National Park Service
U.S. Department of the Interior

George Washington Memorial Parkway
Virginia

Dyke Marsh Wetland

Restoration and Long-term Management Plan / Draft Environmental Impact Statement

January 2014

UNITED STATES DEPARTMENT OF THE INTERIOR – NATIONAL PARK SERVICE

DYKE MARSH WETLAND RESTORATION AND LONG-TERM MANAGEMENT PLAN / DRAFT ENVIRONMENTAL IMPACT STATEMENT, DYKE MARSH WILDLIFE PRESERVE, VIRGINIA

Lead Agency: National Park Service (NPS), U.S. Department of the Interior

This draft Dyke Marsh Wetland Restoration and Long-Term Management Plan/Environmental Impact Statement describes three alternatives for the restoration and management of the Dyke Marsh Wildlife Preserve (Dyke Marsh) at George Washington Memorial Parkway, as well as the environment that would be affected by the alternatives and the environmental consequences of implementing these alternatives.

The purpose of this plan is to develop and implement actions for restoration and long-term management of the tidal freshwater marsh and other associated wetland habitats that have been lost or impacted in the Dyke Marsh on the Potomac River in Virginia. Dyke Marsh wetland resources, plant and animal communities, and natural ecosystem functions have been damaged by previous human uses and are subject to continuing threats, such as alterations to the hydrology in the Potomac River and in nearby tributaries, and other effects from urbanization in the surrounding region. In addition, the NPS is required to restore Dyke Marsh under Public Law (P.L.) 93-251 and Water Resources Development Act of 2007. A restoration and long-term management plan is needed at this time to protect the existing wetlands from erosion, nonnative plant species, loss of habitat, and altered hydrologic regimes; restore wetlands and ecosystem functions and processes lost through sand and gravel mining and shoreline erosion; avoid increased costs from delayed restoration; and improve ecosystem services that benefit the Potomac River watershed and the Chesapeake Bay.

Under alternative A: no action, there would be no restoration. Current management of the marsh would continue and the destabilized marsh would continue to erode at an accelerated rate.

Under alternative B: Hydrologic Restoration and Minimal Wetland Restoration, the focus is on the most essential actions that would reestablish hydrologic conditions that shield the marsh from erosive currents and protect the Hog Island Gut channel and channel wall. A breakwater structure would be constructed on the south end of the marsh, in alignment with the northernmost extent of the historic promontory. Wetlands would be restored to wherever the water is less than 4 feet deep. This alternative would create approximately 70 acres of various new wetland habitats.

Under alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative), up to 245 acres of various wetland habitats would be restored in a phased approach. The initial phase would stabilize the marsh by installing a breakwater on the southern edge of the historic promontory and restoring marsh in the outline of the historic promontory and along the edge of existing marsh to wherever the water is less than 4 feet deep (approximately 40 acres). Future phases would continue marsh restoration within the historic boundaries of the marsh, including an optional 20-acre restoration cell in the area currently serving as mooring for the marina, which would only be implemented should the marina concession no longer be economically viable.

Alternatives B and C both include fill of deep channels near the breakwater, and reestablishment of hydrologic connections to the approximately 30 acres on the inland side of the Haul Road to restore bottomland swamp forest areas.

The potential environmental consequences of the alternatives are analyzed for hydrology and sediment transport, soils and sediments, surface water quality, floodplains, vegetation and wetlands, fish and wildlife, species of special concern, archeological resources, historic structures and districts and cultural landscapes, visitor use and experience, adjacent property owners and the marina, and park management and operations.

The public comment period for the Draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement will end 60 days after publication of the U.S. Environmental Protection Agency's Notice of Availability in the Federal Register. If you wish to comment on the document, you may mail comments to the address listed below or you may submit them electronically at: http://parkplanning.nps.gov/dykemarshdeis. Before including your address, telephone number, electronic mail address, or other personal identifying information in your comments, you should be aware that your entire comment (including your personal identifying information) may be made publicly available at any time. While you can ask us in your comments to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so. After public review, this document will be revised in response to public comments. A final version of this document will then be released, and a 30-day no-action period will follow. Following the 30-day period, the alternative or actions constituting the approved plan will be documented in a record of decision that will be signed by the Regional Director of the National Capital Region. For further information regarding this document, please contact:

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George Washington Memorial Parkway
Virginia

GEORGE WASHINGTON MEMORIAL PARKWAY

Dyke Marsh Wetland Restoration and Long-term Management Plan / Draft Environmental Impact Statement

January 2014

EXECUTIVE SUMMARY

This draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement (plan/EIS) has been prepared to assist the National Park Service (NPS) in developing and evaluating alternatives for wetland restoration and management for the Dyke Marsh Wildlife Preserve (Dyke Marsh). This document has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), the Council on Environmental Quality (CEQ) regulations implementing NEPA (40 CFR 1500–1508) and the NPS Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-Making*, and Section 106 of the National Historic Preservation Act of 1966, as amended.

This draft plan/EIS evaluates alternatives for wetland restoration of Dyke Marsh at the George Washington Memorial Parkway. The plan/EIS assesses the impacts that could result from continuing current management (the no-action alternative) or implementing one of the two action alternatives.

Upon conclusion of this draft plan/EIS and subsequent decision-making process, the preferred alternative, with its various restoration components, will provide a strategy for long-term monitoring management, and restoration of the Dyke marsh.

BACKGROUND

Dyke Marsh is one of the largest remaining tidal freshwater wetlands in the Washington, D.C., metropolitan area. Based on sediment core samples taken within the marsh by the U.S. Geological Survey (USGS) in 2012, it is estimated that the southern marsh is approximately 2000 years old and the northern marsh is 500 years old (Litwin et al. 2013; Litwin et al. 2011). The alluvial deposits beneath the marsh are approximately 50 feet thick, and are composed of defined layers of silt and clay interspersed in layers of sand and gravel. According to historic documents, the original extent of the property covered approximately 650 acres; the main part of the marsh north of the promontory covered approximately 184 acres in 1937, plus 16 acres south of the promontory, and an additional 15 to 20 acres west of the parkway. The current extent of the marsh is about 60 acres, plus the 15 to 20 acres west of the parkway (Litwin et al. 2011). Dyke Marsh includes tidal freshwater marsh, floodplain forest, and swamp forest habitats with a diverse array of plants and animals.

The first manipulations of Dyke Marsh took place in the early 1800s when colonial landowners tried to convert the marsh area first into a place for ships to tie up and then into pasturelands for grazing (NPS 2009a). In an attempt to create a wet meadow, dikes were constructed around the marsh to keep the tidal influx of water out of the marsh. However, the dikes were difficult to maintain and the land was later abandoned. Shortly after, portions of the dikes failed and the inflow of tidal water formed channels through the meadow, and the tidal freshwater marsh was reestablished (NPS 1977).

The marsh was later indirectly affected when Congress resolved to build a memorial parkway for the celebration of the 200th anniversary of George Washington's birthdate. Congress appropriated funds for the project in 1922 and in 1924 established the United States Commission for the Celebration of the Two Hundredth Anniversary of the Birth of George Washington. Construction of the Mount Vernon Memorial Highway, a portion of which would cross a small section of the marsh along the right-of-way of the former Washington, Alexandria, and Mount Vernon Railway, was authorized in 1928. When the George Washington Memorial Parkway was authorized in 1930, additional property was soon purchased in Dyke Marsh (and elsewhere) to establish larger land holdings to ensure the aesthetic value of the Parkway. Approximately 225 acres of the northern portion of the marsh was acquired during this time period. (NPS 1977, 1996).

In the early 1930s, Smoot Sand and Gravel Corporation (SSGC) acquired 650 acres of land along the Potomac River from Bucknell University. This parcel included the southern 260 acres of Dyke Marsh adjacent to the lands belonging to the United States. By 1940, SSGC had dredged a large portion of the open water areas and destroyed a great deal of marshland (NPS 1977). Between 1940 and 1972, approximately 270 acres of the original marsh were mined for sand and gravel by SSGC, including the swamp forest wetlands of the promontory south of Hog Island Gut.

In the late 1950s, the government, local citizens, and various conservation groups in and around Washington, D.C., including the Audubon Society, the Garden Club of America, and the Wildlife Federation, began expressing concern that the marsh was degrading due to SSGC mining activities. On February 8, 1959, Irston Barnes, the president of the Audubon Society of the District of Columbia, published an article in the Washington Post describing the value of preserving Dyke Marsh. In response to this article and the mounting public interest, in April 1959, Representative Frank Smith of Mississippi drafted bill HR 2228, which authorized the Secretary of the Interior to acquire the southern 260 acres of Dyke Marsh from SSGC for the NPS. The bill, which was intended as a tool for preservation, described Dyke Marsh as "an area of irreplaceable wetlands near the Nation's Capital which is valuable for the production and preservation of wildlife" (Cong. Rec. 86 [first sess.] [1959]). Acreage is stated according to historic records.

Congress passed Public Law (P.L.) 86-41 granting the U.S. government a legislative mandate for management of the marsh (UMCES 2004) on June 11, 1959. The passage of this legislation ensured that a substantial portion of the wetland would remain intact, but allowed SSGC to continue to dredge in some areas of the marsh. As a result, mining continued in certain portions of the marsh until 1972, when SSGC relinquished its dredging rights.

In May 1959, the Committee on Public Works submitted a report to accompany bill HR 2228, stating that it was in the interest of the government to own this strip of land along the Potomac River because it would help preserve the aesthetic qualities of the memorial parkway (S. Rep. 86-280 [1959]). A deed completing the exchange and conveying title to the land from SSGC to the United States was executed on May 31, 1960.

Once the property had passed into NPS ownership, the NPS started activities to fill the deep holes created by the dredging. NPS continued to fill dredged areas in Dyke Marsh into the early 1970s. However, in 1972, Superintendent David Richie wrote a letter to the Director of National Capital Parks that emphasized the significant weaknesses in the overall planning for Dyke Marsh rehabilitation. The NPS realized that there was no effective and scientifically sound management plan, and that placing fill materials to restore the marsh should be more thoroughly analyzed. The letter also requested the professional support of the U.S. Army Corps of Engineers (USACE). As a result, the filling of the dredged areas was halted. In response to the situation, PL 93-251 was enacted on March 7, 1974, at the 93rd session of Congress, authorizing the USACE to assist the NPS in planning, designing, and implementing the restoration and expansion of Dyke Marsh (NPS 1977).

As stated in PL 86-41, SSGC had dredging rights in Dyke Marsh until 1979; however, by 1972 the sand and gravel deposits in the marsh had been exhausted, making dredging operations unprofitable. As a result, in 1975 SSGC relinquished their mining rights and granted the NPS permission to begin restoring the last areas of Dyke Marsh. At this time, a little more than half of the original marsh was still intact and the remainder of the acreage under NPS management was dredged open water.

Although impacts on the marsh from dredging activities have caused the most easily recognizable changes to the marsh, several other changes have resulted from past activities in and near the marsh. The outfall of Hunting Creek and Cameron Run into the Potomac River has been altered by the development of the George Washington Memorial Parkway, urbanization within the watershed, the development of a golf course along the creek and parkway, and upstream channelization. The sediment load from Hunting Creek, which was once carried toward the marsh and helped maintain a depositional environment, is now deposited mostly north of the marsh at the creek's confluence with the Potomac River, where mudflats and emergent wetlands are beginning to develop. These changes have greatly reduced the amount of sediment and nutrients supplied to the marsh by Hunting Creek (NPS 1977; UMCES 2004). More recent disturbances rebuilding the Woodrow Wilson Bridge and several associated interchanges at Hunting Creek could further alter the hydrology in the creek and result in additional impacts on the marsh downstream.

PURPOSE AND NEED FOR ACTION

The purpose of this plan is to develop and implement actions for restoration and long-term management of the tidal freshwater marsh and other associated wetland habitats that have been lost or impacted in the Dyke Marsh on the Potomac River in Virginia.

Dyke Marsh wetland resources, plant and animal communities, and natural ecosystem functions have been damaged by previous human uses and are subject to continuing threats, such as alterations to the hydrology in the Potomac River and in nearby tributaries, and other effects from urbanization in the surrounding region. In addition, the NPS is required to restore Dyke Marsh, under P.L. 93-251, and WRDA 2007. Therefore, a restoration and long-term management plan is needed at this time to

- Protect the existing wetlands from erosion, nonnative invasive plant species, loss of habitat, and altered hydrologic regimes;
- Restore wetlands and ecosystem functions and processes lost through sand and gravel mining and shoreline erosion;
- Avoid increased costs (delayed restoration will result in increased restoration costs); and
- Improve ecosystem services that benefit the Potomac River Watershed and the Chesapeake Bay.

OBJECTIVES IN TAKING ACTION

Objectives are "what must be achieved to a large degree for the action to be considered a success" (NPS 2001). All action alternatives selected for detailed analysis must meet project objectives to a large degree and resolve the purpose of and need for action. Objectives are grounded in the enabling legislation, purpose, and mission goals of the George Washington Memorial Parkway, and should be compatible with direction and guidance provided by the 2005 *George Washington Memorial Parkway Long-range Interpretive Plan* (NPS 2005b). The following are specific objectives for this plan/EIS.

NATURAL RESOURCES

- Restore, protect, and maintain tidal freshwater wetlands and associated ecosystems to provide habitat for fish, wildlife, and other biota.
- Ensure that management actions promote native species while minimizing the intrusion of nonnative invasive plants.
- Reduce erosion of the existing marsh and provide for erosion control measures in areas of restored marsh.

- To the extent practicable, restore and maintain hydrologic processes needed to sustain Dyke Marsh.

- Protect populations of state rare species such as swamp sparrow (*Melospiza georgiana*) and river bulrush (*Bolboschoenus fluviatilis)*.

- Increase the resilience of Dyke Marsh and provide a natural buffer to storms and flood control in populated residential areas.

CULTURAL RESOURCES

- Protect the historic resources and cultural landscape features associated with Dyke Marsh and the George Washington Memorial Parkway.

VISITOR EXPERIENCE

- Enhance appropriate educational, interpretation, and research opportunities at Dyke Marsh and enhance accessibility for diverse audiences.

ALTERNATIVES CONSIDERED

The alternatives under consideration include a required "no-action" alternative and two action alternatives that were developed by an interdisciplinary planning team and through feedback from the public and scientific community during the planning process. The two action alternatives would meet, to a large degree, the objectives for this plan and also the purpose of and need for action. The alternatives are described below.

Alternative A: No Action—Under this alternative, there would be no restoration. Current management of the marsh would continue, which includes providing basic maintenance related to the Haul Road, control of nonnative invasive plant species, ongoing interpretive and environmental education activities, scientific research projects, boundary marking, and enforcement of existing regulations. There would be no manipulation of the marsh other than emergency, safety-related, or limited improvements or maintenance actions. The destabilized marsh would continue to erode at an accelerated rate (Litwin et al. 2011).

Alternative B: Hydrologic Restoration and Minimal Wetland Restoration—Under alternative B, the focus is on the most essential actions that would reestablish hydrologic conditions that shield the marsh from erosive currents and protect the Hog Island Gut channel and channel wall. A breakwater structure would be constructed on the south end of the marsh, in alignment with the northernmost extent of the historic promontory, close to the historic edge of hog island gut, and wetlands would be restored to wherever the water is less than 4 feet deep. This alternative also includes fill of some deep channel near the breakwater. The final element of this alternative is the reestablishment of hydrologic connections to the inland side of the Haul Road to restore bottomland swamp forest areas that were cut off when the Haul Road was constructed. Approximately 30 acres west of the Haul Road could be influenced by tidal flows as a result. These actions would not necessarily happen in any particular order, and may be dictated by available funds. However, it is assumed that the breakwater would be constructed first. This alternative would create approximately 70 acres of various new wetland habitats and allow the continued natural accretion of soils and establishment of wetlands given the new hydrologic conditions.

Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)—Under alternative C, the marsh would be restored in a phased approach up to the historic boundary of the marsh and other adjacent areas within NPS jurisdictional boundaries. The initial phase would install a breakwater, establish marsh in the outline of the historic promontory, fill the deep channels within the park, and restore marsh along the edge of existing marsh to wherever the water is less than 4 feet deep (approximately 40 acres) to stabilize the marsh and protect Hog Island Gut. Future phases would continue marsh restoration until a sustainable marsh is achieved and meets the overall goals of the project. The historic boundaries lie between the historic promontory and Dyke Island, the triangular island off the end of the Haul Road. The outer edges of the containment cell structures would be placed at the park boundary in the river. This alternative contains an optional 20-acre restoration cell in the area currently serving as mooring for the marina. Such an option would only be implemented should the marina concession no longer be economically viable for the current concessioner, and no other concessioner expresses interest in taking over the business, eliminating the need for the mooring field. Restoration of 16 acres of wetlands south of the breakwater is also included as an option. Approximately 245 acres of various wetland habitats could be created overall, including the options.

ENVIRONMENTAL CONSEQUENCES

The summary of environmental consequences considers the actions being proposed and the cumulative impacts on resources from occurrences inside and outside the park. The potential environmental consequences of the actions are addressed for hydrology and sediment transport, soils and sediments, surface water quality, floodplains, vegetation and wetlands, fish and wildlife, species of special concern, archeological resources, historic structures and districts and cultural landscapes, visitor use and experience, adjacent property owners and the marina, and park management and operations. Impacts are summarized in chapter 2, table 2-6.

Under the no-action alternative no restoration would occur and erosion would be severe enough that the marsh would likely disappear. The no-action alternative would result in significant adverse impacts on hydrology and sediment transport, soils and sediment transfer, vegetation and wetlands, fish and wildlife, and plant and animal species of concern found in the marsh. The erosion and eventual disappearance of the marsh would result in adverse but not significant impacts on the remaining resources and values.

Alternative B would result in long-term beneficial impacts on most resources, including significant beneficial impacts on hydrology and sediment transport, and vegetation and wetlands, as a result of placement of the breakwater, restoration of marsh that would stabilize erosion, and reintroduction of tidal flows west of the Haul Road. The breakwater, placed on the northern side of the historic promontory, would be visible from parts of the parkway and Mount Vernon Trail, and would therefore result in adverse effects on cultural landscapes and visitor use and experience. There would be short-term adverse impacts on most resources from construction-related activities. None of the short-term impacts would be significant.

Alternative C would result in long-term beneficial impacts on most resources, slightly greater in magnitude than the benefits from alternative B. As with alternative B, the beneficial impacts on hydrology and sediment transport, as well as vegetation and wetlands, would be significant, because the marsh would be stabilized and the amount of vegetation and wetlands would be greatly increased. The magnitude of the increase in marsh would also result in potentially significant benefits for fish and wildlife and species of concern. There would be short-term adverse impacts on most resources during construction, although these impacts would not be significant. For visitor use and experience, impacts from construction may be significant because the impacts would take place over a period of years and would be noticeable, although the impacts would end when construction was complete.

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Acronyms and Abbreviations

BMP	best management practice
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CZMA	Coastal Zone Management Act
CZMP	coastal zone management program
EA	environmental assessment
EIS	environmental impact statement
GPS	global positioning system
NEPA	National Environmental Policy Act
NPS	National Park Service
NRHP	National Register of Historic Places
PCB	polychlorinated biphenyl
PEPC	Planning, Environment, and Public Comment
plan/EIS	Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement
SAV	submerged aquatic vegetation
SHPO	State Historic Preservation Office
SSGC	Smoot Sand and Gravel Corporation
TMDL	total maximum daily load
UMCES	University of Maryland Center for Environmental Sciences
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VA DCR	Virginia Department of Conservation and Recreation
VDGIF	Virginia Department of Game and Inland Fisheries

Chapter 1:

Purpose of and Need for Action

CHAPTER 1: PURPOSE OF AND NEED FOR ACTION

INTRODUCTION

Dyke Marsh is a large wetland area on the Potomac River south of Alexandria, Virginia, that is part of the George Washington Memorial Parkway. The marsh is one of the few remaining tidal freshwater marshes on the Potomac River. Such marshes provide habitat for many species of plants and animals, including rare species and species of state concern. Before the marsh came under the ownership of the National Park Service (NPS), and continuing during NPS administration, it was dredged extensively for the gravel deposits that underlay the marsh, and the result has been loss of acreage and acceleration of erosion in the marsh. Congress has declared in several pieces of legislation that the marsh is a valuable resource to the region, and should be preserved and restored, particularly in Public Law (P.L.) 93-251 in 1974, and most recently in the Water Resources Development Act of 2007 (WRDA 2007, Section 5147).

This draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement (plan/EIS) has been prepared to assist the NPS in developing and evaluating alternatives for wetland restoration and management for the Dyke Marsh Wildlife Preserve (hereafter referred to as "Dyke Marsh." This document has been prepared in accordance with the 1969 National Environmental Policy Act (NEPA) and Section 106 of the National Historic Preservation Act of 1966, as amended.

This "Purpose of and Need for Action" chapter explains what the wetland restoration and long-term management plan intends to accomplish and why the NPS is taking action at this time. This plan/EIS presents several alternatives for implementing wetland habitat restoration within Dyke Marsh, and assesses the impacts that could result from continuing the current practices (the no-action alternative) or implementing any of the action alternatives. Upon completion of this plan/EIS and decision-making process, one of the alternatives will become the Dyke Marsh wetland restoration plan and will guide the long-term, monitoring, management, and restoration of the marsh. Brief summaries of both the purpose and need are presented here, and more information about the marsh and its history is available in the "Background" section of this chapter.

PURPOSE OF THE PLAN

The purpose of this plan is to develop and implement actions for restoration and long-term management of the tidal freshwater marsh and other associated wetland habitats that have been lost or impacted in Dyke Marsh on the Potomac River in Virginia.

NEED FOR ACTION

Dyke Marsh wetland resources, plant and animal communities, and natural ecosystem functions have been damaged by previous human uses and are subject to continuing threats, such as alterations to the hydrology in the Potomac River and in nearby tributaries, and other effects from urbanization in the surrounding region. In addition, the NPS is required to restore Dyke Marsh, under P.L. 93-251, and WRDA 2007, Section 1547. Therefore, a restoration and long-term management plan is needed at this time to

The U.S. Environmental Protection Agency defines "ecosystem services" as "the many life-sustaining benefits we receive from nature—clean air and water, fertile soil for crop production, pollination, and flood control. These ecosystem services are important to our health and well-being, yet they are limited and often taken for granted as being free" (USEPA 2009).

- Protect the existing wetlands from erosion, nonnative plant species, loss of habitat, and altered hydrologic regimes;
- Restore wetlands and ecosystem functions and processes lost through sand and gravel mining and shoreline erosion;
- Avoid increased costs (delayed restoration will result in increased restoration costs); and
- Improve ecosystem services that benefit the Potomac River Watershed and the Chesapeake Bay.

OBJECTIVES IN TAKING ACTION

Objectives are “what must be achieved to a large degree for the action to be considered a success” (NPS 2001). All action alternatives selected for detailed analysis must meet project objectives to a large degree and resolve the purpose of and need for action. Objectives are grounded in the enabling legislation, purpose, and mission goals of the George Washington Memorial Parkway (the park), and should be compatible with direction and guidance provided by the 2005 *George Washington Memorial Parkway Long-range Interpretive Plan* (NPS 2005b). The following are specific objectives for this plan/EIS.

NATURAL RESOURCES

- Restore, protect, and maintain tidal freshwater wetlands and associated ecosystems to provide habitat for fish, wildlife, and other biota.
- Ensure that management actions promote native species while minimizing the intrusion of nonnative invasive plants.
- Reduce erosion of the existing marsh and provide for erosion control measures in areas of restored marsh.
- To the extent practicable, restore and maintain hydrologic processes needed to sustain Dyke Marsh.
- Protect populations of species of concern such as swamp sparrow (*Melospiza georgiana*) and river bulrush (*Bolboschoenus fluviatilis*).
- Increase the resilience of Dyke Marsh and provide a natural buffer to storms and flood control in populated residential areas.

CULTURAL RESOURCES

- Protect the historic resources and cultural landscape features associated with Dyke Marsh and the George Washington Memorial Parkway.

VISITOR EXPERIENCE

- Enhance appropriate educational, interpretation, and research opportunities at Dyke Marsh and enhance accessibility for diverse audiences.

PROJECT SITE LOCATION

The geographic project area for this plan/EIS is the Dyke Marsh Wildlife Preserve, located on the Potomac River in Fairfax County, south of the City of Alexandria, Virginia (figure 1-1), and within the George Washington Memorial Parkway. The project area falls completely within the park boundaries and includes forested areas, wetlands, and open water areas within the Commonwealth of Virginia. Hog Island Gut, the portion of the Dyke Marsh that extends to the west side of the George Washington Memorial Parkway, is considered to be within the project area for this plan/EIS.

Tidal guts are stream-like features found in tidal marshes formed by advancing and receding tides

BACKGROUND

GEORGE WASHINGTON MEMORIAL PARKWAY AND DYKE MARSH

The George Washington Memorial Parkway was authorized in 1930 by the Capper-Cramton Act as a park roadway to run along both shores of the Potomac River from Mount Vernon, Virginia, and Fort Washington, Maryland, northerly to the Great Falls of the Potomac. Its purpose was for the protection and preservation of the lands along the Potomac River and it expanded upon the mission of the previously 1928-authorized Mount Vernon Memorial Highway that was to serve as a scenic, commemorative roadway connecting Washington, D.C., with the George Washington Mount Vernon estate. The George Washington Memorial Parkway incorporated the under-construction Mount Vernon Memorial Highway and extended the parkway beyond the originally envisioned connection of the nation's capital to the first president's home to become a grand gateway and greenway system into Washington, D.C. (NPS 1996).

The *George Washington Memorial Parkway Long-range Interpretive Plan* defines the overall purpose of Dyke Marsh Wildlife Preserve, which is "to protect irreplaceable wetlands which are valuable for the reproduction and preservation of wildlife near the Nation's Capital" (NPS 2005b). The plan states that Dyke Marsh is significant in that it is "one of the largest naturally occurring tidal freshwater marshes in the National Park System," and contains a narrowleaf cattail (*Typha angustifolia*) community that is a dominant vegetative feature. The marsh is an oasis in the Washington, D.C., metropolitan area, providing ample and diverse opportunities for inspiration, wildlife observation, interaction with the natural environment, exercise, and fun through a variety of outdoor experiences. The history of Dyke Marsh illustrates a lineage of human interaction with this environment, from Native American hunting and fishing and colonial farming with the creation of dykes to sand and gravel dredging and current use of the marsh as a preserve and recreation area (NPS 2005b).

Dyke Marsh is also important in that it contributes to the health of the Potomac River and the Chesapeake Bay Watershed by filtering pollutants contributed from adjacent urban land uses.

FIGURE 1-1. DYKE MARSH PROJECT AREA LOCATION

HISTORY OF THE DYKE MARSH SYSTEM

Dyke Marsh Description

Dyke Marsh is one of the largest remaining tidal freshwater wetlands in the Washington, D.C., metropolitan area. Based on sediment core samples taken within the marsh by the U.S. Geological Survey (USGS), it is estimated that the southern marsh is approximately 2,200 years old and the northern marsh is 500 years old (Litwin et al. 2013; Litwin et al. 2011). The alluvial deposits beneath the marsh are approximately 50 feet thick, and are composed of defined layers of silt and clay interspersed in layers of sand and gravel. Although the original extent of the property covered approximately 650 acres. In 1937, the main part of the marsh north of the promontory covered approximately 184 acres, and there were 16.5 acres south of the promontory, and an additional 15 to 20 acres west of the parkway. The current extent of the marsh is about 60 acres, plus the 15 to 20 acres west of the parkway (Litwin et al. 2011; Litwin et al. 2013). Dyke Marsh includes tidal freshwater marsh, floodplain forest, and swamp forest habitats with a diverse array of plants and animals.

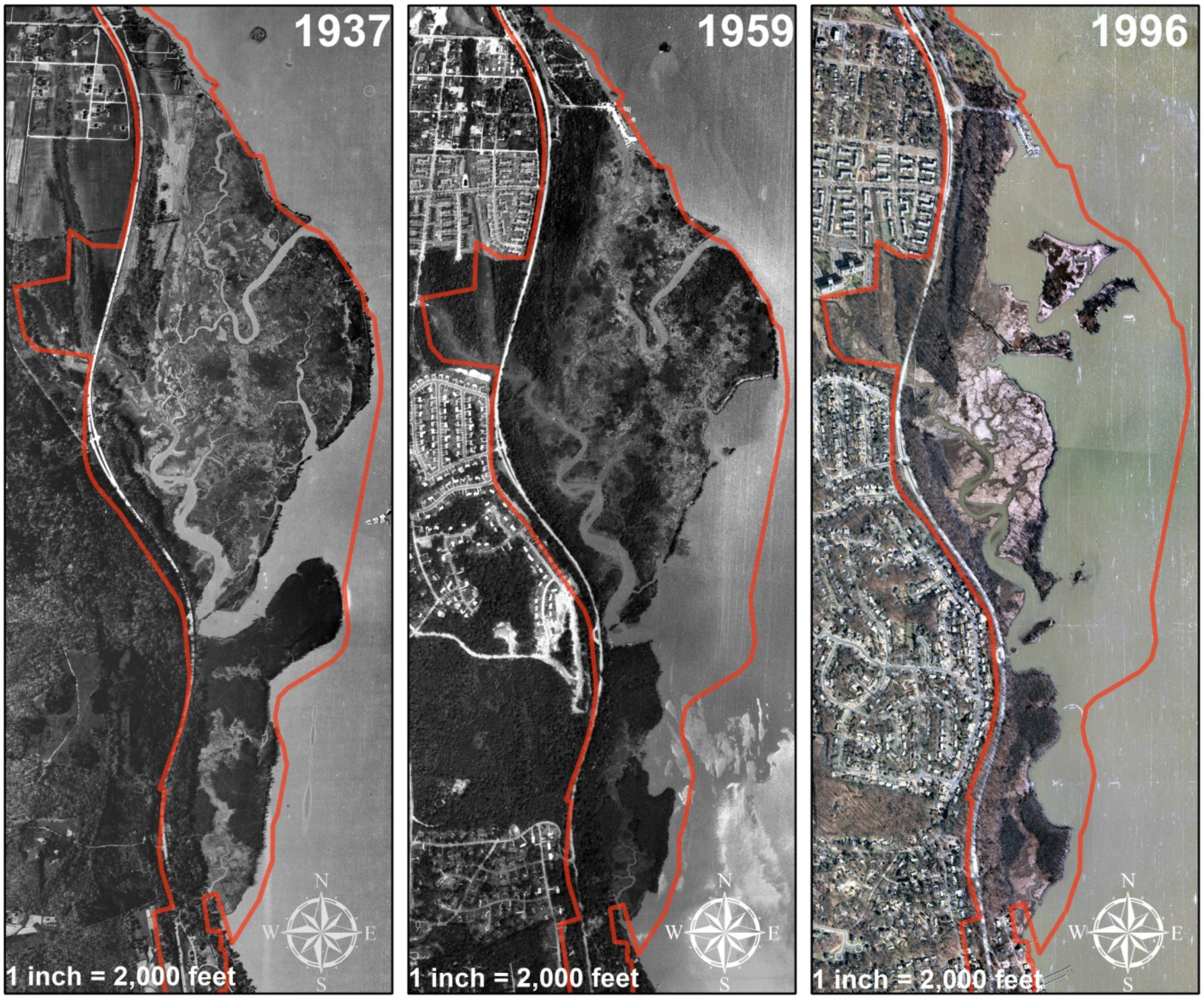
The tidal marsh, floodplain forest, and swamp forest found within Dyke Marsh provide habitat for approximately 300 plant species, 6,000 arthropod species, 38 fish species, 16 reptile species, 14 amphibian species, and over 230 bird species (FODM 2007). In 2011, the breeding bird survey confirmed 40 species of birds breeding in the marsh, including both the least bittern, which is on the state watch list, and the marsh wren (*Cistothorus palustris*). Dyke Marsh has the only known nesting population of marsh wrens in the Upper Potomac River tidal zone. The marsh is dominated by narrowleaf cattail. Other species within the marsh include arrow arum (*Peltandra virginica*), arrowhead (*Sagittaria latifolia*), pickerelweed (*Pontederia cordata*), sweetflag (*Acorus calamus*), spatterdock (*Nuphar lutea*), and wild rice (*Zizania aquatica*) (NPS 2008b). Dyke Marsh is unusual in that it has remained as a climax cattail marsh, possibly because of periodic inundation and river scouring and large storm events that have stifled the establishment of upland successional species (R. Hammerschlag, pers. comm. 2007).

