish	*Ameiurus catus*	demersal · potamodromous · freshwater	10 - ?	7, 8
Yellow bullhead	*Ameiurus natalis*	demersal · freshwater	10 - ?	7
Brown bullhead	*Ameiurus nebulosus*	demersal · freshwater and brackish	? - 40	5, 7, 8
Channel catfish	*Ictalurus punctatus*	demersal · freshwater	15 - ?	5, 6, 7, 8
Labridae (wrasses)				
Tautog	*Tautoga onitis*	reef-associated · brackish and marine	1 - 75	2, 6, 9
Lepisosteidae (gars)				
Longnose gar	*Lepisosteus osseus*	demersal · freshwater and brackish	0 - ?	1, 7
Monacanthidae (filefishes)				
Orange filefish	*Aluterus schoepfii*	reef-associated · marine	3 - 900	2, 9
Moronidae (temperate basses)				
White perch	*Morone americana*	demersal · anadromous · freshwater, brackish and marine	10 - ?	1, 2, 3, 5, 6, 7, 8, 9, 10
Striped bass	*Morone saxatilis*	demersal · anadromous · freshwater, brackish and marine	30 - ?	1, 2, 3, 5, 6, 7, 8, 9, 10
Mugilidae (mullets)				
Mullets	*Mugil* spp.			6
Striped mullet (Flathead mullet)	*Mugil cephalus*	benthopelagic · catadromous · freshwater, brackish and marine	0 - 120	2, 9
White mullet	*Mugil curema*	reef-associated · catadromous · freshwater, brackish and marine	15 - ?	2, 9
Myliobatidae (eagle and manta rays)				
Cownose ray	*Rhinoptera bonasus*	benthopelagic · oceanodromous · brackish and marine	0 - 22	2, 6, 7, 9
Paralichthyidae (large-tooth flounders)				
Summer flounder	*Paralichthys dentatus*	demersal · oceanodromous · marine	10 - 183	2, 6, 7, 8, 9
Percidae (perches)				
Yellow perch	*Perca flavescens*	benthopelagic · freshwater and brackish	? - 56	1, 2, 3, 5, 6, 8, 9, 10
Petromyzontidae (lampreys)				
Sea lamprey	*Petromyzon marinus*	demersal · anadromous · freshwater, brackish and marine	1 – 2,200	2, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Phycidae (phycid hakes)				
Spotted hake (Spotted codling)	*Urophycis regia*	demersal · non-migratory · marine	0 - 494	2, 9
Pleuronectidae (righteye flounders)				
Winter flounder	*Pseudopleuronectes americanus*	demersal · oceanodromous · marine	5 - 143	2, 6, 9
Poeciliidae (Poeciliids)				
Eastern mosquitofish	*Gambusia holbrooki*	benthopelagic · potamodromous · freshwater and brackish	NA	5
Pomatomidae (bluefishes)				
Bluefish	*Pomatomus saltatrix*	pelagic · oceanodromous · brackish and marine	0 - 200	2, 3, 6, 7, 8, 9, 10
Rachycentridae (cobia)				
Cobia	*Rachycentron canadum*	reef-associated · oceanodromous · brackish and marine	0 – 1,200	2, 9
Sciaenidae (drums and croakers)				
Silver perch	*Bairdiella chrysura*	demersal · freshwater, brackish and marine	NA	2, 9
Weakfish (Gray weakfish)	*Cynoscion regalis*	demersal · oceanodromous · brackish and marine	10 - 26	2, 6, 7, 8[f], 9
Spotted seatrout (Spotted weakfish)	*Cynoscion nebulosus*	demersal · brackish and marine	10 - ?	2, 3, 6, 8[g], 9
Spot (Spot croaker)	*Leiostomus xanthurus*	demersal · oceanodromous · brackish and marine	? - 60	1, 2, 3, 5, 6, 7, 8, 9, 10
Southern kingfish (Southern kingcroaker)	*Menticirrhus americanus*	demersal · oceanodromous · brackish and marine	? - 40	2, 9
Northern kingfish (Northern kingcroaker)	*Menticirrhus saxatilis*	demersal · brackish and marine	10 - ?	2, 6, 9
Atlantic croaker	*Micropogonias undulatus*	demersal · brackish and marine	? - 100	2, 6, 7, 8, 9
Black drum	*Pogonias cromis*	demersal · oceanodromous · brackish and marine	10 - ?	2, 6, 9
Red drum	*Sciaenops ocellatus*	demersal · oceanodromous · brackish and marine	10 - ?	2, 6, 9
Scombridae (mackerels, tunas, bonitos)				
Spanish mackerel	*Scomberomorus maculates*	reef-associated · oceanodromous · marine	10 - 35	8
Scophthalmidae (turbots)				
Windowpane flounder (Windowpane)	*Scophthalmus aquosus*	demersal · marine	55 - 73	2, 9
Serranidae (sea basses, groupers and fairy basslets)				
Black sea bass (Black seabass)	*Centropristis striata*	reef-associated · oceanodromous · marine	1 - ?	2, 6, 9
Stromateidae (butterfishes)				
Harvestfish	*Peprilus alepidotus*	benthopelagic · marine	NA	2, 3, 9
Butterfish (American butterfish)	*Peprilus triacanthus*	benthopelagic · oceanodromous · brackish and marine	15 - 420	2, 6, 9
Syngnathidae (pipefishes and seahorses)				
Lined seahorse	*Hippocampus erectus*	reef-associated · non-migratory · marine	1 - 73	2, 9
Dusky pipefish	*Syngnathus floridae*	demersal · marine	? - 22	2, 9
Northern pipefish	*Syngnathus fuscus*	demersal · amphidromous · freshwater, brackish and marine	5 - 366	1, 2, 3, 5, 6, 9, 10
Synodontidae (lizardfishes)				
Inshore lizardfish	*Synodus foetens*	reef-associated · brackish and marine	0 - 200	2, 9
Tetraodontidae (puffers)				
Northern puffer	*Sphoeroides maculatus*	demersal · brackish and marine	10 - 183	2, 7, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Triglidae (searobins)				
Northern searobin	*Prionotus carolinus*	demersal · brackish and marine	15 - 170	2, 6, 9
Striped searobin	*Prionotus evolans*	reef-associated · brackish and marine	? - 180	2, 9
Uranoscopidae (stargazers)				
Northern stargazer	*Astroscopus guttatus*	demersal · marine	? - 36	2, 9

Habitat characteristics terms (based on Froese and Pauly, 2007 and National Marine Fisheries Service, March 2008):

Benthopelagic – living and feeding near the bottom as well as in midwaters or near the surface.
Demersal – living on or near the bottom.
Pelagic – living and feeding in midwaters or near the surface.
Reef-associated – living and feeding on or near coral reefs.
Amphidromous – regularly migrating between estuaries and coastal rivers and streams, usually associated with the search for food or refuge rather than the need to reproduce; can spawn in either freshwater or in a marine environment.
Anadromous – spending most of adult life in salt water and migrating into freshwater streams and lakes to reproduce.
Catadromous – spending most of adult life in fresh water and migrating to salt water to spawn.
Oceanodromous – migrating within oceans typically between spawning and different feeding areas.
Potamodromous – migrating within streams or in rivers.
Freshwater – broadly, all continental aquatic systems such as rivers and lakes; technically, water with salinity less that 0.5 ppt.
Brackish – water with salinity between that of fresh water and sea water; usually 0.5 to 30 ppt.
Marine – pertaining to the sea, from the open oceans to the high water mark and into estuaries.

Notes:

a. Available habitat characteristics and depth information based on Froese and Pauly, 2007.
b. NA indicates not available.
c. Species identified by the MDE (Luckett, pers. comm., February 12, 2008) as needlefish.
d. Species identified by the PRFC as herring.
e. Species identified by the MDE (Luckett, pers. comm., February 12, 2008) as tonguefish (sic).
f. Species identified by the PRFC as grey trout.
g. Species identified by the PRFC as spotted trout.
h. In addition to the species listed in this table, the MDE (Luckett, pers. comm., February 12, 2008) also identified blowfish, sea robin, skate, and sunfish sp. as having been involved in fish kills in the tidal Potomac River; however, these fish could not be identified by species.

Occurrence Sources:

1 – NSWCDL, 1979.
2 – Lippson et al., 1981.
3 – Alliance for the Chesapeake Bay, Not Dated.
4 – NSWCDD, 2001.
5 – NSF Dahlgren, 2007.
6 – NOAA, 2008.
7 – Luckett, pers. comm., February 12, 2008
8 –Cosby, PRFC, pers. comm., March 1, 2011.
9 – Lippson & Lippson, 2006.
10 – Completed fish collection forms from fish sampling conducted by Alliance for the Chesapeake Bay and NSF Dahlgren between 1999 and 2002, provided by Lou Etgen, Interim Director, Alliance for the Chesapeake Bay, November 17, 2008.
11 – Freedom du Lac, 2010.

3.11.4.2 Ecologically and Economically Important Fish

Estuarine Living Marine Resources (ELMR) Program

The NOAA ELMR program developed and maintains a database on the presence, distribution, relative abundance, and life history characteristics of ecologically and economically important fishes and invertebrates in the estuaries of the United States (Stone et al., 1994; Nelson and Monaco, 2000). The database is divided into five study regions, one of which is the Mid-Atlantic, which includes the Chesapeake Bay and the Potomac River. ELMR program staff selected species for inclusion in each regional database based on the following four criteria, together with data availability (Stone et al., 1994; Nelson and Monaco, 2000):

- Commercial value
- Recreational value
- Indicator of environmental stress
- Ecological value

To develop the database, spatial and temporal distribution and relative abundance data were compiled from data sets, technical reports, and peer-reviewed literature.

The mixing salinity zone – defined by 0.5 to 25 ppt salinity – of the Potomac River approximately coincides with the PRTR portion of the river. Of the 51 species of fish included in the ELMR database for the Mid-Atlantic region, 34 species are present in the mixing salinity zone of the Potomac River; these species are shown in Table 3.11-5. Six are shallow-water species:

- Silversides
- Sheepshead minnow
- Bay anchovy
- Killifishes
- Gobies
- Northern pipefish

Ten others are pelagic species – fish that live and feed in midwaters or near the surface:

- Blueback herring
- Alewife
- American shad
- Atlantic menhaden
- White perch
- Striped bass
- Yellow perch
- Bluefish
- Black sea bass
- Butterfish

The remaining 18 are demersal species – fish that live on or near the bottom:

- Hogchoker
- Atlantic sturgeon
- American eel
- Oyster toadfish
- Channel catfish
- Tautog
- Mullets
- Cownose ray

- Summer flounder
- Winter flounder
- Weakfish
- Spotted seatrout
- Spot
- Northern kingfish
- Atlantic croaker
- Black drum
- Red drum
- Northern searobin

For 13 of these 34 species – the 13 that are highlighted in Table 3.11-5 – each of the five life stages is present in the zone at some point during the year. As indicated in the table, of these 13 species, five are shallow-water fishes, five are pelagic, and three are demersal. That is, of the six shallow-water species present in the mixing salinity zone, all but one of them make use of the zone for all five life stages, whereas only half of the 10 pelagic species and only one in six of the 18 demersal species do so.

The assemblages of fish occurring in the Potomac River vary seasonally, regulated primarily by temperature and salinity. Tables 3.11-6 through 3.11-10 summarize the relative abundance data for fish species life stages present in the mixing salinity zone of the Potomac River, based on the ELMR database. The abundance of a species life stage is ranked relative to that of the same life stage of other similar species – i.e., species having similar life modes and gear susceptibilities (susceptibility to capture by a type of fishing gear) (Stone et al., 1994; Nelson and Monaco, 2000). For each species, the life stage occurrence by month is categorized into the following relative abundance rankings by groups of similar species or guilds (Stone et al., 1994; Nelson and Monaco, 2000):

- **Not present** – Species or life stage is not found, questionable data as to identification of species, or recent loss or degradation of habitat suggests absence.
- **Rare** – Species is present, but not frequently encountered.
- **Common** – Species is generally encountered, but not in large numbers; distribution may be patchy.
- **Abundant** – Species is often encountered in substantial numbers relative to other species in a guild.[8]

Summer Flounder
Paralichthys dentatus

- **Highly abundant** – Species is numerically dominant relative to other species within a guild.

[8] Some species (e.g., striped bass and sheepshead minnow) designated as abundant in the Potomac estuary by Lippson et al., 1981 may not be designated as abundant based on the ELMR database. The differences in abundance ratings may be due to differences in the applied definitions of the abundance categories, differences in methodologies (e.g., the comparisons of life-stage occurrence by month within guilds used by the ELMR program), or changes in fish assemblages or occurrence records over time.

Table 3.11-5
Life Stages of Ecologically and Economically Important Species Present in Potomac River Mixing Salinity Zone

Common Name	Life Stages				
	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Shallow-Water Fishes					
Silversides	♦	♦	♦	♦	♦
Sheepshead minnow	♦	♦	♦	♦	♦
Bay anchovy	♦	♦	♦	♦	♦
Killifishes	♦	♦	♦	♦	♦
Gobies	♦	♦	♦	♦	♦
Northern pipefish		♦	♦	♦	♦
Pelagic Fishes					
Blueback herring	♦	♦	♦	♦	♦
Alewife	♦	♦	♦	♦	♦
American shad	♦	♦	♦	♦	♦
Atlantic menhaden			♦	♦	
White perch	♦	♦	♦	♦	♦
Striped bass			♦	♦	
Yellow perch	♦	♦	♦	♦	♦
Bluefish			♦	♦	
Black sea bass			♦	♦	
Butterfish			♦	♦	
Demersal Fishes					
Hogchoker	♦	♦	♦	♦	♦
Atlantic sturgeon			♦	♦	
American eel			♦		
Oyster toadfish	♦	♦	♦	♦	♦
Channel catfish			♦	♦	
Tautog			♦	♦	
Mullets			♦	♦	
Cownose ray			♦	♦	
Summer flounder			♦	♦	
Winter flounder	♦	♦	♦	♦	♦
Weakfish			♦	♦	
Spotted seatrout		♦	♦	♦	
Spot			♦		
Northern kingfish			♦	♦	
Atlantic croaker			♦	♦	
Black drum			♦	♦	
Red drum			♦	♦	
Northern searobin			♦	♦	

Notes: 1. Blank indicates species life stage is not present.
2. Green line indicates that all life stages are present for that species.
3. ♦ indicates species life stage is present.

Source: NOAA, 2008.

Table 3.11-6
Fish Egg Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides				A	H	H	H	H	A			
Sheepshead minnow				C	A	A	A	C	C			
Bay anchovy				R	A	A	H	A	C	R		
Killifishes				A	H	H	H	H	C			
Gobies				C	A	A	A	A	R	R		
Pelagic Fishes												
Blueback herring			R	C	C							
Alewife			C	C	R							
American shad				R	R							
White perch			C	C	C	R						
Yellow perch		C	C									
Demersal Fishes												
Hogchoker					A	H	H	H	A			
Oyster toadfish				C	C	C	C	C	C			
Winter flounder	R	R	R	R								R

Notes:

1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-7
Fish Larvae Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides				A	H	H	H	H	A			
Sheepshead minnow				C	A	A	A	C	C			
Bay anchovy				R	A	A	H	A	C	R		
Killifishes				A	H	H	H	H	C			
Gobies					C	A	A	A	R	R		
Northern pipefish				C	C	C	C	C	C	C		
Pelagic Fishes												
Blueback herring			R	C	C	C						
Alewife			C	C	R							
American shad				R	R							
White perch			C	C	C	R						
Yellow perch		C	C									
Demersal Fishes												
Hogchoker					A	H	H	H	A			
Oyster toadfish				C	C	C	C	C	C			
Winter flounder	R	R	R	R								R
Spotted seatrout				R	R	R	R					

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-8
Fish Juveniles Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides	H	H	H	H	H	H	H	H	H	H	H	H
Sheepshead minnow	A	A	A	A	A	A	A	A	A	A	A	A
Bay anchovy	H	H	H	C	A	H	H	H	H	H	H	H
Killifishes	H	H	H	H	H	H	H	H	H	H	H	H
Gobies					R	C	A	A	A	A	A	A
Northern pipefish	C	C	C	C	C	C	C	C	C	C	C	C
Pelagic Fishes												
Blueback herring					A	A	A	A	A	R		
Alewife					A	C	C	C	C	R		
American shad					C	C	C	C	C	C	R	
Atlantic menhaden	R	R	R	A	H	H	H	H	A	C	R	R
White perch	A	A	A	A	A	A	A	A	A	A	A	A
Striped bass	C	C	C	C	C	C	C	C	C	C	C	C
Yellow perch	C	C	C	C	C	C	C	C	C	C	C	C
Bluefish					R	C	A	A	C	R		
Black sea bass					R	R	R	R	R	R		
Butterfish						R	R	R	R	R		
Demersal Fishes												
Hogchoker	H	H	H	H	H	H	H	H	H	H	H	H
Atlantic sturgeon					R	R	R	R	R	R		
American eel	C	C	C	C	C	C	C	C	C	C	C	C
Oyster toadfish	C	C	C	C	C	C	C	C	C	C	C	C
Channel catfish	C	C	C	C	C	C	C	C	C	C	C	C
Tautog	R	R	R	R	R	R	R	R	R	R	R	R
Mullets						R	R	R	R	R		
Cownose ray						C	C	C	C	C		
Summer flounder	R	R	R	R	R	C	C	C	C	C	R	R
Winter flounder	R	R	R	R	R						R	R
Weakfish				C	C	C	C	C	C	C	R	
Spotted seatrout					C	C	C	C	C			
Spot					C	C	C	C	C	C	R	
Northern kingfish						R	R	R	R	R		
Atlantic croaker	C	C	C	C	C	C	C	C	C	C	R	R
Black drum					C	C	C	C	C	C		
Red drum						C	C	C	C	C	C	
Northern searobin				R	R	R	R	R	R	R		

Notes:

1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-9
Fish Adults Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides	H	H	H	H	H	H	H	H	H	H	H	H
Sheepshead minnow	A	A	A	A	A	A	A	A	A	A	A	A
Bay anchovy	H	H	H	H	H	H	H	H	H	H	H	H
Killifishes	H	H	H	H	H	H	H	H	H	H	H	H
Gobies	A	A	A	A	A	A	A	A	A	A	A	A
Northern pipefish	C	C	C	C	C	C	C	C	C	C	C	C
Pelagic Fishes												
Blueback herring			R	C	C	R						
Alewife		C	A	C	C							
American shad		R	C	C	C							
Atlantic menhaden					R	R	R	R	R	R		
White perch	A	A	A	A	A	A	A	A	A	A	A	A
Striped bass	R	R	C	C	C	C	C	C	C	C	R	R
Yellow perch	C	C	C	C	C	C	C	C	C	C	C	C
Bluefish					R	C	A	A	C	R		
Black sea bass					R	R	R	R	R	R		
Butterfish					R	R	R	R	R	R		
Demersal Fishes												
Hogchoker	H	H	H	H	H	H	H	H	H	H	H	H
Atlantic sturgeon				R	R	R						
Oyster toadfish	C	C	C	C	C	C	C	C	C	C	C	C
Channel catfish	C	C	C	C	C	C	C	C	C	C	C	C
Tautog					R	R	R	R	R			
Mullets						R	R	R	R	R		
Cownose ray						C	C	C	C			
Summer flounder					C	C	C	C	C	C	R	
Winter flounder	R	R	R	R	R						R	R
Weakfish					C	C	C	C	C	C	R	
Spotted seatrout			C	C	C	R	R	R	C	C		
Northern kingfish					R	R	R	R	R	R		
Atlantic croaker				R	R	R	R	R	R	R		
Black drum					C	C	C	C	C	C		
Red drum						C	C	C	C	C		
Northern searobin				R	R	R	R	R	R	R		

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-10
Fish Spawning Adults Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides				A	H	H	H	H	A			
Sheepshead minnow				C	A	A	A	C	C			
Bay anchovy				R	A	A	H	A	C	R		
Killifishes				A	H	H	H	H	C			
Gobies				C	A	A	A	A	R	R		
Northern pipefish				C	C	C	C	C	C	C		
Pelagic Fishes												
Blueback herring			R	C	C							
Alewife			C	C	R							
American shad				R	R							
White perch			C	C	C	R						
Yellow perch		C	C									
Demersal Fishes												
Hogchoker					A	H	H	H	A			
Oyster toadfish				C	C	C	C	C	C			
Winter flounder	R	R	R	R								R

Notes:

1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Potomac River Fisheries Commission Landing Data

The PRFC (described later in this section) collects commercial fishing harvest data for three areas of the Potomac River (Figure 3.11-4, Potomac River Fisheries Commission Commercial Harvest Areas 1 through 3):

- Area 1, which extends upriver from mouth of the Potomac River to Hollins Marsh, Virginia/Colton's Point, Maryland and includes the LDZ. Salinity levels are in the low to high mesohaline range (Figure 3.10-4).
- Area 2, which extends upriver from Hollins Marsh, Virginia/Colton's Point, Maryland to the Harry Nice Bridge, and includes the MDZ. Salinity levels are in the oligohaline to medium mesohaline range.
- Area 3, which extends upriver from the Harry Nice Bridge to Possum Point, Virginia/Moss Point, Maryland, and includes the UDZ. Salinity levels vary from oligohaline to low mesohaline.

Table 3.11-11 displays commercial fishing harvest data for the years 2001 to 2010. The total weight of landings from the PRTR for this period was approximately 58.0 million lbs of fish (Cosby, PRFC, pers. comm., March 1, 2011). During this period, 89 percent of the total fish landings were in Area 1; the remaining 11 percent of landings came from Area 3 (7 percent) and Area 2 (4 percent). The high productivity of Area 1 relative to the other two areas is likely the result of the width of the river, which results in a large water area, and higher salinity levels. These conditions support many of the more sought-after commercial fish species, including summer flounder, blue fish, striped bass, croaker, spot, menhaden, and Spanish mackerel.

The fish species with the largest harvests by weight for the 2001 to 2010 period were: Atlantic menhaden (37.8 million lbs); croaker (8.2 million lbs); striped bass (6.4 million lbs); eel (1.0 million lbs); and spot (1.0 million lbs). Atlantic menhaden is a herring that moves in schools and is used to make fish meal for pet food and fish food. It's an important prey species for larger predators such as striped bass, bluefish, herons, and egrets, and concerns have recently been raised that overfishing of menhaden could lead to declines in species that depend on them. Striped bass is the premier sport fish in the bay, and its population has rebounded after being heavily overfished.

Striped bass
Morone saxatilis

Anadromous Fish

Anadromous fishes spend most of their lives in marine or estuarine waters but return to fresh water to spawn. Eleven anadromous species occur in the Potomac River. The anadromous species of the Potomac River comprise two sturgeons (shortnose sturgeon and Atlantic sturgeon), two herrings (blueback herring and alewife), three shad (hickory shad, American shad, and gizzard shad), threespine stickleback, white perch, striped bass, and sea lamprey. A brief summary of the timing and location of spawning in the Potomac River for these species follows, based on Lippson et al., 1981, unless otherwise noted:

Shortnose sturgeon
- Optimal season from late March through April, when water temperatures are an ideal 48 to 64˚F (Federal Highway Administration, 2000).
- Lower nontidal portions of rivers or at the head of tide if passage into nontidal waters is not possible.
- Areas characterized by fast, turbulent currents and clean gravel/cobble and bounder substrates (Kynard et al., 2007).

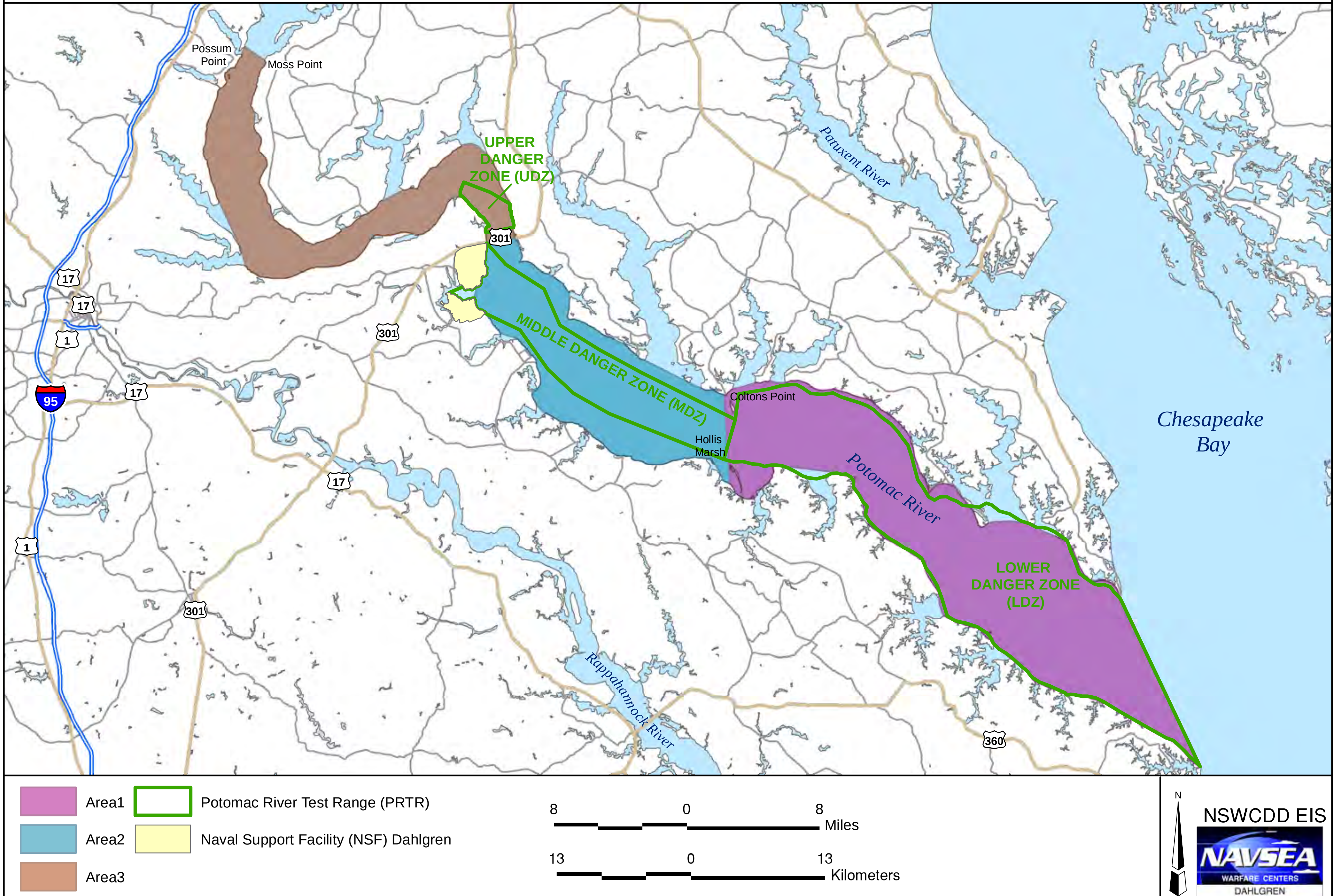
Atlantic sturgeon
- Ascend tributaries in May or June when temperatures reach approximately 64˚F (MDNR, 2011a).
- Tidal fresh water (MDNR, 2011a).

Blueback herring
- Mid-April to mid-May (Lippson et al., 1981); late March through mid-May (MDNR, 2011a).
- Tidal fresh and low brackish waters.
- Mostly in tributaries, but also in the main stem upstream of Maryland Point (upstream of PRTR).

Alewife
- Late March through April (Lippson et al., 1981); late February through April (MDNR, 2011a).
- Tidal fresh and low brackish waters.
- Wide range of substrates, such as gravel, sand, detritus, and submerged vegetation (MDNR, 2011a).
- Mostly in tributaries, but also in the main stem upstream of Maryland Point (upstream of PRTR).

Hickory shad
- Peak mid-April through late May, with temperatures ranging from 54 to 72˚F (MDNR, 2011a).
- Peak temperature 59 to 66˚F (MDNR, 2011a).
- Tidal and nontidal fresh water (MDNR, 2011a).
- Main stem, as well as backwaters, sloughs, and tributaries (MDNR, 2011a).

Potomac River Fisheries Commission Commercial Harvest Areas 1 through 3



Source: Based on Cosby PRFC, pers. comm., February 19, 2008.

Figure 3.11-4

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Table 3.11-11
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
American Eel	3	149,334	109,213	71,814	33,444	33,327	9,883	11,910	34,045	18,315	4,535	475,820
	2	51,981	17,844	35,657	62,524	43,157	54,882	52,659	15,469	28,882	32,220	395,275
	1	12,125	1,538	12,454	12,100	25,294	17,530	32,792	22,040	11,630	23,011	170,514
	TOTAL	**213,440**	**128,595**	**119,925**	**108,068**	**101,778**	**82,295**	**97,361**	**71,554**	**58,827**	**59,766**	**1,041,609**
American Shad (buck)	3	5		34	45	60	15	3	38	81	6	287
	2							40				40
	1	1,487	1,035	1,114	598	716	409	942	467	532	95	7,395
	TOTAL	**1,492**	**1,035**	**1,148**	**643**	**776**	**424**	**985**	**505**	**613**	**101**	**7,722**
American Shad (roe)	3	323	24	458	500	483	343	773	285	677	17	3,883
	2				206	456	78	1,586	92	108	5	2,531
	1	3,162	1,703	6,628	3,995	5,105	3,824	5,691	6,215	3,816	3,799	43,938
	TOTAL	**3,485**	**1,727**	**7,086**	**4,701**	**6,044**	**4,245**	**8,050**	**6,592**	**4,601**	**3,821**	**50,352**
Blue Catfish	3			1,382	12,101	7,953	15,220	38,730	58,895	67,216	163,067	364,564
	2			14	239	250	23	2,704	991	10,233	5082	19,536
	1			120	637	167	177	1,792	244	1,178	4,403	8,718
	TOTAL	**0**	**0**	**1,516**	**12,977**	**8,370**	**15,420**	**43,226**	**60,130**	**78,627**	**172,552**	**392,818**
Bluefish	3	150						1,916	1,617	1,955	10	5,648
	2	83	89		4		586			275	163	1,200
	1	127,619	97,459	23,879	58,643	89,967	44,720	78,262	82,892	32,413	51,339	687,193
	TOTAL	**127,852**	**97,548**	**23,879**	**58,647**	**89,967**	**45,306**	**80,178**	**84,509**	**34,643**	**51,512**	**694,041**
Bullhead	3	18,927	9	6,377	8,352	14,304	204	21,281	22,714	25,791	21,972	139,931
	2	30		693			74	187	644	145	60	1,833
	1											
	TOTAL	**18,957**	**9**	**7,070**	**8,352**	**14,304**	**278**	**21,468**	**23,358**	**25,936**	**22,032**	**141,764**
Carp	3	420	2	395	10	25	22	8,018	28		66	8,986
	2		11	181	155	110	16	194	154	39	105	965
	1	113	20	316	629	612	60		23			1,773
	TOTAL	**533**	**33**	**892**	**794**	**747**	**98**	**8,212**	**205**	**39**	**171**	**11,724**

Table 3.11-11 (Continued)
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Catfish (mixed)	3	72,049	54,804	27,240	1,654	413	888	16,845				173,893
	2	716	48	258		137	37					1,196
	1	89	28	1,100	15							1,232
	TOTAL	**72,854**	**54,880**	**28,598**	**1,669**	**550**	**925**	**16,845**	**0**	**0**	**0**	**176,321**
Channel Catfish	3			39,068	74,424	57,347	44,186	15,087	25,363	31,216	52,327	339,018
	2				67	270	180	197	645	2957	2174	6,490
	1			474	4,346	4,749	502	980	2,023	187	1,451	14,712
	TOTAL	**0**	**0**	**39,542**	**78,837**	**62,366**	**44,868**	**16,264**	**28,031**	**34,360**	**55,952**	**360,220**
Croaker	3	948	6,465	2,277	24,081	786	1,862	138	30,947	19,986	886	88,376
	2	2,543	171	154	325	52	89,328	1,501	9	182	1,105	95,370
	1	1,959,803	1,414,458	1,125,572	1,607,190	481,074	572,493	186,925	293,751	210,570	161,380	8,013,216
	TOTAL	**1,963,294**	**1,421,094**	**1,128,003**	**1,631,596**	**481,912**	**663,683**	**188,564**	**324,707**	**230,738**	**163,371**	**8,196,962**
Gizzard Shad	3	36,031	32,653	78,202	75,377	51,241	30,278	29,622	6,657	16,167	225	356,453
	2	130	242	2,270	4,800	7,565	790	2,906	8,024	1,115	2,340	30,182
	1	66,523	69,730	47,619	30,098	48,915	8,436	18,723	26,972	35,168	14,847	367,031
	TOTAL	**102,684**	**102,625**	**128,091**	**110,275**	**107,721**	**39,504**	**51,251**	**41,653**	**52,450**	**17,412**	**753,666**
Grey Trout	3											
	2	2										2
	1	44,217	57,818	5,273	1,986	974	689	20	74	17	80	111,148
	TOTAL	**44,219**	**57,818**	**5,273**	**1,986**	**974**	**689**	**20**	**74**	**17**	**80**	**111,150**
Hickory Shad	3			90	162						150	402
	2											
	1											
	TOTAL	**0**	**0**	**90**	**162**	**0**	**0**	**0**	**0**	**0**	**150**	**402**
Menhaden	3	55	1,455		77,580	7,845	22,440	201,600	173,367	256,922	7,800	749,064
	2		30	45	102	140	35,520	1,290	1,080	7,761	2,838	48,806
	1	3,328,980	3,120,565	2,438,745	5,333,361	4,751,920	3,244,437	4,834,376	4,416,451	2,746,742	2,780,090	36,995,667
	TOTAL	**3,329,035**	**3,122,050**	**2,438,790**	**5,411,043**	**4,759,905**	**3,302,397**	**5,037,266**	**4,590,898**	**3,011,425**	**2,790,728**	**37,793,537**

Table 3.11-11 (Continued)
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
River Herring	3	5,799	1,730	423	3,208	170	95			1,980		13,405
	2		3,320	65								3,385
	1	29,924	50,036	19,644	16,531	8,337	6,724	6,011	5,476	6,947	928	150,558
	TOTAL	**35,723**	**55,086**	**20,132**	**19,739**	**8,507**	**6,819**	**6,011**	**5,476**	**8,927**	**928**	**167,348**
Spanish Mackerel	3											
	2											
	1	25,970	14,922	21,267	917	2,725	2,019	4,915	3,198	470	68	76,471
	TOTAL	**25,970**	**14,922**	**21,267**	**917**	**2,725**	**2,019**	**4,915**	**3,198**	**470**	**68**	**76,471**
Spot	3						1	3	70	567		641
	2	197	38				136			183	35	589
	1	176,349	140,738	227,430	131,605	95,350	40,575	70,511	29,720	62,714	43,990	1,018,982
	TOTAL	**176,546**	**140,776**	**227,430**	**131,605**	**95,350**	**40,712**	**70,514**	**29,790**	**63,464**	**44,025**	**1,020,212**
Spotted Sea Trout	3											
	2		14									14
	1	1,380	1,910	103	419	71	134	24	31	33	8	4,113
	TOTAL	**1,380**	**1,924**	**103**	**419**	**71**	**134**	**24**	**31**	**33**	**8**	**4,127**
Striped Bass	3	168,586	179,861	118,536	120,301	135,494	137,313	110,171	131,699	103,818	110,146	1,315,925
	2	158,744	86,088	155,055	292,321	88,651	129,302	173,333	186,207	215,800	188,013	1,673,514
	1	324,026	245,084	401,377	346,085	305,488	401,037	310,654	280,973	398,530	374,988	3,388,242
	TOTAL	**651,356**	**511,033**	**674,968**	**758,707**	**529,633**	**667,652**	**594,158**	**598,879**	**718,148**	**673,147**	**6,377,681**
Summer Flounder	3				59		80	495	312	1,106	117	2,169
	2	19	12				222					253
	1	32,034	40,930	28,194	35,565	23,308	29,367	21,574	26,445	23,844	22,270	283,531
	TOTAL	**32,053**	**40,942**	**28,194**	**35,624**	**23,308**	**29,669**	**22,069**	**26,757**	**24,950**	**22,387**	**285,953**
White Catfish	3			1,907	3,100	1,859	3,110	5,328	3,564	18,812	42	37,722
	2			6	434	333	718	1,314	1901	502	2552	7,760
	1			119	172	817	47	1,105	165	87	90	2,602
	TOTAL	**0**	**0**	**2,032**	**3,706**	**3,009**	**3,875**	**7,747**	**5,630**	**19,401**	**2,684**	**48,084**

Table 3.11-11 (Continued)
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
White Perch	3	15,513	8,725	7,722	11,212	9,338	7,122	4,501	5,131	3,361	2,050	74,675
	2	1,181	345	484	278	233	298	1,514	1,233	1,191	486	7,243
	1	17,400	7,257	23,401	23,870	30,775	26,246	23,934	9,652	3,532	9,620	175,687
	TOTAL	**34,094**	**16,327**	**31,607**	**35,360**	**40,346**	**33,666**	**29,949**	**16,016**	**8,084**	**12,156**	**257,605**
Winter Flounder	3											
	2											
	1	113	788	151		28		59		15	21	1,175
	TOTAL	**113**	**788**	**151**	**0**	**28**	**0**	**59**	**0**	**15**	**21**	**1,175**
Yellow Perch	3	961	4,199	990	2,274	1,396	676	128	115	366	168	11,273
	2	5	2			3					3	13
	1	259		46	1,530	591	1,865	558	655		27	5,531
	TOTAL	**1,225**	**4,201**	**1,036**	**3,804**	**1,990**	**2,541**	**686**	**770**	**366**	**198**	**16,817**

Source: Cosby, PRFC, pers. comm., March 1, 2011.

American shad	♦ Peak from mid-April to mid-May (Lippson et al., 1981); peak from mid-April through early June, with temperatures ranging from 55 to 68˚F (MDNR, 2011a). ♦ Peak temperature 64˚F (MDNR, 2011a). ♦ Tidal fresh waters over shallow flats (Lippson et al., 1981); usually gently sloping areas with fine gravel or sandy bottoms (MDNR, 2011a). ♦ Main stem between Mattawoman and Piscataway Creeks, and sometimes upstream to Broad Creek; marginal spawning may occur as far downstream as Maryland Point (upstream of the PRTR).
Gizzard shad	♦ April to June (Lippson et al., 1981), with peak in May (Lippson et al., 1981; MDNR, 2011a). ♦ Primarily tidal fresh waters. ♦ Most of the large tributaries above Maryland Point and the upper freshwater region of the main stem down to approximately Douglas Point (above the PRTR); presumably upper Wicomico River and Nanjemoy Creek; Mattawoman and Piscataway Creeks apparently locations of the most intensive spawning.
Threespine stickleback	♦ April and May. ♦ Shallow weedy areas. ♦ Main stem downstream of the mouth of the Wicomico River (downstream portion of the MDZ and the LDZ).
White perch	♦ Begins when water temperatures reach 46 to 50˚F, and inhibited above 59˚F; optimal temperatures 54 to 57˚F. ♦ Optimal temperatures from first part of April to the end of May; sporadic spawning has been observed at the end of March and into the first week of June. ♦ Fresh to low-salinity waters over fine gravel or sand (MDNR, 2011a). ♦ Shallow waters along the shores preferred, often under overhanging banks. ♦ Main-stem spawning concentrated from Indian Head upstream to Broad Creek and in the bend around Maryland Point (upstream of the PRTR).

Striped bass	♦ Water temperatures from 50 to 73˚F, with peak between 57 to 59˚F. ♦ Usually early April to end of May, with peak beginning mid-to-late April. ♦ Peak in tidal fresh waters in region 15 to 20 nm above Maryland Point (upstream of the PRTR); may shift upstream or downstream depending on freshwater river flow.
Sea lamprey	♦ Begins at water temperature 52˚F, peaks at 57 to 59˚F, and completed by the time water temperatures reach 75˚F. ♦ Rapidly flowing water over gravel bottoms. ♦ Non-tidal waters, or tidal waters if passage is blocked.

3.11.4.3 Management of Fish Resources in the Tidal Potomac River

Fish resources of the tidal Potomac River from the Maryland-Washington, DC boundary line near the Woodrow Wilson Bridge to the mouth of the river, including the PRTR portion of the river, are regulated by the PRFC (PRFC, 2008). The Maryland and Virginia Potomac River Compact of 1958 created the commission and charged it with the establishment and maintenance of a program to conserve and improve the fishery resources of the tidewater portion of the river. The commission regulates all recreational and commercial fishing, crabbing, oystering, and clamming in the main stem of the tidal Potomac River and issues licenses for those activities.

The PRFC coordinates regulations with the MDNR, the Virginia Marine Resources Commission, and the Virginia Department of Game and Inland Fisheries (VDGIF). Additionally, the management of coastal and migratory species is coordinated through the Atlantic States Marine Fisheries Commission (ASMFC). Maryland, Virginia, and other coastal states participate in the Commission process to manage the shared fishery resources.

At the federal level, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976 (16 U.S.C. §1801 *et seq*.), as amended, is the primary law governing marine fisheries management in US federal waters. The MSA developed ten national standards for fishery conservation and management. The first national standard states that "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry" (16 U.S.C. §1851(a)(1)). The MSA established eight regional fishery management councils to promote conservation through preparation of fisheries management plans (FMPs), which are documents that set rebuilding goals and regulations. There are three councils on the East Coast: New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and South Atlantic Fishery Management Council (SAFMC). Due to the migratory nature of fish, all three councils as well as the ASMFC manage one or more of the species occurring in the Potomac River. As part of the fisheries management process, NMFS fisheries science centers coordinate with the councils by researching and analyzing fish populations to assess the status of federally-managed fish stocks.

In the northeast, the Northeast Fisheries Science Center coordinates two stock-assessment programs, referred to as the Northeast Regional Stock Assessment Workshop (SAW) and the

Groundfish Assessment Review Meeting (GARM). These are formal scientific peer-review processes for evaluating and presenting stock-assessment results to managers. The SAW prepares and reviews assessments for fish stocks in offshore US waters of the northwest Atlantic; GARM focuses on 19 groundfish[9] stocks managed under the Northeast Multispecies FMP. Assessments that are prepared by SAW working groups (federally-led assessments), or ASMFC technical assessment committees (state-led assessments) are reviewed by an independent panel of stock-assessment experts called the Stock Assessment Review Committee (SARC). GARM follows a similar protocol. In the southeast, the Southeast Fisheries Science Center coordinates a third stock-assessment program, the SouthEast Data, Assessment, and Review, which is a cooperative Fishery Management Council process initiated to improve the quality and reliability of fishery stock assessments in the south Atlantic, Gulf of Mexico, and US Caribbean.

Table 3.11-12 provides an overview of the status of federally-managed species or stocks that are known to occur in the PRTR portion of the Potomac River. The table identifies the council that manages each species, the stock-assessment program that performed the review, whether or not each species has been overfished historically, whether overfishing is still occurring, and the species' current status. The terms "overfishing" and "overfished" signify "a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis" (16 U.S.C. §1802(34)).

Unless otherwise noted, Table 3.11-12 provides coast-wide stock status. Individual states also conduct surveys in inland and state waters to determine abundance of certain species locally. These estimates may differ from the coast-wide status determinations listed in Table 3.11-12. For example, while the coast-wide status of spot is unknown, juvenile abundance indices have generally declined in Maryland's portion of the Chesapeake Bay and consistent declines in juvenile abundance have occurred in Virginia's portion of the Chesapeake Bay since 1992 (Fabrizio and Montane, 2007).

As mentioned previously, the PRFC, MDNR, and VDGIF coordinate fisheries management in the Potomac River and/or the Chesapeake Bay. These organizations, as well as the Virginia Institute of Marine Science (VIMS), survey the Chesapeake Bay and its tributaries to determine abundance estimates and develop local stock- assessment reports. Depending on the organization responsible for the study, the results may be in the form of juvenile abundance indices or long-term trends. Information is available for approximately half of the federally-managed species. Due to the technical nature of the juvenile abundance indices, this section only summarizes information on long-term trends. One report, Estimating Relative Juvenile Abundance of Ecologically Important Finfish and Invertebrates in the Virginia Portion of Chesapeake Bay, August 2007, prepared by VIMS, provides long-term relative juvenile abundance trends for several species, as shown in Table 3.11-13 (Fabrizio and Montane, 2007). VIMS conducts a trawl survey in the lower Chesapeake Bay, and James, York, and Rappahannock rivers to collect these data. While the Potomac River is not included in their survey area, these trends are likely to be representative of the status of species that occur in the Potomac.

[9] Groundfish is a term used to define bottom-dwelling fish, such as flounder or cod.

Table 3.11-12
Status of Federally-Managed Fish Species Occurring in the PRTR

Species	Fishery Council	Year and Source of Most Recent Stock Assessment	Historically Overfished?	Is Overfishing Occurring?	Status
American Shad	ASMFC	2007 (ASMFC)	Depleted	Unknown[1]	Depleted
Atlantic Sturgeon	ASMFC	1998 (ASMFC)	Yes	No[2]	Unknown
American Eel	ASMFC	2006 (ASMFC)	Unknown	Unknown	Unknown
Atlantic Croaker	ASMFC	2010 (ASMFC)	Unknown	No	Healthy
Atlantic Menhaden	ASMFC	2010 (ASMFC)	No	Yes	Stable/ Unchanged
Black Sea Bass	ASMFC, MAFMC	2006 (SAW) 2008 (DPSWG[3])	No	No	Healthy
Bluefish	ASMFC, MAFMC	2005 (SAW)	No	No	Healthy
Red Drum	ASMFC	2009 (SEDAR[4])	Unknown	No	Stable/ Unchanged
River Herring	ASMFC	1990 (ASMFC)	Unknown	Unknown[5]	Unknown
Spanish Mackerel	ASMFC, SAFMC	2003 (MSAP[6])	Unknown	No	Rebuilding
Spotted Seatrout	ASMFC	N/A	Unknown	Unknown	Unknown
Spot	ASMFC	N/A	Unknown	Unknown	Unknown
Striped Bass	ASMFC	2007 (SAW)	No	No	Healthy
Summer Flounder	ASMFC, MAFMC	2011 (NEFSC[7])	No	No	Healthy
Tautog	ASMFC	2005 (ASMFC)	Yes	Yes	Depleted
Weakfish	ASMFC, SAFMC	2006 (ASMFC) 2008 (SAW)	Depleted	No	Depleted
Winter Flounder (Southern New England/Mid-Atlantic stock complex)	NEFMC	2008 (GARM)	Yes	No	Depleted

Notes:

1. Amendment 3 to the Interstate FMP for shad and river herring establishes a 2013 moratorium unless sustainability can be documented.
2. Amendment 1 to the Atlantic sturgeon FMP mandated all Atlantic coastal states to enact a moratorium on harvest and possession of Atlantic sturgeon.
3. DPSWG indicates Northeast Data Poor Stocks Working Group.
4. SEDAR indicates Southeast Data, Assessment, and Review.
5. Amendment 2 to the Interstate FMP for shad and river herring establishes a 2012 moratorium unless sustainability can be documented.
6. MSAP indicates Mackerel Stock Assessment Panel.
7. NEFSC indicates NOAA Fisheries Service Northeast Fisheries Science Center.

Sources: ASMFC, 2012a, 2012c; MAFMC, 2012.

Table 3.11-13
Relative Juvenile Abundance Trends in Virginia Waters of the Chesapeake Bay

Species	Random Stratified Index[1] Sample Years	Trend
American Eel	1988-2007	Declining
Atlantic Croaker	1988-2006	No
Atlantic Menhaden	2006-2007[2]	Slight increase
Black Sea Bass	1988-2006	Slight decline
Spot	1988-2006	Negative
Striped Bass	1988-2006	Negative
Summer Flounder	1988-2006	No substantial trend (potential slight decline)
Weakfish	Early 1990s - 2006	Slight increase

Notes:
1. The Random Stratified Index survey method allows sampling stations to be chosen at random, including location and water depth.
2. The index for Atlantic Menhaden is new, thus data to estimate long-term trends are unavailable.

Source: Fabrizio and Montane, 2007.

3.11.4.4 Essential Fish Habitat Assessment

Magnuson-Stevens Act

The MSA establishes management authority over all fishing within the United States Exclusive Economic Zone (EEZ); all anadromous fish throughout their migratory range; and all fish on the continental shelf. The MSA established the requirement to describe and identify essential fish habitat (EFH) for each federally-managed fishery in the corresponding FMP. EFH is defined as "...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." National Marine Fisheries Service (NMFS) regulations further define the following terms (NMFS, 1999a; NMFS, 2002):

- **Waters** – Aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate.
- **Substrate** – Sediment, hard bottom, structures underlying the waters, and associated biological communities.
- **Necessary** – The habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem.
- **Spawning, breeding, feeding, or growth to maturity** – Stages representing a species' full life cycle.

As required by the MSA, federal agencies must consult with NMFS Habitat Conservation Division on any proposed federal action that may adversely affect EFH. In addition to EFH designations, areas called habitat areas of particular concern (HAPCs) are designated to provide additional focus for conservation efforts; they represent a subset of designated EFH that are especially important ecologically to a species/life stage or are vulnerable to degradation (50 CFR

§§ 600.805-600.815). Although categorization as an HAPC does not confer additional protection or restriction to the designated area, these areas are fully considered below.

Designated Essential Fish Habitat

EFH has been designated in the Potomac River for one or more life stages of cobia, king mackerel, Spanish mackerel, and red drum (NOAA, 2012c). EFH also has been designated in the mixing water/brackish salinity zone (greater than 0.5 to less than 25.0 ppt salinity) of the Potomac River for the windowpane flounder, summer flounder, and bluefish. In addition, HAPCs in the Potomac River have been designated for red drum and summer flounder. Table 3.11-14 provides a listing of the species and their life stages for which EFH has been designated in the Potomac River, as well as designated HAPCs. Table 3.11-15 identifies the fisheries management plans that designated EFH in the Potomac River and the fishery management council that manages each of the species for which EFH has been designated.

Table 3.11-14
Species Identified as Having EFH in the Potomac River

Species	Egg	Larvae	Juvenile	Adult	HAPC
Cobia	♦	♦	♦	♦	
King Mackerel	♦	♦	♦	♦	
Spanish Mackerel	♦	♦	♦	♦	
Red Drum	♦	♦	♦	♦	♦
Windowpane Flounder			♦	♦	
Summer Flounder			♦	♦	♦
Bluefish			♦	♦	

Notes:
1. ♦ indicates EFH has been designated for species life stage or HAPC has been designated for species.
2. Blank indicates EFH has not been designated for species life stage or HAPC has not been designated for species.