Land Use History

The first manipulations of Dyke Marsh took place in the early 1800s when colonial landowners tried to convert the marsh area first into a place for ships to tie up and then into pasturelands for grazing (NPS 2009a). In an attempt to create a wet meadow, dikes were constructed around the marsh to keep the tidal influx of water out of the marsh. However, the dikes were difficult to maintain and the land was later abandoned. Shortly after, portions of the dikes failed and the inflow of tidal water formed channels through the meadow, and the tidal freshwater marsh was reestablished (NPS 1977).

The marsh was later indirectly affected when Congress resolved to build a memorial parkway for the celebration of the 200th anniversary of George Washington's birthdate. In 1924, Congress established the United States Commission for the Celebration of the Two Hundredth Anniversary of the Birth of George Washington. Construction of the Mount Vernon Memorial Highway, a portion of which would cross a small section of the marsh along the right-of-way of the former Washington, Alexandria, and Mount Vernon Railway, was authorized in 1928. When the George Washington Memorial Parkway was authorized in 1930, additional property was soon purchased in Dyke Marsh (and elsewhere) to establish larger land holdings to ensure the aesthetic value of the parkway. Approximately 225 acres of the northern portion of the marsh was acquired during this period (NPS 1977; 1996).

In the early 1930s, Smoot Sand and Gravel Corporation (SSGC) acquired 650 acres of land along the Potomac River from Bucknell University. This parcel included the southern 260 acres of Dyke Marsh adjacent to the lands belonging to the United States. By 1940, SSGC had dredged a large portion of the open water areas and destroyed a great deal of marshland (NPS 1977). Between 1940 and 1972, approximately 270 acres of the original marsh were mined for sand and gravel by SSGC, including the swamp forest wetlands of the promontory south of Hog Island Gut (see figure 1-2).



Source: Historic imagery courtesy of Fairfax County, Virginia

FIGURE 1-2. DYKE MARSH HISTORICAL AERIAL PHOTOGRAPHS FROM 1937, 1959, AND 1996, SHOWING EXTENT OF DREDGING AND EROSION

In the late 1950s, the government, local citizens, and various conservation groups in and around Washington, D.C., including the Audubon Society, the Garden Club of America, and the Wildlife Federation, began expressing concern that the marsh was degrading due to SSGC mining activities. On February 8, 1959, Irston Barnes, the president of the Audubon Society of the District of Columbia, published an article in the Washington Post describing the value of preserving Dyke Marsh. In response to this article and the mounting public interest, in April 1959, Representative Frank Smith of Mississippi drafted bill HR 2228, which authorized the Secretary of the Interior to acquire the southern 260 acres of Dyke Marsh from SSGC for the NPS. The bill, which was intended as a tool for preservation, described Dyke Marsh as “an area of irreplaceable wetlands near the Nation’s Capital which is valuable for the production and preservation of wildlife” (Cong. Rec. 86 [first sess.] [1959]). Acreage is stated according to historic records.

Congress passed P.L. 86-41 granting the U.S. government a legislative mandate for management of the marsh (UMCES 2004) on June 11, 1959. The passage of this legislation ensured that a substantial portion of the wetland would remain intact, but allowed SSGC to continue to dredge in some areas of the marsh. As a result, mining continued in certain portions of the marsh until 1972, when SSGC relinquished its dredging rights.

In May 1959, the Committee on Public Works submitted a report to accompany bill HR 2228, stating that it was in the interest of the government to own this strip of land along the Potomac River because it would help preserve the aesthetic qualities of the memorial parkway (S. Rep. 86-280 [1959]). A deed completing the exchange and conveying title to the land from SSGC to the United States was executed on May 31, 1960.

Post-dredging Rehabilitation Actions

Once the property had passed into NPS ownership, the NPS started activities to fill the deep holes created by the dredging. NPS continued to fill dredged areas in Dyke Marsh into the early 1970s. However, in 1972, Superintendent David Richie wrote a letter to the Director of National Capital Parks that emphasized the significant weaknesses in the overall planning for Dyke Marsh rehabilitation. The NPS realized that there was no effective and scientifically sound management plan, and that placing fill materials to restore the marsh should be more thoroughly analyzed. The letter also requested the professional support of the U.S. Army Corps of Engineers (USACE). As a result, the filling of the dredged areas was halted. In response to the situation, PL 93-251 was enacted on March 7, 1974, at the 93rd session of Congress, authorizing the USACE to assist the NPS in planning, designing, and implementing the restoration and expansion of Dyke Marsh (NPS 1977).

As stated in PL 86-41, SSGC had dredging rights in Dyke Marsh until 1979; however, by 1972 the sand and gravel deposits in the marsh had been exhausted, making dredging operations unprofitable. As a result, in 1975 SSGC relinquished its mining rights and granted the NPS permission to begin restoring the last areas of Dyke Marsh. At this time, a little more than half of the original marsh was still intact and the remainder of the acreage under NPS management was dredged open water.

With USACE support and dredging operations completed, the NPS began to research marsh restoration. The *Rehabilitation of Dyke Marsh* project included area surveys; mapped out plans for dikes and polders (the reclaimed or low-lying land behind the dikes); and hydrographic surveys showing existing underwater conditions, topography, existing and projected shoreline after marsh expansion, and fill areas. As part of this effort, the NPS, with the help of the USACE, conducted an environmental assessment (EA) of management options for Dyke Marsh (NPS 1977). Three alternatives were analyzed in the EA:

- Take no action, allowing natural processes to guide the evolution of the marsh. No physical manipulation of the marsh would be conducted under this alternative.
- Use intensive management techniques within portions of the remnant marsh. The intensive management alternative involved the deliberate manipulation of existing marshlands through bulldozing, grading, dredge and fill, explosives, ditching, and weirs.
- Investigate the reestablishment of stabilized wetlands in areas that were dredged. The feasibility of this alternative would be checked first through the establishment of a test/demonstration area.

The marsh reestablishment alternative involved constructing a 28-acre test/demonstration area surrounded by newly constructed dikes (figure 1-3). The demonstration area was proposed on the north end of the marsh, stretching from the end of Haul Road and the smaller island out into the Potomac River (NPS 1977). If the demonstration area proved successful, it was proposed that the reestablishment would be expanded to other sections of the marsh. However, based on lack of resources and other considerations, the EA was not published, the NEPA process was never completed, and no restoration actions were ever implemented at the marsh (Pavek, pers. comm. 2013).

Changes to the Dyke Marsh Resulting from Past Activities

As noted earlier, several hundred acres of the marsh were dredged, creating deep holes and channels and removing substantial amounts of marsh vegetation. The alignment of the tidal guts and inlets has also changed since dredging activities began. Sometime during the 1950s, dredging activities removed the promontory of land south of Hog Island Gut, which likely impacted the hydrology of the marsh (figure 1-2).

Although impacts on the marsh from dredging activities have caused the most easily recognizable changes to the marsh, several other changes have resulted from past activities in and near the marsh. The outfall of Hunting Creek and Cameron Run into the Potomac River has been altered by the development of the George Washington Memorial Parkway, urbanization within the watershed, the development of a golf course along the creek and parkway, and upstream channelization. The sediment load from Hunting Creek, which was once carried toward the marsh and helped maintain a depositional environment, is now deposited mostly north of the marsh at the creek's confluence with the Potomac River, where mudflats and emergent wetlands are beginning to develop. These changes have greatly reduced the amount of sediment and nutrients supplied to the marsh by Hunting Creek (NPS 1977; UMCES 2004). More recent disturbances rebuilding the Woodrow Wilson Bridge and several associated interchanges at Hunting Creek could further alter the hydrology in the creek and result in additional impacts on the marsh downstream (Litwin et al. 2013).

After the NPS took ownership of the property, the NPS began the process of refilling dredged areas, and during the 1960s and early 1970s deposited fill material in the marsh. However, this process was conducted without a scientifically based management plan and was halted in 1972. It is not clear from recent studies and photos whether the filling of dredged areas during the 1960s and early 1970s had any measurable impacts.

Haul Road, the path that serves as the current nature trail Dyke Marsh, was constructed as a vehicle road during the 1940s by SSGC. It was used to support dredging operations and to haul construction debris and other dredge spoils. When Haul Road was built, it effectively disconnected the land on the west side of the road from tidal inundation. As a result, succession has occurred in this area, and now large upland trees and exotic invasive species are prevalent in the area west of Haul Road.

Haul Road

Source: NPS 1977

FIGURE 1-3. DYKE MARSH DEMONSTRATION AREA

Erosion in Dyke Marsh is a source of NPS maintenance costs. Erosion, caused primarily by storm waves driven northward up the Potomac River, is evident along the entire western bank of the Potomac River, including along Haul Road. Erosion has progressed from the southeast to the northwest. The riverbed has also eroded, with the downstream two-thirds of the marsh experiencing most of the erosion. The upstream one-third of the marsh is experiencing some deposition (NPS 2009b; Litwin et al. 2011) (figure 1-4).

The Belle Haven Marina, at the north end of Dyke Marsh, contains several moorings, docks, a sailing school, and a rental concession for small sailboats, kayaks, and canoes. The moorings are located in some of the deeper holes created by the dredging, although the area behind the canoe dock is filling in with sediment.

SCIENTIFIC BACKGROUND

Wetlands, the transitional lands between aquatic habitat and upland terrestrial areas, serve several critical functions. They provide habitat as well as breeding and feeding grounds for fish and wildlife, and they serve critical water quality and flood control functions by filtering pollutants and acting as a sponge and a barrier between open water and uplands (Cowardin et al. 1979). Tidal freshwater wetlands occur in the uppermost portion of the estuarine zone, where the inflow of saltwater from tidal influence is diluted by a larger volume of freshwater from upstream and salt concentrations are less than 0.5 parts per thousand.

Tidal freshwater wetlands such as Dyke Marsh once occurred extensively along the rivers in the coastal plain of the Mid-Atlantic, but rivers and coastal wetlands have come under natural and human threats, and the USGS estimates that at least half of the wetlands present in colonial times may have been lost (USGS 2008). Coastal wetlands are under threat from erosion and subsidence. Riverine and inland wetlands have been impacted by such activities as dredging, nonpoint source pollution, and other changes that can in turn affect habitat, hydrology, and wetland function.

PAST RESEARCH ON DYKE MARSH

Since the 1974 congressional mandate to restore Dyke Marsh, the marsh has been the subject of numerous physical and biological surveys. Researchers from the University of Maryland Center for Environmental Sciences (UMCES) Appalachian Laboratory held a workshop in 2004 to compile and review the existing data and collect additional information on Dyke Marsh to assess the feasibility of restoring the dredged portions of Dyke Marsh, while maintaining the integrity and health of the existing marsh. The data included all of the studies conducted on the marsh since the 1990s, such as an inventory of plant species in 1991 (Xu 1991, as discussed in UMCES 2004) as well as a collection of case studies of restoration projects in the region for the purpose of obtaining lessons learned and relating them to the process of establishing feasibility.

The UMCES workshop materials listed several studies on the marsh and other wetlands:

- Inventories of marsh vegetation and plant communities (Xu 1991, as discussed in UMCES 2004).
- Bathymetric surveys of Dyke Marsh to determine erosion rates and underwater topographic pattern left by sand and gravel dredging (Harper and Heliotis 1992; NPS 2009b).
- A hydrologic simulation model for Dyke Marsh to enhance ecosystem monitoring and provide information for future restoration projects (Harper and Heliotis 1992).
- Study of marsh wrens (Spencer 2000).

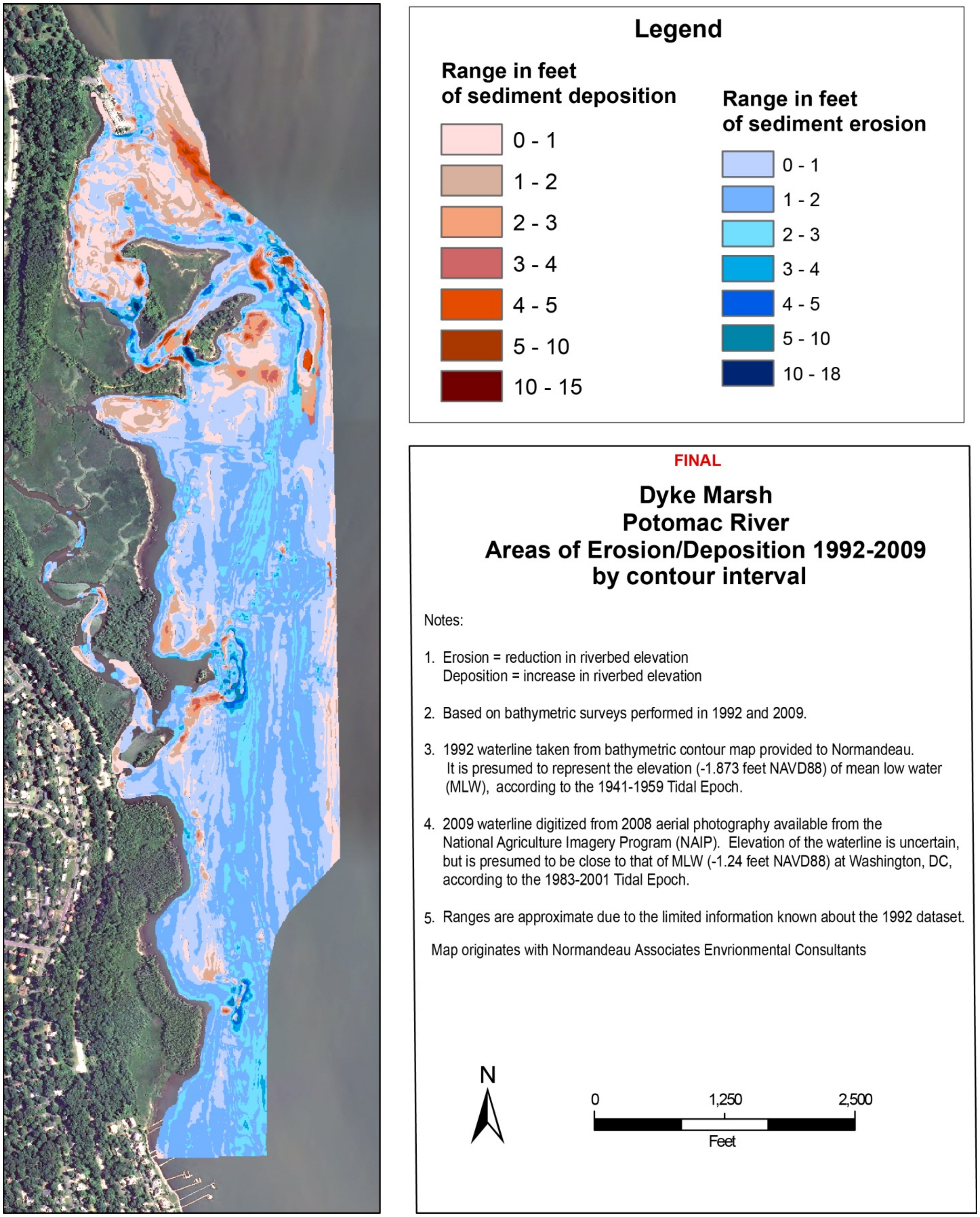


FIGURE 1-4. EROSION AND DEPOSITION AT DYKE MARSH 1992–2009

- Study of terrestrial arthropod and alien plant diversity in the forested areas of Dyke Marsh (Barrows and Kjar 2003).
- Survey of leaf beetles (Cavey et al. 2013).
- Inventory of the various fish species found in and around the Dyke Marsh area (Mangold et al. 2004).
- Annual surveys of breeding birds in the marsh (Cartwright 2004; FODM various years).
- Studies of soils, elevation, and the diversity of vegetation communities and their topographic positions in the marsh (UMCES 2004).
- A seed germination project examining the quantity of seeds and species of seeds floating into the marsh due to tides, river currents, and storms (UMCES 2004).
- Water quality analysis considered samples taken from six different locations around Dyke Marsh, including from the Potomac River and tidal guts, in summer. The water samples were analyzed for ammonia, nitrate+nitrite, nitrite, ortho-phosphate, total suspended solids, and total fecal coliform (UMCES 2004).
- A tidal gauge was installed in May 2004 at the Belle Haven Marina.

More recent studies on the marsh include a 2005 study mapping vegetation within the marsh using ecology field sampling and classification techniques combined with remote sensing technologies (Engelhardt and Elmore 2007), a second vegetation mapping project sponsored by the NPS National Capital Region, and a 2009 bathymetric survey conducted to document areas of erosion and deposition within the marsh (NPS 2009b). The Engelhardt and Elmore (2007) report, titled *Should We Restore Dyke Marsh? A Management Dilemma Facing George Washington Memorial Parkway*, found that “elevation maps, and to a limited degree tidal channel information, could inform the development and interpretation of vegetation maps because vegetation appeared to respond to the physical gradient that elevation and channel size and distance confer” and recommended that elevation maps be used as a guide for marsh restoration designs. The 2009 bathymetry study found that much of the western shoreline of the Potomac River has experienced erosion since 1992. It also found that riverbed erosion has occurred over a much larger area of Dyke Marsh than deposition, with most of the erosion occurring in the southern (downstream) two-thirds of the marsh and most of the deposition occurring in the northern (upstream) third of the marsh (NPS 2009b) (figure 1-4).

The erosional state of Dyke Marsh and several other issues have been further studied by scientists with the USGS in partnership with the NPS and researchers familiar with the marsh. Litwin et al. examined the age of the marsh; the size of the marsh from 1937 to the present; pre- and post- mining configurations of Dyke Marsh; causes, characteristics, and rates of erosion in the marsh; geologic factors that could diminish marsh erosion; and whether or not the marsh is in a naturally sustainable state (Litwin et al. 2011; Litwin et al. 2013). The researchers found that the marsh had been relatively stable for at least 73 years prior to the commencement of dredging, and that the dredging and other alterations significantly altered the tidal creeks that are the marsh’s primary source of sediment (Litwin et al. 2011; Litwin et al. 2013).

These researchers also found that the post-mining marsh remnant is shrinking rapidly as a result of erosion. Storm waves driven upstream from tropical storms, hurricanes, and nor’easters (large-scale coastal storms whose winds blow predominantly out of the northeast) have been the primary agents of marsh erosion, rather than flooding from upriver. Researchers found that linear erosion in the marsh averages between 6 and 8 feet per year, and that the outer walls of Hog Island Gut are not stable without the protective promontory removed in the 1950s that had directed flow from the gut upstream; they also found that without intervention through manmade stabilization of geological features such as the promontory, the marsh would continue to deconstruct (Litwin et al. 2011; Litwin et al. 2013).

The Interagency Workgroup on Wetland Restoration, made up of representatives from the National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency (USEPA), USACE, U.S. Fish and Wildlife Service (USFWS), and the Natural Resources Conservation Service, produced *An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement* in 2003 (IWWR 2003). This guide provides an overall background on wetlands and wetland restoration; discusses project planning, implementation, and monitoring; and provides a list of resources, contacts, and funding sources.

Dyke Marsh

A 2006 feasibility study entitled "The Use of Case Studies in Establishing Feasibility for Wetland Restoration" used Dyke Marsh as a focal point for assessing the importance of incorporating lessons learned from previously completed restoration projects in the success of similar future endeavors (Hopfensperger, Engelhardt, and Seagle 2006). The authors posited that establishing restoration feasibility is "a multifaceted process and aspects of site ecological, social, and economic conditions should be considered." Five completed wetland restoration projects that reported successes and failures were examined and commonalities among them were identified. Most of the case studies that were examined in this study identified the need for the following:

- gathering preexisting and historical information
- developing scenarios through hydrologic modeling
- studying the fill and plant materials to be used in restoration
- using best professional judgment for unanswered questions
- establishing multigroup collaboration
- gaining public support from stakeholders
- post-restoration monitoring.

These lessons were applied to a study that evaluated the feasibility of restoring Dyke Marsh, and it was found that the use of case studies substantially increased confidence in the decision-making process. The additional knowledge focused discussions on the most important ecological, social, and economic aspects of a potential restoration.

Finally, after it was determined at the first alternatives development meeting in 2009 that more information was needed on the hydrodynamics of the marsh and the probability of success of the proposed alternative elements, the USACE engaged hydrologists and engineers to perform more detailed bathymetry studies; conduct one- and two-dimensional hydrodynamic modeling that considers flow depth, velocity, and sediment transport and deposition; and develop or refine the alternatives based on the study findings. This research provided a baseline understanding of current hydrodynamics in the marsh, as well as an understanding of how well the alternatives discussed in chapter 2 will work in reestablishing a sustainable marsh environment. The USACE and its consultants examined existing flows and sediment transport in the marsh, and the effects of the proposed breakwater on flows and sediment transport. All action alternatives were modeled as well to evaluate how the restoration would work over the long term. (USACE 2013)

WETLAND RESTORATION MANAGEMENT ISSUES

Although there are congressional mandates to restore the marsh, marsh restoration is a difficult science, and several issues need to be considered during the restoration process. Most studies on wetland restoration focus on saltwater marsh or nontidal freshwater wetlands. There is a demonstrably smaller body of literature on restoration of tidal freshwater marshes such as Dyke Marsh. Although there are case studies to examine, care and attention are necessary to ensure that the desired restoration objectives are met and that appropriate and proper monitoring occurs, no matter which alternative is selected, to ensure successful adaptive management.

The 2004 workshop held by UMCES defined several priority concerns regarding the long-term persistence and health of the existing marsh and potentially restored areas. These concerns included shoreline erosion, engineered marsh soils, sea level rise, nor'easter storms, urbanization, and invasive species.

Any restoration alternative would require the use of fill material, which the USACE could provide whenever maintenance dredging is required at other nearby sites, although this is not a regular or predictable occurrence. However, to accommodate the uncertain availability and volume of suitable fill, a phased approach would need to be incorporated into the restoration plan. The restoration design must account for the uncertain amount of fill available at any one time. Long-term monitoring and modeling would be required to ensure that the expected outcomes are achieved. The introduction of any foreign fill material could increase the likelihood of introducing nonnative invasive plants because it is difficult to ensure that fill material is completely free of viable seeds, including those from exotic or invasive plants. This would particularly be true if elevation changes prove conducive to the introduction of such species. Therefore, management plans need to account for the possibility of the introduction of invasive species, and how to prevent and manage their presence.

DYKE MARSH SCIENCE TEAM

It is important to the NPS that the development of a restoration plan for Dyke Marsh be based on scientifically sound recommendations. Therefore, the NPS convened a science team for the plan/EIS to provide technical background information and guidance to the NPS as it developed alternatives for the plan/EIS.

The science team consisted of 19 individuals from federal agencies and universities who have particular expertise in some aspect of restoration of tidal freshwater wetlands and/or experience with Dyke Marsh. Federal agencies included the NPS, USACE, National Oceanic and Atmospheric Administration, USGS, and USFWS. Universities represented included the University of Maryland and the University of Rhode Island.

The science team convened via conference calls, meeting five times over a five-month period. The purpose of these meetings was not to develop alternatives or seek group consensus, but to seek information, advice, concerns, and opinions from the individual team members on several key topics, including

- the feasibility of restoring the marsh
- the desired condition of Dyke Marsh
- the ecology of the marsh
- how restoration efforts could impact the marsh over the short and long term
- technical aspects of engineering and wetland restoration on both small and large scales
- methods for protecting the existing marsh from natural factors as well as ongoing restoration activities
- what monitoring and adaptive management protocols should be considered during the restoration process.

A science team report was generated, and the interdisciplinary planning team then used the input from the science team to develop specific alternatives and address questions and concerns raised during the public scoping process.

SCOPING PROCESS AND PUBLIC PARTICIPATION

INTERNAL SCOPING

To initiate this plan/EIS, the NPS held an internal scoping meeting that included several members of the Science Team on November 14 and 15, 2007. The purpose of the meeting was to provide the NPS with an overview of the process required by NEPA and its implementing regulations, as well as to provide an opportunity for the key agency staff to review and confirm the purpose and need for taking action, define plan objectives, discuss potential issues and impact topics, and identify data needs.

PUBLIC SCOPING

NEPA regulations require an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. To help determine the scope of issues to be analyzed in depth in this plan/EIS, public participation was solicited through the use of a newsletter and at a public meeting. The park released a scoping newsletter for the plan/EIS for public review and comment on April 7, 2008. The public was invited to submit comments on the scope of the planning process and potential alternatives through May 23, 2008. During the scoping period, a public scoping meeting was held at Belle View Elementary on April 22, 2008. The meeting presented information about the development of the plan and planning processes. NPS staff members were on hand to answer questions, provide additional information to meeting participants, and record participant input. During the scoping period, nearly 300 pieces of correspondence were received and entered into the NPS Planning, Environment, and Public Comment (PEPC) system either from direct entry by the commenter, or uploading of emails, faxes, and hardcopy letters by NPS staff.

Correspondence from the 45-day scoping period came from over 32 states and three countries (United States, Canada, and Scotland). Of the approximately 50 letters submitted from outside the region immediately surrounding Dyke Marsh (defined as the District of Columbia, Maryland, and Virginia), concerns regarding hunting access in areas near Dyke Marsh were the most prevalent. Among those who commented from the immediately surrounding area, the three topics that received the majority of the comments were expressions of support for the restoration of Dyke Marsh, concerns regarding the impact of the restoration on the Belle Haven Marina, and concerns regarding continued access to hunting in areas near Dyke Marsh.

Additional Public Scoping Meeting Regarding Alternatives. Following the determination in 2009 that additional work was necessary to develop alternatives that were based on up-to-date hydrologic and hydraulic data, the NPS worked together with the USACE and its contractor to develop conceptual restoration alternatives. Once alternatives were developed, the NPS held a public meeting to present them. The meeting was held at the Washington Sailing Marina in Alexandria, Virginia, on May 19, 2012. NPS and USACE staff were on hand to answer questions and the NPS and the contractor who did the modeling work that informed the alternatives gave a brief presentation. The public was invited to submit comments on the potential conceptual alternatives through June 20, 2012. During the comment period following the meeting, more than 600 pieces of correspondence were received and entered into the PEPC system.

Overall, comments received expressed support or opposition for the four alternatives, and also asked what the costs would be or expressed concern over likely project costs. Many commenters expressed concern that the project would cause the Belle Haven Marina to close or would restrict or reduce recreational access and opportunities in the marsh. Several commenters suggested approaches that would allow the marina to remain open and still allow for restoration; for example, several suggested that alternative D should not include the option to fill the sailboat mooring area, and others suggested that the minimal or intermediate restoration alternatives would be more appropriate.

ISSUES AND IMPACT TOPICS

Issues associated with implementing a wetland restoration and long-term management plan for Dyke Marsh were identified by the planning team. The issues identified by the team are discussed below. These form the basis for the impact topics that were carried forward for analysis and that are discussed in chapters 3 and 4 of this plan/EIS. These issues represent existing conditions, as well as concerns that might arise during the implementation of any of the proposed alternatives.

Hydrology and Sediment Transport

The mean tidal range in the area of Dyke Marsh is between 0.5 and 0.9 meter (1.6 and 3.0 feet) (UMCES 2004). Due to the distance from the main river channel to the marsh, there is minimal effect on the shoreline by the main channel flow of the river; however, there are other factors, including two deep channels through the historical marsh area, wave action, and other influences, that affect marsh and shoreline stability and erosion. Drainage in the marsh is controlled by both tidal flows and general flow in the Potomac River (UMCES 2004). Restoration activities would likely need to address hydraulic issues in the marsh. Restoration activities may have some effect on hydrology and flow characteristics in and around the marsh. Tidal influence may be restored to areas west of Haul Road, which would affect the ecological community in that area. Marsh restoration may also help attenuate flooding in the immediate area, with more acres of wetlands to act as a sponge in flooding situations. Tidal guts and meanders are vital elements of a healthy, functioning marsh, and restoration designs would need to maintain the hydrology of the existing marsh while also creating tidal guts in the new marsh.

The prevailing winds and currents and occasional nor'easter storms can cause erosion, scour, and flooding that could imperil newly restored areas. Restoration should be designed and planned with care to provide as much protection from erosion and storm damage as possible, and there should be plans in place should damage occur as the result of one of these storms.