Source: NOAA, 2012c.

Table 3.11-15
Fishery Management Plans Designating Essential Fish Habitat in the Potomac River

Species	Fishery Management Plan	Fishery Management Council
Cobia	Coastal Migratory Pelagics (SAFMC, 2012)	SAFMC
King Mackerel	Coastal Migratory Pelagics (SAFMC, 2012)	SAFMC
Spanish Mackerel	Coastal Migratory Pelagics (SAFMC, 2012)	ASMFC, SAFMC
Red Drum	Red Drum (ASMFC, 2012b)	ASMFC
Windowpane Flounder	Northeast Multispecies (Groundfish) (NEFMC, 2012)	NEFMC
Summer Flounder	Summer Flounder, Scup, and Black Sea Bass (MAFMC, 2011b)	ASMFC, MAFMC
Bluefish	Bluefish (MAFMC, 2011a)	ASMFC, MAFMC

The following discussions describe the species and life stages for which EFH has been designated in the Potomac River, emphasizing the species' habitat, seasonal range, feeding, and life history in the Chesapeake Bay or in the river, as possible based on available information. The sources for each species discussion are cited once at the end of the description. A summary of the EFH utilized by the life stages designated in the Potomac River follows each species discussion.

Cobia

Cobia are migratory, coastal pelagic, warm-water fish that prefer water temperatures greater than 68°F. In the Chesapeake Bay, cobia live in the bay's deep, open waters, and are often found in the shade of wrecks, buoys, and pilings. They are found in the lower Chesapeake Bay from May through October, and can move as far north as Tangier Sound and the mouth of the Potomac River. In the lower Potomac River estuary, cobia are found in the regions closest to the mouth of the river. Around October, cobia migrate out of the Chesapeake Bay to warmer southern waters.

Cobia are opportunistic hunters with a broad diet. They eat mostly crabs and shrimp, but also will feed on squid and small fish. Cobia spawn from June through mid-August in estuarine waters near the mouth of the Chesapeake Bay or just offshore. Eggs collect near the surface of the water.

Sources: Lippson et al., 1981; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Cobia

Eggs Larvae Juveniles Adults	♦ Sandy shoals of capes and offshore bars, high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break, but from the Gulf Stream shoreward. ♦ All coastal inlets. ♦ All state-designated nursery habitats of particular importance to coastal migratory pelagics. ♦ High-salinity bays, estuaries, and seagrass habitat. ♦ Water temperatures greater than 68˚F. ♦ Salinities greater than 25 ppt.

King Mackerel

King mackerel are highly-migratory, coastal epipelagic fish that are found near shore or far out to sea over the continental shelf. Temperature and salinity are believed to be the most important determinants of their distributions; king mackerel usually inhabit waters with temperatures greater than 68°F and salinities between 32 and 36 ppt. In the Chesapeake Bay, king mackerel live near the surface of the bay's open waters, close to shore, and around wrecks, reefs, and other hard structures. While migrating along the Atlantic coast, they occasionally visit the lower bay between June and October, peaking in September. Although EFH has been designated for king mackerel in the Potomac River, due to its preference for higher-salinity, estuarine and coastal oceanic habitats, king mackerel are not expected to occur in the Potomac River, as indicated by the species' absence from Table 3.11-4. If king mackerel do visit the Potomac River, it is expected that their occurrence would be limited to the regions closest to the mouth of the river.

King mackerel eat mostly fish, such as menhaden and anchovies, but also feed on shrimp and squid. They spawn from July through September over the Atlantic continental shelf. Larvae are found near or off the continental shelf, near the Gulf Stream, in waters with temperatures between 22 to 28°C.

Sources: Collette and Nauen, 1983; Godcharles and Murphy, 1986; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

King Mackerel

Eggs Larvae Juveniles Adults	♦ Sandy shoals of capes and offshore bars, high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break, but from the Gulf Stream shoreward. ♦ All coastal inlets. ♦ All state-designated nursery habitats of particular importance to coastal migratory pelagics. ♦ Water temperatures greater than 68˚F. ♦ Salinities greater than 30 ppt.

Spanish Mackerel

Like king mackerel, Spanish mackerel are highly-migratory, coastal epipelagic fish that are found near shore or far out to sea over the continental shelf. Temperature and salinity are believed to be the most important determinants of their distributions. Spanish mackerel usually prefer waters with temperatures between 70 and 81°F, rarely occurring in waters cooler than 64°F, and salinities between 32 and 36 ppt. Spanish mackerel usually avoid freshwater or low salinities near river mouths, although exceptions have been reported.

In the Chesapeake Bay, they usually live near the surface of the bay's open waters, close to shore. Spanish mackerel are found in the lower and middle bay, extending at least to the Patuxent River, and are most common along Virginia's western shore. They migrate from off Florida to the Chesapeake Bay in spring, entering the bay by May and leaving in autumn. As shown in Table 3.11-11, Potomac River commercial fishing harvest data indicate that Spanish mackerel landings from PRFC Area 1, which includes the LDZ, were reported each year from 2002 through 2010. No landings of Spanish mackerel were reported from Areas 2 and 3, which include the MDZ and UDZ, respectively.

Like king mackerel, Spanish mackerel eat mostly fish, such as menhaden and anchovies, but also feed on shrimp and squid. Spanish mackerel spawn off the Virginia and North Carolina coasts from late spring through late summer, and spawn in lower Chesapeake Bay in mid June. Most juvenile Spanish mackerel remain in high-salinity, nearshore ocean waters, although some use estuaries as nursery grounds.

Sources: Collette and Nauen, 1983; Godcharles and Murphy, 1986; Cosby, PRFC, pers. comm., March 1, 2011; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Spanish Mackerel

Eggs Larvae Juveniles Adults	♦ Sandy shoals of capes and offshore bars, high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break, but from the Gulf Stream shoreward. ♦ All coastal inlets. ♦ All state-designated nursery habitats of particular importance to coastal migratory pelagics. ♦ Water temperatures greater than 68˚F. ♦ Salinities greater than 30 ppt.

Red Drum

Red drum are estuarine-dependent fish. Juvenile and adult red drum can tolerate wide ranges of salinities (euryhaline) and temperatures (eurythermal). Juveniles have been found in waters with salinities of 0 to 50 ppt and temperatures of 55 to 82°F. Adults are most abundant in waters with salinities of 30 to 35 ppt, and have been found in waters with temperatures from 36 to 95°F. Larger juveniles and adults are more susceptible to the effects of winter cold waves than are small red drum.

In the Chesapeake Bay, adult red drum most often are found near the shoreline and school near the water surface. Juveniles are common in the bay's shallows and move up the bay as far as the Patuxent River. Red drum visit the Chesapeake Bay from May through November; adults are most common near the mouth of the bay during spring and autumn. Red drum occur sporadically in the Potomac River estuary, generally from June to October, with young fish remaining into late fall. Large adults are seldom caught in the river, except at the mouth, although young fish may be caught upstream or in the lower tributaries.

Juvenile red drum eat zooplankton and small invertebrates; adults feed on smaller fish such as anchovies and menhaden, as well as crabs and shrimp. In the Chesapeake Bay, red drum spawn in nearshore waters in late summer and autumn. After spawning, adults spend more time in the ocean and less in the bay. Larvae are found in vegetated and unvegetated bottoms in estuaries. Young-of-the-year red drum appear in the bay in August and September, and move into shallow, fresher waters, protected from wave action. In fall and winter, after their first year, red drum move into deeper bays and marine littoral areas, and return to the estuary in the spring.

Sources: Lippson et al., 1981; Buckley, 1984; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Red Drum

Larvae	♦ Estuarine wetlands especially important. ♦ Flooded saltmarshes, brackish marshes, tidal creeks, mangrove fringe, seagrasses. ♦ Water temperatures from 36 to 91˚F. ♦ Low salinity.

- Water depths less than 164 ft.

Juveniles

- Utilize shallow backwaters of estuaries as nursery areas and remain until they move to deeper water portions of the estuary associated with river mouths, oyster bars and shell banks, and front beaches.
- Found throughout Chesapeake Bay from September through November.
- Water temperatures from 36 to 91˚F.
- Salinities from 20 to 40 ppt.
- Water depths less than 164 ft.

Adults

- Concentrate around inlets, shoals, and capes along the Atlantic coast – shallow bay bottoms or oyster reef substrate preferred.
- Nearshore artificial reefs.
- Found in Chesapeake Bay in spring and fall, and also along eastern shore of Virginia.
- Water temperatures from 36 to 91˚F.
- Salinities from 20 to 40 ppt.
- Water depths less than 164 ft.

HAPC

- All coastal inlets, and adjoining channels, sounds, and outer bars.
- All state-designated nursery habitats of particular importance to red drum.
- Documented sites of spawning aggregations in North Carolina, South Carolina, Georgia, and Florida, and other identified spawning areas in the future.
- Habitats identified for SAV, especially seagrass beds or SAV prevalent in the Chesapeake Bay.
- Barrier islands and passes between barrier islands into estuaries.

Windowpane Flounder

Windowpane flounder are shoal-water benthic fish that inhabit estuaries, nearshore waters, and the continental shelf. Although windowpane flounders show some small-scale seasonal inshore-offshore movement, they do not undertake extensive migrations seasonally or for spawning. They generally inhabit shallow waters, less than 360 ft deep, with sand to sand/silt or mud substrates, and are most abundant at depths of 3.3 to 6.6 ft. Windowpane flounder are eurythermal and euryhaline. In most bays and estuaries south of Cape Cod, they can be found throughout the year at a wide range of depths and temperatures. Windowpane flounder may move as far up the Chesapeake Bay as the Potomac River.

Windowpane flounder feed mostly on polychaetes, small crustaceans, mysids (various small, shrimp-like, chiefly marine crustaceans of the order Mysidacea), and small fish. In the southern

Mid-Atlantic Bight, both juveniles and adults may migrate to nearshore or estuarine habitats in the autumn.

Sources: Bigelow and Schroeder, 1953; Lippson et al., 1981; Morse and Able, 1995; NMFS, 1999c; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Windowpane Flounder

Juveniles
- Bottom habitats with a substrate of mud or fine-grained sand.
- Water temperatures less than 77˚F.
- Salinities from 5.5 to 36 ppt.
- Water depths from 3.3 to 328 ft.

Adults
- Bottom habitats with a substrate of mud or fine-grained sand.
- Water temperatures less than 80.2˚F.
- Salinities from 5.5 to 36 ppt.
- Water depths from 3.3 to 246 ft.

Summer Flounder

Summer flounder are bottom-dwelling fish that inhabit shallow estuarine waters and the outer continental shelf. Juveniles use a variety of estuarine habitats, including estuarine marsh creeks, which serve as important nursery habitat, and seagrass beds, mud flats, and open bay areas. In the Chesapeake Bay, young-of-the-year occupy tidal creeks with salinities greater than 15 ppt. Some juvenile summer flounder prefer mixed or sandy substrates, whereas others use mud and vegetated habitats. Although reportedly adult summer flounder prefer sandy habitats, they also occupy various habitats with both mud and sand substrates, including marsh creeks, seagrass beds, and sand flats.

Summer flounder exhibit strong seasonal inshore-offshore movements. Generally, adults inhabit shallow coastal and estuarine waters during warmer months and remain offshore during the fall and winter. Juveniles remain inshore and in estuaries during spring, summer, and fall, and may move to deeper waters offshore during colder winter months.

Summer flounder visit the Chesapeake Bay from spring through autumn; most remain in the lower to middle bay, although some move as far north as the Gunpowder River. They usually enter the Potomac River in April and leave by November, but may arrive in March and leave in December. Young summer flounder have been found as far upstream as Indian Head, upriver from the UDZ, but most remain in the lower reaches of the estuary. Commercial fishing harvest data indicate that summer flounder landings from PRFC Area 1, which includes the LDZ, were reported each year from 2002 through 2010, as shown in Table 3.11-11. Landings from Area 1 accounted for 99 percent of the total landings by weight from the PRTR portion of the river during this period, with landings from Areas 2 and 3, which include the MDZ and UDZ, accounting for the remaining 1 percent.

Summer flounder are bottom feeders. Juveniles eat mostly mysid shrimp and adults feed mostly on fish, shrimp, squid, and polychaetes. Summer flounder spawn in shallow coastal waters and in estuaries along the Atlantic Coast.

Sources: Lippson et al., 1981; NMFS, 1999b; Cosby, PRFC, pers. comm., March 1, 2011; CBP, 2012; NOAA, 2012a; 2012b

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Summer Flounder

Juveniles
- Demersal waters, muddy substrate but prefer mostly sand.
- Lower estuaries in mudflats, channels, saltmarsh creeks, and seagrass beds, and open bay areas.
- Water temperatures greater than 52˚F.
- Salinities from 10 to 30 ppt.
- Water depths from 1.6 to 16 ft in estuary.

Adults
- Demersal waters.
- Estuaries.
- Water depths from 0 to 82 ft.

HAPC
- Within adult and juvenile EFH, all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed as well as loose aggregations.

Bluefish

Bluefish are highly-migratory, pelagic fish that inhabit open waters and migrate seasonally. They occur in a wide range of conditions, but prefer warmer waters, at least 57 to 61ºF, and high salinities. Adults are found at much deeper depths than juveniles, ranging from 3 to 1,300 ft. Juvenile bluefish use a variety of pelagic habitats in estuaries, which they use as nursery areas, bays, and the coastal ocean. They usually occupy waters near shorelines or in tidal creeks during the day and occupy open bay or channel waters at night. Although juveniles prefer sandy substrates, they also can be found over silt and clay bottoms. They prefer waters with salinities between 23 and 33 ppt, but can tolerate salinities as low as 3 ppt. Adult bluefish occur in the open ocean, large embayments, and estuaries.

Bluefish visit Chesapeake Bay open waters from spring through autumn. They spawn offshore and juveniles enter the bay in late summer. Bluefish are abundant in the lower bay, but most years also are common in the upper bay as far north as Baltimore. In the Chesapeake Bay, most bluefish are found where DO levels are between 6 and 9 mg/l. In early autumn, bluefish migrate out of the bay and all stages of bluefish have left the estuary by mid November. Adult bluefish start to enter the Potomac River shortly after they enter the Chesapeake Bay, in March or April. Although there are records of their occurrence near Washington, DC, adult bluefish are seldom found above Mathias Point, at the upriver end of the UDZ. Juveniles may be found as far upriver as Liverpool Point, upriver from the UDZ.

Bluefish are opportunistic predators that feed on a wide variety of fish and invertebrates; over 70 species of fish have been found in their stomach contents. Bluefish may be the most voracious predator in the Chesapeake Bay, feeding on squid and schooling fish, such as menhaden, silversides, and anchovies. Juveniles feed on small forage fish found in nearshore habitats.

Sources: Lippson et al., 1981; NMFS, 2006; ASMFC, 2011; NOAA, 2011a, 2011b

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Bluefish

Juveniles

- ♦ Pelagic waters.
- ♦ Estuaries.
- ♦ Water temperatures from 66 to 75˚F.
- ♦ Salinities from 23 to 36 ppt.

Adults

- ♦ Pelagic waters.
- ♦ Estuaries.
- ♦ Water temperatures from 57 to 61˚F.
- ♦ Salinities greater than 25 ppt.

Composition of Essential Fish Habitat in the Potomac River

Based on the above descriptions of the species and life stages for which EFH has been designated and resulting estimates of actual habitat utilization, the composition of EFH in the PRTR is as follows:

- UDZ – juvenile and adult summer flounder and bluefish
- MDZ – juvenile and adult summer flounder and bluefish
- LDZ – juvenile and adult cobia, king and Spanish mackerel, red drum, windowpane and summer flounder, and bluefish

Adverse Nonfishing Activity Effects Described in Fishery Management Plans

Collectively, the FMPs for each of the species for which EFH has been designated in the Potomac River identify multiple nonfishing activities that have the potential to adversely affect EFH quantity or quality (Gulf of Mexico Fishery Management Council and SAFMC, 1983; ASMFC, 1984; NEFMC, 1985; MAFMC, 1987; MAFMC and ASMFC, 1989, 1998; ASMFC, 1991). The identified activities may result, directly or indirectly, in the absolute loss or long-term degradation of the general aquatic environment or specific aquatic habitats, including EFH (NMFS Northeast Fisheries Center, 1985).

In 2005, the Northeast Region Essential Fish Habitat Steering Committee hosted the *Technical Workshop on Impacts to Coastal Fishery Habitat from Nonfishing Activities* to convene scientists, resource managers, and other marine resource professions to review and evaluate existing information on nonfishing impacts for the purpose of updating, as necessary, fishery management plans under the New England and Mid-Atlantic Fishery Management Councils

(NMFS Northeast Regional Office, 2008). Among the specific goals/tasks of the workshop were the following:

- Identify all known and potential adverse effects for each category of nonfishing activity by life history strategies or stages (i.e., benthic/demersal and pelagic) and ecosystem type or strata (i.e., riverine, estuarine/nearshore, and marine/offshore).
- Create a matrix of nonfishing impacts and score the relative severity of each impact using a semiquantitative scoring system.

Table 3.11-16 summarizes the results of the workshop scoring for the estuarine ecosystem strata for those categories of nonfishing activities that, in terms of the nature of the activities and the character of their potential adverse effects on EFH, may be similar to the RDT&E activities evaluated in this EIS.

The potential impacts to the designated EFH in the Potomac River that would result from implementing the alternatives considered in this EIS are assessed in the relevant subsections of Section 4.11 in Chapter 4.

Table 3.11-16
Estuarine/Nearshore Habitat Impact Severity Index Scores

Activity Type/Potential Effect	Benthic/Demersal Stages	Pelagic Stages
Marine Debris		
Entanglement	medium	medium
Ingestion	medium	medium
Contaminant releases	medium	medium
Introduction of invasive species	medium	medium
Introduction of pathogens	medium	medium
Conversion of habitat	medium	medium
Operation and Maintenance of Vessels		
Impacts to benthic habitat	high	medium
Resuspension of bottom sediments	medium	medium
Erosion of shorelines	medium	medium
Contaminant spills and discharges	high	high
Underwater noise	medium	medium
Derelict structures	medium	low
Increased air emissions	low	low
Release of debris	medium	low
Military/Security Activities		
Exclusion of organisms to habitat	low	medium
Noise impacts	medium	medium
Chemical releases	high	medium
Impacts to tidal/intertidal habitats	medium	medium
Blasting injuries from ordnance	medium	medium
Electromagnetic Fields		
Changes to migration of organisms	medium	medium
Behavioral changes	medium	medium
Changes in predator/prey relationships	medium	medium
Source: NMFS Northeast Regional Office, 2008.		

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3.12 Potomac River Birds

3.12.1 Migratory Birds

Migratory birds are a large, diverse group of birds that typically fly north to breed in the temperate or Arctic summer, and return to wintering grounds in warmer regions to the south. In the Western Hemisphere, migratory birds commonly nest in North America and spend the winter in southern North America, Central and South America, the West Indies, and the Caribbean.

All migratory birds are protected under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. §§ 703-712). The MBTA prohibits the taking, killing, or possessing of migratory birds unless permitted by regulation. However, the 2003 National Defense Authorization Act provides that the Secretary of the Interior shall exercise his/her authority under the MBTA to prescribe regulations to exempt the Armed Forces from incidental taking of migratory birds during military readiness activities authorized by the Secretary of Defense. The final rule authorizing the DoD to take migratory birds during military readiness activities (50 CFR Part 21, published February 28, 2007) provides that the Armed Forces must confer and cooperate with the US Fish and Wildlife Service (USFWS) on the development and implementation of conservation measures to minimize or mitigate adverse effects of a military readiness activity if it determines that it may have a significant adverse effect on a population of a migratory bird species. Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, provides additional protection for migratory birds on federal properties and stresses incorporating bird conservation principles in agency management plans.

The Potomac River is located off the main Atlantic flyway, which follows the Atlantic coast. Millions of migratory birds, including waterfowl, shorebirds, and songbirds, use the Atlantic flyway to travel between their summer breeding grounds and winter feeding grounds. Most species of waterfowl that use the flyway are from the northeastern United States and eastern Canada. There are sub-flyways off the main Atlantic flyway that follow major rivers – including the Potomac – and their tributaries. Waterfowl and other birds stop for food and shelter in coves and marshes along the flyway. Chesapeake Bay and the surrounding area serve as a wintering area for variety of ducks, geese, swans, and other migratory birds.

Many species of migratory birds frequent the shoreline and waters of the Potomac River, including waterfowl, raptors, shorebirds, and neotropical migrant birds, as described in the following sections.

3.12.2 Waterfowl

Waterfowl include birds in the family Anatidae (order Anseriformes). Potomac River waterfowl fall into four categories: dabbling ducks, diving ducks, geese, and swans (see text box). All have webbed feet and short legs, and most have wide, flattened bills. Most species migrate seasonally and use aquatic vegetation beds, wetlands, agricultural areas, and shoreline areas for food and nesting habitat. Dabbling ducks are generally found in shallow areas, such as near shallow wetlands and aquatic vegetation. In contrast, diving ducks generally occur in deeper open-water and are likely to be found in the river range. Dabbling ducks can spring into the air and fly away, but diving ducks have to run across the water flapping their wings in order to become airborne.

Potomac River Waterfowl

●**Dabbling ducks** feed primarily on water plants, which they obtain by tipping forward or dabbling in the shallows. They feed on submerged grasses, seeds, and other plant material. Their legs are positioned close to the middle of their bodies, allowing them to walk easily but inhibiting their diving ability. Common dabbling ducks include mallard (*Anas platyrhynchos*), black duck (*Anas rubripes*), pintail (*Anas acuta*), and wood duck (*Aix sponsa*).

●**Diving ducks** feed by diving to the bottom in deep water. Their legs are positioned towards the rear of their bodies, allowing them to dive but making it awkward to walk on land. Some diving ducks prefer plants such as wild celery and pondweed, but most consume a mixed diet consisting of small fish, mollusks, crustaceans, worms, and/or insects. Common diving ducks include canvasback *(Aythya valisineria*), redhead (*Aythya americana*), bufflehead (Bucephala albeola), lesser scaup (*Aythya affinis*), greater scaup (*Aythya marila*), ruddy duck (*Oxyura jamaicensis*), and red-breasted merganser (*Mergus serrator*).

●**Geese** are large, heavy-bodied waterfowl intermediate in size and build between large ducks and the swans. Geese feed on grain, grasses, and aquatic plants. Common geese include Canada geese (*Branta canadensis*), snow geese (*Chen caerulescens*), and Atlantic brant geese (*Branta bernicla*).

●**Swans** are the largest waterfowl species of the family Anatidae. Swans feed on aquatic plants, seeds, and field grain. The native tundra swan (*Cygnus columbianus*) is the most common swan found in the area, followed by the introduced mute swan (*Cygnus olor*).

Sources: Chesapeake Bay Gateways Network, 2009, Chesapeake Bay Program, 2009, USGS, 2011).

Large rafts (i.e., several hundred to several thousand) of diving ducks are observed annually on the Potomac River stretching from the Harry Nice Bridge into the mouth of Upper Machodoc Creek. Canvasback, lesser scaup, and ruddy ducks are the major species comprising these rafts.

Six high priority species, as defined by the Atlantic Coast Joint Venture, a partnership of federal, regional and state agencies and organizations focused on the conservation of habitat for native bird species in the Atlantic Flyway from Maine to Puerto Rico, use the lower Potomac River for wintering and migration habitat (Atlantic Coast Joint Venture, 2005). These priority species include the black duck, mallard, pintail, greater and lesser scaup, and the Southern James Bay population of Canada goose. Dabbling duck species (see text box above) and Canada geese utilize flooded marshes and the adjacent waterbodies to feed on invertebrates, plants and seeds. Scaups are diving ducks and use open-water to feed on SAV and invertebrates.

Fall migrants and overwintering waterfowl are very common in the creeks and bays that empty into the lower Potomac River. For example, NOAA's National Ocean Service (NOS) Environmental Sensitivity Index Maps, which are compiled from a number of databases, indicate that black duck, American coot *(Fulica americana*), American widgeon (*Anas americana)*, bufflehead, Canada goose, gadwall *(Anas strepera)*, and mallard – all except bufflehead are dabbling ducks – overwinter in creeks, such as Gambo Creek, along the river from October to April. Creeks with larger bays and more open water, such as Upper Machodoc Creek, Mattox Creek, Currioman Bay, and Nomini Bay, provide refuge from October to April for

Ruddy Duck
Oxyura jamaicensis

bufflehead, canvasback, common goldeneye (*Bucephala clangula*), red-breasted merganser, mute swan, ruddy duck, lesser scaup, scoter *(Fuligula americana)*, and tundra swan, many of which are divers (NOS, 2005, Environmental Sensitivity Index map VA-116).

MDNR (2010) has estimated the number of waterfowl overwintering in the Chesapeake Bay area to range between about 500,000 and 900,000 birds (Table 3.12-1). Much of the Chesapeake Bay is considered to be a waterfowl concentration area, portions of which extend to the lower Potomac River. Many species of waterfowl – but especially geese, swans, and diving ducks – tend to return year after year to the same wintering and staging areas. MDNR maps of waterfowl concentration or staging areas indicate that several overlap the PRTR, particularly in the upper portion of the LDZ, as shown in Figure 3.12-1 (Waterfowl Concentration Areas) (MDNR, 2010).

Table 3.12-1
Maryland Midwinter Chesapeake Bay Waterfowl Survey
Numbers from 2003 to 2007

Species	2003	2004	2005	2006	2007
Mallard	39,000	48,200	52,800	32,500	39,700
Black duck	22,500	31,700	23,600	13,300	13,800
Gadwall	3,700	2,500	1,400	1,200	1,400
Widgeon	800	6,000	2,000	300	400
Green-winged teal	1,000	1,200	1,000	400	3,300
Shoveler	0	100	100	0	100
Pintail	1,300	4,600	1,900	2,500	500
Total Dabbling Ducks	**68,300**	**94,300**	**82,800**	**50,200**	**59,200**
Redhead	5,100	6,100	9,300	1,800	1,100
Canvasback	40,000	30,800	39,400	33,800	13,700
Lesser scaup	66,600	106,300	189,800	79,500	25,700
Ring-necked	300	200	1,000	500	900
Golden-eye	2,100	1,000	3,000	700	700
Bufflehead	13,100	9,800	22,000	11,800	12,000
Ruddy duck	42,700	34,000	36,100	12,100	19,800
Mergansers	6,500	18,700	5,100	7,000	1,700
Scoters	2,300	8,100	40,600	10,000	2,100
Long-tailed duck	100	400	4,100	700	500
Total Diving Ducks	**178,800**	**215,400**	**350,400**	**157,900**	**78,200**
Brant geese	1,500	1,300	1,700	2,400	500
Snow goose	75,600	93,900	54,900	49,200	46,600
Canada goose	452,900	355,200	383,400	305,400	285,700
Tundra swan	15,100	17,900	13,200	8,200	8,700
Total Geese and Swans	**545,100**	**468,300**	**453,200**	**365,200**	**341,500**
Total Waterfowl	**792,200**	**778,000**	**886,400**	**573,300**	**478,900**
Source: MDNR, 2010.					

Over the last century, the number of waterfowl present in the Chesapeake Bay area has declined due to habitat deterioration, increased human activities, and loss of wetlands (Chesapeake Bay Gateways Network, 2009). Some waterfowl feed on the benthic invertebrates that are abundant in SAV beds, and other birds feed directly on below-ground buds and tubers (Rybicki and Landwehr, 2007). Species that are dependent on native SAV, such as the canvasback, are more sensitive to fluctuations in SAV abundance (see Section 3.11.1) than birds like Canada geese and snow geese, which have adapted their diets to feed on grass and agricultural grain. Another factor contributing to the year-to-year variation in the number of waterfowl wintering in the area is the warm winter temperatures over the last few decades, which has resulted in waterfowl remaining north of traditional wintering areas (MDNR, 2010). The temperatures in the Chesapeake Bay region have increased by about 2°F (1°C) since 1960 (Duffy, 2008).

3.12.3 Raptors

3.12.3.1 Bald Eagle

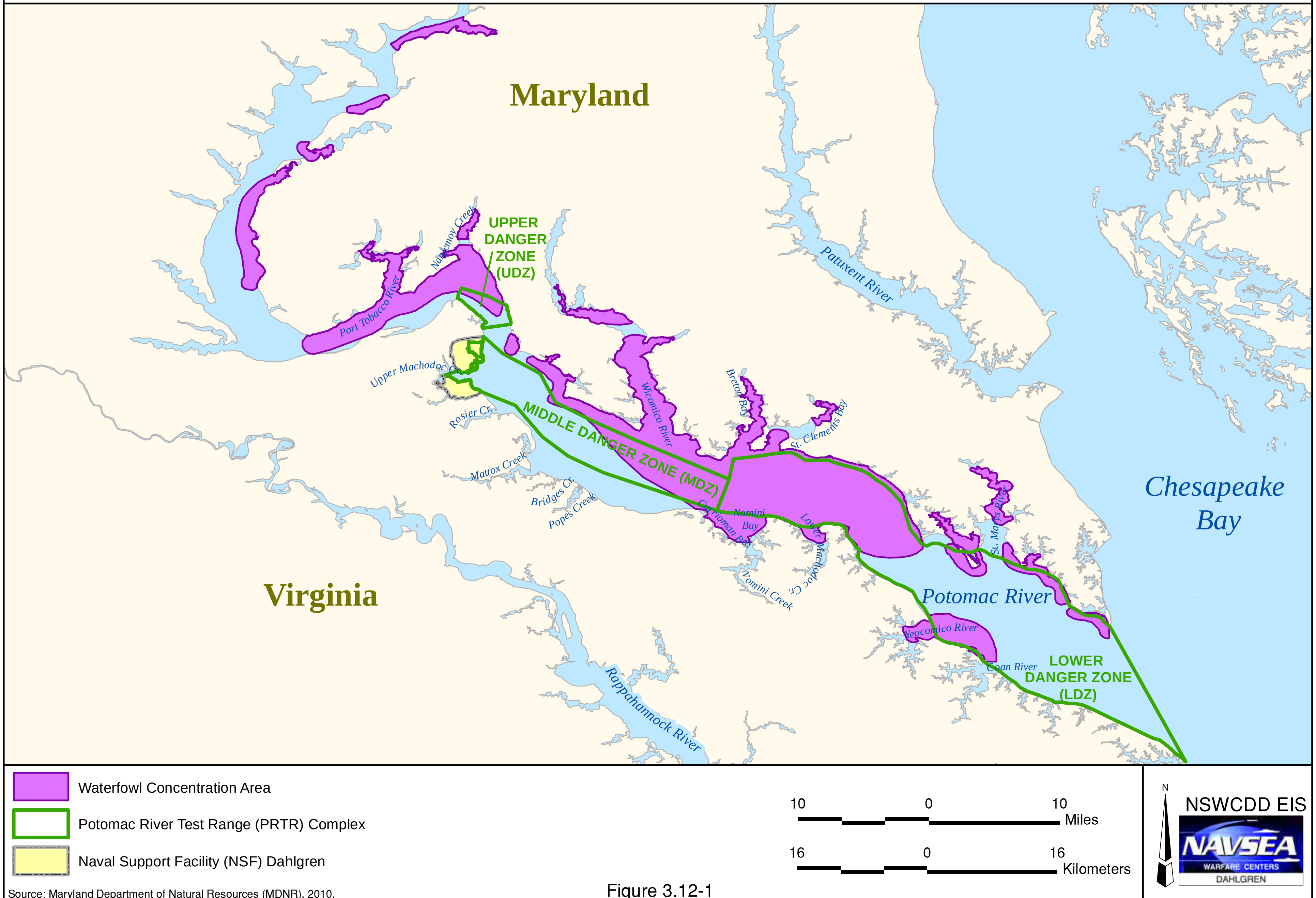
Bald eagles (*Haliaeetus leucocephalus*) are typically found in coastal areas or along the margins of rivers and lakes throughout North America. The bald eagle was originally listed as an endangered species south of the 40th parallel in 1967. On July 4, 1976, it was listed as a national endangered species under the Endangered Species Act (ESA). Its status in the lower 48 states was upgraded to threatened in July 1995, due in large part to increases in eagle populations following a ban on the use of dichlorodiphenyl trichloroethane (DDT). The bald eagle was delisted from the federal threatened and endangered species list on July 28, 2007. It is primarily protected under the Bald and Golden Eagle Protection Act of 1940 (BGEPA) (16 U.S.C. §§ 668-668d), which prohibits taking, possession, and commerce of eagles. It is also protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712). The bald eagle remains listed as a state "threatened" species under Virginia law and VDGIF regulations (USFWS and VDGIF, 2001; VDGIF, 2007). The Lacey Act of 1900 (18 U.S.C. §§ 43-44) and subsequent amendments to the act also protect bald eagles (along with other plants and animals) by making it a federal offense to take, possess, transport, sell, import, or export their nests, eggs and parts that are taken in violation of any state, tribal, US, or foreign law.

Bald eagles feed primarily on fish, but, as opportunistic feeders, their diet also includes waterfowl, other shore and sea birds, small mammals, turtles, and carrion (USFWS, 2007). Bald eagles frequently scavenge for dead or dying fish, waterfowl, and mammals, or steal prey from other smaller birds, such as osprey (VDGIF, 2011). Because they are visual hunters, eagles typically locate their prey from a conspicuous perch or soaring flight, then approach their prey in a shallow glide and grab it with a quick swipe of their talons. Eagles feed by holding the catch in one claw and tearing the flesh with the other claw.

Bald Eagle
Haliaeetus leucocephalus

Bald eagles generally nest near water bodies (e.g., coastlines, rivers, lakes, or streams) that can provide an adequate food supply (USFWS, 2007). Eagles frequently nest in old-growth or tall trees, or structures that include at least one perch with a clear view of the water for foraging (USFWS, 2007). Eagles forage in open water, including the PRTR portion of the Potomac River. Breeding in the Chesapeake Bay area starts in November and can last through mid-July, with most eggs laid mid-January to late February (VDGIF, 2011).

Waterfowl Concentration Areas



Source: Maryland Department of Natural Resources (MDNR). 2010.

Figure 3.12-1

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The Potomac River is a major nesting and migration area for the bald eagle. The Chesapeake Bay region bald eagle population is divided into two distinct groups – one of individuals that migrate to the Chesapeake Bay region, but do not breed there; the other a population of year-round residents that breed in the area (Buehler et al., 1991). The migratory bald eagles come from three geographically-isolated breeding populations in the northeastern, southeastern, and mid-Atlantic regions of the United States, providing both summer and winter migrants.

The bald eagle population in the Chesapeake Bay region has experienced a recovery similar to that seen in many other areas of the United States. In 1962, there were estimated to be 150 breeding pairs in the Chesapeake Bay; the number fell over the next eight years to an estimated low of 80 to 90 pairs in 1970 (Watts and Byrd, 2011). Since then, bald eagles have experienced a dramatic recovery in the region, with an estimated population of more than 2,000 eagles in the Chesapeake Bay region (MDNR, 2000). Bald eagle nesting success in the lower Chesapeake Bay is one of the highest on record in North America, with 74 percent of occupied territories producing at least one young annually since 1995 (Watts and Byrd, 2011). The availability of undeveloped waterfront property is considered to be a major limiting factor for bald eagles in the Chesapeake Bay (Watts and Byrd, 2011).

The number of bald eagles in Maryland has increased since surveys began. The MDNR began eagle surveys in 1977 and documented only 44 occupied nests. By 2004, this number had grown to 390 occupied nests (MDNR, 2004). The Maryland mid-winter bald eagle survey has shown that the number of bald eagles wintering at concentration areas in Maryland has grown from 44 in 1979 to 303 in 2008 (MDNR, 2008). An increasing number of eagles are also nesting – and successfully producing chicks (one to three per nest) – along the Virginia side of the Potomac River (Table 3.12-2). In 2011 there were 726 occupied bald eagle territories recorded in Virginia (Watts and Byrd, 2011). The Potomac River area has shown one of the highest bald eagle population increases in Virginia (Watts and Byrd, 2007, 2008).

Table 3.12-2
Bald Eagle Nesting Along the Potomac River in Virginia from 2005 to 2011

	2005	2006	2007	2008	2009	2010	2011
Number of territories occupied	95	98	123	139	151	141	156
Number of active nests	92	97	117	132	136	137	134(131)
Number of chicks produced	131	136	160	211	205	183	199(103)
Mean number of chicks per active nest	1.49	1.46	1.33	1.67	1.59	1.43	1.52
Mean number of chicks produced per nest	1.72	1.72	1.74	1.91	1.78	1.78	1.93

Notes:

A breeding territory is considered to be “occupied” if a pair of birds is observed in association with the nest and there is evidence of recent nest maintenance.

Nests are considered to be “active” if a bird is observed in an incubating posture or if eggs or young are detected in the nest.

Source: Watts and Byrd, 2006, 2007, 2008, 2010, 2011.

The VDGIF and the USFWS have defined a Potomac River Bald Eagle Concentration Area that includes most of the Virginia shoreline between Pohick Creek and the Harry Nice Bridge (Wetland Studies and Solutions, 2006) – areas adjacent to the UDZ. Figure 3.12-2 (Bald Eagle Concentration Areas and Great Blue Heron Nests/Pairs) shows the areas along the river where bald eagle nests are most concentrated.

Both migratory and residential breeding populations inhabit NSF Dahlgren and its surrounding area year-round (NSF Dahlgren and NAVFAC Washington, 2007; NSF Dahlgren, 2007). The installation's proximity to open water and the presence of forested habitats, combined with an upswing in the bald eagle population throughout the region and a loss of suitable habitat in the areas surrounding the installation, have resulted in an increase in the resident bald eagle population. Between 1983 and 2009 the number of nests documented at NSF Dahlgren went from 1 to 12, and 6 of these nests were active in 2009 (Figure 3.12-3, Bald Eagle Nests).

3.12.3.2 Osprey

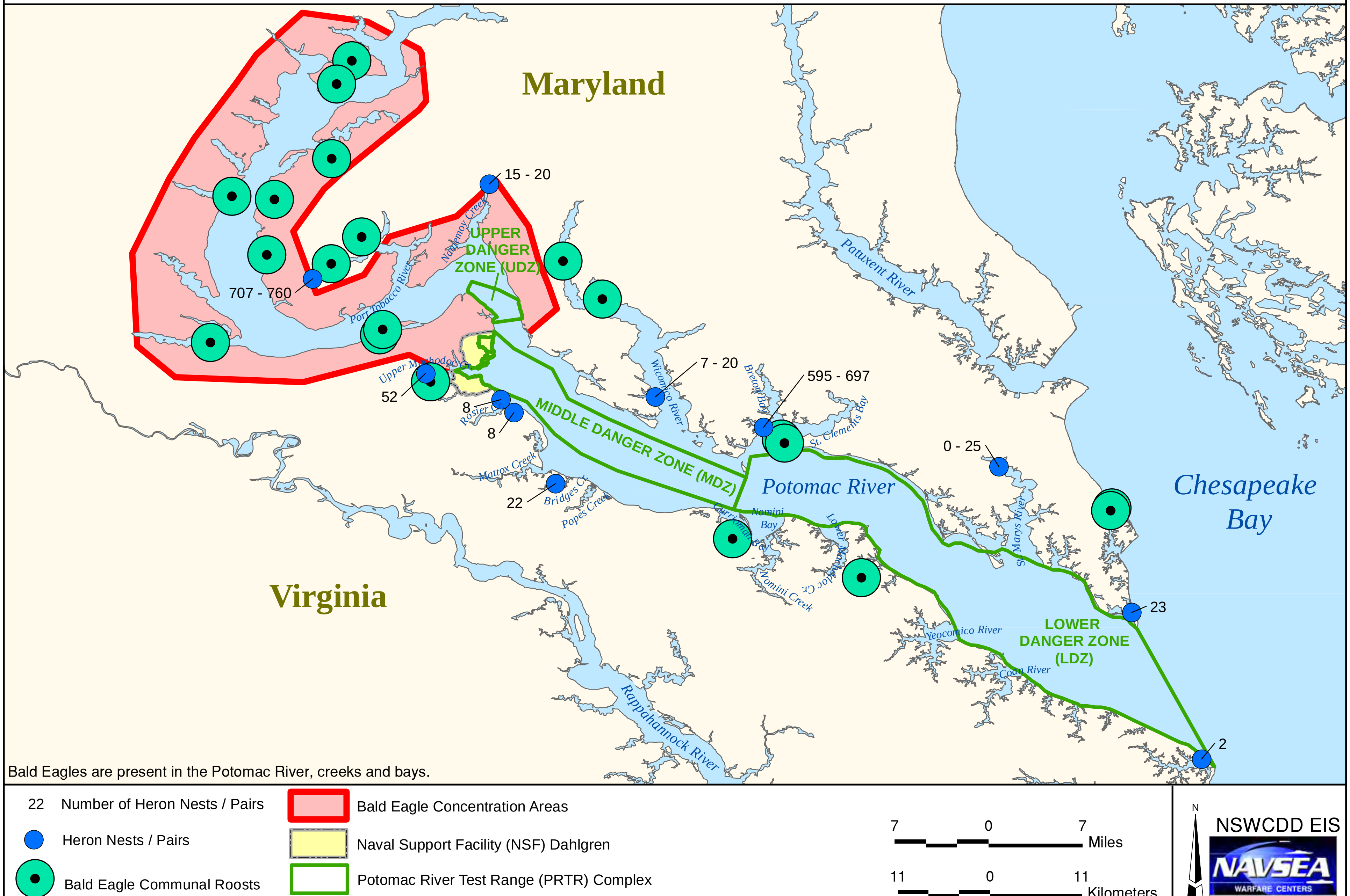
The Chesapeake Bay region is also home to a large population of another raptor – the osprey (*Pandion haliaetus*). The osprey is also known as the "fish eagle" or "fish hawk" and feeds almost exclusively on fish. North American ospreys are migratory, except for the populations of South Florida, Baja California, and the Pacific Coast of Mexico (Vana-Miller, 1987).

Osprey
Pandion haliaetus

Ospreys hunt by soaring over open water and scanning the surface for fish (USFWS, 2008). An osprey spots its prey above the water, after which the bird hovers momentarily, then plunges feet first into the water, accessing only the top 3 ft of water (Poole, et al., 2002). This fishing technique restricts them to catching surface schooling fish and fish in the shallows. The PRTR area of the Potomac provides suitable foraging habitat for ospreys.

Ospreys return to the Chesapeake Bay every spring, usually around the beginning of March, and usually leave by late July to August (USFWS, 2011). During the spring breeding season, more than 2,000 nesting pairs can be found near the Chesapeake Bay (Reshetiloff, 2004). Ospreys regularly forage along the Potomac River and its larger tributaries, such as Gambo and Upper Machodoc Creeks. When fish abundance is low, osprey nestling survival decreases, but when fish are abundant, survival increases to about 50 to 100 percent (State of Maryland Office of Attorney General, 2007). More than 20 active osprey nests are found within the NSF Dahlgren boundaries each year, and a greater number can be found in the installation's vicinity (NSWCDD, 2001). NSF Dahlgren has a program in place to install, monitor, and maintain nesting boxes for eastern bluebirds and wood ducks and nesting platforms for ospreys.

Bald Eagle Concentration Areas and Great Blue Heron Nests/Pairs



Source for Heron Data: National Ocean Service Environmental Sensitivity Index Maps VA-(116,115,111 & 95) , 2005; MD-(54, 52, 44, 43, 29 & 21), 2007.
Source for Bald Eagle Data: Center for Conservatin Biology, 2008.

Figure 3.12-2

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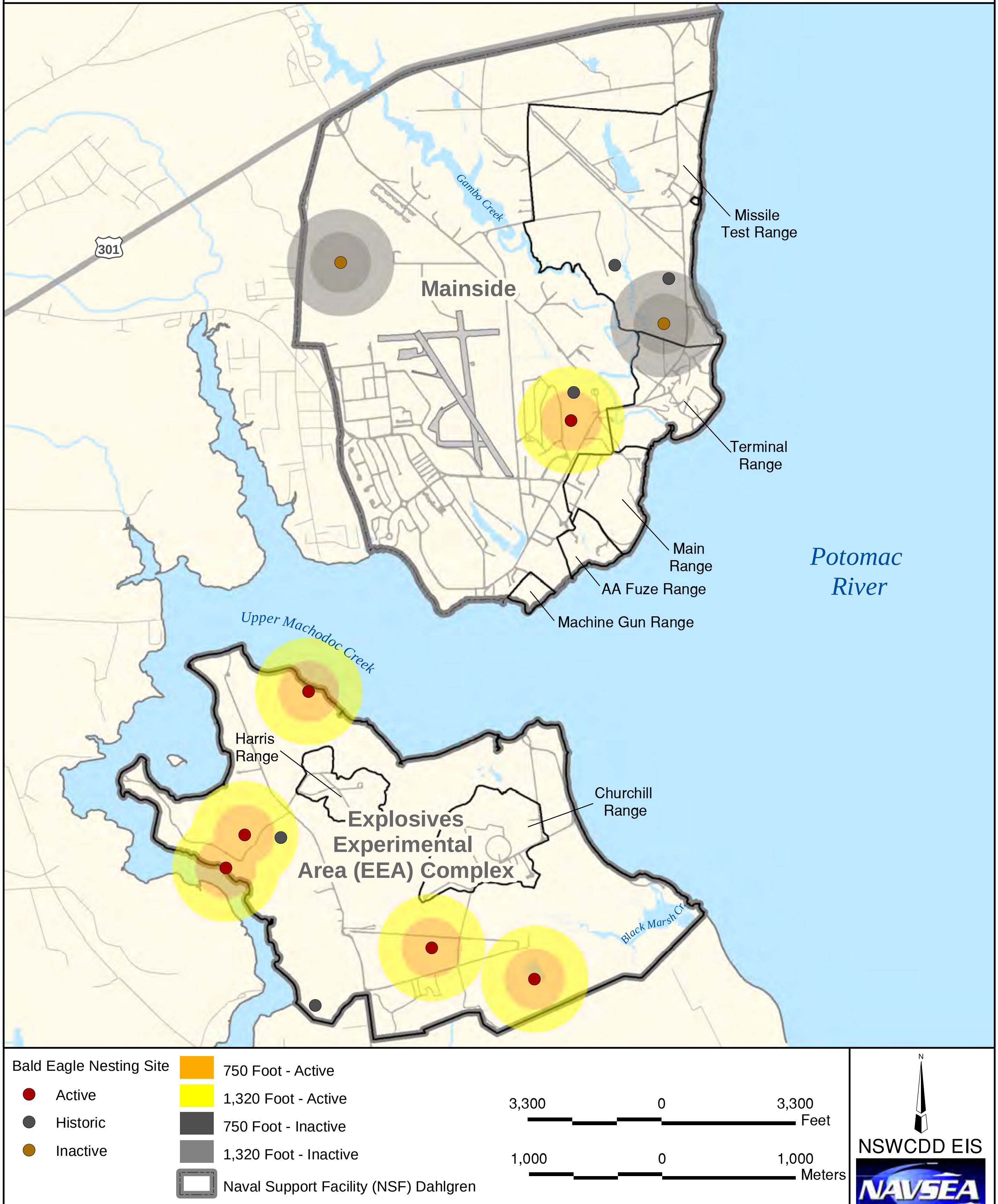
Bald Eagle Nests



Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.12-3

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3.12.4 Wading Birds, Gulls, and Shorebirds

Open-water habitats are also important feeding areas for a number of other migratory species of water birds. The great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), green heron (*Butorides virescens*), herring gull (*Larus argentatus*), and ring- billed gull (*Larus delawarensis*) regularly feed along the edges of open-water habitats, both within and outside NSF Dahlgren (NSWCDD, 2003). All these species are protected under the MBTA; however, similar to the bald eagle, there are year-round and breeding populations of these species in the area.

Great Blue Heron
Ardea herodias

Piscivorous (fish-eating) birds in the area include the great blue heron, the largest heron in the region, with a wing-span of 6 ft. The Potomac River and the surrounding area comprise the main area for this species in Virginia (Watts, 2004). Most great blue herons breed in localized colonies (called rookeries or heronries) of sometimes hundreds of nesting pairs (CBP, 2011a). Two of the largest colonies within the mid-Atlantic region are located along the Potomac River (see Figure 3.12-2) on the headwaters of Nanjemoy Creek – a tributary of the Potomac River – in Charles County about 14 mi (as the heron flies) west-northwest of the Main Range at NSF Dahlgren. The largest colony is found at the Nanjemoy Creek Preserve, which is run by the Nature Conservancy, and has an average of more than 700 nesting pairs annually. The other colony is located on St. Clement's Bay, about 2 mi northeast of the PRTR's MDZ and approximately 14 mi east-southeast of Main Range, with an average of more than 600 nesting pairs annually (NOS, 2007). A smaller rookery which had 52 nests in 2005 (NOS, 2005) is located near NSF Dahlgren on the headwaters of Upper Machodoc Creek, 3 mi from the mouth of the creek and about 2 mi west of NSF Dahlgren.

The great egret and green heron are found along the Potomac River from spring to fall. The great egret feeds on fish, amphibians, and aquatic invertebrates. It returns to the Chesapeake Bay area to breed from mid-March to May (CBP, 2011b). The green-backed heron feeds on small fish, amphibians, and aquatic invertebrates. It returns to the Chesapeake Bay area to breed from April to May (CBP, 2011c).

Herring gulls are a common species seen around landfills, beaches, piers, and many other waterfront areas on the Chesapeake Bay and its tidal rivers. They live in the Chesapeake Bay watershed year-round, but are more common from fall through spring than in the summer (CBP, 2011d). Ring-billed gulls are the bay's most abundant winter gull, but in summer they are less common around the bay and more abundant on freshwater lakes and rivers (CBP, 2011d).

During the spring and fall migration periods, large numbers of shorebirds feed along the shoreline of the Potomac River and its tributaries. These shorebirds include lesser yellowlegs (*Tringa flavipes*), greater yellowlegs (*Tringa melanoleuca*), killdeer (*Charadrius vociferus*), and semipalmated sandpipers (*Calidris pusilla*) (NSWCDD, 2001).

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3.13 NSF Dahlgren's Biological Resources

This section describes the biological resources of the NSF Dahlgren base that have the potential to be affected by the Proposed Action. Because the potential for impacts on off-base terrestrial animals and plants is negligible, these resources are not addressed. Birds found at NSF Dahlgren are considered to be able to move freely on- and off-base.