The hydrology of the marsh has already been impacted by changes in Hunting Creek and Cameron Run, two interconnected systems that have been subject to hardening, urban development, and increased stormwater runoff. The recent construction of a bridge to replace the I-495 Woodrow Wilson Bridge has further changed the upstream environment around Hunting Creek. In addition, National Harbor, a new, large conference center, hotel, and mixed-use complex in Maryland, is just upstream of Dyke Marsh on the opposite side of the Potomac River and could impact the marsh. A water taxi service connects National Harbor to Old Town Alexandria, Mount Vernon, Georgetown, and the Washington Nationals Ballpark for games during the baseball season. Although most of these water taxis are not high-speed boats (there is one higher-speed catamaran in the fleet), the service, along with increased numbers of larger boats docked at the National Harbor marina, could increase wave action, and subsequently affect erosion, within Dyke Marsh. Concerns about flooding in the Belle Haven community surrounding the marsh and potential plans to control the flooding could also affect the success of marsh restoration. All of these issues need to be considered in developing a restoration plan as well as long-term monitoring and management plans for the marsh.

Sea level rise, a consequence of climate change, may be a long-term concern for the successful continuation of both the existing marsh and the restored marsh. Sea level rise is expected to impact coastal wetlands along the eastern seaboard. Tidal gauges around the Chesapeake Bay indicate that sea level rise in Chesapeake Bay is twice the average global rate of 1.8 millimeters per year (Titus et al. 2009), and there is concern by climate change scientists that post-glacial rebound could exacerbate the effects of sea level rise in the area as well. The weight of the glaciers caused the earth’s mantle material to bulge around the edges of the glaciers during the Ice Age, and as the glaciers receded, the bulge settled and continues to settle, creating a small fall in elevation in the Mid-Atlantic region (Litwin and Pavich, pers. comm. 2009; NOAA 2000). Climate change modelers have predicted that mean annual discharge in the Potomac River could increase 20 percent by the 2050s (UMCES 2007). Wetlands could disappear because of inadequate sediment loads. Some studies on the Chesapeake Bay show that sediment loads should be adequate to maintain most wetlands, but there is concern whether sediment loads in the Potomac River are sufficient for Dyke Marsh to keep pace with sea level rise (UMCES 2004). More recent studies have inconclusive findings. Other concerns about the marsh related to sea level rise are whether shoreline erosion would be exacerbated and whether increased salinity in the area resulting from sea level rise could change the marsh ecology (UMCES 2004).

Soils and Sediments

The years of dredging and marsh removal have altered the marsh and riverbed bathymetry. Where shallow contours once existed, there are now deep holes and channels that contribute to the erosion of the marsh as shallower sediments slough off into these deeper waters. To restore the marsh, fill material would likely need to be brought in from outside sources and new soils created through the restoration process. Containment structures would be necessary to keep this new material in place until the marsh becomes established. Construction activities and the new fill material would impact existing soils. Restoration would also encourage sediment deposition in some parts of the marsh.

Surface Water Quality in the Potomac River

The Potomac River, and specifically the Middle Potomac River where Dyke Marsh is located, has been listed as impaired under the Clean Water Act for bacteria and polychlorinated biphenyls (PCBs). Under the Clean Water Act, waters are listed as “impaired” when required pollution controls are not sufficient to attain or maintain applicable water quality standards. Water quality in this stretch of the river is dominated by urban runoff and effluent from upstream, which includes high nutrient loads, turbidity, some heavy metals, and toxic chemicals (NPS 1977; Johnston 2000; UMCES 2004). The marsh appears to have been more affected by dredging activities and changes in hydrology at Hunting Creek than by the other water quality factors; however, restoration success may be affected by existing water quality issues in the river. Conversely, successful restoration may have positive effects on water quality, by increasing the acres of wetlands performing wetland functions such as nutrient capture and filtering in the immediate area of the marsh. Construction activities, particularly during the placement of sheet piling and containment structures, may cause temporary turbidity issues.

Floodplains

Upland areas associated with Dyke Marsh are in the floodplain of the Potomac River, and it is likely that contours, elevation, and area of tidal inundation may change in several areas as a result of restoring the marsh. The success of the marsh restoration is potentially interlinked with and dependent on other local projects under consideration to address concerns about flooding in the area.

NPS Director's Order 77-2 (NPS 2003) governs NPS actions involving floodplains, and directs the NPS to reduce the risk of flood loss, minimize impacts of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains. However, a floodplains statement of findings would not be required for the Dyke Marsh restoration project because the project would restore or protect the natural functions and values of the floodplain.

Vegetation and Wetlands

Dyke Marsh Wetlands

There are both upland and wetland plant communities within the marsh. Dyke Marsh contains tidal freshwater marsh, swamp forest, and floodplain forest, with both uplands and wetlands within the forested areas. Although the goal is to restore the marsh, restoration activities may impact existing wetland areas in addition to creating new wetlands. Restoration design will be done with care to avoid unwanted adverse impacts in existing wetland areas as well as to minimize the introduction of invasive plants like the purple loosestrife (*Lythrum salicaria*), if fill contains seed material for these plants and the restoration activities inadvertently create situations (by creating too high an elevation, for example) in which the plants could become established.

The emergent marsh community is diverse, with seven co-dominant species; the most common species in the existing marsh is narrowleaf cattail. Engineering restoration of the marsh may impact the vegetation in the marsh, and care must be taken to ensure that any impacts are positive and in keeping with the goals and purpose of the restoration activities. Changes in vegetation patterns have been observed in the marsh, with new clumps of spatterdock observed in the waterways over the last several decades, which could be evidence of changing sedimentation patterns in the marsh (UMCES 2004), and marsh restoration may continue to contribute to changes in vegetation patterns. In addition, while the presence of submerged aquatic vegetation (SAV) has been in decline in past decades, it has increased in recent years due to the rapid spread of nonnative SAV. Placing new fill in the riverbed to restore the marsh would likely impact these nonnative SAV species by burying them.

Vegetation in the marsh includes a few species of nonnative invasive plants, such as common reed and purple loosestrife, and this project would affect the park's ability to manage and eradicate these species in the marsh as the restoration occurs, and there could be temporary conditions in which these plants could become established, particularly before other vegetation has been planted. Although it is expected that some of the exotic and invasive plant species would be eliminated as a result of the reintroduction of tidal inundation, aggressive measures to control some of the exotic vegetation may be needed, and management of expected and desired vegetation may be necessary.

Increased tidal exchange in the areas currently cut off by Haul Road would gradually alter numerous tidal floodplain characteristics, including plant community composition. There would be a gradual transition from one set of plant community types to another as adjustments are made to environmental parameters such as tidal inundation, flooding frequency, and soil saturation.

Fish and Wildlife

One of the most important functions of marsh and wetland habitats is to provide habitat and food web for wildlife. Tidal marsh, floodplain forest, and swamp forest are found within Dyke Marsh, and the marsh provides habitat for numerous species of fish, reptiles, amphibians, and birds. Previous dredging of the marsh has greatly reduced the size and changed the hydrologic functions of the marsh, altering the amount and type of habitat available to support both resident and migratory fish and wildlife species.

The proposed project focuses specifically on restoring marsh habitat and hydrologic functions. These actions would provide long-term improvements to the overall habitat for fish and wildlife species. However, they may reduce the habitat quality available for some aquatic species that use the deep holes created by the dredging, because these deeper holes and channels may be filled as part of the restoration. Construction activities have the potential to cause temporary adverse impacts to species and their habitat through physical disturbance, noise disturbance, and burying of sessile aquatic species (those species attached to the substrate and are immobile). Impacts would be dependent upon the implementation of and adherence to BMPs designed to avoid or reduce temporary impacts on resident and migratory species.

Species of Special Concern

Dyke Marsh is considered a cattail climax marsh. It is an important plant community that provides essential habitat for many wildlife species, including several Virginia state-listed rare or sensitive plant and animal species. State-listed species present in the marsh include Davis' sedge (*Carex davisii*), river bulrush, rough avens (*Geum laciniatum*), giant burreed (*Sparganium eurycarpum*), and two bird species: the least bittern and the swamp sparrow (*Melospiza georgiana*). There are no federally threatened or endangered species located within the project area, although the marsh is within the range of the federally listed (endangered) shortnose sturgeon (*Acipenser brevirostrum*), and the Chesapeake Bay distinct population segment of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Multiyear surveys by the USFWS did not find individuals of either species in the marsh (Mangold et al. 2004), indicating that the restoration would have no effect on these species, and they are therefore not discussed further. The state-listed plant heartleaf plantain (*Plantago cordata*) is now extirpated in the marsh and possibly extirpated in the Commonwealth of Virginia, although it is secure globally. Bald eagles (*Haliaeetus leucocephalus*), a de-listed species, are also found in the vicinity of the marsh, and they may well use the marsh as hunting habitat. Although marsh restoration would likely provide long-term benefits to species of concern by expanding and improving the marsh habitat available to the species, construction activities may have the potential to negatively impact these species through physical and noise disturbances.

Archeological Resources

Despite the past dredging activities, a large portion of the preserve property appears to have retained sufficient landscape integrity that it should be considered to have the potential for archeological resources. Essentially, the entire upland area could contain Native American sites dating from the past 5,000 years. These would most likely be short-term, seasonal camps used by people hunting, fishing, or gathering in the marsh and the river (NPS 2009a). The marsh area was dry land until at least 6000 BC, and probably as late as 3000 BC, so Paleo-Indian and Archaic campsites may be present in the undisturbed portions of the marsh (NPS 2009a). Historic uses of the marsh included the 19th century diking to reclaim marsh area to create fast land for better river access and pasturage/agricultural use, as well as hunting, fishing, boating, and occasional illicit activities including bootlegging, gambling, and prostitution. These activities have potentially left behind archeological remains in the form of cabins, cottages, shacks, work sites, watercraft, marine facilities, etc. (Virta 2012a) This plan/EIS primarily focuses on the previously dredged areas and will include measures designed to protect the existing portions of the marsh from damage, so restoration is unlikely to have an adverse impact on any potential sites present in Dyke Marsh. However, restoring tidal influence west of Haul Road has the potential to impact unknown archeological sites if there are land-disturbing activities outside the footprint of the road itself. If ground-disturbing activities cannot avoid potential archeologically sensitive areas, archeological surveys would need to be undertaken to identify and evaluate any resources that may be directly impacted by the marsh restoration activities.

Historic Structures and Districts, and Cultural Landscapes

The entirety of the George Washington Memorial Parkway and the land that encompasses the larger parkway landscape has been listed in the National Register of Historic Places (NRHP) under the nominations for the Mount Vernon Memorial Highway (NPS 1981), George Washington Memorial Parkway (NPS 1995), and the Parkways of the National Capital Region (NPS 1991). The marsh is part of the scenic landscape that the designers of the parkway originally sought to preserve and incorporate into the viewshed of the roadway. The 19th century dikes have been the only lasting structural improvement made to the marsh since historic times. Portions of the dike remain on the southern end of the marsh, near Hog Island Gut, and restoration activities could impact these remnants. No other historic structures associated with the more ephemeral human activities within Dyke Marsh are known to exist, but archeological remains are possible.

Dyke Marsh is an important feature of the overall cultural landscape of the Mount Vernon Memorial Highway along the roadway between Washington, D.C., and Mount Vernon, one of the 19 identified major cultural landscapes of the park. The planting plan of the Mount Vernon Memorial Highway (NPS n.d.c) includes directed view areas for users of the Parkway and several of the opportunities for observing scenic resources included viewing the Potomac River and Dyke Marsh. Views and vistas are significant characteristics of parkways such as the Mount Vernon Memorial Highway, and the features of Dyke Marsh were highlighted as scenic views by Mount Vernon Memorial Highway designers.

Dyke Marsh itself has not yet been formally evaluated for cultural landscape status, and is not one of the 19 currently identified major cultural landscapes of the park. The historic dikes are important features of the human manipulated landscape of the marsh, and human use and vestiges of their activities in the marsh may suggest that Dyke Marsh would qualify as a type of cultural landscape on its own if found to have enough integrity and character to fit the definition. Regardless, the marsh is an important feature of the overall landscape of the southern parkway leading to Mount Vernon (Bies and Virta, pers. comm. 2009; Virta, pers. comm. 2012b). Restoring and expanding the tidal freshwater marsh would enhance the cultural landscape, although altering marsh hydrology with construction of modern breakwaters or other structures related to the restoration could have some adverse impacts.

Visitor Use and Experience

Construction activities would impact both visitor use and visitor experience by restricting access to areas of the marsh during construction activities, reducing the amount of open water within the marsh, and by creating noise and visual disturbances. Visitors would likely not be able to use the marsh for fishing or other recreational enjoyment during construction. Converting open water areas to marsh and filling the deeper holes would have long-term impacts on recreational fishing activities within the marsh itself by increasing nursery areas for fish and other aquatic life. Visitor experience would be impacted visually during the construction process, and when areas of fill that are settling and have not yet been planted, and the when there are areas of vegetation that are not yet mature enough to blend in with the remainder of the marsh. Fill activities and related disturbances would require the use of heavy equipment, which would cause noise. Restoration activities would also include benefits by providing several opportunities for expanded education on the marsh ecosystem and restoration activities and goals.

In addition, users of the Belle Haven Marina may be affected both during marsh restoration activities and after restoration is complete. The configuration of the marsh would change, navigation through and around the marsh would change, and access to the marina from the river might also change, resulting in changes to visitor use and experience.

Adjacent Property Owners and the Marina

Adjacent properties would also be temporarily impacted by construction noise and may be impacted if there is a change in the numbers of waterfowl in the marsh once restoration is complete. More waterfowl and reestablishment of the marsh closer to the licensed duck blinds could increase hunting in the area and affect adjacent property owners. Restoring Dyke Marsh south of the historic promontory may also impact properties to the south of the marsh by causing some changes to the water depth under the docks located on those properties due to the potential for the creation of low energy areas near the restored wetlands, and long-term sediment accretion in those low energy areas where sediments can settle out.

Park Management and Operations

The plan for the incremental restoration of Dyke Marsh, accompanied by a program of environmental monitoring and adaptive management, must include an operations and management plan that specifies how structures will be managed throughout the probably lengthy restoration process (which is expected to last years or decades) and identifies the responsible agencies.

In addition, restoring Dyke Marsh may result in a loss of revenue for the Belle Haven Marina, a concession located at the northern end of the marsh. Restoration may decrease the amount of open water within the marsh area and potentially fill in deep holes, so there could also be a decrease in the number of anglers using the marina boat ramp to access the marsh and the surrounding area for fishing purposes. This could result in a loss of boat ramp revenue for the marina.

Issues Considered but Dismissed from Further Consideration

The following impact topics and issues were dismissed from further analysis, as explained below.

Air Quality

The Washington, D.C., region is a nonattainment area for ground-level ozone and fine particulate matter ($PM_{2.5}$) according to federal health standards. The George Washington Memorial Parkway and Dyke Marsh are classified as a Class II area per the Clean Air Act of 1973. Impacts on air quality from implementing a tidal wetland restoration plan would include fugitive dust and emissions from construction vehicles and equipment, but would not make noticeable contributions to the air quality. Therefore, air quality was dismissed from further analysis.

Land Use

Although there should be accretion of marshland and there may be some associated change in the boundary between wetland and upland areas, there would be no substantial change in land use as a result of the project. Impacts on neighboring properties are addressed under the topic “Adjacent Property Owners and the Marina” (under “Issues and Impact Topics” in this chapter). Therefore, land use was dismissed from further analysis.

Prime Farmlands

There are designated prime farmland soils in the Dyke Marsh study area, but restoration activities would not be expected to affect these soils. Therefore, the topic of prime farmlands was dismissed from further analysis.

Estuarine Resources

Estuaries are partly enclosed coastal bodies of water that are influenced by both connections to the open ocean and to freshwater from one or more rivers flowing into them. The Chesapeake Bay, into which the Potomac River flows, is an estuary, and the river is tidally influenced as far north as Washington, D.C, but is brackish only downstream of the Governor Nice Bridge near Colonial Beach, Virginia. Dyke Marsh is therefore located in the freshwater tidally influenced portion of the Potomac River, and is not considered part of the estuarine zone. Although restoration activities could affect estuarine resources, the estuarine zone begins far enough downstream that impacts would be unlikely. Therefore, the topic of estuarine resources has been dismissed from further analysis.

Climate Change

The impacts on climate change from restoring Dyke Marsh would be mainly due to emissions of nitrous oxides and carbon dioxide from the burning of fuel in vehicles and construction equipment, which can affect global warming. However, these impacts would be short term and negligible. Therefore, impacts of the project on climate change have been dismissed from further analysis. Climate change may impact the restoration project due to sea level rise and changes to salinity, and require adaptive responses to ensure continued project success; these impacts on the project will be addressed in discussions of adaptive management monitoring plan in appendix A of this plan/EIS, and in the “Environmental Consequences” chapter.

Transportation

Restoration work will most likely involve the use of boats accessing the site from the water. There may be a few trucks used to access the marsh restoration sites, especially for work on Haul Road, but their use would be minimal. Should access by land from the George Washington Memorial Parkway be required, construction vehicles would be permitted by the park, and time spent on the parkway would be limited. Therefore, transportation has been dismissed from further analysis.

Minority and Low-income Populations, including Environmental Justice

The actions under this plan would not be expected to have a disproportionate or significant adverse effect on any low-income or minority populations in the area. Therefore, environmental justice has been dismissed from further analysis.

Soundscapes

In accordance with NPS *Management Policies 2006* and Director's Order 47: *Soundscape Preservation and Noise Management* (NPS 2006, 2000a), an important part of the NPS mission is the preservation of natural soundscapes associated with parks. The natural ambient soundscape is the aggregate of all the natural sounds that occur in park units together with the physical capacity for transmitting natural sounds. The frequencies, magnitudes, and durations of human-caused sound considered acceptable varies, being generally greater in developed areas and less in undeveloped areas. Some increased recreational use (e.g., canoeing/kayaking, fishing, and nature observing) of the Dyke Marsh would be expected as a result of marsh restoration activities. These activities would result in some level of human-generated noise, but these levels are generally unobtrusive, with little anticipated effect on wildlife and visitor enjoyment. Construction activities associated with the restoration of the marsh, such as operating equipment, hauling material, etc., would result in dissonant, human-caused sounds. However, any noise caused by construction activities would be temporary and limited in area, with only short-term minor impacts on soundscapes. Also, the impacts of noise on wildlife and on visitor experience are addressed under the appropriate impact topics. Therefore, the topic of soundscapes has been dismissed from further analysis.

Health and Safety

During public scoping, concerns were raised about creating additional mosquito habitat and the potential impact of mosquito-borne viruses on human health and safety. However, any restored marsh area, including areas west (inland) of Haul Road, would be tidally influenced and flushed regularly, avoiding the creation of stagnant water where mosquitoes breed. In addition, Dyke Marsh is located within the flight path of Ronald Reagan National Airport, and concerns were raised about bird strikes by planes taking off from and landing at the airport as a result of more geese and waterfowl being attracted to Dyke Marsh. However, the marsh is over 7 miles from the airport, which means that planes will be flying at several thousand feet above ground level, significantly higher than the typical flight altitude of geese and other birds frequenting the marsh. Most bird strikes occur within 100 feet of the ground, with 74 percent of the strikes occurring at 500 feet or less above ground level, where most birds routinely fly unless they are migrating (Cleary and Dolbeer 2005). Any increase in resident bird populations frequenting the marsh as a result of restoration would not increase the potential for bird strikes on aircraft. Any impacts on health and safety would occur during construction activities and would be negligible, because visitors would be excluded from all construction zones and all construction operations should be following the appropriate Occupational Safety and Health Administration regulations. Therefore, health and safety has been dismissed from further analysis.

Socioeconomics

Restoring Dyke Marsh is not expected to have any socioeconomic effects, other than to the Belle Haven Marina, a concession located at the northern end of the marsh. Restoration of the marsh south of the Belle Haven Marina could affect moorings and their associated revenue from the inventory of the marina, and might otherwise affect marina operations. However, marina related socioeconomic impacts are discussed in both the visitor use and experience section and the park management and operations sections in chapter 4. Therefore, socioeconomics has been dismissed from further analysis.

RELATED FEDERAL LAWS, POLICIES, REGULATIONS, AND PLANS

NPS ORGANIC ACT

By enacting the Organic Act of 1916, Congress directed the U.S. Department of the Interior and the NPS to manage units of the national park system "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S. Code [USC] 1). The Redwood National Park Act of 1978 (Redwood Amendment) reiterates this mandate by stating that the NPS must conduct its actions in a manner that will ensure no "derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress" (16 USC 1a-1). Congress intended the language of the Redwood Amendment to reiterate the provisions of the Organic Act, not to create a substantively different management standard. The House committee report described the Redwood Amendment as a "declaration by Congress" that the promotion and regulation of the national park system is to be consistent with the Organic Act. The Senate committee report stated that under the Redwood Amendment, "the Secretary has an absolute duty, which is not to be compromised, to fulfill the mandate of the 1916 Act to take whatever actions and seek whatever relief as will safeguard the units of the national park system." Although the Organic Act and the Redwood Amendment use different wording (*impairment* and *derogation*) to describe what the NPS must avoid, both acts define a single standard for the management of the national park system—not two different standards. For simplicity, NPS *Management Policies 2006* uses *impairment*, not both statutory phrases, to refer to that single standard.

Park managers must also not allow uses that would cause unacceptable impacts. These are impacts that fall short of impairment, but are still not acceptable within a particular park's environment. According to the NPS *Management Policies 2006* (NPS 2006, Section 1.4.7, 12), "for the purposes of these policies, unacceptable impacts are impacts that, individually or cumulatively, would

- be inconsistent with a park's purposes or values, or
- impede the attainment of a park's desired future conditions for natural and cultural resources as identified through the park's planning process, or
- create an unsafe or unhealthful environment for visitors or employees, or
- diminish opportunities for current or future generations to enjoy, learn about, or be inspired by park resources or values, or
- unreasonably interfere with
    - park programs or activities, or
    - an appropriate use, or
    - the atmosphere of peace and tranquility, or the natural soundscape maintained in wilderness and natural, historic, or commemorative locations within the park, or
    - NPS concessioner or contractor operations or services."

Because park units vary based on their enabling legislation, natural resources, cultural resources, and missions, management activities appropriate for each unit, and for areas in each unit, vary as well. An action appropriate in one unit could impair or cause unacceptable impacts to resources in another unit.

NPS MANAGEMENT POLICIES 2006

The introduction to “Chapter 4: Natural Resources Management” of NPS *Management Policies 2006* states that parks “will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks” and that the NPS “manages the natural resources of parks to maintain them in an unimpaired condition for present and future generations” (NPS 2006).

The NPS *Management Policies 2006* acknowledges that park units are parts of much larger ecosystems and that parks can contribute to the conservation of regional biodiversity (NPS 2006). Conversely, many parks cannot meet their natural resource preservation goals without the assistance and collaboration of neighboring landowners and resources to achieve ecosystem stability and other resource management objectives. Therefore, Section 4.1.4 of the NPS *Management Policies 2006* states that the agency will pursue cooperative conservation with other agencies, Indian tribes, other traditionally associated people, and private landowners in accordance with Executive Order 13352, “Facilitation of Cooperative Conservation.”

Section 4.1.5 (“Restoration of Natural Systems”) of the NPS *Management Policies 2006* states that the NPS will seek to return areas impacted by human disturbances “to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated” and that impacts on natural systems resulting from human disturbances include, among other things, “changes to hydrologic patterns and sediment transport…. and the disruption of natural processes” (NPS 2006).

Other sections of the NPS *Management Policies 2006* most relevant to this plan/EIS are those that are directly related to the restoration objectives, particularly those related to managing natural resources, fostering healthy systems that support native species, and fostering the natural functions of wetlands, such as providing habitat and providing water quality. These sections include the following:

- Section 4.4.1, “General Principles for Managing Biological Resources.” NPS *Management Policies 2006* instructs park units to maintain as parts of the natural ecosystems of parks all native plants and animals. The NPS achieves this maintenance by “preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur.”
- Section 4.4.2, “Management of Native Plants and Animals.” NPS *Management Policies 2006* states that “whenever possible, natural processes will be relied upon to maintain native plant and animal species and influence natural fluctuations in populations of these species,” but that the NPS may intervene to manage individuals or populations of native plants or animals. However, such management actions shall not cause unacceptable impacts on these populations or on other components of the ecosystems that support them.
- Section 4.4.2.4, “Management of Natural Landscapes.” This section states that landscape and vegetation conditions altered by human activity, such as Dyke Marsh, may be manipulated where the park management plan provides for restoring the lands to a natural condition. There are several possible actions, including the restoration of “natural processes and conditions to areas disturbed by human activities”—in this case, the dredging of the marsh.
- Section 4.6.5, “Wetlands.” The restoration of wetlands is the principal purpose of this plan/EIS. The NPS *Management Policies 2006* states that the NPS will “preserve and enhance the natural and beneficial values of wetlands.” The NPS should implement a “no net loss of wetlands policy” and strive for a “long-term net gain of wetlands across the national park system through restoration of previously degraded or destroyed wetlands.”

DIRECTOR'S ORDER 12: CONSERVATION PLANNING, ENVIRONMENTAL IMPACT ANALYSIS, AND DECISION MAKING AND HANDBOOK

NPS Director's Order 12 (NPS 2011) and its accompanying handbook (NPS 2001) lay the groundwork for how the NPS complies with NEPA. Director's Order 12 and the handbook set forth a planning process for incorporating scientific and technical information and establishing a solid administrative record for NPS projects.

NPS Director's Order 12 requires that impacts on park resources be analyzed in terms of their context, duration, and intensity. It is crucial for the public and decision makers to understand the implications of those impacts in the short term and long term, cumulatively, and within context, based on an understanding and interpretation by resource professionals and specialists. Director's Order 12 also requires that an analysis of impairment of park resources and values be made as part of the NEPA document.

DIRECTOR'S ORDER 77-1: WETLAND PROTECTION

The purpose of Director's Order 77-1 is to establish NPS policies, requirements, and standards for implementing Executive Order 11990: "Protection of Wetlands" (42 FR 26961). Executive Order 11990 was issued by President Carter in 1977 in order "…to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative…" The USACE regulates development in wetland areas pursuant to Section 404 of the Clean Water Act (33 CFR, Parts 320–330). NPS Director's Order 77-1: *Wetland Protection* and Procedural Manual 77-1 provide NPS policies and procedures for complying with Executive Order 11990. As stated:

> Actions proposed by the NPS that have the potential to have adverse impacts on wetlands will be addressed in an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). If the alternative in an EA or EIS will result in adverse impacts on wetlands, a "Statement of Findings (SOF)" documenting compliance with this Director's Order and its implementation procedures will be completed.

NPS Director's Order 77-1 (NPS 2002) directs that adverse impacts to wetlands be avoided to the extent practicable, and that unavoidable impacts will be minimized and compensated for with restoration of degraded wetlands. The restoration of Dyke Marsh is intended to result in mostly beneficial impacts on wetlands, and the intent of this project is to restore and expand the marsh. However, the placement of the stone breakwater under the action alternatives is expected to have some long-term adverse impacts on existing shallow water habitat. Best management practices and other conditions specifically identified in the procedural manual will be followed and less than 0.25 acre of existing marsh will be impacted. Therefore, the project fits within the exception 4.2.1(h) of the procedural manual and a wetlands statement of findings is not necessary.

DIRECTOR'S ORDER 77-2: FLOODPLAIN MANAGEMENT

Director's Order 77-2: *Floodplain Management* was issued in response to Executive Order 11988, Floodplain Management. This order applies to all proposed NPS actions that could adversely affect the natural resources and functions of floodplains or increase flood risks. This includes those proposed actions that are functionally dependent upon locations in proximity to the water and for which non-floodplain sites are not practicable alternatives. Some of the alternatives would raise the base flood elevation in the area very slightly, but overall the project would protect, restore, and enhance the functions of the floodplain, and provide additional buffers to the floodplain by restoring wetlands, so a floodplain statement of findings would not be required.

DIRECTOR'S ORDER 28: CULTURAL RESOURCE MANAGEMENT

This director's order (NPS 1998a) sets forth the guidelines for the management of cultural resources, including cultural landscapes, archeological resources, historic and prehistoric structures, museum objects, and ethnographic resources. This order calls for the NPS to protect and manage cultural resources in its custody through effective research, planning, and stewardship in accordance with the policies and principles contained in the NPS *Management Policies 2006*.

OTHER FEDERAL LEGISLATION, EXECUTIVE ORDERS, COMPLIANCE, AND NATIONAL PARK SERVICE POLICY

National Environmental Policy Act, 1969, as Amended

NEPA is implemented through regulations of the Council on Environmental Quality (CEQ) (40 CFR 1500–1508). The NPS has in turn adopted procedures to comply with the act and the CEQ regulations, as found in Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision Making* and its accompanying handbook (NPS 2011, 2001). Section 102(2)(c) of this act requires that an environmental impact statement (EIS) be prepared for proposed major federal actions that may significantly affect the quality of the human environment. This act and its amendments are the basis on which this plan/EIS is being prepared.

National Parks Omnibus Management Act of 1998

The National Parks Omnibus Management Act of 1998 (16 USC 5901 et seq.) underscores NEPA in that both are fundamental to NPS park management decisions. Both acts provide direction for articulating and connecting the ultimate resource management decision to the analysis of impacts using appropriate technical and scientific information. Both also recognize that such data may not be readily available and provide options for resource impact analysis in this case.

The National Parks Omnibus Management Act directs the NPS to obtain scientific and technical information for analysis. The NPS handbook for Director's Order 12 states that if "such information cannot be obtained due to excessive cost or technical impossibility, the proposed alternative for decision will be modified to eliminate the action causing the unknown or uncertain impact or other alternatives will be selected" (NPS 2001).

Endangered Species Act of 1973, as Amended

This act requires all federal agencies to consult with the Secretary of the Interior on all projects and proposals with the potential to impact federally endangered or threatened plants and animals. It also requires federal agencies to use their authorities in furtherance of the purposes of the Endangered Species Act by carrying out programs for the conservation of endangered and threatened species. Federal agencies are also responsible for ensuring that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat.

Migratory Bird Treaty Act of 1918

The Migratory Bird Treaty Act implements various treaties and conventions between the United States and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under this act, it is prohibited, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export at any time or in any manner, any migratory bird included in the terms of this Convention…for the protection of migratory birds…or any part, nest, or egg of any such bird" (16 USC 703).

Code of Federal Regulations (CFR), Title 36 (1992)

Title 36, Chapter 1, of the CFR provides the regulations "for the proper use, management, government, and protection of persons, property, and natural and cultural resources within areas under the jurisdiction of the National Park Service" (36 CFR 1.1(a)).

National Historic Preservation Act of 1966, as Amended

Section 106 of this act requires federal agencies to consider the effects of their undertakings on properties listed or potentially eligible for listing on the NRHP. All actions affecting the cultural resources of the park must comply with this legislation.