The main source of information for this section (unless otherwise noted) is the *Integrated Natural Resources Management Plan*, *Naval Support Facility Dahlgren, Dahlgren, Virginia* (NSF Dahlgren, 2007). Every DoD installation that has suitable habitat for conserving and managing natural ecosystems is required to prepare, maintain, and implement an Integrated Natural Resources Management Plan (INRMP). An INRMP is a long-term planning document that guides implementation of the natural resources program to ensure support of the installation's mission while protecting and enhancing the installation's natural resources for multiple use, sustainable yield, and biological integrity. NSF Dahlgren's INRMP documents the installation's mission; the baseline condition of natural resources; the impacts of the mission on natural resources; the management approaches to conserve and enhance natural resources; and specific projects aimed at protecting and enhancing existing natural resources.

3.13.1 NSF Dahlgren's Ponds, Streams, and Creeks

Aquatic resources other than the Potomac River associated with NSF Dahlgren include ponds, streams, and creeks within the installation. These water bodies include Upper Machodoc Creek, Gambo Creek, and Black Marsh Creek; two natural ponds – Beaver Pond and Lespedeza Pond; and two manmade freshwater impoundments – Hideaway Pond and Cooling Pond (Figure 3.10-1, Surface Water Resources - Dahlgren).

Upper Machodoc Creek is approximately 17 mi long, approximately 3,000 ft wide at the mouth, and about 6 ft deep. SAV is present most years in Upper Machodoc Creek near the mouth of Williams Creek (e.g., Orth et al., 2005, 2006, 2007), west of Gambo Creek. Prior to 2002, SAV was also generally found in the more upstream reaches of the creek (e.g., Orth et al., 2005, 2006, 2007). Species found include wild celery, common elodea, coontail, and the invasive Eurasian watermilfoil.

The Alliance for the Chesapeake Bay and NSF Dahlgren conducted fish sampling at two stations on the Potomac River and four stations on Upper Machodoc Creek in conjunction with a SAV study conducted between 1999 and 2002 (NSF Dahlgren, 2007). A total of 27 fish species was collected at the Upper Machodoc Creek stations during these efforts (completed fish collection forms provided by Lou Etgen, Interim Director, Alliance for the Chesapeake Bay, November 17, 2008). The most abundant species were white perch and Atlantic silverside. These species comprised 54.8 and 18.0 percent of the total catch, respectively. Other species that represented at least 1.0 percent of the total catch were Atlantic menhaden, gizzard shad, bay anchovy, banded killifish, mummichog, striped killifish, and striped bass. Additional species of recreational and commercial importance included channel catfish, yellow perch, bluefish, spotted seatrout, and spot.

In addition to the species collected, anadromous fish species, such as striped bass, hickory shad, American shad, alewife, and white perch, use wetlands associated with Upper Machodoc Creek and Gambo Creek for nursery areas.

Gambo Creek is tidally influenced as far inland as the northern boundary of the installation. The creek is bordered by extensive tidal wetlands dominated by saltmarsh cordgrass and big cordgrass (*Spartina cynosuroides*).

Many waterfowl use the creeks and ponds at NSF Dahlgren. Dabbling ducks are common winter inhabitants in the tidal creeks and in Hideaway Pond (NSF Dahlgren, 2007). Tundra swans are a common sighting just offshore in Upper Machodoc Creek, as well as in the Potomac River, and the flock numbers 10 to 15 swans.

Large groups of 30 to 50 black ducks are often seen in Gambo Creek Marsh, and the total wintering population is estimated at 100 to 150 individuals. Three of the five Mainside bald eagle nests are in this area, one of which was active during the 2009 nesting season (see Figure 3.12-2). The area also provides important roosting and foraging habitat for eagles, ospreys, and other birds; nursery habitat for fish; and habitat for uncommon dragonflies, such as the blue-faced meadowhawk (*Sympetrum ambiguum*) and the unicorn clubtail (*Arigomphus villosipes*). The Gambo Creek area has been categorized as a Special Interest Area (SIA) due to its unique ecological characteristics and high-quality rare species' habitat (Figure 3.13-1, Special Interest Areas).

Blue-faced Meadowhawk
Sympetrum ambiguum

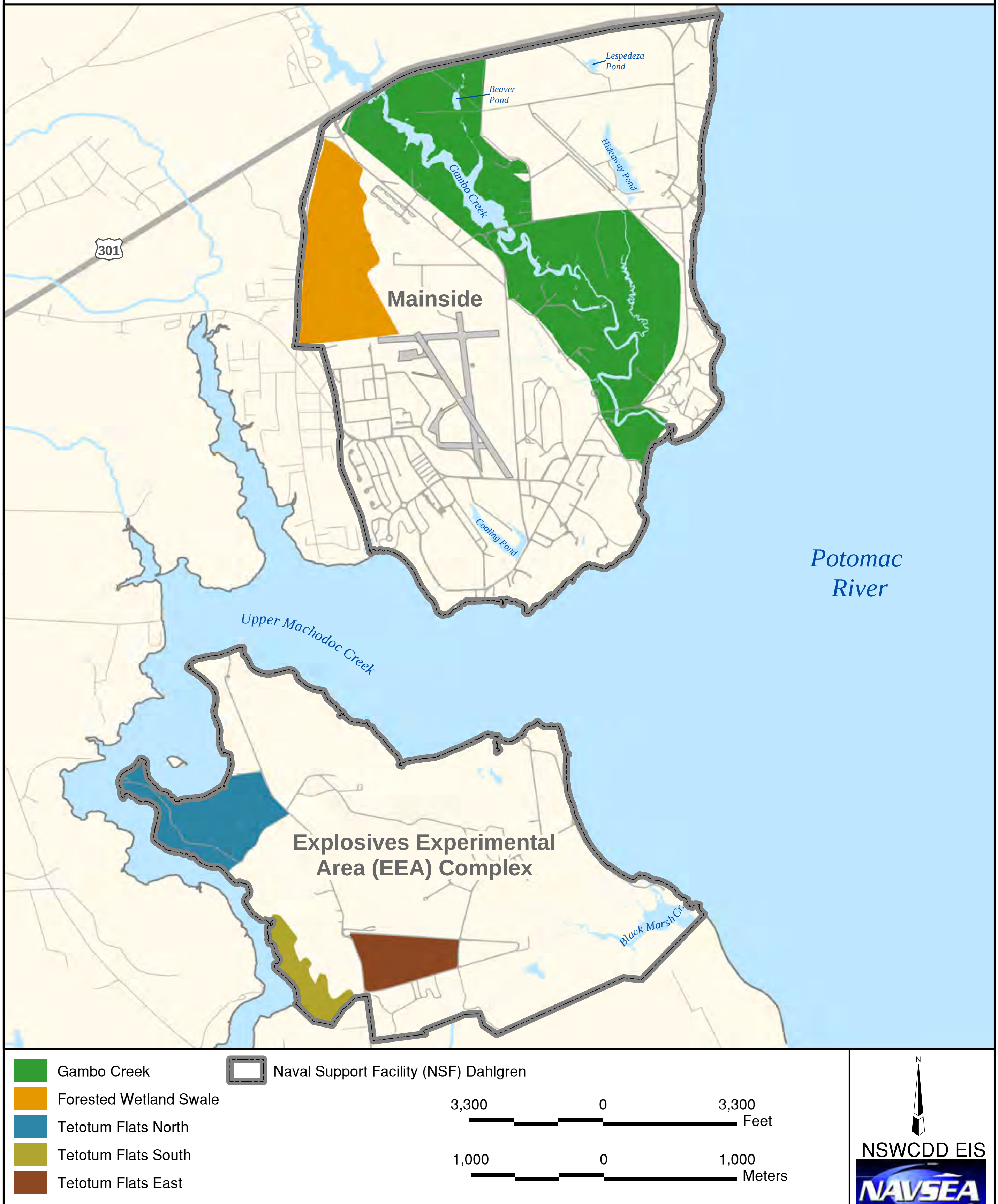
Four ponds are present on NSF Dahlgren. Hideaway Pond, an impoundment of approximately 13 ac, was created along a marshy drainage area flowing into Gambo Creek, and is located in a relatively isolated area on Mainside (see Section 3.10.1.4). Cooling Pond, which is approximately 10 ac in size, is located in the community support area of NSF Dahlgren. Beaver Pond is located north of Gambo Creek in the north central portion of Mainside. Lespedeza Pond is located at the C-Gate area (NSF Dahlgren, 2006).

Common freshwater fish found in Hideaway Pond and Cooling Pond include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), and channel catfish (NSF Dahlgren, 2007). Both ponds are managed as a catch-and-release fishery (ATSDR, 2006). The 1978 floral and faunal survey identified a total of 32 species of fish in the following water bodies: Gambo Creek, Black Marsh, Hideaway Pond, and Cooling Pond (NSWCDL, 1979).

3.13.2 NSF Dahlgren's Vegetation

NSF Dahlgren is about 28 percent developed. A little more than half – 52 percent – of the installation is forested. Wetlands account for 14 percent of NSF Dahlgren's land (see Section 3.10.2), while grasslands or early successional fields make up about 6 percent.

Special Interest Areas



Source: NSWCDD GIS (2008 - 2011)

Figure 3.13-1

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Forests at NSF Dahlgren are of three basic types: mixed pine-hardwood; hardwood; and pine. Figure 3.13-2 (Forest Cover Types) shows the distribution of forest types on the installation.

- **Mixed Pine-Hardwood Forest –** This is the predominant forest-cover type at NSF Dahlgren, comprising approximately 31 percent of the installation. Mixed forests are considered transitional between pine and various hardwood types; in the absence of disturbance, succession will strongly favor hardwoods. Site index and hydrologic regime strongly influence the hardwood component of the forest. On moist sites, sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and tulip poplar (*Liriodendron tulipifera*) colonize the site, along with loblolly pine (*Pinus taeda*). In such stands, hardwoods grow quickly and form a single stratum canopy with the pines. On drier sites, several oak species, including southern red oak (*Quercus falcata*) and white oak (*Q. alba*), may invade areas that were first colonized by pines and, over time, become their canopy co-dominants. Understories are varied, and depend on site conditions.
- **Hardwood Forests –** Hardwood forests comprise 14 percent of NSF Dahlgren. On poorly-drained sites, common overstory species include blackgum (*Nyssa sylvatica*), red maple, willow oak (*Q. phellos*), and water oak (*Q. nigra*). On drier sites, oaks such as black oak (*Q. velutina*), southern red oak, and chestnut oak (*Q. prinus*), along with hickories (*Carya alba* and *C. ovata*), dominate the overstory. Understories often include American holly (*Ilex opaca*), flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), Virginia creeper (*Parthenocissus quinquefolia*), partridgeberry (*Mitchella repens*), blueberry (*Vaccinium* spp.), and ground pine (*Lycopodium* spp.).
- **Pine Forests –** Pine forests comprise 7 percent of NSF Dahlgren. Such forests are indicative of disturbance or intensive maintenance. Dominant overstory species include loblolly pine and Virginia pine (*Pinus virginiana*), with lesser amounts of tulip poplar and sweetgum. Older pine stands may support an understory with oak (*Quercus* spp.) and other hardwood seedlings. The shrub and herbaceous components of pine forests are often sparse, but may include Japanese honeysuckle (*Lonicera japonica*), trumpet creeper (*Campsis radicans*), poison ivy (*Toxicodendron radicans*), Virginia creeper, and blueberry.

All NSF Dahlgren forested areas are managed for the production of timber, wildlife habitat, and outdoor recreation by the Navy Natural Resources Conservation Program.

Grasslands and early successional fields are occupied by shrubs, grasses, and herbaceous vegetation typically mowed less than twice a year. The exact vegetative composition of these communities is highly variable, and is influenced by previous land use and adjacent ecological communities. Various native warm-season grasses, such as broomsedge (*Andropogon virginicus*), big bluestem (*Andropogon gerardii*), and switchgrass (*Panicum virgatum*), as well as perennials, such as goldenrods (*Solidago* spp.), bonesets (*Eupatorium* spp.), partridge pea (*Cassia fasciculata*), and bushclovers (*Lespedeza* spp.) are common in these areas.

Both the Virginia and Maryland shorelines of the river outside NSF Dahlgren are characterized by similar habitats, except that a greater percentage of the cover is made up of agricultural fields, with crops including corn, tobacco, small grains, and hay.

3.13.3 NSF Dahlgren's Wildlife

Wildlife surveys conducted in 1978 documented 16 amphibian, 16 reptilian, 157 avian, and 20 mammalian species at NSF Dahlgren (NSWCDL, 1979). A complete list of wildlife species present on the installation is included in the INRMP (NSF Dahlgren, 2007).

3.13.3.1 Amphibians and Reptiles

NSF Dahlgren's wetlands, ponds, and wooded areas provide habitat for a number of common amphibians and reptiles. Frogs and toads comprise the largest group of the amphibians in the area. Common frogs and toads found on the installation include the American toad (*Bufo americanus*), green frog (*Rana clamitans*), southern leopard frog *(Rana sphenocephala*), spring peeper *(Pseudacris crucifer*), green tree frog (*Hyla cinerea*), and upland chorus frog (*Pseudacris triseriata feriarum*).

Green Tree Frog
Hyla cinerea

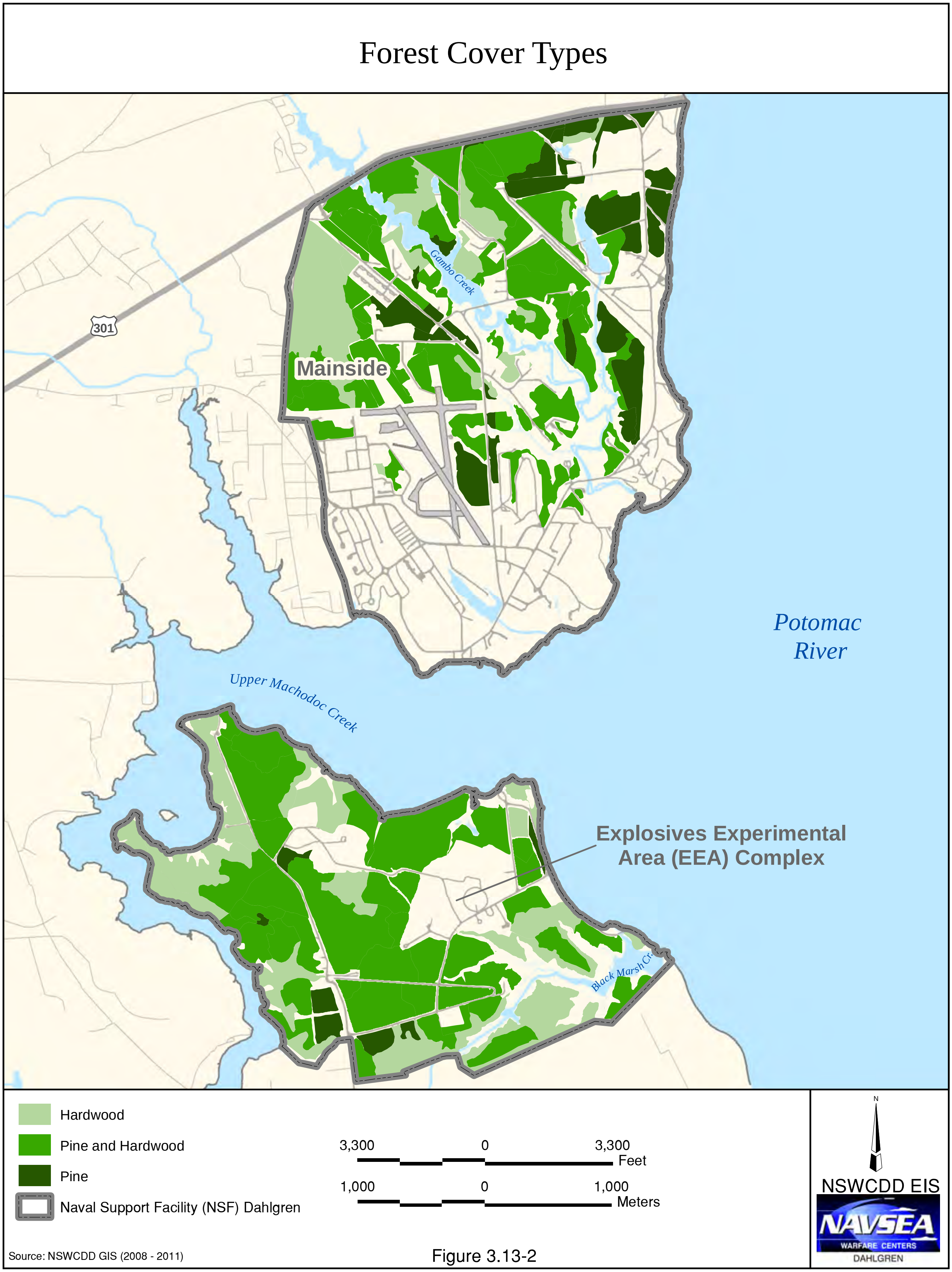
Reptiles found on the installation include snakes, turtles, and lizards. Common snakes include the northern water snake (*Nerodia s. sipedon*), black rat snake (*Elaphe obsoleta*), and northern black racer (*Coluber constrictor constrictor*). Turtles include the common snapping turtle (*Chelydra serpentina*), red-bellied turtle (*Pseudemys rubriventris*), eastern mud turtle (*Kinosternon subrubrum*), and eastern box turtle (*Terrapene carolina*). Lizards found on the installation include ground skinks (*Scincella lateralis*) and five-lined skinks (*Eumeces fasciatus*).

3.13.3.2 Birds

The avian population at and near NSF Dahlgren is particularly diverse, and includes a large number of migratory birds and waterfowl that over-winter in the area (see Section 3.12.1 and 3.12.2) as well as many neotropical migrant birds, which nest in the region or farther north and overwinter in the Caribbean or South America. The hardwood forests found on the installation and along the Potomac River are strategically important for local breeding populations of neotropical migrants and as stopover areas for northern populations moving through the region in the fall. These forests make the installation a stopover ground during migrations for many species and a nesting area for some. Forest-dwelling neotropical migrant birds include the brown thrasher (*Toxostoma rufum*), wood thrush (*Hylocichla mustelina*), ovenbird (*Seiurus aurocapillus*), black and white warbler (*Mniotilta varia*), red-eyed vireo (*Vireo olivaceous*), white-eyed vireo (*Vireo griseus*), common yellowthroat (*Geothlypis trichas*), scarlet tanager (*Piranga olivacea*), summer tanager (*Piranga rubra*), and various woodpeckers. Also found in the forests are the red-shouldered hawk (*Buteo lineatus)*, sharp-shinned hawk (*Accipiter striatus*), barred owl (*Strix varia*), and screech owl (*Megascops asio*).

Common yellowthroat
Geothlypis trichas

Forest Cover Types



Source: NSWCDD GIS (2008 - 2011)

Figure 3.13-2

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Although detailed seasonal waterfowl surveys have not been conducted at NSF Dahlgren, incidental observations by the Natural Resources Manager and sportsmen suggest that common species found in on-base and nearby waters include the following: mallard, black duck, canvasback, lesser scaup, ruddy duck, and tundra swan. Less common species include blue-winged teal (*Anas discors*), wood duck, red-breasted merganser, ring-necked duck (*Aythya collaris*), common goldeneye (*Bucephala clangula*), and bufflehead.

In accordance with the MBTA and Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, natural resources management at NSF Dahlgren supports conservation objectives identified by Partners in Flight (PIF). PIF is a consortium of state, federal, and private organizations dedicated to the conservation and management of neotropical migratory birds and their habitats. PIF identified bird species and habitats most in need of conservation and outlined conservation objectives in its *Bird Conservation Plan for the Mid-Atlantic Coastal Plain* (Watts, 1999). PIF conservation objectives that are applied to natural resources management at NSF Dahlgren include:

- Identifying and maintaining significant blocks of mixed upland forest and considering the value of hardwood-dominated forests in management decisions.
- Preventing any loss of forested wetlands.
- Avoiding the conversion of mixed forests or hardwood-dominated forests to pine monoculture.
- Using open spacing for planting and conducting multiple thinnings in pine stands to delay canopy closure and promote understory vegetation.
- Monitoring and controlling infestations of common reed in salt, freshwater, and brackish marshes.

In addition to these measures, migratory bird nesting habitat has been improved on NSF Dahlgren by the installation, monitoring, and maintenance of nesting boxes for eastern bluebirds and wood ducks. These efforts help to support regional goals under the North American Waterfowl Management Plan (NAWMP) and the Joint Agreement of Cooperation to Perpetuate North American Waterfowl Populations, which was signed by the USFWS and the DoD in 1988.

The DoD has established bird conservation regions that include bird species of concern in that region (DoD, 2009). As a list for NSF Dahlgren has not been finalized, the list for Fort AP Hill in Caroline County, Virginia (adjacent to King George County) was used to determine which bird species observed at NSF Dahlgren (NSF Dahlgren, 2007) may be considered species of concern based on being listed on one or more of the following eight different priority lists (DoD, 2009):

- Birds of Conservation Concern (BCC)
- Game Birds Below Desired Condition
- Non-migratory Bird Species of Concern
- North American Waterbird Conservation Plan
- North American Waterfowl Management Plan (NAWMP)
- Partners in Flight (PIF)
- US Shorebird Conservation Plan (SCP)
- Threatened and Endangered Species (50 CFR § 17.11)

Table 3.13-1 lists these bird species and identifies the priority list(s) with which they are associated.

Table 3.13-1
Bird Species of Concern Observed at NSF Dahlgren

Order & Scientific Name	Common Name	Priority List(s)
Order Ciconiiformes		
Botaurus lentiginosus	American Bittern	PIF
Egretta thula	Snowy Egret	NAWCP
Order Anseriformes		
Anas discors	Blue-winged Teal	NAWMP
Bucephala albeola	Bufflehead	NAWMP, PIF
Branta canadensis	Canada Goose	NAWMP
Aythya valisineria	Canvasback	BCC, NAWMP, PIF
Bucephala clangula	Common Goldeneye	NAWMP
Aythya affinia	Lesser Scaup	BCC, NAWMP, PIF
Anas platyrhynchos	Mallard	BCC, NAWMP
Mergus serrator	Red-breasted Merganser	NAWMP
Aythya americana	Redhead	NAWMP, PIF
Aythya collaris	Ring-necked Duck	BCC, NAWMP
Oxyura jamaicensis	Ruddy Duck	NAWMP
Cygnus columbianus	Tundra Swan	NAWMP
Aix sponsa	Wood Duck	BCC, NAWMP
Order Galliformes		
Colinus virginianus	Northern Bobwhite	NMBSC
Order Falconiformes		
Falco sparverius	American Kestrel	BCC, PIF
Buteo lineatus	Red-shouldered Hawk	PIF
Order Charadriiformes		
Scolopax minor	American Woodcock	BCC, PIF, SCP
Chilidonias niger	Black Tern	BCC
Gallinago gallinago	Common Snipe	PIF, SCP
Sterna hirundo	Common Tern	BCC
Tringa melanoleuca	Greater Yellowlegs	SCP
Charadrius vociferous	Killdeer	PIF
Tringa flavipes	Lesser Yellowlegs	SCP

Table 3.13-1 (Continued)
Bird Species of Concern Observed at NSF Dahlgren

Order & Scientific Name	Common Name	Priority List(s)
Order Podicipediformes		
Podiceps auritus	Horned Grebe	PIF
Order Columbiformes		
Zenaida macroura	Mourning Dove	BCC
Order Cuculiformes		
Strix varia	Barred Owl	PIF
Coccyzus americanus	Yellow-billed Cuckoo	PIF
Order Apodiformes		
Chaetura pelagica	Chimney Swift	PIF
Order Caprimulgiformes		
Caprimulgus carolinensis	Chuck-will's-widow	BCC, PIF
Order Coraciiformes		
Ceryle alcyon	Belted Kingfisher	PIF
Order Piciformes		
Melanerpes carolinus	Red-bellied Woodpecker	PIF
Order Passeriformes		
Empidonax virescens	Acadian Flycatcher	PIF
Dendroica virens	Black-throated Green Warbler	BCC, PIF
Polioptila caerulea	Blue-gray Gnatcatcher	PIF
Guiraca caerulea	Blue Grosbeak	PIF
Cyanocitta cristata	Blue Jay	PIF
Toxostoma rufum	Brown Thrasher	PIF
Poecile carolinensis	Carolina Chickadee	PIF
Thryothorus ludovicianus	Carolina Wren	PIF
Tyrannus tyrannus	Eastern Kingbird	PIF
Sturnella magna	Eastern Meadowlark	PIF
Pipilo erythrophthalmus	Eastern Towhee	PIF
Contopus virens	Eastern Wood-pewee	PIF
Spizella pusilla	Field Sparrow	PIF
Corvus ossifragus	Fish Crow	PIF
Ammodramus savannarum	Grasshopper Sparrow	PIF
Dumetella carolinensis	Gray Catbird	PIF
Myiarchus crinitus	Great Crested Flycatcher	PIF
Wilsonia citrinia	Hooded Warbler	PIF
Lanius ludovicianus	Loggerhead Shrike	PIF

Table 3.13-1 Continued)
Bird Species of Concern Observed at NSF Dahlgren

Order & Scientific Name	Common Name	Priority List(s)
Seirus aurocapillus	Louisiana Waterthrush	PIF
Cistothorus palustris	Marsh Wren	PIF
Parula Americana	Northern Parula	BCC
Order Passeriformes (Cont'd)		
Icterus spurius	Orchard Oriole	BCC, PIF
Dendroica palmarum	Palm Warbler	PIF
Dendroica pinus	Pine Warbler	PIF
Dendroica discolor	Prairie Warbler	BCC, PIF
Euphagus carolinus	Rusty Blackbird	PIF
Piranga rubra	Summer Tanager	PIF
Cistothorus platensis	Sedge Wren	PIF
Melospiza georgiana	Swamp Sparrow	PIF
Vireo griseus	White-eyed Vireo	PIF
Hylocichla mustelina	Wood Thrush	BCC, PIF
Helmitheros vermivorus	Worm-eating Warbler	PIF
Icteria virens	Yellow-breasted Chat	PIF
Vireo flavifrons	Yellow-throated Vireo	PIF

Key to Priority Lists:
Birds of Conservation Concern (BCC)
North American Waterfowl Management Plan (NAWMP)
Partners in Flight (PIF)
US Shorebird Conservation Plan (SCP)

Sources: DoD, 2009; NSF Dahlgren, 2007.