Archeological Resources and Protection Act of 1979

The Archeological Resources Protection Act prohibits unauthorized excavation on federal and Indian lands, establishes standards for permissible excavation, prescribes civil and criminal penalties, requires agencies to identify archeological sites, and encourages cooperation between federal agencies and private individuals.

Coastal Zone Management Act 1972, as Amended

The Coastal Zone Management Act (CZMA) (16 USC 1451 et seq.) seeks to preserve and protect coastal resources. Through this act, states are encouraged to develop coastal zone management programs (CZMPs) to allow economic growth that is compatible with the protection of natural resources, the reduction of coastal hazards, the improvement of water quality, and sensible coastal development. The act provides financial and technical incentives for coastal states to manage their coastal zones in a manner consistent with CZMA standards and goals. Section 307 of the act requires that federal agency activities that affect any land or water use or natural resource of the coastal zone must be consistent to the maximum extent practicable with the enforceable policies of the state CZMP. Federal agencies and applicants for federal approvals must consult with state CZMPs and must provide the CZMP with a determination or certification that the activity is consistent with CZMP-enforceable policies, where those policies will have a possible effect on state coastal resources, as defined by the CZMP and local land use plans. The proposed restoration of the marsh is within tidal waters and therefore must be consistent to the extent practicable with the CZMA and the related state and local coastal zone policies and plans.

Clean Water Act of 1972, as Amended

The Clean Water Act is a comprehensive statute aimed at restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Section 404 of this act is administered by the USACE and regulates the discharge of dredged and fill material to waters of the United States, including wetlands under federal jurisdiction. The Clean Water Act also requires the establishment of state water quality standards for surface waters, as well as federal water quality standards, and the development of guidelines to identify and evaluate the extent of nonpoint-source pollution. Section 401 of the act, "Water Quality Certification," gives states the authority to review projects that must obtain federal licenses or permits and that result in a discharge to state waters. The purpose of the water quality certification is to ensure that a project will comply with state water quality standards and other appropriate requirements of state law, and it is required for any project that also requires a USACE Section 404 wetland permit, such as this plan does.

Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds"

Migratory birds are of great ecological and economic value to this country and to other countries. They contribute to biological diversity and bring tremendous enjoyment to millions of people who study, watch, feed, or hunt these birds throughout the United States and other countries. The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. Such conventions include the Convention for the Protection of Migratory Birds with Great Britain on behalf of Canada 1916, the Convention for the Protection of Migratory Birds and Game Mammals–Mexico 1936, the Convention for the Protection of Birds and Their Environment–Japan 1972, and the Convention for the Conservation of Migratory Birds and Their Environment–Union of Soviet Socialist Republics 1978. These migratory bird conventions impose substantive obligations on the United States for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act, the United States has implemented these migratory bird conventions with respect to the United States. This executive order directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act.

Executive Order 13508, "Chesapeake Bay Protection and Restoration"

This executive order and supporting reports (Federal Leadership Committee for the Chesapeake Bay 2009, 2010) direct federal agencies to lead the effort in restoring and protecting the Chesapeake Bay. Federal agencies will share federal leadership, planning, and accountability while restoring Chesapeake Bay water quality, developing agricultural practices to protect the Chesapeake Bay, reduce water pollution from federal lands and facilities, and protect Chesapeake Bay as the climate changes. Agencies will also assist in expanding public access to the Chesapeake Bay and conserve landscapes and ecosystems, monitoring and decision support for ecosystem management, and identifying living resources protection and restoration. Key goals are the restoration of 4,000 acres of wetlands per year, to reach 30,000 acres by 2025, and wetlands enhancement goals of 10,000 acres per year, for a total of 150,000 acres by 2025. The restoration of Dyke Marsh contributes directly to both of these goals.

RELATIONSHIP TO OTHER PARK PLANNING DOCUMENTS, POLICIES, AND ACTIONS

2005 George Washington Memorial Parkway Long-range Interpretive Plan

There is no current general management plan or resource management plan for the parkway. The 2005 *George Washington Memorial Parkway Long-range Interpretive Plan* (NPS 2005b) is used in this EIS as a guiding document and serves several purposes: it serves as an interpretive document for the various units of the park, acts as a guide for visitor use and experience, and sets forth the major interpretive themes for the entire parkway, which ultimately will inform all projects that occur within any of the parkway units. There are individual plans for each of the parkway's management units, including Dyke Marsh.

Superintendent's Compendium, George Washington Memorial Parkway (2007)

The compendium for the George Washington Memorial Parkway exercises the discretionary authority of the superintendent of the park to manage permits, closures, and other restrictions within the park. The compendium also serves as the rules governing the park and directs management plans and other actions. Provisions for the protection of natural and cultural resources within the specific management units are enumerated in the compendium.

RELATIONSHIP TO OTHER STATE AND LOCAL PLANNING DOCUMENTS, POLICIES, AND ACTIONS

Chesapeake Bay Agreements

In 1983 and 1987, the states of Maryland, Virginia, and Pennsylvania; the District of Columbia; the Chesapeake Bay Commission; and the USEPA signed agreements that established the Chesapeake Bay Program to protect and restore the Chesapeake Bay's ecosystem. This agreement committed to living resource protection and restoration, vital habitat protection and restoration, water quality protection and restoration, sound land use, and stewardship and community engagement. In June of 2000, the parties listed above signed Chesapeake 2000, a new agreement for the restoration of the Chesapeake Bay (Chesapeake Bay Program 2000). The signatories pledged to implement over 100 specific actions designed to restore the health of the bay and its living resources. This plan includes a goal to restore 25,000 acres of both tidal and nontidal wetlands. Activities on federal land must be consistent with the provisions of this agreement. A new 2013 draft agreement is under review that continues goals from previous agreements, including wetland restoration and water quality goals (Chesapeake Bay Program 2013).

Virginia Coastal Resources Program

The Virginia Coastal Resources Program is a network of programs administered by a number of agencies and is the state's program under the federal CZMA. Pertinent programs and laws relate to wetlands management, subaqueous lands management, and sediment and erosion control, in addition to stormwater management and point-source pollution control, which do not apply in the case of Dyke Marsh. Federal actions that can have reasonably foreseeable effects on Virginia's coastal resources or uses must be consistent with this program. Federal agencies must obtain all applicable permits and approvals listed under the enforceable policies of the program prior to commencing any project that would affect coastal resources. Further discussion of the specific programs follows.

Virginia Floodplain Development Regulations

Floodplain development in Virginia is governed by Code 10.1-602, "Floodplain Code," and 44 CFR 60.1, "Criteria for Land Management and Use." The Floodplain Code and Criteria for Land Management and Use set forth several strategies to prevent or mitigate flood damage. When development is proposed in flood hazard areas the following measures are required:

- permits
- review of the proposed development
- review of permit applications to determine whether development will be reasonably safe from flooding

- water supply systems that are designed to minimize or eliminate infiltration of floodwaters into the systems
- sanitary sewage systems that are designed to minimize or eliminate infiltration of floodwaters into the systems and discharges from the systems into floodwaters
- development that is engineered and designed to prevent hazards associated with flooding.

Uses not permitted in the floodplain include structures intended for human habitation; storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, plant, fish, or other aquatic life; sewage systems or wells; solid or hazardous waste disposal facilities; wastewater treatment ponds or facilities except as otherwise permitted by Virginia Administrative Code; and filling that would cause an obstruction to flow that is not otherwise permitted. Activities allowed in the floodplain must meet the following criteria: (1) there must be no rise in the base flood elevation and (2) the activities must relate to certain structures necessary to open space or historical areas and campgrounds. The Dyke Marsh project would affect the floodplain, but it is not an activity that involves the placement of structures in the floodplain.

Virginia Water Control Law

Virginia has received authority from the USEPA to implement the requirements of the federal Clean Water Act, including setting water quality standards, designating uses, and implementing the National Pollutant Discharge Elimination System permit programs. Virginia's Water Control Law is the vehicle by which the protection of high-quality state waters is mandated. The law also provides for the restoration of all other state waters so they will allow reasonable public uses and will support the growth of aquatic life. The Water Control Law frames how state water quality standards are derived and outlines the designated uses for the waters of the commonwealth.

Virginia Endangered Plant and Insect Species Act (1979)

The Endangered Plant and Insect Species Act, Chapter 10, Sections 3.2-1000–1011 of the Code of Virginia, as amended, mandates that the Virginia Department of Agriculture and Consumer Services conserve, protect, and manage endangered and threatened species of plants and insects. Program personnel cooperate with the USFWS, the Virginia Department of Conservation and Recreation (VA DCR), Division of Natural Heritage, and other agencies and organizations on the recovery, protection, or conservation of listed threatened or endangered species and designated plant and insect species that are rare throughout their worldwide ranges. The Virginia Departments of Game and Inland Fisheries and Agriculture and Consumer Services share legal authority for endangered and threatened species and are responsible for their conservation in Virginia. A third state agency, the VA DCR, Division of Natural Heritage, produces an inventory of the commonwealth's natural resources and maintains a data bank of ecologically significant sites.

Virginia Chesapeake Bay Preservation Act (1988)

The Virginia Chesapeake Bay Preservation Act requires that the counties, cities, and towns near tidal waters in the commonwealth incorporate general water quality protection measures into their comprehensive plans, zoning ordinances, and subdivision ordinances. It also requires that Chesapeake Bay Preservation Areas be defined and protected. It is the policy of the NPS to consider the local laws during the planning process and comply with them to the extent possible.

Virginia Erosion and Sediment Control Law

The goal of the state erosion and sediment control program is to control soil erosion, sedimentation, and nonagricultural runoff from regulated land-disturbing activities to prevent the degradation of property and natural resources. The regulations behind the law specify minimum standards, which include criteria, techniques, and policies that must be followed on all regulated activities. The Department of Conservation and Recreation Erosion and Sediment Control Program oversees state and federal activities such as would occur during Dyke Marsh restoration activities.

Maryland Coastal Zone Management Program

The Potomac River is under the jurisdiction of the State of Maryland to the shoreline on the Virginia side of the river. Although the restoration work in Dyke Marsh is planned within Virginia waters, the project should undergo coordination and consultation with Maryland. As with Virginia's program, Maryland's CZMP requires a consistency determination for all federal actions within designated coastal zone areas and tidal waters.

Maryland Wetlands and Waterways and Water Management Programs

Like Virginia, Maryland has been granted authority to implement the requirements of the Clean Water Act and to protect and manage tidal and nontidal waters and wetlands. The Wetlands and Waterways Program at the Maryland Department of the Environment regulates all activities within Maryland waters and wetlands. The Water Management Program, also within the Maryland Department of the Environment, regulates discharge into Maryland waterways and water quality. Although the restoration would occur in Virginia waters, coordination with this Maryland program should occur.

Fairfax County Chesapeake Bay Preservation Ordinance and Policy, 1993, as Amended

Following from the Virginia Chesapeake Bay Preservation Act, the county ordinance has been passed, according to Section 118-5, "Purpose and Intent," to "encourage and promote (1) the protection of existing high-quality state waters, (2) the restoration of all other state waters to a condition or quality that will permit all reasonable public uses and will support the propagation and growth of all aquatic life…, (3) the safeguarding of the clean waters of the commonwealth from pollution, (4) the prevention of any increase in pollution, (5) the reduction of existing pollution, and (6) water resource conservation in order to provide for the health, safety, and welfare of the present and future citizens of Fairfax County and the Commonwealth of Virginia."

Under this ordinance, all tidal wetlands, such as in Dyke Marsh, have been designated "Resource Protection Areas." Disturbance and development activity in such areas is subject to county review. Indigenous vegetation is encouraged, as is minimization of disturbed area and impervious surfaces. Although no structures would be likely to be built for the proposed restoration, review would still be required.

Fairfax County Wetlands Zoning Ordinance and Wetlands Board

The lands between mean low and mean high tide are subject to the Fairfax County Wetland Zoning Ordinance, and disturbance in these areas requires a permit from the county's Wetlands Board. The board works in close coordination with state and federal agencies in the determination of the need for permits and the appropriateness of activities. The Fairfax County Wetlands Board issues permits for all shoreline activities that may impact vegetated or nonvegetated wetland areas along the shoreline in Fairfax County.

The Wetlands Board considers whether or not alteration or stabilization of the shoreline is warranted based on the guidelines of the Virginia Marine Resources Commission. The goal of the board, through the public hearing and permitting process, is "to…protect public and private property…and the natural environment, [by] preserving wetlands wherever possible…and to accommodate development in a manner consistent with wetlands preservation." As with other local and state regulations, the NPS considers local laws in the planning process.

Chapter 2:

Alternatives

CHAPTER 2: ALTERNATIVES

This chapter describes the various actions that could be implemented to restore and provide long-term management of Dyke Marsh Wildlife Preserve (Dyke Marsh). National Environmental Policy Act (NEPA) requires federal agencies to explore a range of reasonable alternatives and to analyze what impacts the alternatives could have on the human environment, which the act defines as the natural and physical environment and the relationship of people with that environment. The analysis of impacts from these alternatives is presented in “Chapter 4: Environmental Consequences,” and the conclusions are presented in the summary of environmental consequences later in this chapter.

Alternatives are developed by working from the purpose of and need for action statements in “Chapter 1: Purpose of and Need for Action,” as well as the objectives statements, also in chapter 1; gathering public input; and informing the process with sound scientific and technical data. Alternatives must meet the project objectives to a large degree and address the reason for this draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement (plan/EIS). Alternatives must fall within stated constraints, including compliance with National Park Service (NPS) policies. They also must be based on environmental differences and not technical, logistical, or economic differences.

The alternatives under consideration must include a “no-action” alternative, as prescribed by NEPA regulations in 40 CFR 1502.14. The no-action alternative is the alternative in which existing conditions and trends are projected into the future without any substantive changes in management. In this document, the no-action alternative is the continuation of current management activities in Dyke Marsh, without any modifications to hydrologic conditions or restoration of marsh vegetation.

ALTERNATIVES DEVELOPMENT PROCESS

The alternatives development process ensured that the scientific and technical feasibility of marsh restoration approaches were explored and important elements of the restoration were identified. Desired outcomes and objectives were established and used in the development of the alternatives.

A science team that consisted of experts from the NPS, the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (USACE), and academics with extensive knowledge of Dyke Marsh met several times to discuss marsh restoration and possible alternatives. It was decided at an early alternatives development meeting that more information was needed on hydrology and current conditions before alternatives could be finalized. The NPS then engaged the USACE to further update the bathymetry for the marsh, conduct hydrologic modeling, and develop conceptual alternatives based on the outcome of the models. The public and science team provided feedback during the planning process. Because these action alternatives would be technically and economically feasible, and show evidence of common sense, they are considered reasonable (CEQ 1981). In addition, the USGS also completed research on erosion in the marsh that informed the development of alternatives (Litwin et al. 2011). That report is discussed in more detail in chapters 1 and 3.

The USACE performed 1- and 2-dimensional hydrodynamic modeling, sediment transport modeling, and examined how different alternative scenarios would affect the hydrologic regime in the marsh, deflect some of the erosive energies of the river during storms, and encourage sediment deposition in the restoration areas of the marsh.

The USACE then prepared a conceptual design for each of the alternatives, proposed phasing for containment cells and types of materials that would be used, and reviewed these alternatives with the NPS through a series of meetings. These alternatives were presented to the public at a public meeting in May, 2012. Comments from this meeting further informed the alternatives.

In September 2013, the NPS conducted a Choosing by Advantages / Value Analysis workshop to identify a preferred alternative by determining which alternative offered the most advantages for the best value. The discussions and analysis at the workshop led to further refinement of the alternatives that had been previously presented to the public in May 2012. One alternative was dismissed because it was redundant with the elements of another alternative, and elements of two alternatives were combined to create a new alternative that had more advantages than what was previously presented. Alternatives and alternative elements that were dismissed are discussed in the "Alternatives Considered but Dismissed from Further Detailed Analysis" section in this chapter.

INTRODUCTION AND OVERVIEW OF ALTERNATIVES

This chapter describes the alternatives developed by the interdisciplinary team for this plan/EIS. Restoration alternatives include actions to restore hydrologic conditions and marsh vegetation as well as strategies for long-term management of the marsh. In addition, this chapter provides background information used in determining the restoration alternatives and the long-term management actions considered in this plan/EIS. The chapter provides a summary of adaptive management approaches and benchmarking metrics, discusses alternatives considered but dismissed, and identifies the NPS preferred and environmentally preferable alternative.

The alternatives carried forward for detailed analysis are briefly summarized below.

Alternative A: No Action—Under this alternative, there would be no restoration. Current management of the marsh would continue, which includes providing basic maintenance related to the Haul Road, control of nonnative invasive plant species, ongoing interpretive and environmental education activities, scientific research projects, boundary marking, and enforcement of existing regulations. There would be no manipulation of the marsh other than emergency, safety-related, or limited improvements or maintenance actions. The destabilized marsh would continue to erode at an accelerated rate (Litwin et al. 2011).

Alternative B: Hydrologic Restoration and Minimal Wetland Restoration—Under alternative B, the focus is on the most essential actions that would reestablish hydrologic conditions that shield the marsh from erosive currents and protect the Hog Island Gut channel and channel wall. A breakwater structure would be constructed on the south end of the marsh, in alignment with the northernmost extent of the historic promontory, and wetlands would be restored to wherever the water is less than 4 feet deep. This alternative also includes fill of some deep channels near the breakwater. The final element of this alternative is the reestablishment of hydrologic connections to the inland side of the Haul Road to restore bottomland swamp forest areas that were cut off when the Haul Road was constructed. Approximately 30 acres west of the Haul Road could be influenced by tidal flows as a result. These actions would not necessarily happen in any particular order, and may be dictated by available funds. However, it is assumed that the breakwater would be constructed first. This alternative would create approximately 70 acres of various new wetland habitats and allow the continued natural accretion of soils and establishment of wetlands given the new hydrologic conditions.

Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)—Under alternative C, the marsh would be restored in a phased approach up to the historic boundary of the marsh and other adjacent areas within NPS jurisdictional boundaries. The initial phase would install a breakwater, fill the deep channels within the park, establish marsh in the outline of the historic promontory, and restore marsh along the existing edge to the negative 4-foot contour (approximately 40 acres) to stabilize the marsh and protect Hog Island Gut. Breaks would also be installed to reintroduce tidal flows west of the Haul Road. Future phases would continue marsh restoration until a sustainable marsh is achieved and meets the overall goals of the project. The outer edges of the containment cell structures would be placed at the park boundary in the river. This alternative contains an optional 20-acre restoration cell in the area currently serving as mooring for the marina. Such an option would only be implemented should the marina concession no longer be economically viable for the current concessioner, and no other concessioner expresses interest in taking over the business, eliminating the need for the mooring field. Restoration of 16 acres of wetlands south of the breakwater is also included as an option. Approximately 245 acres of various wetland habitats could be created overall, if all options were implemented.

ALTERNATIVE A: NO ACTION

Under alternative A, no restoration would occur, and the marsh would be managed as it is currently, including providing basic maintenance related to the Haul Road, controlling non-native invasive plant species, and enforcing existing regulations (table 2-1 lists management actions). There would be no manipulation of the marsh other than emergency, safety-related, or limited improvements or maintenance actions. The destabilized marsh would continue to erode at an accelerated rate (Litwin et al. 2011).

Current management actions that would continue to be implemented include continuation of scientific research and evaluation in the marsh and continuation of management of nonnative invasive plants. Educational and interpretive activities would continue to inform the public about marsh ecology and natural processes in the marsh. Cooperation with various entities, such as the group “Friends of Dyke Marsh,” would continue.

IMPLEMENTATION COSTS—ALTERNATIVE A

Costs related to the no-action alternative include costs for oversight or participation in monitoring, data management, and research activities; management and coordination of activities such as educational and interpretive activities, enforcement of existing regulations that would protect the marsh, and facilities management related to the park. Annual cost for these activities can range in value, but have been about $16,000 per year over the past several years (Steury, pers. comm. 2013).

TABLE 2-1. CURRENT MARSH-RELATED MANAGEMENT ACTIONS

Activity	Description
Monitoring, Data Management, and Research	Currently several ongoing monitoring and research efforts are taking place in Dyke Marsh. These activities would continue, although they might be modified as necessary, and new studies might be added after being approved and permitted by the NPS. Research activities include the following: • Conduct NPS-initiated research concerning marsh ecology, as well as hydrology and water levels. • Cooperate with other government, university, and non-government organization research. Examples of these types of research at Dyke Marsh include sediment elevation tables, vegetation studies, fish and wildlife studies, bird counts and breeding bird surveys, and cultural and social science research studies related to environmental compliance. • Conduct other research as funded (e.g., National Science Foundation Grant to Katia Engelhardt at University of Maryland). This research is looking at the feedback between tidal marsh geomorphology and ecology. The goal of the research is to forecast the impact of sea level rise on tidal freshwater marsh diversity, sediment dynamics, and the maintenance of marsh surfaces.
Educational and Interpretive Activities, Including Partnership Programs	• Conduct marsh-focused curriculum-based programs for local schools. • Oversee volunteer River Steward program to assist with trash cleanup and resource monitoring. • Maintain existing partnerships at current staffing level with organizations, such as Friends of Dyke Marsh. • Conduct weekend birdwatching walks with Friends of Dyke Marsh.
Management of Nonnative Invasive Plant Species	• As necessary, apply NPS-approved herbicides to control *Phragmites*, purple loosestrife (*Lythrum salicaria*), and other nonnative invasive plant species. • Manage volunteer groups who physically remove non-native plants and tag/cut plants for later application with NPS-approved herbicides. • Remove nonnative invasive plants and debris from the Haul Road area.
Enforcement of Existing Regulations (36 CFR/ Compendium) to Protect the Marsh	• Limit public access during marsh wren breeding season. • Prohibit vessels with internal combustion engines from coming within 25 meters of the marsh edge. • Maintain a no-wake zone within the park. • Allow fishing in compliance with state fishing regulations. • Continue cooperation with state agencies on fish and wildlife regulations.
Facilities Management	• Maintain and install interpretive signage. • Maintain the Haul Road, the boardwalk, and Mount Vernon Trail in the area of the marsh. • Conduct shoreline cleanups in and near the marsh with volunteer groups. • Conduct emergency stabilization from storms.

ELEMENTS COMMON TO BOTH ACTION ALTERNATIVES

Several elements are common to both action alternatives (i.e., alternatives B and C). These include the creation of a breakwater structure in the general historic location of the promontory at the south end of the marsh that provided protection from waves during strong storms, and filling the deep channels within the park boundary just north of the historic promontory. Other common elements include the approaches to construction of containment cells, achievement of natural edges on the outer perimeter of restored marsh area, creation of breaks in the Haul Road to hydrologically reconnect the former bottomland swamp forest with tidal flows, and approach to vegetation reestablishment. It is also expected that the research, maintenance, invasive plant control, enforcement, and educational actions described under the no-action alternative (alternative A) would continue under all of the action alternatives.

GENERAL CONSTRUCTION APPROACH

Construction would take place from the water to the greatest extent possible, using marine construction equipment. Material would be brought in by barge and stored on the barges. There would be little, if any, need for staging areas on land in the park.

BREAKWATER STRUCTURE AT LOCATION OF HISTORIC PROMONTORY

All of the action alternatives include the construction of a breakwater structure in the historic location of the promontory that was dredged and, as a result, altered the hydrology of the marsh. Construction of the breakwater in that area would redirect erosive flows in the marsh, particularly during strong storms, and would reestablish hydrologic conditions that would encourage sediment accretion (Litwin et al. 2011; USACE 2013).

One of the most prominent and important features of the Dyke Marsh system is the large tidal gut, Hog Island Gut. The gut once meandered through the marsh with its mouth facing in a northerly direction. Direct dredge mining and erosion of the marsh has removed the promontory and other wetlands that created the bend in the tidal gut channel, and it now empties to the south and downstream, thereby increasing its vulnerability to erosion and channel widening within the gut channel itself (Litwin et al. 2011). The USACE models indicate that establishment of a breakwater just downstream of the current mouth of the gut would both protect the gut by introducing a bend in the channel and would also redirect flows and encourage sediment accretion. Therefore, a breakwater structure is included in both action alternatives.

Under alternative B, the breakwater would be placed on historic northern edge of the promontory, close to the historic edge of Hog Island Gut, forcing flows in the gut to turn to the north, as this channel once did. No other restoration would be associated with the breakwater. It would extend into the river about a half of the distance that the original promontory extended into the river.

Under alternative C, the breakwater would be aligned with the historic southern edge of the promontory, and emergent marsh would be created within the outline of the historic promontory to the north of the breakwater (figure 2-1).

The breakwater structure would be constructed of armorstone or riprap to create a stone breakwater. Armorstone boulders are typically larger than 2,000 pounds each, and Class III riprap is smaller rock, which in Virginia ranges from 500 to 1,500 pounds (Chesapeake Materials 2013). A stone breakwater would be constructed in a trapezoidal shape. The side slopes of the stone would be approximately 2:1 from the top of the breakwater to the river bottom elevation, including at the end section (figures 2-2 and 2-3). It is expected that the stone would be brought in by barge and placed from the water.

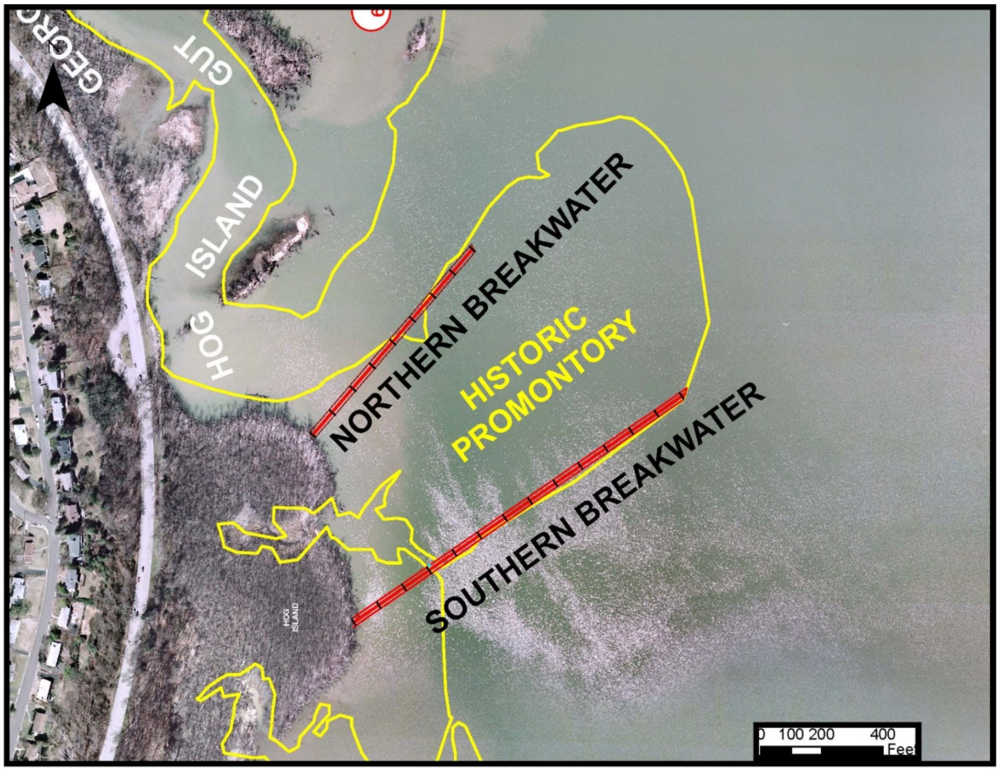


FIGURE 2-1. PLACEMENT OPTIONS FOR THE BREAKWATER STRUCTURES

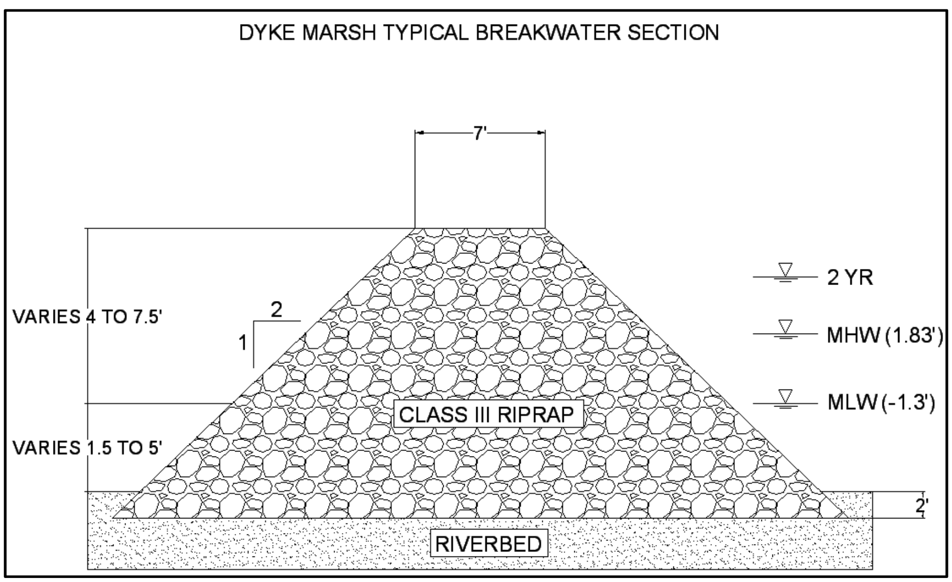


FIGURE 2-2. CONCEPTUAL DRAWING OF A STONE BREAKWATER

FIGURE 2-3. EXAMPLE OF A STONE BREAKWATER

The cost constructing the breakwater at each location (excluding the wetland cells) is shown in table 2-2.

TABLE 2-2. COSTS FOR CONSTRUCTION OF THE BREAKWATER STRUCTURES

Location	Stone Breakwater
Northern Boundary (upstream)	$946,404[a]
Southern Boundary (downstream)	$2,515,785[a]

[a] Maximum bottom width of stone breakwater is: northern boundary – 58 feet and southern boundary – 60 feet

DEEP CHANNEL FILL WITHIN NPS BOUNDARIES

All action alternatives include fill in the deep channel assumed to be formed by dredging (Litwin et al. 2011) just north of the historic extent of the promontory in an area that is approximately 12.6 acres (see figures 2-7 and 2-8 later in this chapter for the location of these channels). The deep channel fill would help to reestablish some of the hydrologic conditions conducive to accretion rather than erosion. The channels would be filled with larger material (gravel or larger), and placement of fill in the channels would be delivered to the site via barge. The backhoe equipment would use sonar and Global Positioning System (GPS) coordinates to deposit the material in the appropriate areas.