3.13.3.3 Mammals

The only large mammal species that has been documented at NSF Dahlgren is white-tailed deer (*Odocoileus virginianus*). Medium and small mammals include red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), groundhog (*Marmota monax*), beaver (*Castor canadensis*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), river otter (*Lontra canadensis*), muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), and long-tailed weasel (*Mustela frenata*). A number of small rodents and insectivores are also found at NSF Dahlgren.

3.13.4 Special Interest Areas (SIAs)

Five SIAs totaling approximately 1,033 ac have been established at the installation (Figure 3.13-1). SIAs are areas with unique ecological characteristics and/or high quality habitat for rare species. Of the five, two are wetland areas on Mainside that possess unique ecological characteristics and high-quality rare species habitat; the remaining three are areas on the EEA that provide nesting habitat for bald eagles.

Forested Wetland Swale SIA – This 167-ac SIA is located in the northwestern portion of Mainside. It consists of several parallel, seasonally-flooded low troughs in a flat topography. It includes an extensive forested wetland and herbaceous wetlands along firebreaks. Tree species in the forested wetland include red maple, black gum, willow oak, and pin oak (*Quercus palustris*). The shrub layer is sparse to non-existent. The herbaceous layer includes sedges and peat moss (*Sphagnum* spp.). Coyle's purse-web spider (*Sphodros coylei*), a funnel-web spider listed on Virginia's Natural Heritage watch list, was documented in this area during Virginia Department of Conservation and Recreation, Division of Natural Heritage surveys conducted in 1991 and 1992 (NSF Dahlgren, 2007).

Gambo Creek SIA - This SIA is approximately 643 ac in size and consists of a brackish-intertidal emergent marsh community along Gambo Creek. The extensive marshes along Gambo Creek are dominated by saltmarsh cordgrass (*Spartina alterniflora*), marsh elder (*Iva frutescens*), and pigweed (*Amaranthus cannabinus*). The area is well-buffered by mixed hardwood and pine forests. In addition to providing valuable wetland habitat, three of the five known Mainside bald eagle nests are in this area; one of the nests was active during the 2008 nesting season. The area also provides important roosting and foraging habitat for eagles, ospreys, and other birds; nursery habitat for fish; and habitat for uncommon invertebrates.

Tetotum Flats North SIA - This SIA includes approximately 124 forested acres adjacent to Upper Machodoc Creek. Bald eagles have nested in this area intermittently since 1983 and have utilized at least two separate nest sites.

Tetotum Flats South SIA - The Tetotum Flats South SIA is in the southwestern corner of the EEA, adjacent to Upper Machodoc Creek. It consists of approximately 44 forested acres and has also supported an active bald eagle nest site.

Tetotum Flats East SIA - This SIA is in the interior portion of the EEA and includes approximately 55 forested acres. Bald eagles have consistently nested at this site since 1997.

3.13.5 Hunting and Fishing

NSF Dahlgren's diverse forests, grasslands, wetlands, ponds, and creeks provide habitat for flourishing wild game and fish populations that support recreational hunting and fishing activities. The NSF Dahlgren Natural Resources Manager is responsible for managing base fish and wildlife populations, as well as for overseeing hunting and fishing activities as a recreational activity. The goal of the Outdoor Recreation Program is to enhance quality of life for the NSF Dahlgren community by allowing for maximum natural resources-based recreational use in a manner that does not interfere with the military mission. Because of NSF Dahlgren's mission, general public access to the installation is not permitted. However, active and retired military personnel, current and retired NSA South Potomac civilian government employees, NSA South Potomac residents and their dependents, and NSA South Potomac on-installation contractors – as well as the guests of any of the above, except those of retired civilian employees – may hunt and fish (NSA South Potomac Instruction 5090.2). Because of activities on the ranges and the presence of UXO in some areas, as well as for natural resource management purposes, access to recreational areas for specific activities is limited based on time of day, day of the week, and time of year (NSA South Potomac, October 2009a, October 2009b). Proper credentials are required for access, and state and base user permits are required for hunting, trapping, and fishing.

3.13.5.1 Hunting

Primary game species include white-tailed deer, wild turkey, quail, rabbit, dove, and squirrel. Deer, wild turkey, waterfowl, and small-game hunting areas on NSF Dahlgren are shown in Figure 3.13-3 (Hunting Areas). Mainside is divided into nine hunting compartments and the EEA is divided into four compartments. Areas open to hunting are subject to change based on range testing schedules and bald eagle nesting activities. Designated bow and gun areas within these compartments are delineated in base hunting and fishing instructions. Hunting compartments on Mainside are located throughout the northern and eastern portions of the installation (the ranges and Mission Area), but the base community support area to the south is off limits to hunting. EEA's hunting compartments are located along the southern and western borders. The entire northern and eastern portions of the EEA are off limits to hunting because of potential UXO contamination and range activities. Wildlife populations are monitored as part of the Fish and Wildlife Management Program, and this information is used to determine management activities, particularly for white-tailed deer.

White-tailed Deer

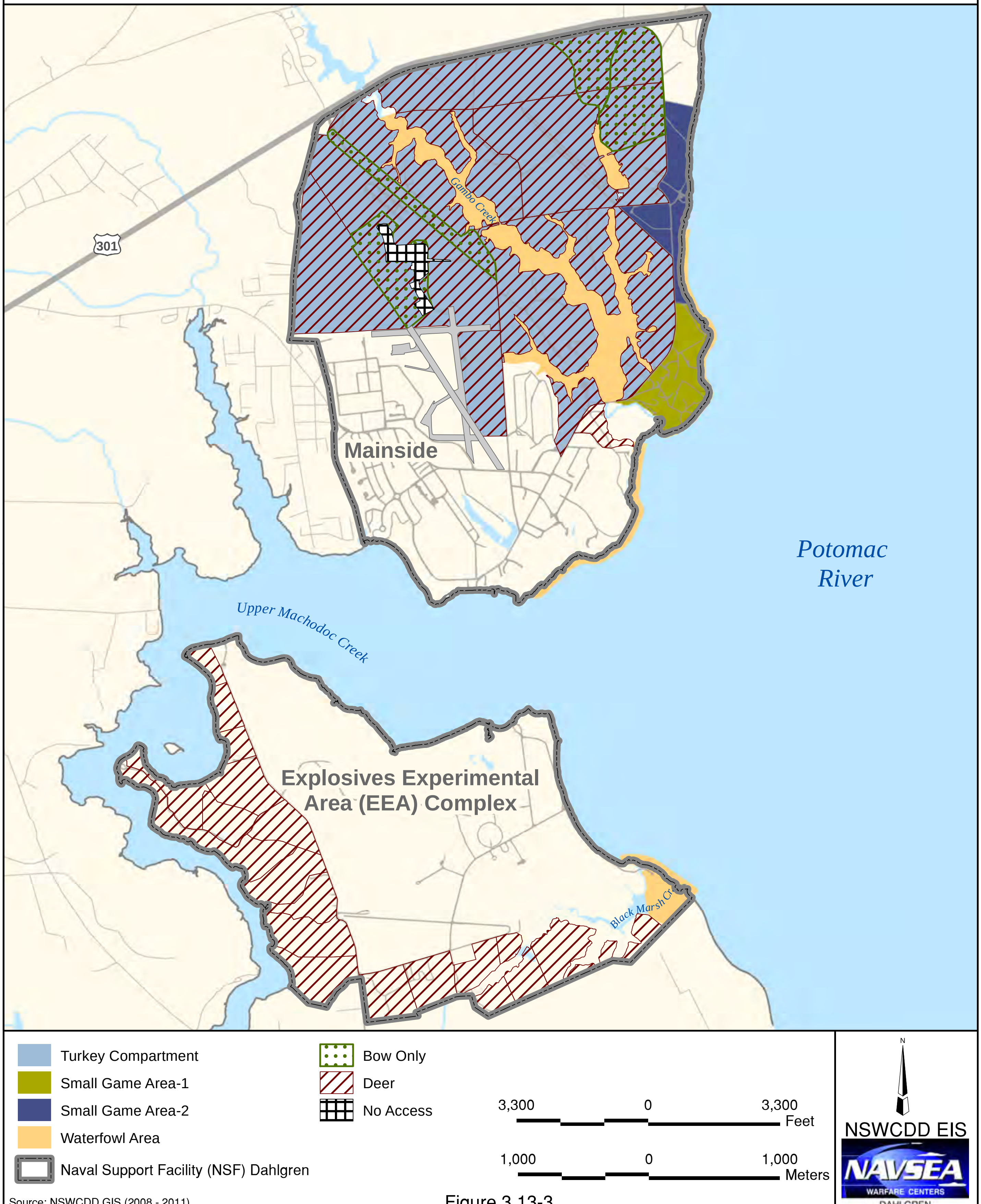
White-tailed deer are common throughout Virginia, including NSF Dahlgren. They are a very adaptable species and thrive in a variety of habitats, including those with high levels of human activity. Over the past 25 years, white-tailed deer populations have increased to unprecedented levels in many parts of the animal's range. When predation and other losses are low and food is plentiful, deer populations can double every two to three years. High deer populations cause concerns about impacts to native plant communities, wildlife habitat, deer-human interactions, and deer herd health. These concerns have been studied and documented and the need to manage them is well recognized.

White-tailed Deer
Odocoileus virginianus

NSF Dahlgren's regulated deer hunting program started during the 1980/81 hunting season as a means to control the resident deer population. The hunting program has continued as the primary means of managing the deer herds. Seasons and bag limits comply with those set for Virginia.

Available deer habitat on Mainside and the EEA is about 1,600 and 1,530 ac, respectively. Rough post-hunting season population estimates since 1995/96 have ranged from 100 to 150 animals for Mainside and 110 to 150 for the EEA. Based on an optimal density of one deer per 20 ac – which would place the desired populations on Mainside and the EEA at about 80 and 77, respectively – the estimates suggest that the population is above the desired level. Since the hunting program began, total deer harvests on Mainside have ranged from 20 to 60, with an average of 37 deer per year; the corresponding numbers for the EEA are 23 to 65, with an

Hunting Areas



Source: NSWCDD GIS (2008 - 2011)

Figure 3.13-3

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average of 39 per year. In order to reduce the deer population to carrying capacity, the 2007/2008 harvest objective was to double the total harvest at each site.

Wild Turkey

Observations and harvest data indicate that wild turkeys are abundant on Mainside and the EEA. Turkey hunting is permitted in designated areas on Mainside during the Fall Season and Spring Gobbler Season established by the state. On the EEA, turkey hunting is permitted in the fall during the Firearms Season and during the Spring Gobbler Season. Approximately four or five birds are harvested annually on Mainside and one or two birds are harvested annually on the EEA.

Small Game

The installation supports a variety of small game animals. All legal game species may be harvested in accordance with state seasons and bag limits. However, the most-often-hunted species are the bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaida macroura*), eastern cottontail, and eastern gray squirrel. A few sportsmen also hunt American woodcock (*Philohela minor*). Furbearers at NSF Dahlgren include beaver, river otter, muskrat, mink, red fox, gray fox, raccoon, striped skunk, long-tailed weasel, and opossum. Trapping is permitted at the installation; however, demand is low, and very little trapping actually occurs.

Waterfowl

Waterfowl hunting is permitted along the Mainside Potomac River and Upper Machodoc Creek shorelines, along Gambo Creek, and near the mouth of Black Marsh Creek. Gambo Creek Marsh has been designated as an SIA based in part on its value as wintering waterfowl habitat.

3.13.5.2 Fishing

Recreational fishing is permitted at Hideaway Pond, Cooling Pond, Gambo Creek, and portions of the Potomac River and Upper Machodoc Creek shorelines on Mainside. The EEA is closed to fishing because of the presence of UXO and range activities. Open fishing areas receive low to moderate fishing pressure. Largemouth bass, bluegill, brown bullhead, and channel catfish are present in both ponds. Hideaway Pond and Cooling Pond are catch-and-release fisheries only. Fish caught from the ponds may be kept for mounting purposes only, due to potential health risks from high levels of mercury. Flat-bottomed boats are available for use on Hideaway Pond. Personal boats may be used, but gasoline-powered boats are prohibited on NSF Dahlgren ponds.

Management of Potomac River fisheries is primarily the responsibility of the Potomac River Fisheries Commission. However, many of the management practices implemented under NSF Dahlgren’s Land Management Program support Potomac River fisheries management through habitat and water quality protection.

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3.14 Protected Species

3.14.1 Laws and Regulations

The Endangered Species Act (ESA) of 1973 (16 U.S.C. § 1531 et seq.; 50 CFR Part 17, Subpart I, and 50 CFR Part 402) and subsequent amendments provide for the conservation of threatened and endangered species of animals and plants, and the habitats in which they are found. The ESA prohibits jeopardizing endangered and threatened species or adversely modifying critical habitats essential to their survival without specific authorization from the USFWS or the National Marine Fisheries Service (NMFS) depending on the species and the area within which it occurs. A species is considered “endangered” if it is in danger of extinction throughout all or a significant portion of its range, and “threatened” if it is likely to become endangered in the foreseeable future due to any of the following factors (Section 4(a) (1) (A-E), 1982 amendment):

- The present or threatened destruction, modification, or curtailment of its habitat or range
- Overutilization for commercial, recreational, scientific, or educational purposes
- Disease or predation
- The inadequacy of existing regulatory mechanisms
- Other natural or manmade factors affecting its continued existence

Section 7(a) (2) of the ESA requires federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. Federal agencies are required to consult with the USFWS or NMFS if an action may affect a listed species. The Navy ensures that consultations are conducted according to guidance provided in the Navy *Environmental Resources Program Manual* (OPNAVINST 5090.1C).

In Virginia, the statutes under Article 6, Endangered Species, of the Wildlife and Fish Laws prohibit the taking, transportation, possession, sale, or offer for sale within the commonwealth of species listed on the federal endangered species list or any other species designated by the state board (Code of Virginia §§ 29.1-563-570). The Maryland law that covers threatened and endangered species is the Nongame and Endangered Species Conservation Act (Code of Maryland §§ 10-2A-01-09). Under this act, any species designated under the federal ESA is deemed an endangered species, as are other species designated by the state secretary based on habitat and population factors.

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361-1421h) establishes a federal responsibility to conserve marine mammals, with management vested in the Department of Commerce’s NMFS for whales, dolphins, porpoises, seals, and sea lions. The Department of the Interior’s USFWS is responsible for all other marine mammals (i.e., manatees, polar bears, sea otters, and walruses). The act prohibits the "taking" of marine mammals in the United States or on the high seas, subject only to limited exceptions. The term “take,” as defined in Section 3 (16 U.S.C. § 1362) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, which provided two levels of “harassment” – Level A (potential injury) and Level B (potential disturbance).

The National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 104(c)(3) [16 U.S.C. § 1374 (c)(3)]. For military readiness activities the relevant definition of harassment is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment"), or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 U.S.C. § 1362 (18)(B)(i)(ii)].

Section 101(a)(5) of the MMPA directs the Secretary of the Department of Commerce (NOAA) to allow, upon request, the incidental (but not intentional) taking of marine mammals by US citizens who engage in a specified activity (exclusive of commercial fishing), if certain findings are made and regulations are issued. Authorization will be granted by the Secretary for the incidental take of marine mammals if the taking will have a negligible impact on the species or stock and will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

Appendix G contains the correspondence exchanged to date with federal and state fish and wildlife resources agencies as part of the ESA Section 7 coordination effort for this EIS. In response to Section 7, a Biological Assessment evaluating the impacts of the Proposed Action on species listed on or proposed for listing on the ESA was prepared and is included as Appendix H of this EIS. Table 3.14-1 lists the protected species found, or potentially found, within four miles of NSF Dahlgren or within the PRTR. Species include fish, sea turtles, birds, and plants, described below.

3.14.2 Fish

Two federally-listed endangered fish species – the shortnose sturgeon (*Acipenser brevirostrum*) (also state-listed) and the Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) are found in the PRTR section of the Potomac River.

The USFWS listed the shortnose sturgeon as endangered throughout its range in 1967 under the Endangered Species Preservation Act of 1966. The NMFS took over jurisdiction of the shortnose sturgeon in 1974, following the enactment of the ESA of 1973. Maryland and Virginia also list it as an endangered species. There are 19 Distinct Population Segments (DPSs) of shortnose sturgeon in 25 river systems. The Chesapeake Bay DPS includes shortnose sturgeon that occur in the Potomac River in Maryland and Virginia.

The Atlantic sturgeon was listed under the ESA on February 6, 2012. The Atlantic sturgeon is comprised of five DPSs that are listed as endangered or threatened. The Chesapeake Bay DPS which includes Potomac River Atlantic sturgeon is listed as endangered.

Table 3.14-1
Federal and State Status of Protected Species Potentially Found within Four Miles of NSF Dahlgren or within the PRTR

Federal Status	Virginia Status	Maryland Status	Common Name	Scientific Name
Fish				
FE	SE	SE	Shortnose sturgeon	*Acipenser brevirostrum*
FE			Atlantic sturgeon	*Acipenser oxyrhynchus*
Sea Turtles and Terrestrial Reptiles				
FT/FE[1]	ST	ST	Loggerhead turtle	*Caretta caretta*
FT/FE[2]	SE	SE	Kemp's ridley turtle	*Lepidochelys kempii*
FT	ST	ST	Green turtle	*Chelonia mydas*
FS			Northern diamondback terrapin	*Malaclemys terrapin terrapin*
Birds				
FS	ST	SE	Loggerhead shrike*	*Lanius ludovicianus*
FS		SE	Black rail	*Laterallus jamaicensis*
FS			Cerulean warbler	*Dendroica cerulean*
FS	ST		Bald eagle*	*Haliaeetus leucocephalus*
	ST	SE	Upland sandpiper	*Bartramia longicauda*
	SSC		Winter wren*	*Troglodytes troglodytes*
	SSC		Little blue heron	*Egretta caerulea caerulea*
	SSC	ST	Least tern	*Sterna antillarum*
	SSC		Northern harrier*	*Circus cyaneus*
	SSC		Tricolored heron	*Egretta tricolor*
	SSC		Yellow-crowned night heron	*Nyctanaa violacea violacea*
	SSC		Barn owl	*Tyto alba pratincola*
	SSC	SE	Sedge wren*	*Cistothorus platensis*
	SSC		Brown creeper	*Certhia americana*
	SSC		Forster's tern	*Sterna forsteri*
	SSC		Dickcissel	*Spiza americana*
	SSC		Great egret*	*Ardea alba egretta*
	SSC		Purple finch*	*Carpodacus purpureus*
	SSC		Golden-crowned kinglet*	*Regulus satrapa*
	SSC	SI	Common moorhen	*Gallinula chloropus cachinnans*
	SSC		Magnolia warbler*	*Dendroica magnolia*
	SSC		Red-breasted nuthatch	*Sitta Canadensis*
	SSC		Caspian tern	*Sterna caspia*
	SSC		Hermit thrush	*Catharus guttatus*
Plants				
FT	SE	SE	Swamp pink	*Helonias bullata*
	ST		Narrow-leaved spatterdock	*Nuphar sagittifolia*
FE	SE	SE	Harperella	*Ptilimnium nodosum*
	ST	SE	New Jersey rush	*Juncus caesariensis*
FT	ST	SE	Sensitive joint-vetch	*Aeschynomene virginica*
	SE		Tropical water hyssop	*Bacopa innominata*

Notes: FE = Federal Endangered; FT= Federal Threatened; FS= Federal Species of Concern; SE = State Endangered; ST = State Threatened; SSC = State Species of Special Concern; SI = State In Need of Conservation.

[1]Nine distinct population segments of loggerhead turtles were recently identified within the global population. The only distinct population segment that occurs within Study Area of this EIS—the Northwest Atlantic Ocean distinct population segment—is listed as threatened.[2] As a species, the green turtle is listed as threatened, but the Florida and Mexican Pacific coast nesting populations are listed as endangered. Green turtles found in the Study Area might not all be from the Florida population.

* Species observed at NSF Dahlgren.

Sources: NSF Dahlgren, 2007; Townsend, 2009; NMFS, 2011; MDNR, 2010; VDGIF, 2011; USFWS, 2011; NFS, 2011; NOAA, 2012; USFWS, January 21, 2013.

3.14.2.1 Shortnose Sturgeon

The shortnose sturgeon inhabits large coastal rivers of eastern North America, ranging from the Saint John River in New Brunswick, Canada, to the Saint Johns River in northeastern Florida (NMFS, 1998).

Shortnose Sturgeon
Acipenser brevirostrum

The shortnose and the Atlantic sturgeon share many characteristics – both are long-lived, late-maturing, estuarine-dependent, anadromous (ascending rivers from the sea to spawn) species. The shortnose sturgeon is the smaller of the two sturgeon species that occur in the Chesapeake Bay. The shortnose sturgeon rarely exceeds three to four feet in length and its mouth is broader than that of the Atlantic sturgeon. The shortnose sturgeon is a demersal (living on or near the bottom) omnivore that uses its flattened snout to search through bottom sediments and its sensitive barbels (whisker-like tactile organs) to find crustacea, insects, worms, and small mollusks, which it sucks into its mouth.

The shortnose sturgeon spends most of its life in slow-moving tidal rivers or in nearshore marine waters, then moves upstream to fresh waters to spawn. Shortnose sturgeon spawn at or above the head-of-tide (the farthest point upstream affected by tidal fluctuations) in most rivers. Mature adults migrate to spawning areas in the spring.

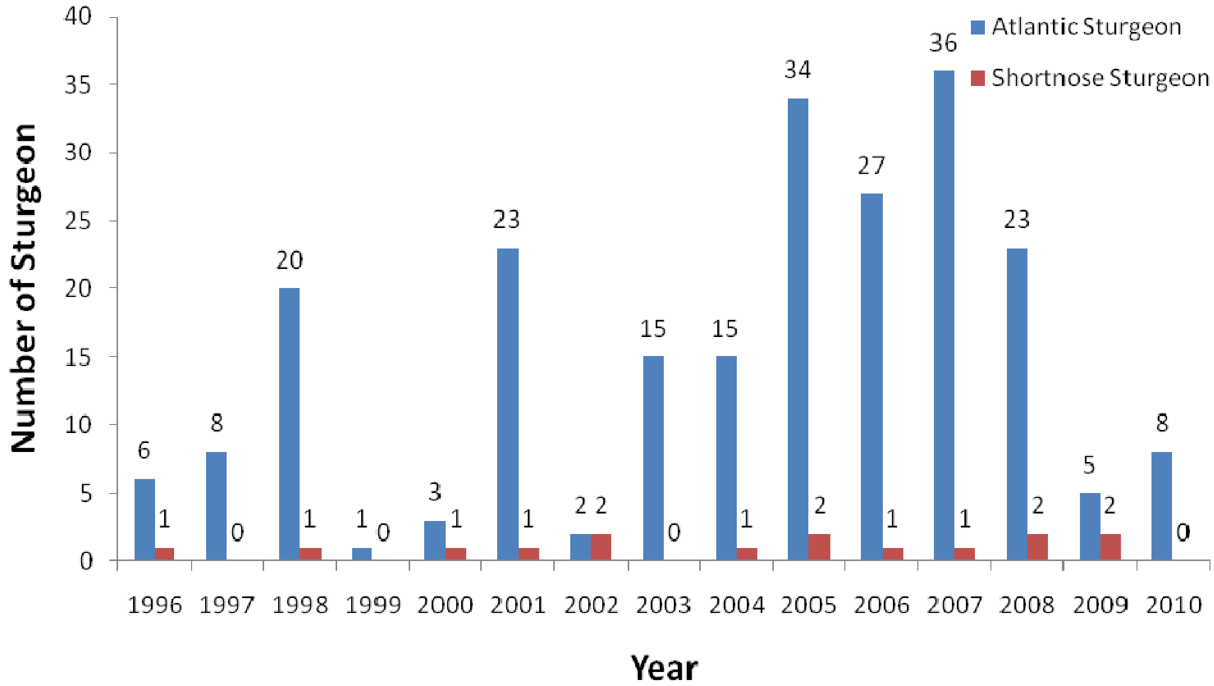
The area immediately downstream from Little Falls on the Potomac River just above Washington, DC would likely be their primary potential spawning area on the Potomac River. Below Little Falls Dam, which is 117 mi upstream from the mouth of the Potomac River and 1.5 mi above the head of tide, appears to offer suitable habitat for spawning. However, there are no records of shortnose sturgeon spawning in the Potomac River, despite detailed tracking of two tagged females with late stage eggs (Kynard et al., 2007, 2009).

After hatching, the young-of-the-year remain in freshwater for about one year before moving downstream to the zone where fresh and salt water interface. This interface is located generally in and upstream of the upper MDZ in the spring and upstream of the UDZ in the fall. Juveniles (three to ten years of age) occur at the fresh-saline water interface in most rivers, where they shift slightly upstream in spring and summer and downstream in fall and winter. Adults are generally found upstream while spawning in the spring and spend the remainder of the year at the fresh and saltwater interface.

There is little scientific evidence that an historic shortnose sturgeon population lived in the Potomac River with the exception of one capture recorded in 1876. A small number of shortnose sturgeon have been found in the Potomac River over the last 15 years. From 1996 to 2010, 15 shortnose sturgeon were documented in the river primarily as a result of the USFWS's Atlantic Sturgeon and Shortnose Sturgeon Reward Program carried out by the USFWS in cooperation with the Chesapeake Bay Program and the MDNR Sturgeon Reward Program, but also as the result of other research. Under the Reward Capture Program, commercial fishermen reported sturgeon captures and received a cash reward. The fish were held by the fishermen until scientists arrived to inspect them and then were released back into the river. Figure 3.14-1

(Sturgeon Captures in the Potomac River 1996-2010) shows the number of shortnose and Atlantic sturgeon captured annually and Figure 3.14-2, Potomac River Shortnose Sturgeon Captures (1996-2010), shows the locations of captures.

Figure 3.14-1
Sturgeon Captures in the Potomac River (1996-2010)



Note: Total includes recaptured sturgeon.
Source: Eyler, USWFS, pers. comm., January 11, 2011.

Shortnose sturgeon were found by commercial fishermen and scientists at the following locations (Eyler, pers. comm., January 11, 2011):

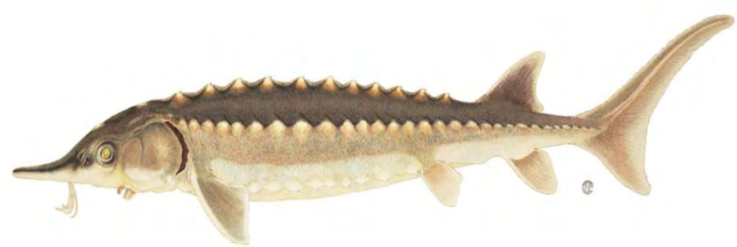
- Three at the mouth of Potomac Creek, which is approximately 5 NM (8 km) upriver from the PRTR UDZ (one on May 17, 1996 and two on March 8, 2002).
- Four near the mouth of the river around Ophelia, Virginia (caught on May 3, 2000; March 26, 2001; December 10, 2004; and May 22, 2005) where the Potomac River enters the bay.
- One at the mouth of the Saint Mary's River (April 12, 1998) in the PRTR LDZ.
- One near Craney Island (September 20, 2005), which is well upstream of the UDZ.
- One near the mouth of Popes Creek, along the PRTR MDZ (March 22, 2006).
- Three captures around Cobb Bar (near Cobb Island in the MDZ); one of which was a fish that was captured twice within a few days (March 14 and 17, 2008).
- One near Colonial Beach, also in the MDZ (March 13, 2009).
- One near Cole's Point in the LDZ (April 9, 2009).

The reward program operated year round from 1996 through 2005. However, beginning in 2006 the USFWS discontinued the program from May 31st to October 1st due to concern that the water temperatures in the summer months were too high for sturgeon to be held safely by fishermen while awaiting inspection by scientists, especially with the large numbers of Atlantic sturgeon being reported in 2006 (Eyler and Mangold, pers. comm., January 11, 2011). USFWS has continued to shut down the reward program in the summer months to protect sturgeon from the stress of being held during warm weather, with no reward offered from June 1st through September 30th. However, it is likely that sturgeon are present during the summer months in the Potomac River based on information collected when the reward program operated from June through September (Eyler and Mangold, pers. comm., January 11, 2011).

The locations of the sturgeon collected by the reward program are based on where fishermen are setting their fishing gear (Eyler and Mangold, pers. comm., January 11, 2011). Therefore, the sturgeon captures on the Potomac River may or may not reflect areas preferred by sturgeon more of the time.

3.14.2.2 Atlantic Sturgeon

The range of the Atlantic sturgeon extends farther north – to Hamilton Inlet on the coast of Labrador – than the shortnose sturgeon, but they share the southern extent of their range at the Saint Johns River in Florida (Atlantic Sturgeon Status Review Team [ASSRT], 2007).



Atlantic Sturgeon
Acipenser oxyrhynchus

The Atlantic sturgeon has long been an important commercial species in North America, beginning with Jamestown, the first successful English colony in the Americas founded in 1607 on the James River, Virginia (Smith, 1624). The early colonists survived by dining on sturgeon when other food was scarce. Later, pickled sturgeon and caviar roe (eggs) became one of the first exports from the New World (Roberts, 2007). Records from the 1700s and 1800s continued to document large numbers of sturgeon in many rivers along the Atlantic coast, and in 1870 a caviar market was established (ASSRT, 1997; Smith and Clugston, 1997). Both the shortnose sturgeon and Atlantic sturgeon were of commercial importance along the eastern shores of North America in the 1800s because of the quality and taste of their flesh and caviar.

During the late 1800s, the Chesapeake Bay supported the second largest caviar fishery in the eastern United States. However, in the early 1900s sturgeon populations collapsed as a result of overfishing (Murawski and Pacheco, 1977, as cited in ASSRT, 1997). The remaining sturgeon fishery switched in the 1900s to targeting sturgeon for flesh, rather than caviar. Continued overfishing prompted the Atlantic States Marine Fisheries Commission to impose a coast-wide moratorium for fisheries targeting Atlantic sturgeon in 1998 (ASSRT, 2007; NFS, 2011). Factors other than overfishing, such as deterioration of habitat and blockage of spawning runs, have also contributed to the decline or extirpation of Atlantic sturgeon populations (Stevenson and Secor, 1999).

Shortnose Sturgeon Reward Captures in the Potomac River (1996-2010)

Shortnose Sturgeon Original Capture (Minimum of one capture)
Shortnose Sturgeon Recapture (Minimum of one recapture)
NSF Dahlgren
Depth of less than 18 ft
Potomac River Test Range (PRTR)
County Boundaries

Note: Number in circle represents number of captures/ recaptures at location, if more than one.

6 0 6 Miles
10 0 10 Kilometers

N

NSWCDD EIS
NAVSEA WARFARE CENTERS DAHLGREN

Source: Eyler, USFWS, 2011.

Figure 3.14-2

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Atlantic sturgeon, like shortnose sturgeon, are demersal omnivores. Although these two species occur in the same geographic areas, they usually do not compete for food (ASSRT, 2007). Several studies in the Northeastern US found that shortnose and Atlantic sturgeon feeding activity generally does not overlap except for brief periods, likely because the two species occur in different river stretches/salinity zones, at different water depths, and seeking different prey (Haley and Bain, 1997; Kahnle and Hattala, 1988; both as cited in ASSRT, 2007).

Atlantic sturgeon are primarily marine and spend less of their time in fresh or brackish water than do shortnose sturgeon. Atlantic sturgeon spawning is thought to take place between the salt front and fall line of large rivers. In the Potomac River, this area is located below Little Falls Dam and extends up to Great Falls, which is 10 miles upriver of Little Falls, well above the Proposed Action area. However, there are no records of Atlantic sturgeon spawning in the Potomac River. Juvenile Atlantic sturgeon primarily stay within freshwater but move progressively seaward as they age. In general, juveniles remain within the riverine system for one to six years before migrating to the coast and out to the continental shelf where they grow to maturity.

In the Potomac River, a total of 226 Atlantic sturgeon have been reported, primarily through the Sturgeon Reward Program (Eyler, pers. comm., January 11, 2011). As shown in Figure 3.14-3 (Potomac River Atlantic Sturgeon Captures (1996 - 2010)), most Atlantic sturgeon have been captured below the Nice Bridge in the areas covered by the MDZ and LDZ. The number reported varies annually and was highest from 2005 to 2008 (Figure 3.14-1). The yearly fluctuations in the number of captures are thought to reflect changes in the sturgeon population, not the participation of commercial fishermen in the reward program. There seem to be stronger year classes of sturgeon that move up into the Chesapeake Bay in certain years but not others (Eyler and Mangold, pers. comm., January 11, 2011).

3.14.3 Sea Turtles and Terrestrial Reptiles

3.14.3.1 Sea Turtles

All sea turtle species are protected under the ESA. The ESA and the protection it affords to sea turtles are discussed above in Section 3.14.1. Five of the seven species of sea turtles existing in the world today occur in coastal and inland Virginia waters (VIMS, 2011): loggerhead (*Caretta caretta*), green (*Chelonia mydas*), Kemp’s ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and – although infrequently – hawksbill (*Eretmochelys imbricata*). Sea turtles are observed in Virginia’s inshore and nearshore waters from May to November (VDGIF, Not Dated). During winter months, sea turtle distribution shifts either south or offshore, where water temperatures are warmer and prey is more abundant (e.g., Epperly et al., 1995a; 1995b). The lower Chesapeake Bay, its tributaries, and the Atlantic coastline provide important developmental habitat for immature sea turtles because of SAV beds and a rich diversity of bottom-dwelling fauna that afford cover and forage. Occasionally, adult females use Virginia’s ocean-facing beaches as nesting sites.

Approximately 5,000 to 10,000 sea turtles enter the Chesapeake Bay each spring/summer as water temperatures rise (VIMS, 2011). Sea turtles use the bay and its tributaries as a feeding ground because of the abundance of SAV and benthic prey. The majority of these turtles are either juvenile loggerhead or Kemp's ridley sea turtles that use the bay seasonally as a feeding ground.

3.14.3.2 Sea Turtles in the Potomac River

Three sea turtle species are known to occur in the lower Potomac River based on reported stranding and/or incidental capture records: loggerhead turtle, Kemp’s ridley turtle, and green sea turtle, as described below.

Loggerhead Turtle

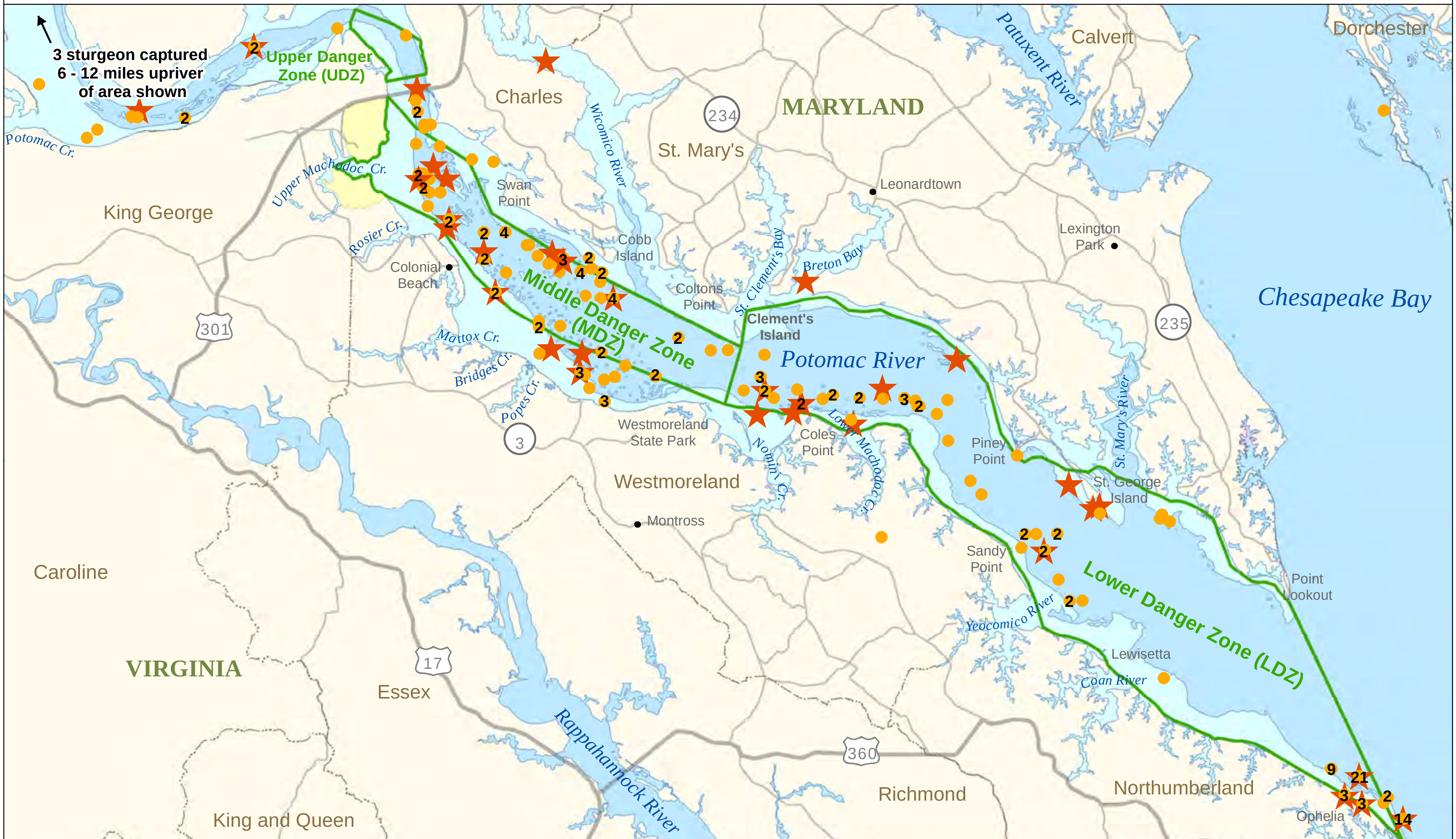

Loggerhead Sea Turtle
Caretta caretta

The loggerhead turtle is a large, hard-shelled sea turtle that is named for its disproportionately large head. The head supports powerful jaws that enable it to feed on hard-shelled prey (NFS, 2011). The average straight carapace length (SCL) of an adult loggerhead is about 3 ft and the average weight is 250 lbs (Ehrhart and Yoder 1978 as cited in NMFS and USFWS, 2008)). Adults are mainly reddish-brown in color on top and yellowish underneath. The diet of loggerhead turtles changes with age and size. Very little is known of the diet of oceanic juveniles, but they are thought to be primarily carnivorous, consuming mainly sea jellies and other invertebrates (NMFS and USFWS, 2008). Between the ages of 7 to 12 years, oceanic juveniles migrate to coastal waters (NFS, 2011). Juvenile loggerhead turtles are omnivorous and feed on a wide variety of organisms inhabiting coastal waters. Although they may forage on pelagic (free swimming) crabs, mollusks, jellyfish, and vegetation captured at or near the surface, benthic (bottom dwelling) invertebrates such as mollusks, and benthic crabs comprise the majority of their diet (Dodd, 1988; NMFS and USFWS, 2008).

The waters off the Virginia and North Carolina coasts are important transitional habitat for juvenile sea turtles. Juvenile sea turtles along the US Atlantic Coast exhibit seasonal foraging movements, migrating north along the coast in the early spring to coastal development habitats and south in the fall (Morreale and Standora, 2005). Coastal waters of Virginia, particularly the Chesapeake Bay, serve as developmental habitat for juvenile loggerhead and Kemp’s ridley sea turtles, which take up residency during the summer months (Lutcavage and Musick, 1985). The presence of juvenile sea turtles in the Chesapeake Bay area and in Virginia coastal waters peaks from May through October (VIMS, 2011). As waters cool in the fall, most sea turtles migrate out of the Chesapeake Bay and Virginia coastal waters to travel southward at least as far as Cape Hatteras, North Carolina to avoid cold stunning[10]. Along the US coast loggerheads successfully nest from Texas to Virginia with the majority of nests – about 80 percent – occurring in six Florida counties (NMFS and USFWS, 2008). There are no records of nesting in the Chesapeake Bay or its tributaries.

[10] Cold stunning is the state that turtles enter when they are suddenly exposed to cold water of less than 50°F (less than 10 °C). In this circumstance, they may become lethargic and begin to float on the surface of the water, making them susceptible to predators, accidental boat strikes, and even death if water temperatures continue to drop (Witherington and Ehrhart, 1989).

Atlantic Sturgeon Reward Captures in the Potomac River (1996-2010)



Atlantic Sturgeon Original Capture (Minimum of one capture)

Atlantic Sturgeon Recapture (Minimum of one recapture)

NSF Dahlgren

Depth of less than 18 ft

Potomac River Test Range (PRTR)

County Boundaries

6 0 6 Miles

10 0 10 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Note: Number in circle or star represents number of captures/ recaptures at location, if more than one.

Source: Eyler, USFWS, 2011.

Figure 3.14-3

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Kemp’s Ridley Turtle

Kemp's ridleys are considered the smallest marine turtle in the world with a SCL of approximately 2.0 to 2.3 ft (with shell length and width being nearly equal) and weight of about 100 lbs (NMFS, USFWS, and SEMARNAT, 2010; NFS, 2011). The carapace is round to somewhat heart-shaped and the coloration changes from grey-black in hatchlings to the lighter grey-olive top and cream-white or yellowish bottom of adults (NMFS, USFWS, and SEMARNAT, 2010).

Kemp's ridleys range includes the US Atlantic seaboard from New England to Florida, and the Gulf of Mexico. Kemp’s ridleys share a general life history pattern similar to other sea turtles, such as the loggerhead (NMFS, USFWS, and SEMARNAT, 2010). Feeding grounds and developmental areas are found on the Atlantic and Gulf coasts of the US. Young Kemp’s ridley hatchlings and small juveniles feed on the macroalgae *Sargassum* and associated floating species in habitats of the North Atlantic Ocean. Kemp’s ridleys move as large juveniles and adults to benthic, nearshore feeding grounds along the US. Atlantic and Gulf coasts (Morreale and Standora, 2005).

Next to loggerheads, the Kemp’s ridley is the second most abundant sea turtle in mid-Atlantic waters. Young Kemp’s ridleys may forage during warmer months in the Chesapeake Bay area, generally heading southward out of Chesapeake Bay by early November (Lutcavage and Musick 1985, Keinath, 1993). Kemp’s ridley sea turtles feed primarily on crabs and blue crabs and rock crabs comprise most of their diet in the Chesapeake Bay area (Burke et al., 1994). During the winter, Kemp’s ridleys migrate south to warmer waters in Florida (Marquez, 1994).

Nesting is limited to the beaches of the western Gulf of Mexico (NMFS, USFWS, and SEMARNAT, 2010).

Green Sea Turtle

The green turtle is the largest hard-shelled sea turtle, with adults reaching an SCL of 3.3 ft and 300 to 350 lbs in weight and a maximum size of 4.0 ft and 440 lbs in weight (NMFS and USFWS, 1991; NFS, 2011; USFWS, 2011). The adult ranges in color from solid black to gray, yellow, green, and brown on top, while the bottom is yellowish white (NFS, 2011). The common name refers to the color of the green turtle’s fat.

Very young green turtles (hatchlings) eat a variety of plants and animals, but adult green turtles feed mainly on seagrasses and marine algae (USFWS, 2011). While offshore, green turtles are not obligate herbivores and may consume invertebrates (NMFS and USFWS, 2007). Important adult feeding areas are found in Florida, where seagrasses are abundant.

In US Atlantic and Gulf of Mexico waters, green turtles are found in inshore and nearshore waters from Texas to Massachusetts, and are also found around the US Virgin Islands and Puerto Rico (NMFS and USFWS, 1991; NFS, 2011). The green sea turtle has only been recorded twice in Maryland waters as of 2001 (Litwiler, 2001), making it an infrequent visitor to the area. Green turtles also share a general life history pattern similar to other sea turtles, using three types of habitat – oceanic beaches (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas (NFS, 2011).

Similar to the loggerhead and Kemp’s ridley sea turtles, post-hatchling and early-juvenile green turtles are found in the open ocean (NMFS and USFWS, 1991; NFS, 2011; USFWS, 2011). Green turtles grow slowly (NMFS and USFWS, 1991). Once they reach a carapace length of about 7.9 to 9.8 in, they migrate to shallow, nearshore areas (<164 ft in depth) where they tend to remain. The optimal developmental habitats for late juveniles and foraging adults are warm, shallow waters (10 to 16 ft in depth), with an abundance of submerged aquatic vegetation, close to nearshore reefs or rocky areas that are used by green turtles for resting.

Juvenile green turtles use estuaries along the Atlantic coast as summer developmental habitat, including Chesapeake Bay (Epperly et al., 1995a, 1995b). Adults are predominantly tropical and are only occasionally found north of southern Florida. Green turtles mainly nest from North Carolina south, with most of the primary nesting beaches occurring in a six-county area in east central and southeastern Florida (NMFS and USFWS, 1991). In August 2011 a green sea turtle nested at Cape Henlopen State Park, Delaware (Delaware Department of Natural Resources and Environmental Control, 2011). The eggs were moved in October 2011 to a climate-controlled room at the University of Delaware, as the temperature was getting too low for survival. Six turtles hatched and were taken to Morehead City, North Carolina where they were released into warmer waters (Delaware Department of Natural Resources and Environmental Control, 2011).

Sea Turtle Strandings and Incidental Captures in the Potomac River

The Virginia Institute of Marine Science (VIMS) and MDNR record sea turtle strandings and incidental captures in commercial fishing nets in Virginia and Maryland; data are then provided to NMFS. Figure 3.14-4 (Sea Turtle Strandings in the Potomac River (1991-2010)) shows locations of sea turtle strandings in the Potomac River and Figure 3.14-5 (Incidental Captures of Sea Turtles in the Potomac River (1991-2010)) depicts locations where sea turtles were incidentally captured in fishing nets. In recorded strandings, the sea turtle is often found dead or in poor condition. Therefore, strandings data provides the location where the turtle was found and not necessarily the location where the mortality occurred in the case of dead turtles. Some degree of transport may have occurred prior to the turtle’s washing up at the stranding site.

Tables 3.14-2 and 3.14-3 list sea turtle strandings and incidental takes, respectively, in the Potomac River from 1991 through 2010 (VIMS, 2011; Tulipani, pers. comm., March 4, 2009 and January 7, 2010; Schofield, pers. comm., December 4, 2009; Testa, pers. comm. January 11, 2011; Trapani, pers. comm., January 11, 2011). Data are based on sea turtles records from St. Mary’s County, Maryland and Northumberland County, Virginia. Both these counties front both the Potomac River and the Chesapeake Bay (see Figures 3.14-4 and 3.14-5), but only occurrences of turtles in the Potomac River are presented here. No sea turtles have been recorded from the Potomac River upriver of St Mary’s and Northumberland Counties.

Seventy-two percent of recorded incidents (69 of 96) have been incidental captures of sea turtles in fishing nets, with the remaining 28 percent (27 of 96) consisting of strandings. The majority (84 percent) of turtles found in the Potomac River have been loggerheads, with Kemp’s ridley comprising most of the remaining turtles (13 percent), but with one green turtle captured incidentally (Tables 3.14-2 and 3.14-3).

Most sea turtle occurrences in the Potomac River were recorded from May through July, with a few incidents later in the year. The presence of juvenile sea turtles in the Chesapeake Bay area is highest during warmer months (Coles, 1999; Tulipani, VIMS, pers. comm., March 4, 2009 and January 7, 2010; Schofield, MDNR, pers. comm., December 4, 2009; Testa, pers. comm., January 11, 2011; Trapani, Virginia Aquarium, pers. comm., January 11, 2011). These observations confirm that the Chesapeake Bay area serves as developmental habitat for juvenile loggerhead and Kemp’s ridley sea turtles and rarely for green sea turtles.

Table 3.14-2
Sea Turtle Strandings in the Potomac River

Species	Loggerhead	Kemp's ridley	Green	Leatherback	Unidentified
1991*	1	0	0	0	0
1992*	0	0	0	0	0
1993*	0	0	0	0	0
1994*	0	0	0	0	0
1995*	1	0	0	0	0
1996*	1	0	0	0	0
1997	6	1	0	0	0
1998	2	0	0	0	0
1999	6	0	0	0	1
2000	1	0	0	0	0
2001	0	1	0	0	0
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	3	0	0	0	0
2008	1	0	0	0	0
2009	0	0	0	0	0
2010	2	0	0	0	0
Total	24	2	0	0	1

Notes: * Only Maryland data.

Numbers represent total from Maryland and Virginia shorelines. Only sea turtles found in the Potomac River are listed here. The only counties where sea turtles were recorded are St. Mary's County, Maryland and Northumberland County, Virginia.

Sources: Tulipani, VIMS, pers. comm., March 4, 2009 and January 7, 2010; Schofield, MDNR, pers. comm., December 4, 2009; Testa, MDNR, pers. comm. January 11, 2011; Trapani, Virginia Aquarium, pers. comm., January 11, 2011.

Table 3.14-3
Sea Turtle Incidental Captures in the Potomac River

Species	Loggerhead	Kemp's ridley	Green	Leatherback	Unidentified
1991*	0	0	0	0	0
1992*	0	0	0	0	0
1993*	0	0	0	0	0
1994*	0	0	0	0	0
1995*	0	0	0	0	0
1996*	0	0	0	0	0
1997	23	2	0	0	0
1998	11	1	0	0	0
1999	12	2	0	0	0
2000	2	1	0	0	0
2001	3	3	1	0	0
2002	6	1	0	0	1
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	0	0	0	0	0
Total	57	10	1	0	1

Notes: * Only Maryland data.

Numbers represent total from Maryland and Virginia shorelines. Only sea turtles found in the Potomac River are listed here. The only counties where sea turtles were recorded are St. Mary's County, Maryland and Northumberland County, Virginia.