CONSTRUCTION APPROACH FOR CONTAINMENT CELLS

The restored marsh would be constructed using a series of containment cells that would be filled with hydraulic slurry using clean fill that has been tested. A containment cell is a structure placed in the open water that allows for fill to be placed inside to raise the elevation of the river bed. Depending on the location of the cells, a variety of materials would be used to construct the containment cell walls. Although several cells, especially those within the 4-foot depth contour, would be smaller to address specific situations, larger cells would be generally used, although the NPS would adjust size and configurations of the containment cells to address design and construction constraints. Phasing of the restoration would generally target filling cells adjacent to vulnerable areas, such as next to the channel wall of Hog Island Gut, and areas immediately along the shoreline first, and then work outward toward the river channel.

Coir biologs are tubes or logs made of coir or coconut fiber bound by high strength twisted coir netting that provide attenuation of wave energy in shallow places; over time, the logs will degrade.

Staked-in-place hay bales or coir biologs would be used as containment cell walls for cells that are closer to shore, in shallower water, and more protected from wave action or flow. Hay bales secured with stakes can be placed in more protected water up to 4 feet deep before it becomes difficult to stabilize them against the current (USACE 2013). These biodegradable options would last long enough for construction to be completed, the fill to settle, and the marsh to establish itself. Similar materials also might be used if internal subdivisions are needed within a larger containment cell with harder outer edges.

Geotextile tubes are large tubes made from high strength fabric filled with sand slurry; they can be several hundred feet in length, and several feet in diameter.

Steel sheet piling would be used to protect the containment cells during restoration for cells that are further into the river in deeper water and are more exposed to flow and wave action. Sand-filled geotextile tubes might also be used in select areas (geotextile tubes are large tubes made from high strength fabric filled with sand slurry or water; they can be several hundred feet in length, and several feet in diameter). The geotextile tubes would be removed after restoration. The sheet piling would be configured to allow intertidal exchange when installed, or cut or perforated once the fill has been placed but before any planting takes place to begin to allow the development of a seed bank (figure 2-4). Once all restoration activities are complete, the sheet piling would be removed, cut or driven into the river bed so the result would be a soft edge to the marsh. Plans addressing intertidal exchange would be developed in greater detail at later stages of design.

Vinyl sheet piling might be used for containment cells that are located in only slightly deeper water, where hay bales would not be sturdy enough but steel sheet piling would not be necessary. As with the steel sheet piling, the vinyl sheet piling would be installed from the water using pile drivers or vibrating equipment. The vinyl piling would be cut or driven into the river bed when the restoration activities are complete. A list of all options for containment cell materials is shown in table 2-3.

Source: USACE.

FIGURE 2-4. EXAMPLE OF SHEET PILING CONFIGURED TO ALLOW FOR INTERTIDAL EXCHANGE

TABLE 2-3. POTENTIAL CONTAINMENT CELL MATERIALS AND WHERE THEY WOULD BE USED

Containment Cell Materials	Where Used
Coir Biologs	In shallow water (up to 4 feet deep); on the leeward side of more substantial containment that will dissipate wave energy.
Hay Bales	In shallow water (up to 4 feet deep); on the leeward side of more substantial containment that will dissipate wave energy.
Geotextile Tubes (sand-filled)	In medium depth water that is slightly more exposed, although low energy areas are still desirable. Geotextile tubes are generally temporary or maintained. They are typically removed or hidden (covered). USACE 1998.
Vinyl Sheet Piling	In deeper water that is moderately protected, but where solutions for shallower water would not work.
Steel Sheet Piling	In deeper water or in situations where flows or wave action requires sturdier materials. Steel sheet piling is typically cut or driven into the river bed after restoration activities are complete.

NATURAL EDGES ON THE OUTERMOST EXTENT OF THE CONTAINMENT CELLS

Whichever alternative is selected for implementation, the outermost edge of the restored marsh (the edge furthest from the shore) would be designed to be a soft, natural edge without noticeable armoring or sheet piling. Achieving a soft, natural edge would require that the outermost containment cell not be completely filled and be designed so the toe of the slope is at the outermost wall of the containment cell at the NPS boundary. Emergent marsh vegetation would not be established all the way to the edge of this cell because the slope and increasing water depth would not support emergent marsh vegetation throughout the cell (figure 2-5). However, it is likely that submerged aquatic vegetation (SAV) would become established in the deeper waters riverward of the emergent marsh. Based on the conceptual design, a possible approach would be to place some sort of barrier, such as riprap or armorstone, geotextile tubes, or possibly coir biologs, in increments back from the sheet piling so that the area on the lee side of the barriers would be at an approximate 20:1 slope, and the outside of the barriers would be closer to a 3:1 slope where the fill material has been allowed to slump over the barriers. Vegetation would be established at the appropriate elevations, with plants such as yellow pond-lily (*Nuphar lutea*) in deeper areas and narrowleaf cattail (*Typha angustifolia*) in shallower areas. SAV would likely become established in the deeper water.

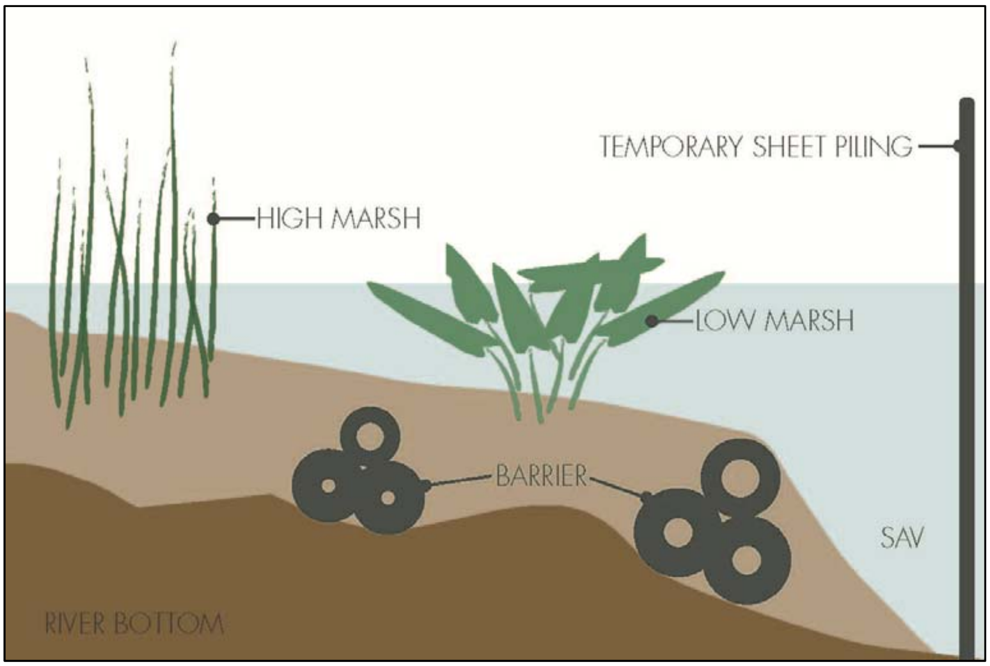


FIGURE 2-5. CONCEPTUAL ELEVATION DRAWING OF THE OUTER CONTAINMENT CELL TO ACHIEVE SOFT, NATURAL EDGES

To achieve natural edges for the newly created tidal guts, the openings and the beginnings of the channels would be cut mechanically, and additional guts would be allowed to form naturally over time. The walls of the tidal gut mouths would be stabilized with biodegradable materials until the guts reach equilibrium.

APPROACHES TO VEGETATION REESTABLISHMENT

Both of the action alternatives include some degree of marsh reestablishment. Use of vegetation appropriate to the elevation (water depth) within the containment cells is an important component of the restoration process. Several options can be used, depending on factors such as available seed sources, type of wetlands desired in a cell, available plant material, and cost constraints. These options include allowing plants to establish naturally by seed or other propagules, seeding mudflats, or transplanting plugs of nursery plants. Revegetation activities could be conducted by NPS staff, contractors, or volunteers. The NPS would prepare the planting plans. Plant species used for the plantings would include narrowleaf cattail, river bulrush (*Bolboschoenus fluviatilis*) if available, wild rice (*Zizania aquatica*), jewelweed (*Impatiens capensis*), arrow arum (*Peltandra virginica*), pickerel weed (*Pontederia cordata*), and yellow pond-lily, among others. In addition, goose exclosures would be used to prevent herbivory by geese.

Exclosures consist of stakes placed around the edges of the restored marsh, with strings stretched between the stakes and flagged so they are visible by birds and other wildlife (figure 2-6). The strings would be placed at intervals that prevent geese from landing between them. Costs for vegetation reestablishment would vary depending on the type of planting strategy used, and the type of labor used.

FIGURE 2-6. EXAMPLE OF GOOSE EXCLOSURES AT ANACOSTIA PARK, WASHINGTON, DC

WASHINGTON GAS PIPELINE

A Washington Gas pipeline, buried beneath the river bottom, passes through the project area for both action alternatives (figures 2-7 and 2-8), near the area of the historic promontory. As discussed in chapter 3, the pipeline is grandfathered from a permit issued to Washington Gas in 1961. The NPS will work with Washington Gas to ensure appropriate construction practices are used so that vibrations in the vicinity of the pipeline are minimized and there are no adverse impacts to the pipeline. Washington Gas has provided a list of mitigation measures, including specific requirements for pile driving and minimum distances to ensure that the northern promontory and sheet piling do not impact the gas line during construction. There would be no expected impacts on the gas line after construction is completed.

REESTABLISH HYDROLOGICAL CONNECTIONS TO THE INLAND SIDE OF THE HAUL ROAD

All action alternatives include the reintroduction of tidal flows to both sides of the Haul Road via the installation of culverts or bridges. Reintroduction of intertidal exchange would encourage reestablishment of a floodplain swamp forest and facilitate the management of nonnative invasive vegetation species that have established in the area. Although the configuration and materials used for the culverts and bridges would be determined later in the design process, it is likely that two to three breaks would be introduced in the road, although there could be breaks up to every 200 feet, depending on final design, resulting in 10 or 12 breaks in the road. Contractors would use heavy equipment, such as a backhoe, to cut each break in the road. To minimize disturbance of individual sites, contractors would work backwards out of the Haul Road toward the marina driveway. Contractors would prepare the site, install a bridge or concrete box culvert, and move toward the marina driveway to install the next break. Appropriate sediment and erosion control practices would be used, and the removal of trees, should removal be necessary, would be mitigated by planting new native trees or possibly other appropriate native vegetation in the disturbed area.

ADAPTIVE MANAGEMENT APPROACHES INCLUDED IN THE ACTION ALTERNATIVES

Adaptive management is used when there are clearly defined desirable outcomes to a project, but there is uncertainty or incomplete information to ensure that the outcome will be achieved. According to a Department of the Interior technical guide on adaptive management prepared for its bureaus and agencies (Williams, Szaro, and Shapiro 2007), adaptive management is

> a systematic approach for improving resource management by learning from management outcomes…An adaptive approach involves exploring ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems…

Adaptive management will be a key element in the implementation of all the action alternatives in this plan/EIS. Marsh restoration would be phased, and there are many factors that could affect the success of this restoration project, contributing to uncertainty. Adaptive management would be useful in this planning effort to make adjustments to vegetation establishment, manage nonnative invasive species throughout the marsh, and track the overall restoration approach to ensure restoration is successful. Adaptive management frameworks describe the initial actions being taken, metrics used to ensure objectives are being met, monitoring actions to be taken, and subsequent actions that would be taken if monitoring indicates the objectives are not being met. The adaptive management framework for this project is discussed in detail in appendix A. The plan would establish baseline preconstruction conditions, monitor postconstruction conditions, and compare conditions to control sites or reference marsh. The marsh at Piscataway Park on the Potomac River would be used as a control site and reference marsh. The NPS would monitor vegetation establishment (amount of vegetation and species types), elevation, and rates of erosion or accretion. Vegetation in the newly created marsh should be approximately the same as what is currently in the existing marsh or in the reference control marsh at Piscataway Park, a limit on nonnative species (in terms of percentage of overall vegetation) would be established, and nonnative species would be removed upon discovery. Characteristics such as elevation, erosion, and accretion would be monitored to make sure the breakwater and other changes are working as expected. Hydrology and salinity would also be monitored.

ALTERNATIVE B: HYDROLOGIC RESTORATION AND MINIMAL WETLAND RESTORATION

Alternative B would achieve a minimal level of marsh restoration, and focuses on the most essential actions to reestablish hydrologic conditions that would shield the marsh from erosive currents and protect the Hog Island Gut channel and channel wall.

A breakwater structure would be constructed just south of the historic Hog Island Gut channel, in alignment with the northern extent of the historic promontory. No additional marsh would be created within the historic extent of promontory.

North of the breakwater, wetlands would be restored in the areas where current water depth is 4 feet or less (the outer extent of which is shown as the negative 4-foot contour line on plans) and would be phased so that containment cells would first be placed along the weakest areas of the Hog Island Gut channel identified in the USGS study (Litwin et al. 2011). The USGS has identified several points in the channel as being particularly susceptible to breaching, and these areas would be the first ones to be protected with new wetland cells. The remaining cells would be constructed in the areas less susceptible to breaching. In addition, the deep channel areas adjacent to the historic promontory and the proposed breakwater would be filled. The final element of this alternative would include the reestablishment of hydrologic connections to the inland side of the Haul Road to restore bottomland swamp forest areas that were cut off when the Haul Road was constructed.

Implementation of this alternative would create up to approximately 70 new acres of wetland habitat of various types, including approximately 25 acres of restored marsh, and allow the continued natural accretion of soils and establishment of wetlands due to the restored hydrologic conditions (figure 2-7).

IMPLEMENTATION COSTS—ALTERNATIVE B

Implementation costs include several elements, including mobilization and demobilization, earthwork cut and fill for the proposed marsh, deep channel fill, the breakwater, using the cost for the more expensive riprap construction, hay bales, and vegetation. With this type of construction project, the most substantial costs are associated with mobilization and demobilization, or getting the barges, material, and equipment in place. The other major cost is associated with the construction of the breakwater. The breakwater for alternative B would be less expensive than for the other action alternatives because it would be shorter and constructed in shallower waters for the most part, requiring less material for construction. Costs are not included for fill material in any of the alternatives, because it is assumed that fill will be donated from dredging activities in the region as it becomes available. the overall cost for alternative B is between $4 and $7 million, depending on the materials for the breakwater and the approach to revegetation. Revegetation costs could range between $0 and $40,000 per acre, depending on the methods used. Because design for all of the alternatives is in the very early stages, estimated costs are general, and have been rounded to the nearest million to provide an order of magnitude estimate.

ALTERNATIVE C: HYDROLOGIC RESTORATION AND FULLEST POSSIBLE EXTENT OF WETLAND RESTORATION (PREFERRED ALTERNATIVE)

As with alternative B, the two primary objectives of alternative C would be to reestablish hydrologic conditions that would protect Hog Island Gut and redirect erosive flows through the establishment of a breakwater. Under alternative C, the marsh would be restored in a phased approach up to the historic boundary of the marsh and other adjacent areas within NPS jurisdictional boundaries (figure 2-8). Phased restoration would continue until a sustainable marsh is achieved and meets the overall goals of the project. The historic boundaries lie between the historic promontory and Dyke Island, the triangular island off the end of the Haul Road. The outer edges of the containment cell structures would be placed at the park boundary in the river.

The initial phase of this alternative would first fill the deep channels on NPS property and establish a breakwater structure at the southern alignment of the historic promontory to provide immediate protection to Dyke Marsh from erosion. Emergent marsh would be restored within the area of the historic promontory to simulate the original extent of the land mass, and allow for the future phases to be implemented and allow for full restoration. The deep channel areas north of the historic promontory would also be filled within the NPS boundary prior to placement of the containment cells. After the breakwater is established and the deep channel areas are filled, the marsh would then be restored to the negative 4-foot contour at strategic locations to further reduce the risk of erosion and storm surges and promote sedimentation within the existing marsh. Up to 35 acres of marsh would be restored during this first phase. The southern alignment of the breakwater would be longer and would allow for somewhat more protection of the marsh from erosive storm waves than alternative B.

All subsequent phases would establish containment cells no further than the historic marsh boundary. The location of these cells would be prioritized based on the most benefits the specific locations could provide to the existing marsh (i.e., erosion protection, increased sedimentation potential, improved hydrology, etc.). The timing of these subsequent phases and the size and number of cells built during these phases would be dependent upon available funds and materials.

In addition to the construction of containment cells, tidal guts would be cut into the restored marsh area that would be similar to the historical flow channels of the original marsh. The outer edges of the containment structures would be placed at the park boundary, the historic limit of the marsh. However, with the intent to establish soft, natural edges on the outside of the restored marsh, the extent of restored marsh would be inside the outermost edge of the containment cells when restoration is complete.

This alternative, like alternative B, would also introduce breaks in the Haul Road, returning tidal flows to approximately 20–30 acres west of the Haul Road, which would help to re-establish the historic swamp forest originally found on the site.

Approximately 16 additional acres of wetland may be restored south of the new breakwater to fill out the southernmost historic extent of the marsh. This area would not be protected from storms, and would be one of the last features implemented. In addition, the marsh restoration would extend north of Dyke Island, and tidal guts would be created. This alternative contains an optional 20-acre restoration cell in the area currently serving as a mooring area for the marina. Such an option would only be implemented should the marina concession no longer be economically viable for the current concessioner, and then only if no other concessioner expresses interest in taking over the business, which would eliminate the need for the mooring field. In total, under this alternative, approximately 245 acres of various wetland habitats could be created.

IMPLEMENTATION COSTS—ALTERNATIVE C

As noted previously, mobilization and demobilization would comprise a considerable portion of the cost. The cost of the breakwater assumes the use of the more expensive riprap in construction. Steel and vinyl sheet piling and the cost of armorstone for the underwater barriers to create the slopes for the soft marsh edge represent substantial portions of the cost. The cost for fill material is not included because it is assumed these portions would be donated. The initial phase, including deep channel fill, construction of the breakwater, and vegetation restoration to the negative 4-foot contour, would cost up to $10–12 million. Overall costs could range between $35 and $45 million, depending on which approach to revegetation is selected.

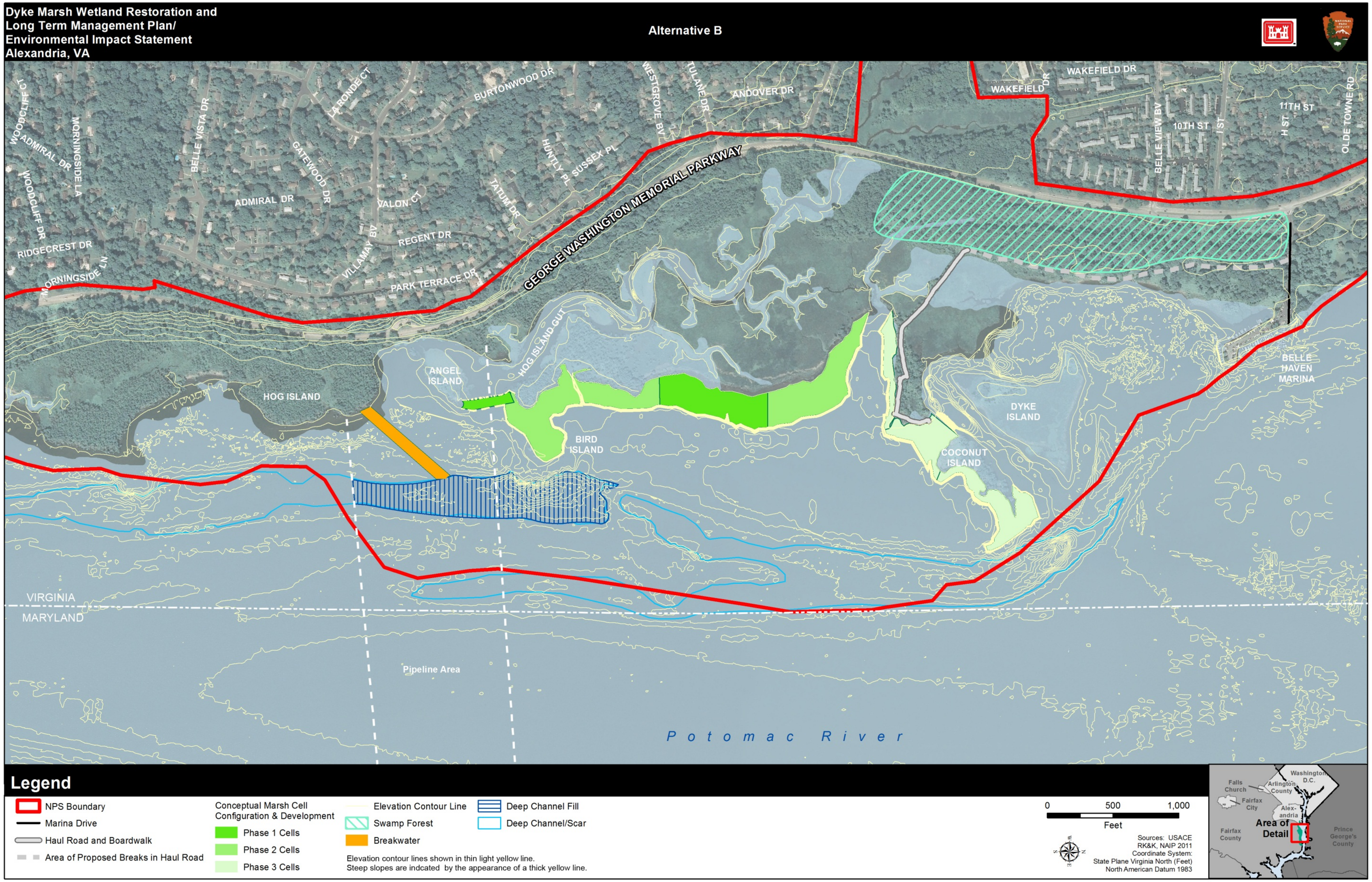


FIGURE 2-7. ALTERNATIVE B, WITH POSSIBLE CONTAINMENT CELL CONFIGURATION

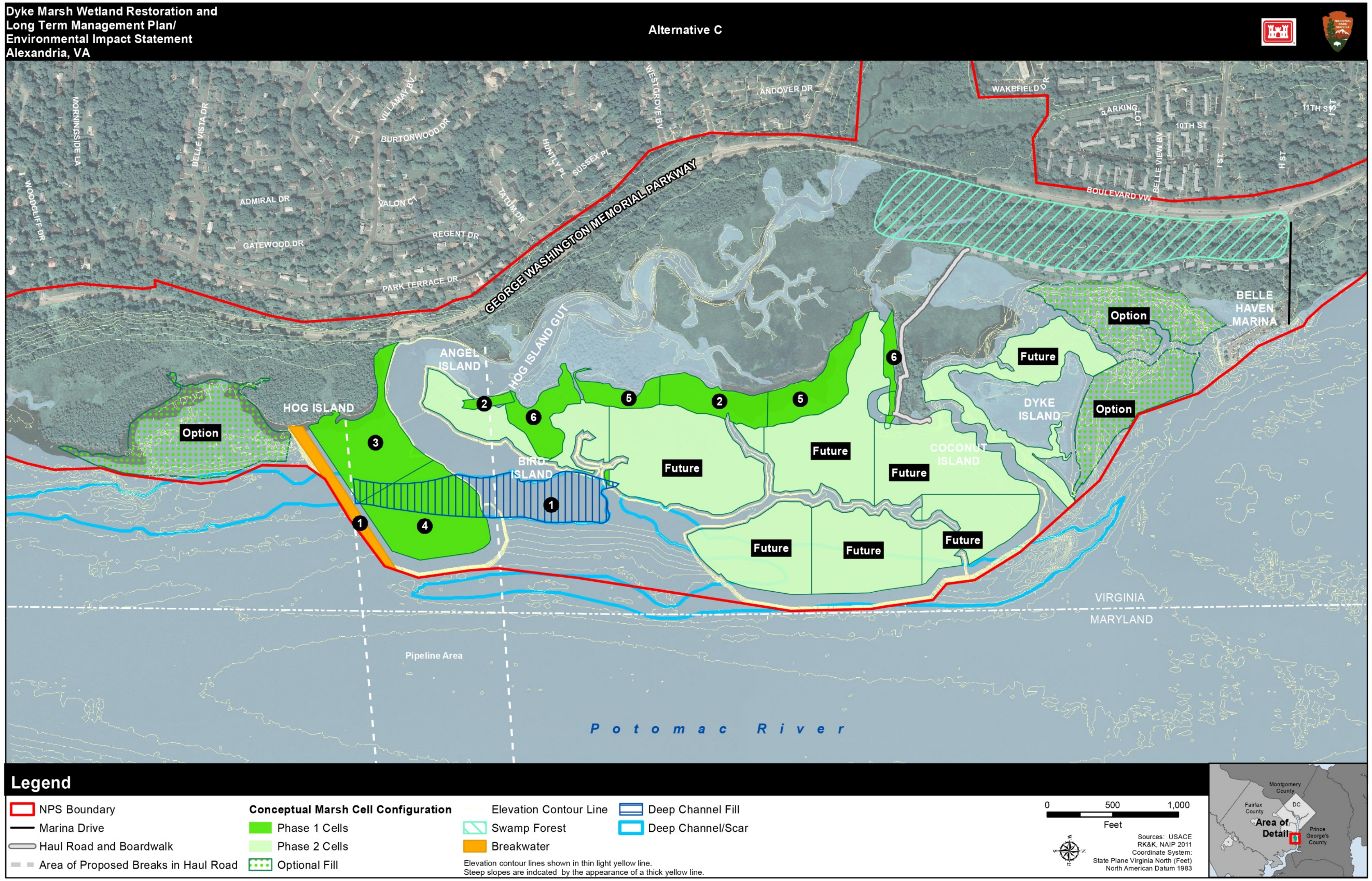


FIGURE 2-8. CONCEPTUAL PLAN OF ALTERNATIVE C, WITH POSSIBLE CONTAINMENT CELL CONFIGURATION

SUMMARY OF ALTERNATIVES AND HOW THEY MEET THE PLAN OBJECTIVES

Table 2-4 compares the alternatives and summarizes the actions being considered within each alternative. Table 2-5 compares how each of the alternatives described in this chapter would meet the plan objectives. The action alternatives analyzed must meet all objectives, as stated in "Chapter 1: Purpose of and Need for Action," and they must address the stated purpose of taking action and resolve the need for action. Therefore, the alternatives were individually assessed in light of how well they would meet the objectives for this plan/EIS, which are stated in the "Objectives in Taking Action" section in chapter 1. Alternatives that did not meet the objectives were not analyzed further (see the "Alternatives Considered but Dismissed from Further Detailed Analysis" section).

The environmental analysis described in "Chapter 4: Environmental Consequences" looks at the effects of each alternative on each impact topic; these impacts are summarized in table 2-6.

TABLE 2-4. SUMMARY OF ALTERNATIVES

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Management Actions	Continue current management actions: monitoring and research; educational activities relating to the marsh; nonnative invasive plant species management; enforcement of regulations related to use of the marsh; facilities maintenance	Same as alternative A	Same as alternative A
Promontory area changes	No changes	Breakwater structure at northern alignment of historic promontory	Breakwater structure at southern alignment of historic promontory with wetland vegetation to the north of the breakwater to simulate the original land mass
Wetland restoration (general)	No restoration other than emergency, safety-related, or limited improvements or maintenance	Restoration of wetlands to the negative 4-foot contour, phased to protect the vulnerable sections of the channel wall of Hog Island Gut	Restoration of wetland between the breakwater area and Dyke Island, with restoration between Dyke Island and the marina (with an optional cell by the marina and in the marina mooring field); option to restore additional marsh to the south of the breakwater; introduce tidal guts with cut and fill; containment cells built to the edge of park boundary with gradual edges Initial phase is restoration of the promontory area and restoration of vegetation to the negative 4-foot contour to stabilize the marsh and reduce erosion
Haul Road area changes	No changes	Reintroduce tidal flows inland of the Haul Road by installing culverts or bridges	Same as alternative B

TABLE 2-5. ANALYSIS OF HOW THE ALTERNATIVES MEET PLAN OBJECTIVES

Objective	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Natural Resources			
Restore, protect, and maintain tidal freshwater wetlands and associated ecosystems to provide habitat for fish, wildlife, and other biota.	Does not meet objective; current management would allow continued erosion and eventual disappearance of the marsh.	Meets objective; would protect and stabilize important areas of the marsh and restores additional acreage.	Meets objective; would protect and stabilize important marsh features and allows for full restoration of the marsh.
Ensure that management actions promote native species while minimizing the intrusion of nonnative invasive plants.	Partially meets objective; nonnative invasive species would be removed according to current management practices in the marsh. Establishment of additional native species would be difficult with eroding marsh.	Meets objective; would allow establishment of additional marsh, which is habitat for native species. Potential for establishment of nonnative invasive species increases with acres of marsh restored over the short term, but monitoring and adaptive management would discourage and prevent establishment of nonnative invasive species.	Meets objective; would allow establishment of additional marsh, which is habitat for native species. Potential for establishment of nonnative invasive species increases with acres of marsh restored over the short term, but monitoring and adaptive management would discourage and prevent establishment of nonnative invasive species. The higher number of acres would ultimately allow for establishment of more native species than alternative B.
Reduce erosion of the existing marsh and provide for erosion control measures in areas of restored marsh.	Does not meet objective; alternative would allow for continued erosion and eventual disappearance of the marsh.	Meets objective; alternative would provide for stabilization of marsh through construction of breakwater.	Meets objective; alternative would provide for stabilization of marsh through construction of breakwater, and southern alignment of the breakwater allows for somewhat more protection of the marsh from erosive storm waves than alternative B.
To the extent practicable, restore and maintain hydrologic processes needed to sustain Dyke Marsh.	Does not meet objective; alternative does not include restoration of hydrologic processes, and marsh is not currently sustainable.	Meets objective; installation of the breakwater and restoration of the marsh to the negative 4-foot contour would stabilize the marsh and establish hydrologic processes needed to create a sustainable marsh.	Meets objective; installation of the breakwater and restoration of the marsh to the negative 4-foot contour would stabilize the marsh and establish hydrologic processes needed to create a sustainable marsh. The additional marsh restoration under this alternative would meet this objective better than alternative B.

Objective	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Protect populations of species of concern such as swamp sparrow (*Melospiza georgiana*) and river bulrush (*Bolboschoenus fluviatilis*).	Does not meet objective; habitat would decrease for all species of concern over time and marsh would eventually disappear.	Meets objective; would stabilize marsh and protect existing marsh areas, as well as adding additional acres of marsh that can support species of concern.	Meets objective; would stabilize marsh and protect existing marsh areas, as well as adding additional acres of marsh that can support species of concern. More fully meets this objective than alternative B because more marsh would be restored.
Increase the resilience of Dyke Marsh by providing a natural buffer to storms and provide for flood control in populated residential areas.	Does not meet objective; marsh would eventually disappear and its ability to provide a buffer would decrease over time and eventually cease.	Meets objective; would increase marsh acreage, and breakwater would help buffer wave energy during storm events.	Meets objective; would increase marsh acreage, and breakwater would help buffer wave energy during storm events. The higher acreage of marsh restored means this alternative would better meet this objective than alternative B.
Cultural Resources			
Protect the historic resources and cultural landscape features associated with Dyke Marsh and the George Washington Memorial Parkway.	Does not meet objective; would allow for eventual disappearance of the marsh, a component landscape, and erosion would threaten undiscovered archeological resources and hasten deterioration of remnants of the historic dike.	Partially meets objective; would increase marsh acreage and stabilize it, therefore protecting and enhancing the viewshed from some directions, and also protecting dike remnants and possible archeological resources. Breakwater would be very obvious from some perspectives, and would be a new element in the component landscape.	Meets objective; would increase marsh acreage and stabilize it, therefore protecting and enhancing the viewshed from some directions, and protecting dike remnants and possible archeological resources. Breakwater would be much less visible, if at all, because it would be further away from the open part of the parkway than the location of the breakwater in alternative B, and would also have marsh screening it.
Visitor Experience			
Enhance appropriate educational, interpretation, and research opportunities at Dyke Marsh and enhance accessibility for diverse audiences.	Does not meet objective; interpretive and educational opportunities would decrease over time as marsh erodes.	Meets objective; restoration would allow for increased opportunities for education and interpretation.	Meets objective; same as alternative B.

TABLE 2-6. SUMMARY OF ENVIRONMENTAL CONSEQUENCES

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Hydrology and Sediment Transport	The existing flow regime would continue, and there would be continued erosion and loss of marsh over time. The marsh would disappear without intervention, and there would be no opportunity for beneficial hydrologic conditions or sediment accretion; unique characteristics of the marsh, including the marsh itself, would be lost. This would result in a significant long-term adverse effect on hydrology and sediment transport. **Cumulative**: The no-action alternative would contribute adverse effects to the impacts of other past, present, and reasonably foreseeable projects in this area. This contribution would be appreciable because of the marsh expected to be lost as a result of hydrologic change and erosion.	Construction of the breakwater would allow significant beneficial changes to hydrology and sediment transport to occur by shielding the marsh from storms, redirecting flows, and creating low energy areas in which sediment would settle out, accrete, and marsh areas could develop. Construction of the breakwater would result in localized, significant beneficial impacts on hydrology because it would restore natural hydrologic and sediment transport processes that were present in the marsh prior to the removal of the historic promontory. The establishment of these fundamental changes would also allow for measurable benefits to other key resources in the marsh. The marsh restoration configuration would also create long-term benefits on hydrology and sediment transport by establishing restored wetlands areas and protecting Hog Island Gut, furthering the beneficial impacts created by the breakwater. The breaks in Haul Road would beneficially reintroduce tidal flows to lower areas west of Haul Road. Construction would temporarily divert flows, creating some adverse impacts on hydrology and sediment transport within the marsh. These impacts would not be significant. **Cumulative**: Alternative B would contribute mostly beneficial impacts on hydrology and sediment transport to the impacts of other past, present, and reasonably foreseeable projects. The contribution would be noticeable because most of the cumulative impacts from other actions are localized and have a limited effect on the hydrology and sediment transport in the immediate area of the marsh.	As under alternative B, the construction of the breakwater would allow significant beneficial changes to hydrology and sediment transport to occur by shielding the marsh from storms, redirecting flows, and creating low energy areas in which sediment would settle out, accrete, and marsh areas could develop. Construction of the breakwater would result in localized, significant beneficial impacts on hydrology because it would restore natural hydrologic and sediment transport processes that were present in the marsh prior to the removal of the historic promontory. The establishment of these fundamental changes would also allow for measurable benefits to other key resources in the marsh. More wetland acreage (up to 245 acres) would ultimately be restored than under alternative B, and would result in similar but larger beneficial impacts than alternative B. Impacts of the Haul Road would be the same as under alternative B. Short-term construction impacts under alternative C would be similar to, but of a slightly greater magnitude than those described under alternative B, and they would be similar to alternative B under phase one of the project. **Cumulative**: The contribution of the beneficial impacts of alternative C on Dyke Marsh and the Potomac River to the impacts from past, present, and reasonably foreseeable projects would be appreciable because the impacts of the other projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Soils and Sediments	Marsh soils would erode over time, and the marsh would disappear without intervention. Unique characteristics of the marsh would be lost. This would result in a significant long term adverse effect on soils, because soils are necessary for a healthy marsh. **Cumulative**: The no-action alternative would continue to contribute adverse impacts on soils and sediments in Dyke Marsh and the Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable future projects. The contribution would be appreciable because of the magnitude of the loss of soils in the marsh, and the relatively localized impacts from the other projects.	Sediments on the river bottom would be covered with fill that would eventually become wetland soils. There are no significant ecological benefits from replacing one type of soil or sediment with another. The soils west of Haul Road would become hydric and support the reestablishment of wetlands in this area. Soil disturbance and river bottom compaction from construction activities would be both short- and long-term, adverse, and relatively minor. **Cumulative**: Alternative B would contribute beneficial impacts on soils and sediments in Dyke Marsh and the Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable future projects. The contribution would be noticeable because most of the cumulative impacts from other actions are localized and have a limited effect on the soils and sediment in the immediate area of the marsh.	Impacts on soils and sediments would be similar to but larger in scale than impacts under alternative B. Sediments on the river bottom would be replaced with fill that would eventually become wetland soils, resulting in beneficial impacts and allowing marsh restoration to succeed. The impacts on soils west of Haul Road would be the same as under alternative B. These benefits would be substantial, but not significant. The breakwater would be longer than alternative B, so impacts related to covering of the river bottom with armorstone for the breakwater would be the similar to, but slightly greater than impacts under alternative B. **Cumulative**: Alternative C would contribute long-term beneficial impacts on soils and sediments in Dyke Marsh and the adjacent Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable projects. The contribution would be appreciable, particularly because the cumulative impacts are localized for the most part, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Surface Water Quality in the Potomac River	Erosion would continue and the marsh would eventually disappear. Marsh sediments would be carried downstream. Fewer wetlands would decrease the filtering ability of the marsh, and lower the ability of the marsh to provide water quality improvements locally. Impacts would be long-term and adverse, but given the overall volume of water in the Potomac River flowing by Dyke Marsh, adverse effects would be relatively minor, and not significant. **Cumulative**: The adverse impacts on water quality of continued and accelerated erosion of the marsh from the no-action alternative would be a noticeable but not appreciable contribution to the impacts on water quality from other projects, because the impacts from the marsh erosion would largely be localized.	Marsh restoration would provide localized benefits to water quality by increasing marsh acreage, and increasing water quality benefits of restored marsh. These mostly localized benefits would not be significant. Construction would cause short-term adverse impacts related to disturbing sediments on the bottom. Best management practices (BMPs) would be used to prevent water quality issues; containment walls would also prevent and minimize impacts. There would be some initial scour around the breaks in Haul Road. These impacts would not be significant. **Cumulative**: Alternative B would contribute mostly localized long-term beneficial impacts on water quality in the marsh and the river to the impacts of other past, present, and reasonably foreseeable projects. The contribution would be only somewhat noticeable, given the localized nature of the impacts from alternative B and the impacts of many of the other projects.	The benefits to water quality would be greater than but similar in nature to those under alternative B. The benefits would be noticeable, but mostly localized, and not significant. Similar to alternative B, construction would cause short-term adverse impacts related to disturbing the sediments on the bottom; BMPs would be used during installation to prevent water quality issues. Impacts would not be significant. **Cumulative**: Implementation of alternative C would possibly contribute long-term beneficial impacts on water quality to the impacts of other past, present, and reasonably foreseeable projects. The contribution would be noticeable, but not appreciable, because the impacts from alternative C would still be mostly localized, even with the larger acreage of expansion.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Floodplains	The continued erosion of the marsh under the no-action alternative would not change the base flood elevation, but would adversely affect floodplain functions and values, including the ability of the marsh to provide a buffer to the parkway and inland properties in storm conditions, and provide habitat for floodplain species of plants and wildlife. These impacts would be noticeable, but would not be significant; the impacts would become evident slowly over time. **Cumulative**: The continued erosion of the marsh and reduction of floodplain function and values under alternative A would contribute adverse impacts to the mostly beneficial cumulative impacts on floodplains from other projects over time. The contribution would be noticeable, and not appreciable, because the impacts from the erosion of the marsh would affect only the immediate vicinity of the marsh.	Restoration of the marsh would raise the base flood elevation by 1.2 inches, but would also increase marsh area that would provide a buffer to the parkway and inland properties during storm events, and could therefore lessen the severity of floods. Other floodplain functions and values would also be increased. The magnitude of the benefits would be less than the magnitude of benefits under alternative C. Although important, these benefits would not be significant. **Cumulative**: Alternative B would contribute beneficial, but mostly localized impacts to the mostly beneficial impacts of other past, present, and reasonably foreseeable projects, resulting in overall benefits to the floodplain in Dyke Marsh and on the Potomac River. The contribution of alternative B to the cumulative scenario would be noticeable, but not appreciable, because the impacts would be mostly localized.	Restoration of the marsh would raise the base flood elevation by 1.8 inches, but would also noticeably increase marsh area. The increases in marsh area would provide a greater buffer from flooding to the parkway and inland properties during storm events than alternative B. Other floodplain functions and values would also be increased. There would also be some short-term adverse impacts on floodplain function and values as the result of the placement of the containment structures that could restrict the assimilative capacity of the existing marsh temporarily. Although the beneficial impacts would be important, these benefits and the short-term adverse impacts would not be significant. **Cumulative**: Alternative C would contribute beneficial, but localized impacts to the beneficial impacts from other projects, as well as short-term adverse construction-related impacts, resulting in overall benefits to the floodplain in Dyke Marsh and on the Potomac River. The contribution from the long-term beneficial impacts would be noticeable, whereas the contribution from the short-term adverse impacts would be imperceptible.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Vegetation and Wetlands	The no-action alternative would result in erosion and disappearance of the marsh and its vegetation over time, including plants such as river bulrush. Additional impacts include reduced or eliminated functions and values that Dyke Marsh wetlands provide. These adverse effects on vegetation and wetlands would be significant because tidal freshwater marsh is regionally threatened, and Dyke Marsh is important in a regional context. In addition, the river bulrush community is unusual, and there are very few tidal freshwater wetlands in this region, particularly with similar plant communities. **Cumulative**: The no-action alternative would continue to contribute noticeable adverse effects on wetlands and vegetation in the marsh to the impacts from other past, present, and reasonably foreseeable projects. The contribution of impacts from the no-action alternative would be appreciable because of the types of vegetation and the acreage affected.	The new restored wetland vegetation (70 acres) would protect existing vegetation, including river bulrush and other unusual plants, in addition to increasing overall marsh acreage and protecting the tidal freshwater marsh from disappearing. Because the new vegetation under alternative B is protecting this important regional resource, the beneficial impacts would be significant. The breaks in Haul Road and resulting hydrologic reconnections would discourage continued establishment of nonnative invasive plants because repeated inundation favors the reestablishment of native plants over nonnative plants. Anticipated impacts and changes in vegetation as a result of water depth and salinity changes associated with climate change would be monitored and addressed through the adaptive management monitoring plan. **Cumulative**: Implementation of alternative B would contribute beneficial long-term impacts to the mostly localized impacts of other projects. The contribution would be noticeable, and not appreciable, because most of the cumulative impacts from other actions are localized and have a limited effect on the wetlands and vegetation in the immediate area of the marsh.	The new restored wetland vegetation (245 acres) would protect existing vegetation, including river bulrush and other unusual plants, in addition to increasing overall marsh acreage and protecting the tidal freshwater marsh from disappearing. Implementation of phase one would protect the existing marsh then allow additional restoration to move forward in the future. Long-term beneficial impacts would be significant, because alternative C would protect an important regional resource. Benefits associated with the breaks in Haul Road would be the same as for alternative B. Anticipated impacts and changes in vegetation as a result of water depth and salinity changes associated with climate change would be monitored and addressed through the adaptive management monitoring plan. **Cumulative**: Alternative C would contribute long-term benefits to the impacts from other projects, including protection of the marsh from some of the erosive effects of other projects. The contribution of the beneficial impacts of alternative C on wetland restoration and vegetation colonization in Dyke Marsh would be appreciable, particularly since the cumulative impacts of other past, present, and reasonably foreseeable projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Fish and Wildlife	Dyke Marsh would continue to provide suitable habitat for invertebrates, as well as juvenile and adult fish species. However, the amount of habitat available for use by fish and wildlife would continue to slowly decline over time with the loss of marsh due to erosion. Some of these species are species of concern; these species and other unusual species such as the marsh wren would be adversely affected. As a result of the loss of marsh under this alternative and the associated magnitude of adverse impacts on wildlife, impacts would be significant. **Cumulative**: In the short term, contributions of adverse effects from the no-action alternative to the effects on terrestrial and aquatic fish and wildlife in the area from other projects would likely be imperceptible, but in the long term, with the continued erosion of the freshwater tidal marsh and loss of habitat, the no-action alternative would likely contribute noticeable adverse effects to the overall adverse cumulative effects on terrestrial and aquatic fish and wildlife species in the area.	Alternative B would increase wetland and marsh habitat by approximately 70 acres, allowing a greater habitat area, which would increase the number of species and population sizes over the long term. Although there are new acres added, and the marsh would be stabilized, the amount of new habitat and associated benefits would be noticeable, but not significant. Construction-related impacts would result from the use of marine equipment, and include temporary displacement of fish and wildlife as the result of construction noise and vibrations. Less mobile species of aquatic wildlife could be buried during the fill process. Restrictions on construction periods would likely be put in place per agreements with state wildlife agency to minimize adverse effects from vibration and construction noise on species of fish and wildlife that breed in the marsh. Adverse construction impacts are not likely to be large enough to be significant under alternative B. **Cumulative**: Alternative B would contribute mostly beneficial impacts on wildlife in Dyke Marsh and the Potomac River to the impacts from other past, present, and reasonably foreseeable future projects. The contribution would be somewhat noticeable because it would increase the amount of available habitat to species in the local area.	Alternative C would increase wetland and marsh habitat by up to 245 acres, with a smaller first phase that would stabilize and slightly increase overall marsh acreage, and would substantially increase the number of species and population sizes over the long term. The amount of new habitat and associated benefits would be noticeable and potentially significant. Similar construction-related impacts as alternative B, but larger in scope. **Cumulative**: Alternative C would contribute long-term beneficial impacts on wildlife to the mostly localized impacts from other past, present, and reasonably foreseeable projects. The contribution would be appreciable because the cumulative adverse impacts of projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Species of Special Concern	The continuing loss of marsh soils and the lack of new soils being formed from sediment deposition would lead to loss of habitat for existing communities of river bulrush and giant bur-reed. Because these plants both function to bind marsh soil, loss of colonies of river bulrush and giant bur-reed would make adjacent parts of the marsh more vulnerable to erosion. Loss of marsh would also result in loss of potential nesting and forage habitat for the least bittern and swamp sparrow, and would result in long-term adverse impacts for both species of birds. Because it is expected that the marsh would completely erode over time and it provides important habitat for these state-listed species of concern, the adverse impacts on the river bulrush, giant bur-reed, and both bird species would be significant. Under the no-action alternative, the floodplain swamp behind Haul Road would continue to be hydrologically restricted and habitat for Davis' sedge and rough avens would continue to be lost **Cumulative**: The no-action alternative would continue to contribute adverse effects on the three plant species of concern and both bird species of concern in the marsh to the adverse impacts from other projects. The contribution from the impacts of the no-action alternative would be appreciable because of the large acreage of marsh that would eventually be lost, and because habitat would be reduced.	Restoration of marsh would provide additional nesting and foraging habitat for both the swamp sparrow and the least bittern, and increase acreage in which river bulrush and giant bur-reed could become established, resulting in long-term beneficial impacts. Temporary displacement of both bird species near the construction area would be likely during construction. Both bird species would be expected to readily recolonize the marsh after construction was complete. To prevent disturbance of the birds during their breeding seasons, restrictions on construction would be put into place in consultation with the state. Reconnection of tidal flows west of Haul Road would discourage continued establishment of nonnative invasive plants in the areas with restored hydrologic connection, and would create conditions that would encourage reestablishment of rough avens and Davis' sedge. The NPS would identify the populations of Davis' sedge and rough avens prior to construction, and protect the plants during construction activity. The long-term benefits would be noticeable, but not large enough in magnitude to be significant. Because BMPs would be incorporated and there would be limitations on construction during breeding periods, impacts related to construction would be short-term adverse, but not significant. **Cumulative**: Alternative B would contribute long-term beneficial impacts on habitat for the plant and bird species of concern in Dyke Marsh to the mostly localized but adverse impacts of other projects. This contribution would be noticeable. The alternative would also contribute some short-term adverse impacts to the overall scenario. With mitigation, the contribution of these short-term adverse construction-related impacts would be imperceptible.	The impacts on Davis' sedge and rough avens would be the same as under alternative B. The larger acreage restored under alternative C would provide similar benefits for the marsh plants river bulrush and giant bur-reed, and for both bird species, by increasing acreage in which the plants could occur, and by increasing nesting and foraging habitat. The magnitude of the benefits could result in these impacts being significant. Construction impacts would be similar to those described under alternative B, although they would be more extensive, and would be temporary. Restrictions on construction periods would be put in place in consultation with the state to avoid interference with breeding seasons. **Cumulative**: Alternative C would contribute long-term beneficial impacts on habitat for the plant and bird species of concern in Dyke Marsh to the mostly localized adverse impacts of other projects. The contribution would be noticeable, and possibly appreciable, given the greater extent of marsh restored under alternative C than alternative B. The contribution of short-term adverse construction impacts from this alternative would be more noticeable than under alternative B, but would still be imperceptible.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Archeological Resources	Ongoing erosion would wash away or potentially damage the archeological resources of the George Washington Memorial Parkway. The surviving section of the dyke that gave the marsh its name would be threatened, as would other archeological resources that might be present in the marsh, but have not been discovered. Impacts from the no-action alternative (alternative A) would not be significant because the adverse effects are not certain. However, if the dyke or other resources are damaged, it would constitute an adverse effect under Section 106 of National Historic Preservation Act. **Cumulative**: The no-action alternative would allow the marsh to continue to erode, threatening the surviving remnant of the dyke and any other archeological resources that might be present along the river's shoreline, and would contribute potential adverse effects to the effects of the other projects. This contribution would likely range from imperceptible to noticeable, depending on whether the dyke remnants are harmed.	Restoration activities under both alternatives would stabilize the marsh and substantially reduce erosion, which would therefore protect archeological resources in and adjacent to the marsh. The impacts would be the same for both alternatives. Introduction of low energy tidal flows west of Haul Road would not affect any archeological resources. Construction activities in the marsh would take place from the water and would not affect archeological resources, and construction to create breaks in the Haul Road also would not affect archeological resources, because the road is built on fill material and archeological resources below the road would have been extensively disturbed in the past. The beneficial impacts would not be significant. **Cumulative**: The restoration of the marsh and reduction of erosion under alternative B would contribute beneficial impacts on archeological resources in the park to impacts from other projects by protecting the archeological resources in Dyke Marsh. The contribution would be appreciable.	Same as alternative B.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Historic Structures, Districts, and Cultural Landscapes	Erosion of the marsh under alternative A would result in long term adverse effects under NEPA on historic districts and associated component landscapes: a landscape feature important to the George Washington Memorial Parkway and Mount Vernon Memorial Highway would disappear. These impacts would be noticeable, and could rise to a level of significance because of the marsh's importance as a scenic feature in the historic district. **Cumulative**: The no-action alternative would contribute an adverse effect to the impacts of the other projects in the park. The contribution would therefore be appreciable, because the no-action alternative would result in the loss of a prominent landscape feature.	Marsh restoration under alternative B would stabilize and restore the marsh, resulting in beneficial impacts on the historic landscape. The existing remnants of the dike would be protected by reduced erosion, and by measures put in place during construction. The breakwater would be constructed of large stones, and would therefore look somewhat natural, but it would be visible from the parkway, and would not be screened, resulting in adverse impacts on the historic landscape. Changes introduced to the landscape by the breakwater would be very noticeable and possibly significant, depending on the viewpoint and duration of the view. **Cumulative**: Alternative B would contribute beneficial impacts to the impacts from the other projects by halting the erosion of Dyke Marsh and therefore limiting the deterioration of the landscape, but it would also contribute adverse effects to the viewshed, and would not mitigate the cumulative harm from the other projects that affect the viewshed. The contribution of beneficial impacts would be noticeable, and the contribution of adverse effects to the viewshed would range from noticeable to appreciable depending on the viewpoint and duration of the view (duration depends on whether the viewer is in the park or driving by).	Marsh restoration under alternative C would stabilize and restore a large area of marsh, resulting in beneficial impacts on the historic landscape. The existing remnants of the dike would be protected by reduced erosion, and by measures put in place during construction. The breakwater would be constructed of large stones, would be further south than the breakwater under alternative B, and would be screened with marsh plantings, so it would not be particularly noticeable from the parkway. It would represent a minimal intrusion into the historic landscape, and would not be significant. **Cumulative**: Restoration of Dyke Marsh under alternative C would contribute beneficial impacts on the cultural landscape and historic district to the adverse impacts of the other projects. The contribution would be appreciable, because erosion of the marsh would be prevented and the breakwater would not be highly intrusive.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Visitor Use and Experience	Marsh erosion would adversely alter visitor use and experience over time. Nature viewing would be altered and access to the marsh would decrease and disappear over time, including access to the end of the Haul Road trail, although visitors could still recreate in the area by boat, and the changes would be gradual. Because the changes would happen gradually, for most visitors the changes would not be noticeable. For other users, such as bird watchers, the changes could represent a measurable adverse effect as opportunities decrease, and the number of species and number of individual birds decrease. Overall, the impacts on visitor use and experience would not rise to a level of significance. **Cumulative**: Alternative A would contribute long-term adverse impacts to the impacts of other past, present, and reasonably foreseeable projects. Because the changes would occur over a long period of time, the contribution would be imperceptible.	There would be some long-term beneficial impacts on visitor use and experience related to experiencing improved wetland and marsh habitats and having more marsh to explore by paddle craft after restoration is complete. The largest impacts would occur during construction and would be adverse. Construction activity would be evident over an extended period of time, and parts of the park would be closed during construction. These impacts would be temporary and would not be significant, however. Long-term beneficial impacts on visitor use and experience would not be significant. **Cumulative** Implementation of alternative B would contribute mostly long-term beneficial and short-term adverse impacts to the overall adverse impacts of the cumulative projects. The contribution of beneficial impacts would be noticeable. Contribution of adverse impacts would be imperceptible.	There would be long-term beneficial impacts on visitor use and experience related to experiencing improved wetland and marsh habitats and having more marsh to explore, including new tidal guts, by paddle craft after restoration is complete. Long term beneficial impacts on visitor use and experience would not be significant. As with alternative B, the largest impacts would occur during construction and would be adverse. Construction activity for future phases would cover a larger area than alternative B, and would be evident over a period of years. Impacts on the visitor use of the marina would be minimal, although access to the marsh by paddle craft would be limited. Parts of the park would be closed during construction, although the areas would change as work is completed and new cells or phases are started. Because the impacts would take place over a period of years, and would be noticeable, construction-related impacts could be significantly adverse, although they would end when construction was complete. **Cumulative:** Alternative C would contribute both short-term adverse and long-term beneficial impacts to the relatively small adverse cumulative effects. The contribution of the impacts would be noticeable, because the impacts from C would be of a larger scale than the impacts from the cumulative projects.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Adjacent Property Owners, and the Marina	Alternative A would have minimal impacts on adjacent property owners and the marina. Erosion of the marsh would exacerbate flooding in adjacent areas, and overtime, the marina could become more exposed, which could affect how much shelter the mooring field provides, and the ease of using the marina. Erosion of the marsh could also increase the amount of maintenance and protection needed on the parkway as the shoreline moves closer to it in the future. These impacts would be noticeable, but would not be a large enough magnitude to be significant. **Cumulative**: No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.	Construction activities would affect adjacent landowners by increasing noise and large equipment in the Dyke Marsh area. The magnitude of construction-related impacts would not be as large under alternative B as under alternative C. Over the long term, alternative B would provide some additional buffering from flooding in the adjacent community, and provide some protection for the parkway itself. The breakwater would be visible from properties to the south but would be less visible than the breakwater proposed in alternative C. There may be increased noise during hunting season, although the restored marsh would still be relatively far from the property line, so hunting would increase noticeable in adjacent waters. These impacts are all relatively minor and would not be significant. **Cumulative**: No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.	Construction activities would affect adjacent landowners by increasing noise and large equipment in the Dyke Marsh area. The magnitude of construction-related impacts would larger than under alternative B. Over the long term, alternative C would provide noticeably more buffering from flooding in the adjacent community than currently exists, and would also provide some protection for the parkway itself. The breakwater would be visible from properties to the south but would be less visible than the breakwater proposed in alternative C. There may be noticeably more noise during hunting season with the extent of the restored marsh closer to the property line, making it more likely that waterfowl would be found closer to the property line. Sediment accretion in and adjacent to the restored marsh south of the breakwater could slightly affect the depth of the water under adjacent docks, but it would not be noticeable and would not affect the use of these docks. These impacts are all relatively minor and would not be significant. **Cumulative**: No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

	Alternative A: No Action	Alternative B: Hydrologic Restoration and Minimal Wetland Restoration	Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative)
Park Management and Operations	Under the no-action alternative (alternative A), the marsh would continue to erode, which would result in decreased research and educational opportunities, and increase maintenance efforts to protect the parkway, Mount Vernon trail, and other facilities adjacent to the marsh. The marina is expected to continue to operate at capacity, but might experience a loss of revenue from decreased rentals of paddle craft over an extended period of time as the marsh erodes. The mooring field and other parts of the marina could become more exposed over time and less appealing to marina users. Increased maintenance would not likely become necessary for the next fifteen years, however, and these impacts would not be significant. **Cumulative**: No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.	Both action alternatives require the implementation of a monitoring program to ensure the restoration is successful, and increased management to ensure that geese exclosures and nonnative invasive plant management is working. During construction, staff time would be required to interact with construction personnel, and research and educational activities might be refocused. Overall, the level of effort necessary under alternative B would be less than under alternative C, and would not be of a magnitude that could be considered significant. **Cumulative**: No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.	Both action alternatives require the implementation of a monitoring program to ensure the restoration is successful, and increased management to ensure that geese exclosures and nonnative invasive plant management is working. A greater amount of staff time would be required to interact with construction personnel under alternative C, and research and educational activities would be refocused. Overall, the level of effort necessary under alternative C would be much greater than under alternative B, but it would likely be spread out over time, and would be focused over short amounts of time and would therefore not be significant. **Cumulative**: No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.

ALTERNATIVES CONSIDERED BUT DISMISSED FROM FURTHER DETAILED ANALYSIS

The following alternatives were considered but dismissed from further detailed analysis for reasons explained below.

1. **Restore to the extent of 1937 marsh** with marsh edges extending to the edge of the park boundary. This alternative would not be technically feasible because construction would be needed outside the park boundary to achieve this extent of restored wetland, and the NPS does not have authority to work outside the boundaries of its property. In addition, very deep channels at the north end of the park would need to be filled; it may not be technically feasible to fill them to the extent required. The alternative is very similar to alternative D, although it would result in more adverse impacts; it would be more costly due to the amount of fill required, and would probably result in less natural marsh edges than would result from alternative D. This alternative was therefore considered and dismissed from more detailed analysis.
2. **Restore only in accretion areas identified in 2009 study** (NPS 2009c), south of the Haul Road and north to the area just south of the Belle Haven Marina; just north of the historic promontory; and from the historic promontory south of Hog Island Gut. Further hydrologic modeling has shown that these areas are not actually accreting, so the alternative would not be technically feasible without other modifications, and would therefore be unreasonable even with the restoration of the historic promontory that would restore hydrologic conditions. This alternative is similar to alternative B because it also considers fill to the negative 4-foot contour. This alternative was therefore considered but dismissed from further analysis.
3. **Alternative C presented at Public Scoping and Alternatives Meetings: Hydrologic Restoration and Intermediate Extent of Wetland Restoration**. This alternative was presented during public scoping and alternatives meetings (figure 2-9). This alternative, which made use of large containment cells, and only restored wetlands between the breakwater and Dyke Island, was considered redundant to, and offers less flexibility than, the new alternative C, phased hydrologic restoration and full extent of wetland restoration presented in this chapter.
4. **Restore the marsh using the 1976 USACE Demonstration Cell (28 acres)**. The USACE proposed a marsh restoration demonstration cell in 1976. The demonstration cell was 28 acres and was proposed to be placed “in the area outside of the existing Haul Road between the larger wooded island (Coconut Island south of Dyke Island) and the remnant spit” (NPS 1977), and would have included diking and natural revegetation. The location of the demonstration cell designed by the USACE in 1976 is not in a protected location and would be highly vulnerable to erosion and lacks inclusion of tidal guts. The alternative would not meet the purpose and need of the plan, because the restoration would not be successful over the long term. This alternative included restoration of the historic promontory, which has been incorporated into action alternatives carried forward for analysis.