Sources: Tulipani, VIMS, pers. comm., March 4, 2009 and January 7, 2010; Schofield, MDNR, pers. comm., December 4, 2009; Testa, MDNR, pers. comm. January 11, 2011; Trapani, Virginia Aquarium, pers. comm., January 11, 2011.

Sea Turtle Strandings in the Potomac River (1991-2010)

Kemp's Ridley
Loggerhead, Kemp's Ridley
Potomac River Test Range (PRTR)
Unidentified
Loggerhead

Note: Number in circles indicates number of strandings at location.

Sources: Tulipani, VIMS, 2009, 2010; Schofield, MDNR, March 2009, December 2009, January, 2011; Trapani, Virginia Aquarium Stranding Response Program, 2011.

3 0 3 Miles

5 0 5 Kilometers

N

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Figure 3.14-4

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Incidental Captures of Sea Turtles in the Potomac River (1991-2010)

Loggerhead

Loggerhead, Kemp's Ridley

Green, Kemp's Ridley, Loggerhead, Unidentified

Potomac River Test Range (PRTR)

Note: Number in circles indicates number of incidents at location.

Sources: Tulipani, VIMS, 2009, 2010; Schofield, MDNR, March 2009, December 2009, January, 2011; Trapani, Virginia Aquarium Stranding Response Program, 2011.

3 0 3 Miles

5 0 5 Kilometers

N

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NAVSEA WARFARE CENTERS DAHLGREN

Figure 3.14-5

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The number of sea turtle strandings and incidental captures has decreased from its peak in the late 1990s. Almost 70 percent (67 turtles) of incidental captures/strandings were recorded in a three-year period from 1997 to 1999.The large number of turtles recorded in 1997 and 1999 reflect the numerous turtles that were captured or stranded at one location near the mouth of the river between Ophelia and Point Lookout, as shown in Figures 3.14-4 and 3.14-5. Many turtles were incidentally captured by fishing boats at this location. Most of the turtles stranded at this location were live turtles that were released back into the water. Excluding the large number of sea turtles captured/stranded in 1997 to 1999, there has been an average of less than two (1.4) sea turtle strandings or incidental captures per year in the Potomac River.

The reduction in the number of turtles recorded since the early 2000s may be due to a recovery in crab populations, thus reducing turtle foraging on fish caught in nets; less fishing activity in the Lower Potomac River; use of turtle exclusion devices by fishing boats; lower reporting of sea turtle incidents, fewer sea turtles in the area due to reduced prey abundance; or a combination of these and perhaps other factors.

The MDNR studied sea turtles in the Maryland portion of Chesapeake Bay from 2001 to 2007 (Kimmel, 2004, 2007). Fifty-four loggerheads, 19 Kemp's ridleys and 4 green turtles were examined as part of a sea turtle tagging and health-assessment study from July 2001 to August 2006 (MDNR, 2011). These turtles were reported by pound netters with nets at various locations throughout Maryland's Chesapeake Bay, including Herring Bay, Fishing Bay, and the Pocomoke River. In the Potomac River, the most upriver sea turtle stranding recorded during this time period was slightly above Piney Point in the LDZ (Kimmel, 2004).

Sea turtles have not been sighted in the PRTR MDZ by NSF Dahlgren's range control boat operators, who are present there five days a week (Patteson, pers. comm., August 4, 2008). Although sea turtles spend only a fraction of their time at the surface, the lack of sightings combined with other information on their distribution indicates that they are unlikely to be found upriver from the lower LDZ.

Based upon stranding, incidental capture, and tracking data, sea turtles are considered to be restricted to the lower part of the Potomac River, rarely venturing farther upstream than Piney Point/Sandy Point in the lower section of the LDZ.

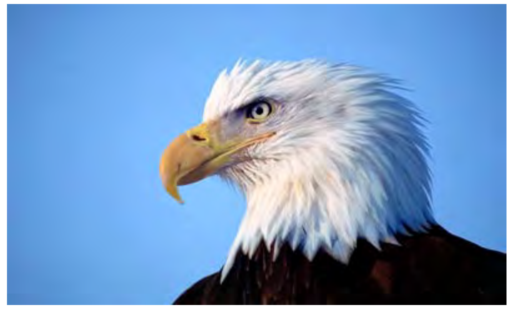
3.14.3.3 Terrestrial Reptiles

One terrestrial reptile – the northern diamondback terrapin (*Malaclemys terrapin terrapin*) – is a federal species of concern that may occur within a four-mile radius of the installation, based on information from the *Atlas of Amphibians and Reptiles in Virginia* (Mitchell and Reay, 1999) and the VDGIF database (NSF Dahlgren, 2007). The diamondback terrapin is known to occur statewide in Virginia, and prefers quiet salt and brackish tidal waters, though it is also found in mud flats, shallow bays, coves, and tidal estuaries. Terrapins are occasionally observed in the Chesapeake Bay and in the Atlantic Ocean, and potentially could occur in the Potomac River on occasion (Roble, pers. comm., March 31, 2011).

The brackish marshes, creeks, and riverbanks associated with the Potomac River and the areas around NSF Dahlgren are suitable habitat for the terrapin. However, during the last reptile survey effort at NSF Dahlgren, an attempt was made to focus on rare and threatened reptiles, and the diamondback terrapin was not observed (Buhlmann and Mitchell, 1997). No diamondback terrapins have been observed on the installation to date.

3.14.4 Birds

Historically, the bald eagle is the only species of bird known to occur at NSF Dahlgren that was protected by the ESA. Bald eagles have been known to nest at NSF Dahlgren since 1983. As discussed in Section 3.12.3, the bald eagle was removed from the ESA list of threatened or endangered species in 2007 and is no longer covered under the ESA, but remains protected by the Bald and Golden Eagle Protection Act (BGEPA), the Migratory Bird Treaty Act, and the Lacey Act. It is also protected as a state-listed threatened species under Virginia law. Coordination with the USFWS Virginia Field Office online process for compliance with the BGEPA is included in Appendix G.


Bald Eagle

As discussed in Section 3.12.3, bald eagles use NSF Dahlgren for nesting and foraging (see Figure 3.12-3 for active nests). NSF Dahlgren's bald eagle management practices are outlined in the installation's *Bald Eagle Management Plan* (NSF Dahlgren and NAVFAC Washington, 2007) and are implemented in cooperation with VDGIF and USFWS to ensure protection of the species and compliance with the BGEPA. Management includes the protection of documented nesting and foraging habitat, the monitoring of nesting activity and success, and the enforcement of the Bald Eagle Protection Guidelines for Virginia developed by the USFWS and VDGIF (USFWS and VDGIF, 2001) and National Bald Eagle Guidelines (USFWS, 2007). Requests for deviations from these guidelines must be approved by USFWS and VDGIF.

NSWCDD RDT&E activities at NSF Dahlgren have the potential to disturb bald eagles due to human activity, aircraft operation, and loud noises generated by explosives. However, aircraft use and ordnance testing at the ranges is intermittent, has a historic presence, is consistent with past practices, and bald eagles have demonstrated tolerance for these activities at NSF Dahlgren. Therefore, these activities are allowed to proceed during the bald eagle nesting season, as specified in the National Bald Eagle Management Guidelines (USFWS, 2007). Guidelines in the NSF Dahlgren *Bald Eagle Management Plan* (NSF Dahlgren and NAVFAC Washington, 2007) require that, when prudent, the USFWS be consulted if the following circumstances occur:

- A bald eagle builds a nest within a quarter-mile of existing test ranges, if testing was not routinely conducted at the time of nest establishment.
- A given test on an existing range is significantly different from those conducted historically.
- A new testing area is proposed.

Currently, approximately 408 ac on Mainside and 552 ac on the EEA are constrained by bald eagle protection zones (PZs) around active bald eagle nests. The first PZ – PZ1 – extends from the nest tree to a radius of 750 ft, and the second zone – PZ2 – extends from 750 ft to 1,320 ft (a quarter-mile) in radius (NSF Dahlgren and NAVFAC Washington, 2007). Historical nesting sites are assumed to be inactive unless aerial or ground surveys document otherwise. PZs remain in place while the nest is active and for three consecutive nesting seasons after the last season during which the nest was occupied (USFWS and VDGIF, 2001; NSF Dahlgren and NAVFAC Washington, 2007).

Federal avian species of concern that may occur within a four-mile radius of the installation include three species – the loggerhead shrike (*Lanius ludovicianus*), the black rail (*Laterallus jamaicensis*), and the cerulean warbler (*Dendroica cerulean*) (Table 3.14-1) (NSF Dahlgren, 2007). In addition, a number of avian species that are listed as state species of special concern may be potentially found in or near NSF Dahlgren (Table 3.14-1) (NSF Dahlgren, 2007). Nine bird species listed as state threatened or state species of special concern[11] have been observed at NSF Dahlgren (NSF Dahlgren, 2007).

3.14.5 Marine Mammals

Marine mammals, including pinnipeds (sea lions, seals, and walruses), otters, polar bears, cetaceans (whales, dolphins, and porpoises), dugongs, and manatees are protected species under the jurisdiction of NMFS and USFWS through the MMPA. Some marine mammals are also threatened or endangered species; however, none of the marine mammals that are known to occur in the Potomac River are threatened or endangered species. Therefore, their protection is afforded by the MMPA, but not by the ESA.

Information on marine mammals in the Potomac River and Chesapeake Bay is limited primarily to strandings and sighting reports by individuals. Systematic survey data are not available. It is likely that marine mammals found in the Chesapeake Bay are feeding on the many fish species that are available, such as silversides, anchovies, and menhaden, as well as shellfish (crabs), which are abundant in the bay.

A bottlenose dolphin (*Tursiops truncatus*) breaches the water

Since 1995 four species of marine mammal have been sighted or stranded in the Potomac River: the bottlenose dolphin (*Tursiops truncatus*), the harbor porpoise (*Phocoena phocoena*), Risso's dolphin (*Grampus griseus*), and the minke whale (*Balaenoptera acutorostrada*). These species are not ESA-listed, nor are they considered depleted under the MMPA.

In addition, there are two historical records of the West Indian manatee's (*Trichechus manatus*) being sighted in the Potomac River, with the most recent sighting occurring in August 1980 when a single manatee was sighted in the river at Washington, DC (Rathburn and Bonde, 1982, as cited in DoN, 2009).

Table 3.14-4 provides a list of marine mammal strandings in the Potomac River since 1995. The marine mammal was found dead all these stranding, usually in a state of moderate or advanced decomposition. Therefore, strandings data provides the location where the marine mammal was found and not necessarily the location where the mortality occurred. Some degree of transport is likely to have occurred prior to the marine mammal washing up at the stranding site.

[11] Maryland state status categories include threatened, endangered, and in need of conservation (not a legal status) Virginia state status categories include threatened, endangered, and special concern (not a legal status).

The only marine mammal regularly sighted in the Potomac River is the bottlenose dolphin. NOAA's NOS ESI maps (2005) indicate that marine mammals are found in the lower Potomac River from the mouth to Sandy Point, Virginia (the same part of the river where sea turtles are observed). NSF Dahlgren's range control boat operators, who are on the river in the PRTR MDZ five days a week, confirm that marine mammals are not sighted in this most active part of the river range (Patteson, pers. comm., August 4, 2008).

Table 3.14-4
Potomac River Marine Mammal Strandings 1995 - 2011

Observation Year	Common Name	Stranding State	Stranding County
1995	Minke Whale	MD	St. Mary's
1995	Bottlenose Dolphin	MD	St. Mary's
1996	Bottlenose Dolphin	MD	St. Mary's
1999	Harbor Porpoise	MD	St. Mary's
2000	Bottlenose Dolphin	MD	St. Mary's
2001	Bottlenose Dolphin	VA	Northumberland
2002	Risso's Dolphin	MD	Charles
2002	Bottlenose Dolphin	VA	Northumberland
2003	Harbor Porpoise	MD	St Mary's
2003	Bottlenose Dolphin	VA	Northumberland
2004	Bottlenose Dolphin	MD	St. Mary's
2009	Bottlenose Dolphin	VA	Northumberland
2010	Bottlenose Dolphin	VA	Northumberland
2010	Unidentified Delphinid	VA	Northumberland

Notes: Only years with strandings are listed. No marine mammal strandings were reported in the Potomac River in 2011.
Sources: Collins-Payne, NMFS, pers. comm., March 23, 2006, May 23, 2007, and October 13, 2009; Swingle et al., 2011, 2012.

Marine mammal species that have been sighted or stranded in the lower Potomac River are described below.

Bottlenose Dolphin

Bottlenose dolphins are large and robust, with adult body lengths ranging from 8 to 12 ft, depending on habitat (American Cetacean Society, 2004a). They are opportunistic feeders that use many feeding strategies to prey on fish primarily, and sometimes squid and crustaceans (American Cetacean Society, 2004a). In the US Atlantic, the bottlenose dolphin is distributed along the coast from Long Island, New York to the Florida Keys (NOAA, 1994). North of Cape Hatteras, North Carolina, there are concentrations of dolphins found nearshore in embayments and within several miles of the coast, as well as concentrations offshore near the continental shelf margin, about 37 to 124 mi from the coast (NOAA, 1994). Two ecotypes (forms) of bottlenose dolphins are recognized in the western North Atlantic Ocean: the nearshore (coastal) and offshore stock (NMFS, 1997). The dolphins in the Chesapeake Bay form a part of the Western North Atlantic coastal migratory stock.

In Virginia, bottlenose dolphins occur along the entire ocean coast, within one mile of shore, and in the Chesapeake Bay and its tributaries from late spring into the winter. In the Chesapeake Bay area and its tributaries, nearshore bottlenose dolphins are found from April to November (VDEQ, 1997). Since 1995, nine bottlenose dolphin strandings and one unidentified delphinid stranding have been reported in the Potomac River (Table 3.14-4).

Bottlenose dolphins are most likely attracted to the Chesapeake Bay area because of the abundant sources of food. These dolphins feed on a variety of prey, including eels, catfish, menhaden, shrimp, and crabs, all of which are abundant in the bay. The Virginia Marine Science Museum Stranding Program is permitted by NMFS and the state to manage the Virginia Marine Mammal Stranding Network. In Maryland waters, the MDNR Cooperative Oxford Laboratory responds to marine mammal strandings.

In 1987, an apparent disease epidemic broke out, caused by a poisoning by brevetoxin, a neurotoxin produced by *Ptychodiscus brevis* – the dinoflagellate responsible for Florida's red tide (NOAA, 1994; Litwiler, 2001). This poisoning led to infection by bacterial and viral pathogens, resulting in the death of about half of the coastal migratory stock of bottlenose dolphins between Florida and New Jersey (NOAA, 1994). As a result, in 1993 NMFS listed the coastal migratory stock of bottlenose dolphins as depleted under the MMPA and required that a conservation plan be developed. The number of bottlenose dolphins in the northern migratory management unit stretching from New Jersey to Virginia is estimated at about 17,466 individuals (Waring et al., 2007). The population size of bottlenose dolphins in the Chesapeake Bay has not been quantified.

Harbor Porpoise

Harbor porpoises are the smallest cetaceans in the North Atlantic, with a maximum length of 6 ft and a maximum weight of 200 lbs (American Cetacean Society, 2004b). In the North Atlantic they feed on a variety of small, schooling clupeoid (herring-like) and gadoid (cod-like) non-spiny fish, including herring, cod, whiting, and sardines, consuming approximately 10 percent of their body weight each day (American Cetacean Society, 2004b). Harbor porpoises are normally found in subpolar to cool-temperate waters of the northern hemisphere (American Cetacean Society, 2004b, Culik, 2010). The harbor porpoise is an inshore species inhabiting shallow, coastal waters (American Cetacean Society, 2004b).

The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,700 individuals (Waring et al., 2007). Their occurrence in the Chesapeake Bay area is seasonal and is in small numbers. There are two relatively recent records – one in 1999, the other in 2003 – of harbor porpoise strandings in the Maryland portion of the Lower Potomac River near Leonardtown and Scotland in St. Mary's County (Table 3.14-4) (NMFS, 2007).

Risso's Dolphin

Risso's dolphin is a moderately large, robust animal, with an average length of 10 ft and a maximum length of approximately 12.5 ft (American Cetacean Society, 2004c). They primarily feed on cephalopods, such as squid and octopus (Culik, 2010). It is a widely-distributed species, found in the western North Atlantic from Newfoundland southward to the Gulf of Mexico, throughout the Caribbean, and around the equator (Culik, 2010). Risso's dolphins are pelagic, mostly occurring seaward of the continental slope and in deep oceanic waters from 1,312 to 3,281 ft (Culik, 2010). The best estimate of abundance for the western North Atlantic stock is 20,479 individuals (Waring et al., 2007). Based on their depth preferences, they are unlikely to be found in the Potomac River and, in general, strandings in Virginia are rare (Blaylock, 1985). There is one record of stranding in Charles County, Maryland (Table 3.14-4) (NMFS, 2007).

Minke Whale

The minke whale is a small baleen whale, reaching an adult length of about 26 ft, with a maximum length of about 33 ft (American Cetacean Society, 2004d). In the western North Atlantic, minke whales feed primarily on small schooling fish, such as sand lance, capelin, herring, cod, and mackerel, as well as on krill (American Cetacean Society, 2004d). Minke whales are distributed in polar, temperate, and tropical waters, but are less common in the tropics than in cooler waters, resulting in greater abundance in New England waters than in the mid-Atlantic (Waring et al., 2007). Minke whales off the eastern coast of the US are considered to be part of the Canadian East Coast stock that ranges from the eastern half of the Davis Strait (between Greenland and Baffin Island) to the Gulf of Mexico, and is estimated to consist of 3,312 individuals (Waring et al., 2007).

Minke Whale
Balaenoptera acutorostrata

The southernmost sighting in recent NMFS shipboard surveys was of one individual offshore of the mouth of Chesapeake Bay, in waters with a bottom depth of 11,400 ft (Mullin and Fulling, 2003). There is one record of a stranding in the Potomac River in 1995 near Piney Point, Maryland (Table 3.14-4); however as this individual was dead and in a moderate state of decomposition when found, it is uncertain where it died.

West Indian Manatee

The West Indian manatee is found along the coast of Florida and in the Caribbean (USFWS, 2008). Most adult manatees are about 10 ft long and weigh 800 to 1,200 lbs (USFWS, 2008). West Indian manatees are classified as endangered under the ESA.

Manatees are herbivores that feed opportunistically on a wide variety of marine, estuarine, and freshwater plants (USFWS, 2013). They prefer large, slow-moving rivers, river mouths, and shallow coastal areas such as coves and bays (USFWS, 2008). Their range is generally restricted to the southeastern United States with individuals occasionally ranging as far north as Massachusetts and as far west as Texas (USFWS, 2013).

Based on the manatee’s sensitivity to cold waters, they are unlikely to occur in the Chesapeake Bay during the winter months, and all sightings in the northern three-quarters of the Chesapeake Bay are from the summer (DoN, 2009). When ambient water temperatures drop below 68°F manatees aggregate within the confines of natural and artificial warm-water refuges or move to the southern tip of Florida (USWFS, 2001). The mean surface water temperature of the PRTR is below 68°F for eight months of the year, from October through May (Table 3.10-5), limiting the time when manatees could be present. As there have been no manatee sightings in the Potomac

River for more than 30 years and the temperature of the water in the PRTR is too cold for manatees most of the year, the presence of manatees on the PRTR is considered highly unlikely.

3.14.6 Insects

The northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) is listed under the ESA as a threatened species and has been identified by USWFS as potentially occurring in the area (USFWS, January 21, 2013). Their habitat includes open, undisturbed beaches, sand flats, dunes, water edges, woodland paths, and sparse grassy areas (USFWS, 1994). Adult beetles are usually active along the water's edge on bright, clear, sunny days; and eggs are usually deposited below the surface of the sand, above the high-tide mark (Lippson and Lippson, 2006).

The beetle has been observed on beaches along the lowest reaches of the Virginia side of the Potomac River – along the lower PRTR LDZ. Potomac River northeastern beach tiger beetle populations were surveyed in 1998 and again in 2004 (Knisley, pers. comm., September 24, 2008). Populations of tiger beetles were observed between Hull Creek and the mouth of the Little Wicomico River, along the LDZ, 25 mi south of the MDZ's downriver boundary (Figure 3.14-6, Northeastern Beach Tiger Beetle Occurrences). Although the MDNR's database indicates that the beetle occurs on St. Mary's County's shores, populations no longer exist on the Maryland beaches of the Potomac River (Knisley, pers. comm., September 24, 2008).

3.14.7 Plants

In 2004, a rare-plant survey was completed by ESA, Inc. for state-listed and federally-listed rare, threatened, and endangered plant species that are known to occur in the vicinity of NSF Dahlgren (DoN, 2004). Surveyors searched for swamp pink (*Helonias bullata*), narrow-leaved spatterdock (*Nuphar sagittifolia*), small whorled pogonia (*Isotria medeoloides*), harperella (*Ptilimnium nodosum*), New Jersey rush (*Juncus caesariensis*), sensitive joint-vetch (*Aeschynomene virginica*), and water hyssop (*Bacopa innominata*). None of the target species or any other rare plants were found on the installation (DoN, 2004).

The sensitive joint-vetch has been identified by USFWS as potentially occurring in the area (USFWS, January 21, 2013). However, even if this species occurs somewhere on the installation, it is unlikely to be present in the range areas. Sensitive joint-vetch occurs in fresh to slightly brackish tidal river systems, within the intertidal zone, typically occurring at the outer fringe of marshes or shores (USFWS, 1999).

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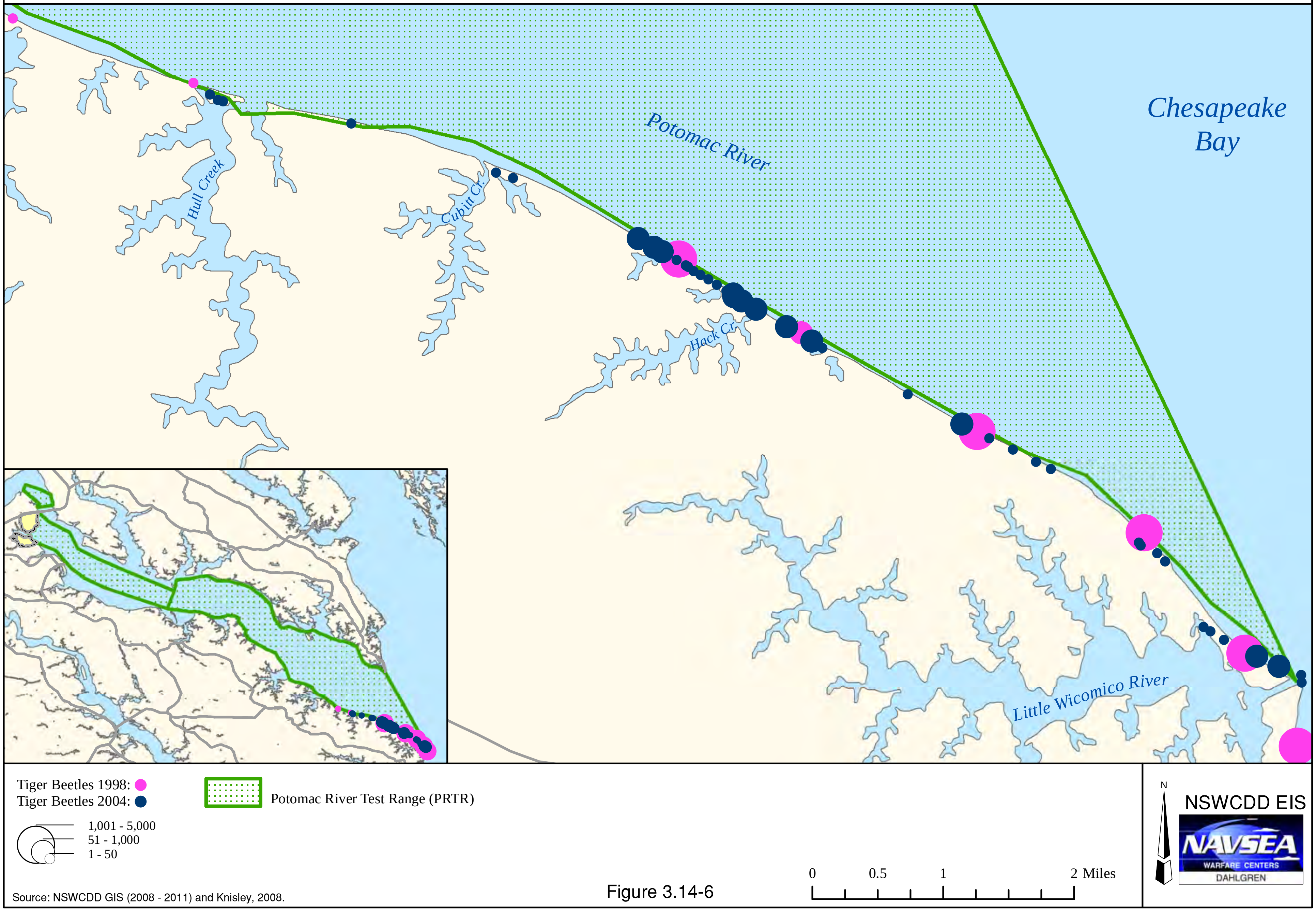
Northeastern Beach Tiger Beetle Occurrences



Source: NSWCDD GIS (2008 - 2011) and Knisley, 2008.

Figure 3.14-6

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