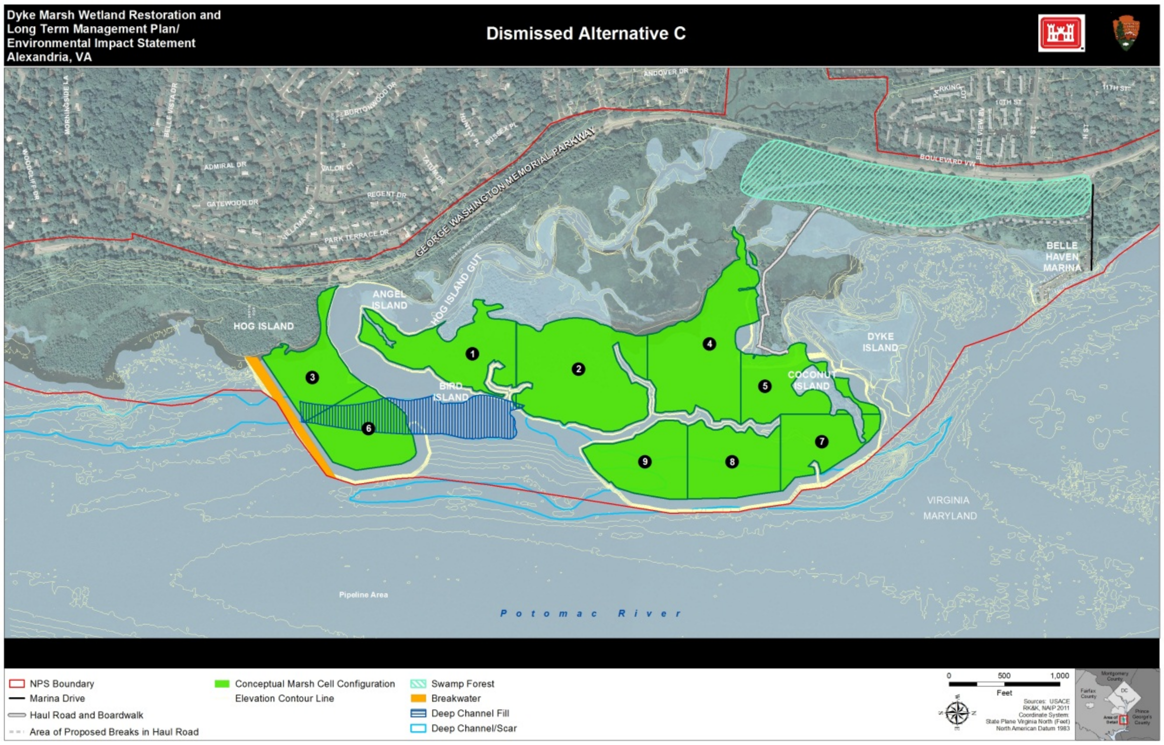


FIGURE 2-9. DISMISSED ALTERNATIVE C, AS SHOWN IN PUBLIC MEETING ALTERNATIVES DISPLAY

5. **Fill all the deep channels on the north end of the marsh to restore marsh hydrology, and restore the historic promontory**. These deep channels extend outside the park boundaries, and it would not be feasible to fill them successfully without working outside the park boundaries. In addition, based on the modeling for other alternatives, it is unlikely that filling these channels would noticeably affect restoration one way or the other and would therefore not be technically feasible. The more important element to restoration of marsh hydrology is the restoration of the historic promontory in some form, and although restoration of the historic promontory is part of this alternative, this feature has been incorporated into other action alternatives carried forward for analysis. Alternative B would accomplish much the same objective as this alternative, and has a higher likelihood of success and would also be less expensive (the cost of deep fill could be high). Therefore, this alternative was dismissed.

6. **Construction option B: use of small containment cells during restoration construction**. In preparing the conceptual designs for the alternatives carried forward for analysis, the USACE proposed two options for containment cell configurations: small and large containment cells. The small cells option was dismissed from further analysis because the larger cells of the other options would accomplish the same purpose and objective, but would be substantially less expensive.

7. **Restore marsh in other areas on the Potomac**. It was suggested during public scoping that restoring other areas outside the original extent of Dyke Marsh should be considered. This proposal would not meet the purpose of or need for restoration of Dyke Marsh; therefore, was dismissed from further analysis.

8. **Construct the breakwater using steel sheet piling**. Use of steel sheet piling filled with earth (slurry fill) was considered for the breakwater along the historic promontory. The depth of a sheet piling breakwater wall would be approximately three times the river depth. About two-thirds of the sheet piling would be embedded below the river bottom to ensure the breakwater is strong

enough (figures 2-4 and 2-5). Similar to the stone breakwater, the construction would be expected to take place from the water. The sheet piling would be put in place using boats equipped with either pile drivers or vibrating equipment that would slide the sheet piling into the river bottom. This construction method was dismissed because it is similar in cost to building an armorstone breakwater, requires more maintenance over time and might need replacement, and is less visually consistent with the historic and natural character of the George Washington Memorial Parkway. The armorstone breakwater is also more permeable than the steel sheet piling, allowing for the creation of more habitat for various species of fish and wildlife.

9. **Construct a breakwater on the north end of the marsh**. This alternative was suggested during public scoping. Because a breakwater located on the north end of the marsh would not restore hydrologic conditions necessary for successful restoration, and would not meet the project purpose and objectives, it was dismissed.

CONSISTENCY WITH THE PURPOSES OF THE NATIONAL ENVIRONMENTAL POLICY ACT

NEPA requires an analysis of how each alternative meets or achieves the purposes of the act (Section 101[b]). Each alternative analyzed in a NEPA document must be assessed as to how it meets the following purposes:

1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
2. ensure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;
3. attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences;
4. preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice;
5. achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life’s amenities; and
6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources (42 USC 4331).

The Council on Environmental Quality (CEQ) has promulgated regulations for federal agencies’ implementation of NEPA (40 CFR 1500–1508). Section 1500.2 states that federal agencies shall, to the fullest extent possible, interpret and administer the policies, regulations, and public laws of the United States in accordance with the policies set forth in the act (Sections 101(b) and 102(1)); therefore, other acts and NPS policies are referenced as applicable in the following discussion, which describes to what extent the various alternatives meet the purposes of NEPA listed above.

Purpose 1: Fulfill the Responsibilities of Each Generation as Trustee of the Environment for Succeeding Generations

George Washington Memorial Parkway is a unit of the national park system. As the trustee of the land, the NPS would continue to fulfill its obligation as trustee of Dyke Marsh for future generations. Alternative A (no action) would not support this purpose well because the alternative would not allow for restoration and protection of wetland resources, plant and animal communities, and natural ecosystem functions that have been damaged by previous human uses and are subject to continuing environmental threats. Additionally, alternative A would not restore Dyke Marsh, as required under P.L. 93-251 and WRDA 2007. Alternatives B and C would provide better long-term protection of Dyke Marsh. Alternative C would best meet this purpose because it would result in the most acreage of existing wetlands being protected from erosion, nonnative invasive plant species, loss of habitat, and altered hydrologic regimes. Alternative C would restore wetlands and ecosystem functions and processes to a greater degree than alternative B. Both alternatives B and C would create conditions that would allow the enhancement of Dyke Marsh and George Washington Memorial Parkway and improved ecosystem services that benefit the Potomac River Watershed and the Chesapeake Bay. The anticipated benefits to the environment increases with the acreage of wetlands restored and protected.

Purpose 2: Ensure for All Americans Safe, Healthful, Productive, and Aesthetically and Culturally Pleasing Surroundings

The alternatives would meet this purpose similar to the way they meet Purpose 1, based on the difference in the amount of wetlands to be restored and protected. Under alternative A, there would be no wetlands restoration. Current management of the marsh would continue, which includes providing basic maintenance related to the Haul Road, control of nonnative invasive plant species, ongoing interpretive and environmental education activities, scientific research projects, boundary marking, and enforcement of existing regulations. There would be no manipulation of the marsh other than emergency, safety-related, or limited improvements or maintenance actions. The destabilized marsh would continue to erode and would not contribute to productive or aesthetically pleasing surroundings. Alternatives B and C would allow the NPS to ensure a safe, healthful, productive, and more pleasing environment within the boundaries of Dyke Marsh as a result of planting of native vegetation in areas of fill that would ultimately mature and blend in with the remainder of the marsh. Restoring and expanding the tidal freshwater marsh would enhance the cultural landscape. The anticipated benefits associated with productive and aesthetically pleasing surroundings increase with the acreage of wetlands restored and protected.

Purpose 3: Attain the Widest Range of Beneficial Uses of the Environment Without Degradation, Risk of Health or Safety, or Other Undesirable and Unintended Consequences

Similar to Purpose 1, alternative A would not meet this purpose since the alternative would not allow for restoration and protection of wetland resources, plant and animal communities, and natural ecosystem functions that have been damaged by previous human uses and are subject to continuing environmental threats. Additionally, alternative A would not restore Dyke Marsh, as required under P.L. 93-251 and WRDA 2007. The action alternatives, in particular alternative C, would allow for the widest range of beneficial uses of the environment by providing habitat for fish, wildlife, and other biota; protecting rare populations of state rare species, as well as protecting historic resources and enhancing visitor use and experience of Dyke Marsh. Both action alternatives would result in some temporary adverse environmental impacts or degradation as a result of construction activities; however, in the long-term, successful wetland restoration would have positive effects on water quality by increasing wetland and floodplain functions, on soils from decreased erosion, and on wildlife and wildlife habitat as a result of increased areas of native vegetation. However, both alternatives include mitigation that would limit or reduce any degradation and other unintended consequences.

Purpose 4: Preserve Important Historic, Cultural, and Natural Aspects of our National Heritage and Maintain, Wherever Possible, an Environment that Supports Diversity and Variety of Individual Choice

Alternative A would not provide for protection of important cultural and historic aspects of Dyke Marsh because the marsh would continue to erode. The marsh is a component landscape of the George Washington Memorial Parkway historic district. It was present in George Washington's time and when the George Washington Memorial Parkway was created. Its loss has an appreciable impact on the George Washington Memorial Parkway historic district. Continued erosion of Dyke Marsh would therefore degrade the cultural landscape of the George Washington Memorial Parkway. Without marsh restoration, wetland vegetation, include species of concern, would have a decrease success of colonization, which could indirectly affect the natural aspects of the park's heritage, such as changing or impeding river views from the parkway and the shore adjacent to the marsh and may limit some individual choices regarding visitor use of Dyke Marsh. Alternative A would allow for Haul Road to continue to erode, possibly to the point where visitor use (particularly by birders as they areas is heavily used by this group) of the area would be restricted. Alternative B would preserve the cultural, historic, and natural aspects of the environment and would provide individual choice as a result of wetland restoration and protection. Alternative C would provide the most preservation of these aspects of the park's heritage and allow for more individual choice at Dyke Marsh with regards to future management of the area.

Purpose 5: Achieve a Balance Between Population and Resource Use that Will Permit High Standards of Living and a Wide Sharing of Life's Amenities

Alternative A would not lend itself to a balance between population and resource use because it would allow for continuation of existing management of Dyke Marsh, resulting in further destabilization of the marsh from continued erosion, and NPS would only take emergency actions to remedy the issue. Alternative A would have limited benefits regarding the balance between population and resources use of Dyke Marsh. Alternatives B and C would restore and protect Dyke Marsh and aim to strike a balance between population and resource use by limiting impacts to park resources through restoration and protection activities while allowing for increased recreational, educational, and research uses and opportunities by the local population as well as research organizations such as the National Science Foundation and universities. Restoration adjacent to the marina would be implemented only if the marina were to become economically infeasible and closed, allowing for optimal balance of natural and recreational uses.

Purpose 6: Enhance the Quality of Renewable Resources and Approach the Maximum Attainable Recycling of Depletable Resources (42 USC 4331)

None of the alternatives directly addresses the recycling of depletable resources, although the marsh would eventually erode to the point it would disappear under alternative A. Both action alternatives involve wetland restoration and protection and would result in enhancing the quality of renewable natural resources in the park by allowing for NPS management and protection of the wetlands and wildlife at Dyke Marsh. Alternative C would meet this purpose to a greater degree than alternative B because more acres of wetlands would be restored and protected to support the renewable resources of Dyke Marsh and the George Washington Memorial Parkway.

NATIONAL PARK SERVICE PREFERRED ALTERNATIVE

The preferred alternative is the alternative “which the agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic environmental, technical, and other factors” (CEQ 1981). The NPS has identified alternative C as its preferred alternative upon consideration of factors such as the degree to which alternatives would meet plan objectives (see table 5), environmental impacts (see “Chapter 4: Environmental Consequences”), the degree to which alternatives provide management flexibility, and costs. Alternative C would provide the greatest amount of benefits from its initial phases of restoration by stabilizing the marsh and allows for flexibility in restoration approaches such that full marsh restoration is possible.

ENVIRONMENTALLY PREFERABLE ALTERNATIVE

The NPS is required to identify the environmentally preferable alternative in its NEPA documents for public review and comment. The NPS, in accordance with the Department of the Interior NEPA regulations (43 CFR 46) and the CEQ’s Forty Questions, defines the environmentally preferable alternative (or alternatives) as the alternative that best promotes the national environmental policy expressed in NEPA (Section 101(b)) (516 DM 4.10). The CEQ’s Forty Questions (CEQ 1981) further clarifies the identification of the environmentally preferable alternative stating:

> this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources (CEQ 40 Questions, Question 6a).

Alternative C was identified as the environmentally preferable alternative because it would provide the most beneficial impacts on resources and values, including short-term stabilization of the marsh and minimization of erosion. The alternative would also allow for future restoration of the entire marsh by placing the breakwater on the southern alignment, and therefore allowing restoration of the promontory. This alternative would allow for the most environmental benefits, including creation of habitat, water quality and floodplain protection benefits, restoration of cultural landscapes, and improvement of visitor experience. Under alternative B, future restoration would be limited by the configuration of the breakwater, and under alternative A (no action), the marsh would continue to erode, eventually entirely; therefore neither of those alternatives would be considered environmentally preferable.

Chapter 3:

Affected Environment

CHAPTER 3: AFFECTED ENVIRONMENT

This "Affected Environment" chapter describes existing conditions of the natural and cultural environments that would be affected by the implementation of the actions considered in this draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement (plan/EIS). This chapter discusses the following natural and cultural environments:

- Hydrology and Sediment Transport
- Soils and Sediments
- Surface Water Quality in the Potomac River
- Floodplains
- Vegetation and Wetlands
- Fish and Wildlife
- Species of Special Concern
- Archeological Resources
- Historic Structures and Districts
- Cultural Landscapes
- Visitor Use and Experience
- Adjacent Property Owners and the Marina
- Park Management and Operations.

Impacts for each of these topics are analyzed in "Chapter 4: Environmental Consequences." In all but the "Adjacent Property Owners and the Marina" sections, the affected environment described is the extent of the Dyke Marsh Wildlife Preserve (Dyke Marsh), located in the George Washington Memorial Parkway, and includes Dyke Marsh proper and the associated lands around it.

HYDROLOGY AND SEDIMENT TRANSPORT

The mean tidal range in the area of the marsh is between 0.5 and 0.9 meter (1.64 and 2.95 feet) (UMCES 2004), and U.S. Geological Survey (USGS) data show that the mean streamflow in the Potomac River ranged between 4,017 and 23,760 cubic feet per second between the years of 1931 and 2011. The highest flows generally tend to occur in the spring months, such as March and April, due to upstream snowmelt and spring rain events. Some annual high flows also occur in other months due to storm events (USGS 2012). Nutrients and sediments, which are critical to the health of the marsh, are delivered to the marsh through the hydrology of the tidal guts and the process of water washing over the wetlands during the ebb and flow of tides.

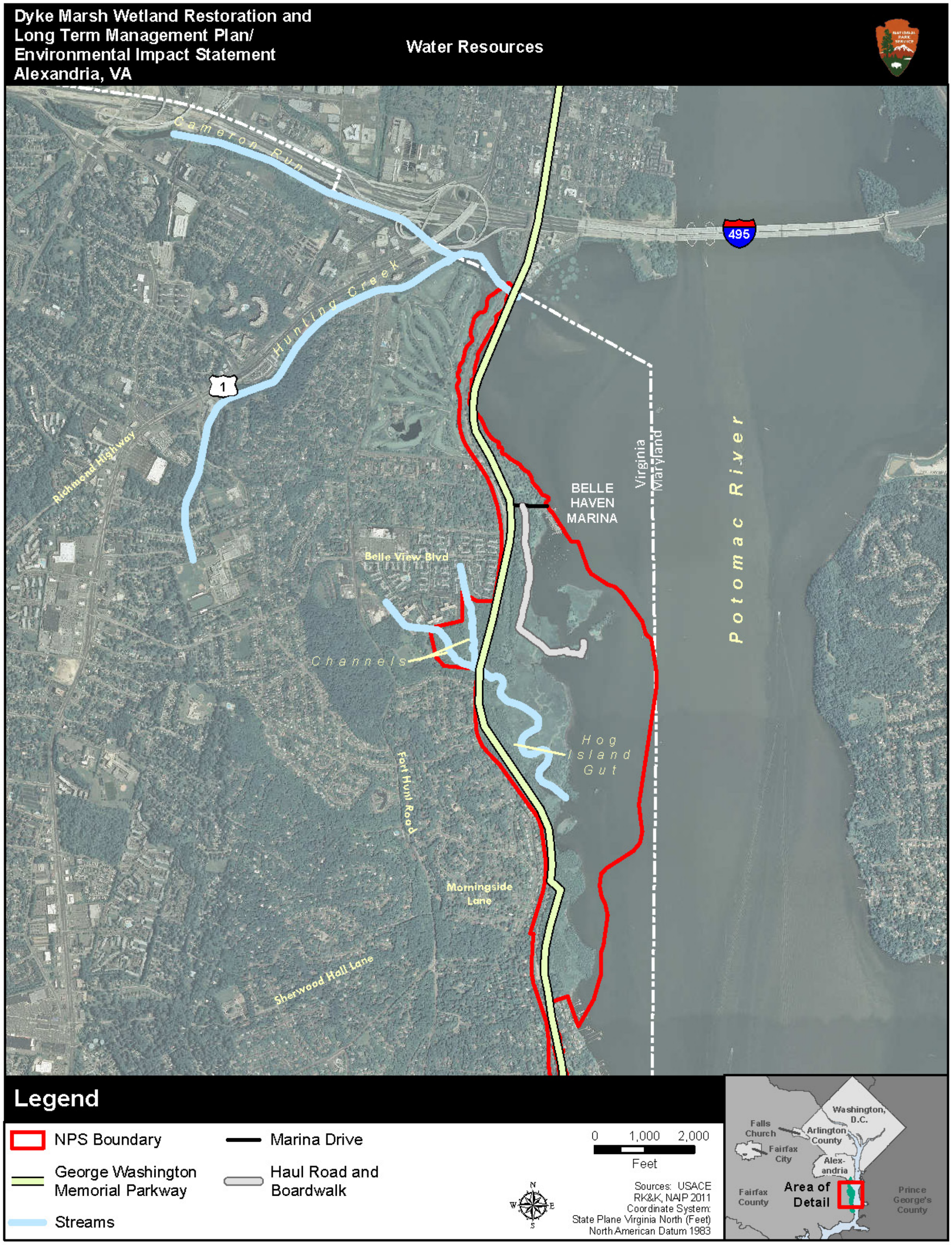


FIGURE 3-1. WATER RESOURCES

Drainage in the marsh is controlled both by tidal flows and general flow in the Potomac River (UMCES 2004). A 2009 bathymetry study in the marsh indicates that although the main channel of the river used for shipping is on the east side of the Potomac, there are deep channels that may have been created by or enlarged as a result of hydrologic changes caused by past sand and gravel dredging activity (NPS 2009b). These channels run upstream–downstream through the marsh and act as main channels that exacerbate erosive effects in the marsh (figure 3-2). The depth of the Potomac River adjacent to the eastern edge of the marsh was historically shallow (≤4 feet) and provided some protective measures to the shoreline (Litwin et al. 2011). However, the current deep channels, approximately 12 to 16 feet deep, off the eastern edge of the marsh allow wave energy to impact the shoreline (Litwin et al. 2011). These effects have been compounded by the removal of a small promontory from the southern end of the marsh, immediately downstream of the two channels (see figure 1-2 for changes to the marsh over time). This removal took place during the first stages of dredging for sand and gravel in the 1930s. This promontory served as an energy barrier for the southern marsh, especially from storm-induced waves from the south; prevented the full brunt of flood flows from pushing up the Hog Island Gut; and allowed sediments to aggrade in the marsh (Litwin et al. 2011). The islands on the northern end of the marsh, originally tidal guts that have now become isolated, are also allowing increased flow through these channels.

Shoreline Erosion

Hog Island Gut, the last significant tidal gut remaining in the marsh, currently empties downstream into the river near the location of the historic dikes and the location of the former promontory. In the past, this gut and other guts in the marsh had more meanders and emptied upstream toward the north. Historic photos and the USGS study show evidence of changes in flow regime and morphology in the gut, creating straighter channels that now drain downstream to the south, rather than bending north and emptying upstream (Litwin et al. 2011). Existing river flows are directed through the marsh and the marsh outflows are in a southerly direction. Additionally, the mouth of Hog Island Gut is slowly moving deeper into the marsh due to sediment deposition in that area, and the smaller tidal tributaries are being eroded (Litwin et al. 2011). These changes have allowed for more efficient flow into and out of the guts as tides flow and ebb, and increased erosion and widening in the guts. The two islands at the upstream extent of the marsh, which are remnants of tidal guts, help protect the marsh from southeasterly flows and provide shelter to a large section of marsh. Figure 3-3 shows Hog Island Gut in 2009 and in 1939, and how its configuration has changed, as well as the location of the promontory of land removed in the dredging process. It also shows the channels that connect the gut with the surrounding neighborhoods discussed in the "Adjacent Property Owners and the Marina" section.

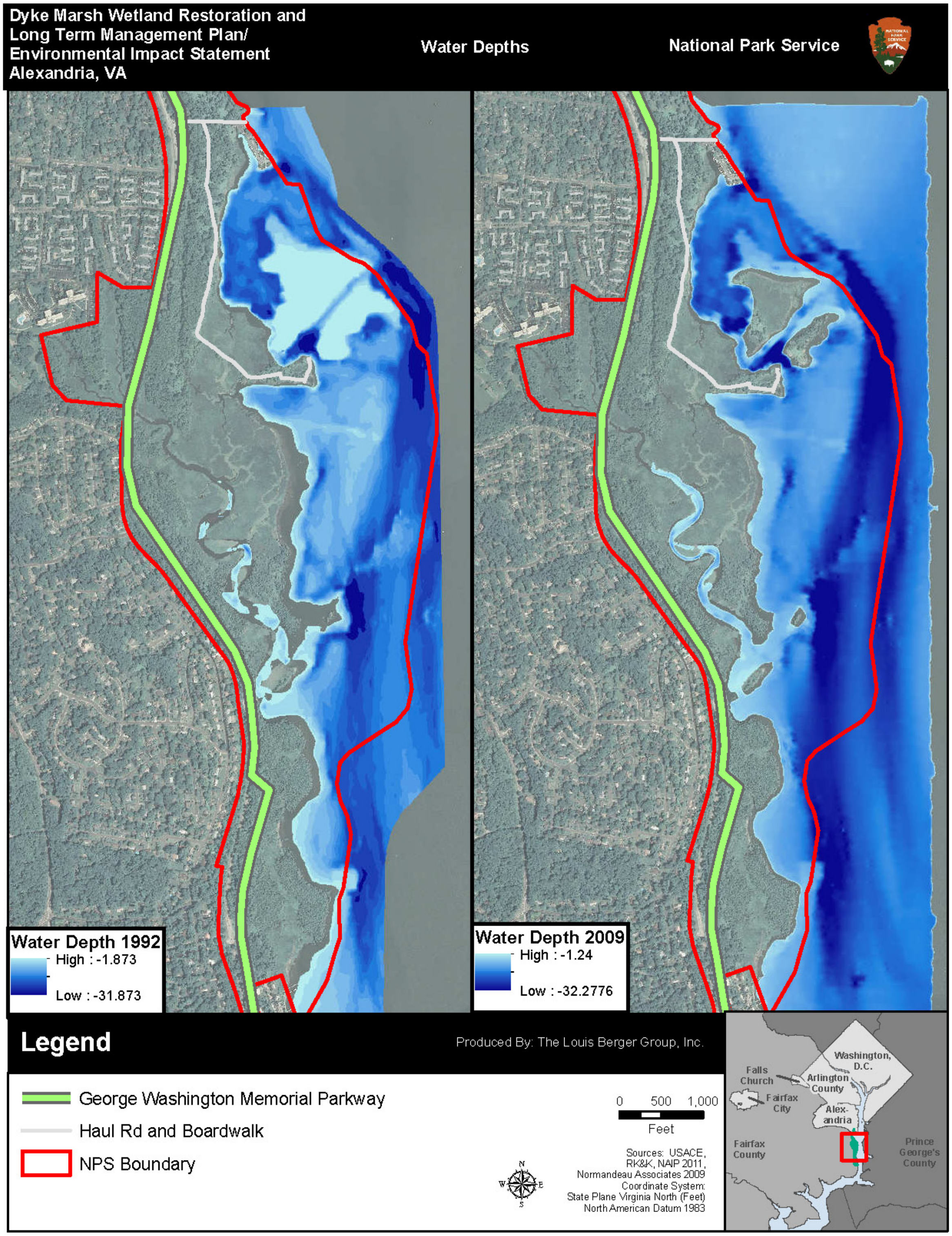


FIGURE 3-2. WATER DEPTHS IN AND AROUND DYKE MARSH (1992 AND 2009)

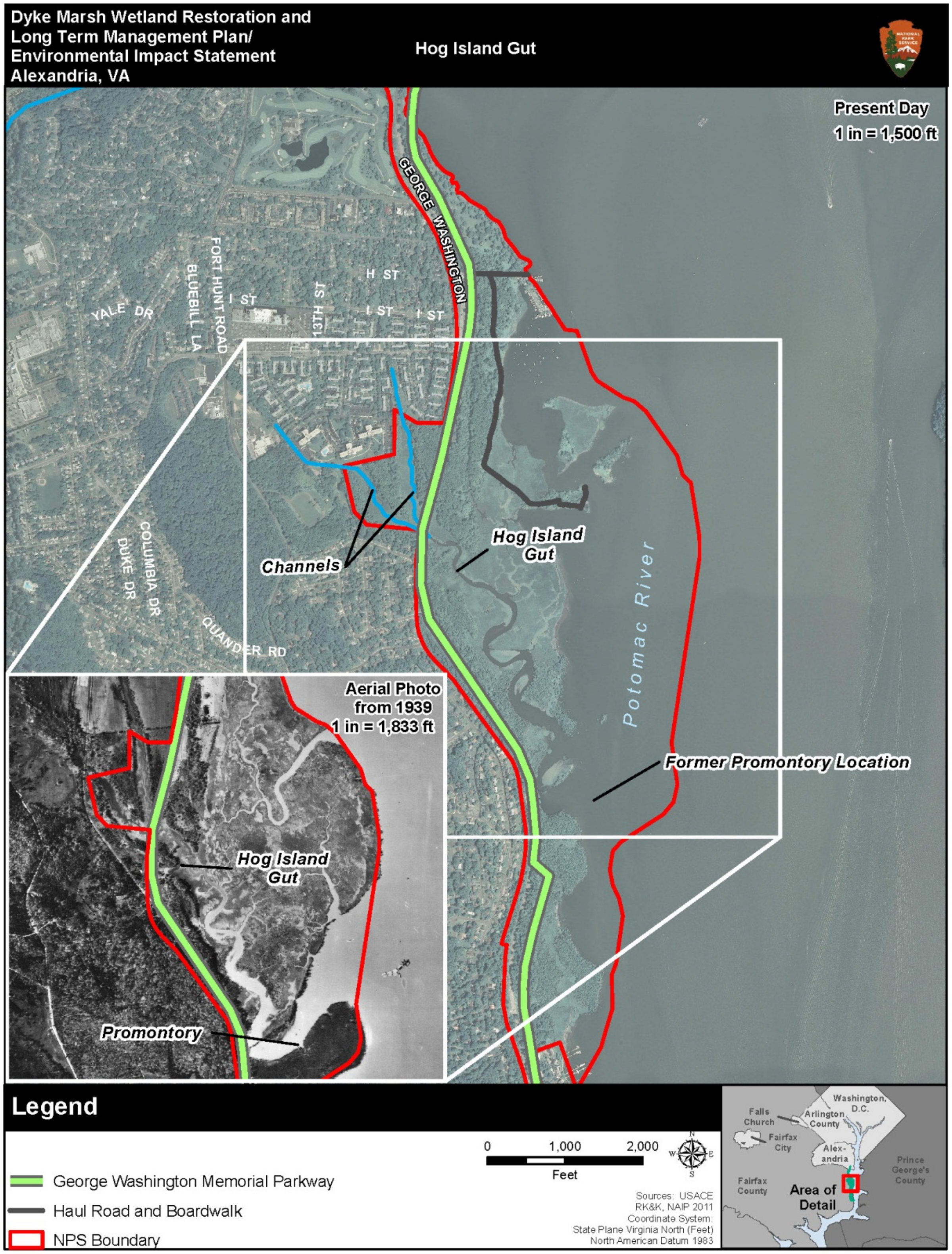


FIGURE 3-3. HOG ISLAND GUT

The bathymetry study showed that the marsh is currently in an erosional state, with losses of shoreline on the western bank of the Potomac River, particularly in the southern two-thirds of the marsh, and around Hog Island Gut (NPS 2009b). Currently the erosional processes that seem to be having the most impact on Dyke Marsh are due to wave action and sediment transport rather than flooding (Litwin et al. 2011). From 1987 to 2006, shoreline erosion resulted in the lateral loss of at least 90 feet of shoreline for much of the eastern marsh edge (Litwin et al. 2011). Although vertical shoreline scour due to wave action is dampened by the presence of exposed root systems, minimum scour depths are approximately 45 to 60 centimeters (18 to 24 inches) (Litwin et al. 2011). Some areas in the upstream end of the marsh are depositional, although the two islands in the northern end of the marsh have lost land mass since 1992 (NPS 2009b). The rate of erosion of the southern marsh is greater than that of the northern marsh islands; recently, the erosion of the southern marsh has increased following a breach of a protective peninsula (Litwin et al. 2011). Figure 1-4 in chapter 1 shows the areas of the marsh that are accreting and those that are eroding. More recent hydrodynamic modeling used to characterize possible impacts shows sediment transport and flow velocities confirm current conditions with regard to erosion and accretion.

Other historical hydrologic influences on the marsh have been flows from Hunting Creek and Cameron Run, which drain into the Potomac River to the north of Dyke Marsh. These waterways traditionally brought sediment to the marsh. Hunting Creek joins Cameron Run at its confluence with the Potomac River. Cameron Run has been channelized upstream, and in the last century, Hunting Creek has been significantly altered due to the construction of a golf course, the construction of the bridge on the parkway, and construction of Interstate 495 (I-495) and its access ramps immediately adjacent to the mouth of Hunting Creek. The hydrology has changed and there is now noticeable deposition in the mouth of the creek and increasingly large mud flats in the embayment in the Potomac River immediately south of the creek, but upstream of Dyke Marsh. These water bodies are shown on figure 3-1.

SOILS AND SEDIMENTS

Dyke Marsh is situated on top of recently deposited alluvium that is approximately 50 feet thick (NPS 1977). To a large extent, the surface soils at Dyke Marsh reflect the source materials in the uplands to the west of the marsh, although some of the smaller materials could be derived from materials almost anywhere in the Potomac River drainage.

Extensive boring in the marsh, performed from 1932 to 1934 by Smoot Sand and Gravel Corporation (SSGC) as preparation for the dredging and mining operations, and in 1976 by the U.S. Army Corps of Engineers (USACE), has revealed the predominance of sand and gravel deposits between 16 feet and 50 feet, overlain by soft depositional mud and with lenticular interlaid units of silt and clay. Such a sedimentary sequence reflects the changing conditions in depositional environment from one of swift-moving waters, where only heavy sands and gravel would fall out of the water column, to one of slack water, allowing finer silts and clays to settle (NPS 2000b). The years of dredging and marsh removal (from the early 1930s to 1972) have altered the marsh and riverbed topography. Where shallow contours once existed, there are now deep holes and channels that contribute to the erosion of the marsh, because shallower sediments slough off into these deeper waters.

In March 2004, soil samples collected in the marsh were analyzed for particle size. All samples collected had higher than 60 percent organic matter and were composed largely of silt and clay with little, if any, sand. Soil types in these marsh samples included silty clay, silty clay loam, clay, silt loam, and clay loam, with the majority of samples being silty clay and silty clay loam (UMCES 2004). Major soil types in the marsh are Honga peat, Woodstown sandy loam, Mattapex loam, and Gunston silt loam. These soils are described in table 3-1.

TABLE 3-1. SOILS OF DYKE MARSH

Soil Name	Description
Honga peat	This very deep soil is found in coastal plains in brackish submerged upland marshes along tidally influenced bays and rivers. Its parent material consists of organic deposits of intermediate decomposition, derived from salt-tolerant herbaceous plants, and is underlain by loamy mineral sediments. This soil is flooded by tidal waters and is very poorly drained, but becomes extremely acidic when drained.
Woodstown sandy loam	This very deep, moderately well-drained soil is found on the Atlantic coastal plain in upland marine terraces, and old stream terraces at elevations of 5 to 120 feet. Its parent material consists of sandy marine and old alluvial sediments.
Mattapex loam	This very deep, moderately well-drained soil is found on the Atlantic coastal plain in flat depressions, swales, marine terraces, and uplands at 5 to 120 feet. Its parent material consists of silty aeolian deposits over fluviomarine sediments.
Gunston silt loam	This very deep, somewhat poorly drained soil is found on the Atlantic coastal plain in uplands and on summits and shoulders on hillsides. Its parent material consists of marine sediments.

Source: NRCS 2009b.

More recently, sediment sampling and physical property testing was completed to assess sediment transport trends within the Dyke Marsh area of the Potomac River. Thirty sediment samples were obtained and physical property testing (sieve analyses) completed. The majority of samples consisted predominantly of clay and silt with sediments often dark olive gray with no overall structure or layering. The clay and silt were typically soft and loose near the surface, and became firmer one to two feet down. Core samples taken from the northern part of Dyke Marsh and near the mouth of Cameron Run appeared to have a greater fraction of sand and fine sand (USACE 2010).

SURFACE WATER QUALITY IN THE POTOMAC RIVER

Dyke Marsh and the Dyke Marsh Wildlife Preserve are located on the upper tidal portion of the Potomac River, immediately south of the City of Alexandria, Virginia, near Washington, D.C. The portion of the Potomac River where Dyke Marsh is located, shown in figure 3-1, is tidally influenced, although the water is fresh. The Potomac River and its upstream tributaries flow through agricultural, forested, and highly urbanized areas, and are subject to pollution from point-source discharges and nonpoint-source runoff from many land uses. The reach of the river around Dyke Marsh is dominated by urban runoff and effluent (NPS 1977; Johnston 2000; UMCES 2004). Water quality concerns in this area include high nutrient loads, turbidity, some heavy metals, and toxic chemicals from stormwater runoff, combined sewer overflows from the District of Columbia during heavy rains, and legacy sources of chemicals. The portion of the river near and around Dyke Marsh has been listed under Section 303(d) of the Clean Water Act as impaired for polychlorinated biphenyls (PCBs). Most of the waters of the Dyke Marsh project area are not listed for bacteria; however, Hunting Creek and its adjacent embayment are listed as impaired for bacteria. These impaired waters include a portion of the northern waters of the Dyke Marsh project around the Belle Haven Marina (VA DEQ 2012b). The states or the U.S. Environmental Protection Agency (USEPA) must therefore develop total maximum daily loads (TMDLs) on the listed water bodies for these pollutants. TMDLs are the maximum daily amount of pollutant that can enter the waterway and allow that waterway to attain and maintain water quality standards. A TMDL for PCBs was developed and approved in 2007 (ICPRB 2007) and is designed to bring the concentrations of PCBs in the water column down to levels that would meet applicable water quality criteria and ultimately lead to fish tissue concentrations of PCBs that would not exceed jurisdictional thresholds. As of late 2012, fish consumption advisories continue for fish caught in the river around Washington, D.C., due to the higher than normal concentrations of PCBs found in the tissue of these fish.

In spite of the water quality issues, the marsh and nearby river are able to attain a number of their various designated uses, such as supporting aquatic life, as required by the Clean Water Act. Under the state classification of waterways, the part of the river around Dyke Marsh is designated as a Class II waterway, or tidal water in the Chesapeake Bay or its tributaries, and is to be maintained to support aquatic life and for beneficial uses such as swimming and boating. The Virginia Department of Environmental Quality has noted that the area around Dyke Marsh supports aquatic life uses and wildlife, although it does not support fish consumption in the area due to the accumulation of PCBs in fish tissue. The Virginia Department of Environmental Quality also noted that the waters within the Dyke Marsh project boundary support recreational use of the marsh, although the waters immediately north of the project boundary cannot support recreational use (VA DEQ 2012a) due to elevated levels of the bacterium *Escherichia coli* (*E. coli*). This bacterium is an indicator organism for other pathogens, and its presence can pose health risks to those who experience full-body exposure (e.g., from swimming), or even partial exposure to waters being discharged from the Hunting Creek/Cameron Run tributary. The District of Columbia and the USEPA developed a bacteria TMDL for the portion of the Potomac and its tributaries under District jurisdiction, but the Virginia TMDL for bacteria has not been developed.

FLOODPLAINS

Floodplains are fluvial lands adjacent to freshwater streams and rivers that receive floodwaters once the water has overtopped the bank of the main channel. This is typically the result of a higher than normal influx of upstream water supplies (water moving from higher elevations to lower elevations). Floodplains are important resources in the storage and filtering of these floodwaters. Dyke Marsh provides several floodplain functions and values, including flood storage and natural moderation of floods, nutrient reduction, wildlife habitat for floodplain species, scenic open space.

A flood zone is an area subject to the risk of flooding by any natural means, either by water cresting the banks of channels (fluvial floodplain) or by tidal storm surges. Tidal storm surges occur when water is pushed by high winds from a low elevation to a higher elevation because of coastal storms and hurricanes. Dyke Marsh is located in the upper reaches of the Potomac River estuary where freshwater discharges from the Potomac River headwaters are present. Flooding of the project site is more closely associated with winds, changing barometric pressure, and storm surges than with influx from spring runoff. This is due primarily to the fact that the average land elevation is near sea level, and the river, has a large flood storage capacity.

The maximum elevation throughout Dyke Marsh is approximately +6 feet relative to mean low water. Flooding of the entire project area only occasionally occurs. The Federal Emergency Management Agency has identified the entire extent of Dyke Marsh to be flood zone affected environment, or below the 100-year flood elevation of 10.8 feet National Geodetic Vertical Datum of 1929 (FEMA 1990; County of Fairfax 2010).

VEGETATION AND WETLANDS

VEGETATION COMMUNITIES OF DYKE MARSH

The National Capital Region vegetation classification and mapping project, which began in 2001, has identified 12 plant communities in the floodplain forests and wetlands of Dyke Marsh. These plant communities, and the predominant species found in them, are presented in table 3-2 and described in more detail below

TABLE 3-2. PLANT COMMUNITIES AT DYKE MARSH

Vegetation Community	Dominant Species Present
Successional tuliptree forest (circumneutral type)	tuliptree (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), sugar maple (*Acer saccharum*), American sycamore (*Platanus occidentalis*), red oak (*Quercus rubra*), red maple (*Acer rubrum*), black locust (*Robinia pseudoacacia*), black walnut (*Juglans nigra*), white ash (*Fraxinus americana*), American beech (*Fagus grandifolia*), and slippery elm (*Ulmus rubra*)
Mixed deciduous shrubland (including mostly nonnative species)	poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), various briar species (*Smilax* spp.), porcelain-berry (*Ampelopsis brevipedunculata*), Asian bittersweet (*Celastrus orbiculatus*), English ivy (*Hedera helix*), Japanese honeysuckle (*Lonicera japonica*), Asiatic tearthumb (*Polygonum perfoliatum*), kudzu (*Pueraria lobata*), wisteria (*Wisteria sinensis*), grapevine species (*Vitis* spp), honeysuckle species (*Lonicera maackii*, *Lonicera morrowii*), privet (*Ligustrum* spp.), silktree (*Albizia julibrissin*), multiflora rose (*Rosa multiflora*), and Japanese wineberry (*Rubus phoenicolasius*)
Successional box elder floodplain forest	box elder (*Acer negundo*), American sycamore, sugarberry (*Celtis laevigata*), red maple, tuliptree, black locust, sweetgum, slippery elm, bitternut hickory (*Carya cordiformis*), green ash (*Fraxinus pennsylvanica*), black walnut, American hornbeam (*Carpinus caroliniana*), red mulberry (*Morus rubra*), and eastern cottonwood (*Populus deltoids*)
Piedmont/Central Appalachian silver maple forest	silver maple (*Acer saccharinum*), box elder, and American sycamore
Successional sweetgum floodplain forest	sweetgum, tuliptree, red maple, white oak (*Quercus alba*), willow oak (*Q. phellos*), black oak (*Q. nigra*), white ash, hickory (*Carya* spp.), black gum (*Nyssa sylvatica*), and flowering dogwood (*Cornus florida*)
Northern Piedmont/Central Appalachian maple-ash swamp forest	green ash, red maple
Ash swamp blackgum freshwater tidal swamp	pumpkin ash (*Fraxinus profunda*), green ash, black gum (*Nyssa sylvatica*), red maple, sweetgum, and American elm (*Ulmus americana)*
Freshwater tidal mixed high marsh	orange jewelweed (*Impatiens capensis*), arrow arum (*Peltandra virginica*), tearthumb (*Polygonum* spp.), river bulrush (*Bolboschoenus fluviatilis*), and narrowleaf cattail (*Typha angustifolia*)
Pond lily tidal marsh	pond lily (*Nuphar lutea* ssp. *advena*), arrow arum, pickerelweed (*Pontederia cordata*), wild rice (*Zizania aquatica*), broadleaf arrowhead (*Sagittaria latifolia*), smooth beggartick (*Bidens laevis*), sweetflag (*Acorus calamus*), and/or river bulrush
Pickerelweed tidal marsh	arrow arum and pickerelweed
Reed grass tidal marsh	common reed (*Phragmites australis*)
Successional mixed deciduous forest (including several nonnative species)	common hackberry (*Celtis occidentalis*), red maple, white ash, black walnut (*Juglans nigra*), tuliptree (*Liriodendron tulipifera*), American elm, Virginia pine (*Pinus virginiana*), black cherry (*Prunus serotina*), red maple, black locust (*Robinia pseudoacacia*), oak species (*Quercus* spp.), white mulberry (*Morus alba*), wild cherry (*Prunus avium*), and spring cherry (*Prunus subhirtella*). Nonnative species include Norway maple (*Acer platanoides*), tree-of-heaven (*Ailanthus altissima*), pawlonia (*Paulownia tomentosa*); also contains weedy hydrophytic/alluvial trees often occurring on catastrophically disturbed sites; nonnative shrubs and nonnative vines and/or native vines are often abundant in the understory, the latter climbing into the upper tree strata

Source: NPS 2009g; Teague, pers. comm. 2012.

Floodplain and Swamp Forest Vegetation

> *Adventitious roots are roots that develop in an unusual place, such as the trunk of a tree.*

Floodplain forests such as those found at Dyke Marsh occur along rivers where periodic flooding submerges low-lying vegetation. Although flooding occurs most often in the spring, it can also occur at other times of the year depending on the elevation above the river. For this reason, floodplain forests are dominated by trees that are adapted to saturated soils. In these forests, receding water leaves silt clinging to the lower trunks of many trees. These trees then send out new adventitious roots from the buried trunk into the soil just below the surface. Floodplain forests are characterized by a dense understory of herbaceous plants that grow rapidly during summer months in the absence of woody shrubs. These forests become established on building banks and in areas with sandbars or sandy beaches with natural levees where light, wind-blown seeds germinate and establish in the moist open areas (Searcy n.d.). Throughout the history of Dyke Marsh, the floodplain forest has remained a relatively stable community (NPS 1993), with the floodplain's co-dominant tree species being pumpkin ash and red maple. Swamp forest, temporarily and seasonally flooded forest, such as Central Appalachian Maple/Ash Swamp Forest, is also present in Dyke Marsh on disturbed mesic areas underlain by rich soils with moderately high base saturation levels (NVI 2009).

Marsh Wetland Vegetation

Dyke Marsh contains an extensive, valuable wetland complex characterized as a freshwater tidal mixed high marsh, which is the principal marsh community along all the estuarine rivers in the northern half of Virginia, from the Potomac River to the James River. This association occupies the higher-elevation zone of freshwater to slightly oligohaline (brackish) river marshes. These are mixed, dense, and often diverse marshes with highly variable species composition and patch dominance. Vegetation occurring in wetland areas of Dyke Marsh is described in the following "Wetlands" section.

Vegetation at Dyke Marsh

More than 373 species of vascular plants (representing 93 families) have been inventoried in the marsh proper and its adjoining swamp forest and floodplain forest (Xu 1991; Steury 2011). Of these 373 species, 60 are species found only in wetland areas (Engelhardt, Seagle, and Hopfensperger 2005). Elevation is a good predictor of vascular plant species distribution at Dyke Marsh. For example, although both annual and perennial dominant species of the marsh can occur on the majority of the marsh elevation gradient, orange jewelweed was not identified at elevations lower than 0.15 meter (6 inches), and narrow-leaved spatterdock (*Nuphar sagittifolia*) was not identified at elevations higher than 0.49 meter (1.6 feet) (UMCES 2004).

WETLANDS

Most of the vegetation of Dyke Marsh is classified as wetland vegetation. Wetlands are areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation adapted for life in saturated soil conditions (USACE 1987). Wetlands provide important environmental and economic functions and values to their immediate environment and to their adjacent upland areas. For example, wetlands trap sediment and pollutants from stormwater runoff and provide a natural filter before this runoff enters local waterways. Wetlands can store large volumes of water and function as a "sponge," reducing the likelihood of flooding during storm events and protecting the shoreline from erosion. Additionally, wetlands provide excellent habitat for fish, shellfish, and wildlife.

The USACE requires that an area be dominated by hydrophytic vegetation, contain hydric soils, and display indicators of wetland hydrology to be considered a wetland. The National Park Service (NPS) definition of wetlands is similar to that of the USEPA and USACE; however, the NPS definition is broader in scope and affords a greater jurisdiction than that of the USACE. The NPS classifies wetlands based on the U.S. Fish and Wildlife Service (USFWS) *Classification of Wetlands and Deepwater Habitats of the United States*, also known as the Cowardin classification system. Based on the Cowardin classification system, a wetland must have one or more of the following attributes:

- The habitat at least periodically supports predominantly hydrophytic (wetland) vegetation.
- The substrate is predominantly undrained hydric soil.
- The substrate is nonsoil and saturated with water, or is covered by shallow water at some time during the growing season (Cowardin et al. 1979).

As described above, Dyke Marsh has tidal freshwater marsh, swamp forest, and floodplain forest, with wetland areas within the forested areas. Two wetland types, as identified by the National Wetlands Inventory, comprise the majority of the preserve: palustrine (freshwater), persistent emergent, seasonally tidal (PEM1R); and palustrine, broad-leaved deciduous forested, seasonally tidal (PFO1R). The remainder of the wetlands in the preserve are composed of smaller, fragmented wetland areas and are a combination of scrub-shrub wetlands and forested wetlands, including palustrine, broad-leaved deciduous scrub-shrub, seasonally tidal (PSS1R); palustrine, broad-leaved deciduous scrub-shrub / persistent emergent, seasonally tidal (PSS1/EM1R); palustrine, broad-leaved deciduous forested, temporarily tidal (PFO1S); palustrine, broad-leaved deciduous forested, temporarily flooded nontidal (PFO1A); and palustrine, broad-leaved deciduous forested / persistent emergent, seasonally tidal (PFO1/EM1R) (USFWS 2000). These wetlands can be loosely grouped into freshwater emergent wetlands, freshwater forested wetlands, and freshwater scrub-shrub wetlands, as well as the riverine wetlands that form the guts in the marsh (figure 3-4). The forested wetlands also loosely correspond with the swamp forest and floodplain forest vegetation communities discussed above.

The PEM1R wetland plant community is dominated by several different species, such as narrowleaf cattail (*Typha angustifolia*), spotted touch-me-not or orange jewelweed (*Impatiens capensis*), rice cutgrass (*Leersia oryzoides*), arrow arum (*Peltandra virginica*), sweetflag (*Acorus calamus*), river bulrush (*Bolboschoenus fluviatilus*), and spatterdock (*Nuphar lutea*) (Hopfensperger 2007). The PFO1R wetland plant community is dominated by pumpkin ash (*Fraxinus profunda*), box elder (*Acer negundo*), red maple (*Acer rubrum*), common water willow (*Justicia americana*), and silver maple (*Acer saccharinum*), (Hopfensperger 2007).

Source: USFWS 2000

FIGURE 3-4. WETLANDS

CHANGES IN VEGETATION OVER THE YEARS

According to available research and historical data, substantial changes have occurred in the vegetation communities of Dyke Marsh in recent decades. These changes demonstrate the dynamics found in an active marsh ecosystem (NPS 2000b) and provide evidence of changing sedimentation patterns in the marsh (UMCES 2004). The presence of submerged aquatic vegetation (SAV) has increased in recent years, despite experiencing an overall decline in past decades. Prior to the 1930s, SAV had a major presence in the marsh and surrounding waters (UMCES 2004). SAV began to decline in the late 1930s and was not recorded as present in the 1977 *Dyke Marsh Environmental Assessment* (NPS 1977). SAV began to reappear in the early 1980s, and by 1986 the cover of SAV in continuously inundated portions of the marsh was 70 percent to 100 percent (UMCES 2004). Prior to 1996, various reports concluded that SAV was reestablishing in the Potomac River, including Dyke Marsh (Johnston 2000). The dominant species is hydrilla (*Hydrilla verticillata*), a nonnative species. Other species include eelgrass (*Vallisneria americana*), waternymph (*Najas minor*), and common hornwort (*Ceratophyllum demersum*). Both waternymph and common hornwort are also nonnative.

NONNATIVE INVASIVE PLANT SPECIES

Several nonnative invasive plant species exist in and around Dyke Marsh. They include a possibly nonnative variety of hedge false bindweed (*Calystegia sepium*), lady's thumb (*Polygonum persicaria*), hydrilla, brittle naiad (*Najas minor*), common reed, and climbing nightshade (*Solanum dulcamara*). In the marsh itself, there are two small existing patches of *Phragmites* that are currently being managed by the park with NPS-approved herbicides and physical removal. The area west of Haul Road, which has been cut off from tidal inundation, contains several invasive species including porcelain berry (*Ampelopsis brevipedunculata*), bush honeysuckle (*Lonicera amur*), Japanese honeysuckle (*Lonicera japonica*), and English ivy (*Hedera helix*). Purple loosestrife (*Lythrum salicaria*) is another known invasive species that has been observed in very small patches on the edges of the islands and the marsh; however, no purple loosestrife has been observed in the interior of the emergent marsh (UMCES 2004; Hopfensperger 2007).

FISH AND WILDLIFE

Five-lined Skinks

One of the most important functions of marshes and wetlands is to provide habitat and food web support for fish and wildlife. The fish and wildlife of Dyke Marsh are indicative of species that occupy the freshwater and terrestrial communities in the Washington, D.C., area (NPS 2000b). Previous dredging of the marsh has greatly reduced its size, changed its hydrologic functions, and altered the amount and type of habitat available to support both resident and migratory fish and wildlife species. However, despite these alterations, the marsh provides habitat for 38 fish species, 16 reptile species, 14 amphibian species, 34 mammal species, more than 200 bird species, and many species of invertebrates (UMCES 2004; Barrows and Kjar 2003; Johnston 2000; Mangold et al. 2004; FODM 2012). The number of breeding bird species in the marsh varies; in a 2003 breeding bird survey, there were at least 46 species of birds confirmed to be breeding in the marsh (Booth 2006), but in 2011 there were 40 confirmed breeding species (FODM 2012).

TERRESTRIAL WILDLIFE

Amphibians and Reptiles

Many species of amphibians and reptiles inhabit the emergent marsh, the most common being the bullfrog, leopard frog, common snapping turtle, painted turtle, and several species of water snakes (for scientific names, see table 3-3) (NPS 1977). The most commonly observed of these species are listed in table 3-3.

TABLE 3-3. COMMONLY OBSERVED SPECIES OF AMPHIBIANS AND REPTILES IN DYKE MARSH

Species	Common Name	Preferred Habitat in Dyke Marsh
Plethodon cinereus	red-backed salamander	Swamp and floodplain forests
Bufo americanus	American toad	Marsh, swamp, and floodplain forests
Hyla versicolor	eastern gray treefrog	Swamp and floodplain forests
Rana clamitans	green frog	Marsh, swamp, and floodplain forests
Rana catesbeiana	bullfrog	Marsh
Rana palustris	pickerel frog	Marsh, swamp, and floodplain forests
Chelydra serpentina	snapping turtle	Marsh
Chrysemys picta	painted turtle	Marsh
Pseudemys rubriventris	red-bellied turtle	Marsh
Terrapene carolina	box turtle	Swamp and floodplain forests
Trachemys scripta	red-eared turtle	Marsh
Kinosternon subrubrum	mud turtle	Marsh
Stenotherus odoratus	musk turtle	Marsh
Eumeces fasciatus	five-lined skink	Swamp and floodplain forests
Coluber constrictor	black racer	Marsh, swamp, and floodplain forests
Diadophis punctatus	ring-neck snake	Swamp and floodplain forests
Elaphe obsoleta	black rat snake	Swamp and floodplain forests
Nerodia sipedon	northern water snake	Marsh, swamp, and floodplain forests
Thamnophis sirtalis	eastern garter snake	Marsh, swamp, and floodplain forests

Source: UMCES 2004.

Birds

Dyke Marsh is important to many resident and migratory bird species, which form the most conspicuous and diverse faunal element at Dyke Marsh. Currently, at least 40 species are confirmed breeding species. A survey of breeding birds in 2003 found 46 species that were confirmed to be breeding in the marsh, 6 species that were probable breeders, 15 species that were possible breeders, and 25 species that make use of the marsh at some part of the year, but were deemed not to be in suitable breeding habitat (Cartwright

2004; see appendix B for the full list of breeding bird species in 2011). A more recent survey found 40 species of confirmed breeding birds, 9 species of probable breeders, and an additional 19 species that were possibly making use of the marsh for breeding habitat (FODM 2011). Migratory birds generally inhabit Dyke Marsh from July 9 to November 11 (NPS 2000b). Table 3-4 provides a list of some of the commonly observed bird species in Dyke Marsh.

TABLE 3-4. COMMONLY OBSERVED SPECIES OF BIRDS IN DYKE MARSH

Species	Common Name	Preferred Habitat
Haliaeetus leucocephalus	bald eagle	Floodplain forests
Anas rubripes	black duck	Marsh and swamp
Anas platyrhynchos	mallard	Marsh and swamp
Anas crecca carolinensis	green wing teal	Marsh and swamp
Pandion haliaetus	osprey	Floodplain forests
Ardea herodias	great blue heron	Marsh, swamp, and floodplain forests
Cistothorus palustris	marsh wren	Marsh
Vireo olivaceus	Red-eyed vireo	Floodplain forests
Protonotaria citrea	prothonotary warbler	Swamp and floodplain forests
Corvus brachyrhynchos	American crow	Floodplain forests
Corvus ossifragus	fish crow	Marsh, swamp, and floodplain forests

Source: NatureServe 2009.

The bald eagle, black duck, mallard, green wing teal, Virginia rail, osprey, and great blue heron are common in the marsh (NPS 2000b). Dyke Marsh also supports the only known nesting population of marsh wrens (*Cistothorus palustris*) in the upper Potomac tidal zone, although this species began a decline in 2000 and has shown only limited indications of recovery in succeeding years (FODM 2009). According to a study of reproductive success of marsh wrens by Spencer (2000), territories of male marsh wrens, which prefer dense, tall vegetation near more steeply sloped shorelines, comprised 13.89 acres (30 percent) of the total available habitat in Dyke Marsh. All the successful breeding nests of marsh wrens were found attached only to cattail. Alternative vegetation species with attached nests include sweetflag, swamp mallow (*Hibiscus moscheutos*), common reed, tidalmarsh amaranth (*Amaranthus cannabinus*), rush (*Juncus* spp.), and river bulrush.

Bird populations at Dyke Marsh have changed over time. For instance, ospreys, warbling vireos, and prothonotary warblers have noticeably increased their population size since 1993. In 2008, an estimated total of 21 prothonotary warbler territorial males were documented in at least two nest locations, whereas such sightings were rare in the early 1990s. Another example of the dynamic change occurring in bird populations is the replacement of American crows by fish crows as Dyke Marsh breeders (for scientific names, see table 3-4). American crows have not bred at Dyke Marsh since 2005. Breeding pairs of fish crows were documented in 2006 and again in 2008 (FODM 2009). Breeding pairs of both purple martins (*Progne subis*) and screech owls (*Megascops asio*) were documented in 2012 and 2013.

Mammals

A total of 34 species of mammals, with the majority being insectivores, have been observed at Dyke Marsh (UMCES 2004; Johnston 2000). Among these, the most commonly observed species are listed in table 3-5.

TABLE 3-5. COMMONLY OBSERVED SPECIES OF MAMMALS IN DYKE MARSH

Species	Common Name	Preferred Habitat
Didelphis virginiana	Virginia opossum	Marsh, swamp, and floodplain forests
Blarina brevicauda	northern short-tailed shrew	Marsh, swamp, and floodplain forests
Scalopus aquaticus	eastern mole	Swamp and floodplain forests
Sylvilagus floridanus	eastern cottontail	Marsh, swamp, and floodplain forests
Tamias striatus	eastern chipmunk	Swamp and floodplain forests
Marmota monax	woodchuck	Swamp and floodplain forests
Sciurus carolinensis	eastern gray squirrel	Swamp and floodplain forests
Castor canadensis	American beaver	Marsh, swamp, and floodplain forests
Peromyscus leucopus	white-footed mouse	Marsh, swamp, and floodplain forests
Ondatra zibethicus	common muskrat	Marsh
Vulpes vulpes	red fox	Marsh, swamp, and floodplain forests
Procyon lotor	common raccoon	Marsh, swamp, and floodplain forests
Odocoileus virginianus	white-tailed deer	Marsh, swamp, and floodplain forests

Source: UMCES 2004.

One species that has been severely affected by human activity is the muskrat (*Ondatra zibethicus*). This species historically had large stable populations in the marsh but is now in decline, presumably as a result of dredging activities, which have dramatically changed the macro-environment and size of the marsh (NPS 1993).

AQUATIC WILDLIFE

Fish

Dyke Marsh provides habitat for a large variety fish species. Fish habitat consists of the marsh surface, vegetated and unvegetated near shore shallows (less than 3 feet deep) and some deeper pools (between 15 feet and 25 feet deep) (Mangold et al 2004; NPS 2009f). Thirty-seven fish species were identified in a three-year inventory conducted by the USFWS between 2001 and 2003. The 3 most common fish species were bluegill sunfish (*Lepomis macrochirus*), pumpkinseed sunfish (*Lepomis gibbosus*), and banded killifish (*Fundulus diaphanus*). Dyke Marsh provides suitable nursery habitat for juveniles of American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa pseudoharengus*). Other species found in the marsh include white perch (*Morone americana*), yellow perch (*Perca flavescens*), striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and possibly Atlantic sturgeon (*Acipenser oxyrhynchus*) (Mangold et al. 2004). Several anadromous fish, which live in the ocean but breed in freshwater, use the Potomac River for spawning, during which time they are more susceptible to disturbances. Examples of such fish are alewife, blueback herring, white perch, American shad, and striped bass (NPS 2000b).

Invertebrates

The exact composition of the benthic community in Dyke Marsh is not known, but reports show the presence of a variety of worms, mollusks, arthropods, and insects (UMCES 2004). A variety of native snails and clams are common in the marsh, as well as species characteristic of polluted waters, such as tubifex worms (*Tubifex tubifex*), leeches (*Macrobdella decora*), and chironomid flies (family: Chironomidae). Over 300 individual species were identified in the preserve during an arthropod inventory conducted by the NPS and the Laboratory of Entomology and Biodiversity at Georgetown University (Barrows and Kjar 2003). Cavey et al. (2013) documented 36 species of leaf beetles from Dyke Marsh.

SPECIES OF SPECIAL CONCERN

As noted in chapter 1, although there are no federally listed species found in the marsh, several state-listed species of both plant and animal are found in Dyke Marsh. Based on input from the USFWS, the USACE, NPS staff, and local academics with knowledge of the marsh, six state-listed species of special concern occur in the preserve, including two bird species and four plant species (table 3-6). In addition, the marsh is used as foraging habitat by the bald eagle (*Haliaeetus leucocephalus*), a recently delisted species, although there are no nests in Dyke Marsh itself (Fernald, pers. comm. 2008). In 1984, the endangered green floater (*Lasmigona subviridis*), a small mussel, was found along the Potomac River, but not in the marsh (UMCES 2004). Also, two species of sturgeon have been found in the Potomac River, but have not been found in Dyke Marsh.

TABLE 3-6. SPECIES OF SPECIAL CONCERN AT DYKE MARSH

Scientific Name	Common Name	State Status
Ixobrychus exilis	least bittern	S3 – Watchlist, vulnerable
Melospiza georgiana	swamp sparrow	S1 for breeding – Critically imperiled
Carex davisii	Davis' sedge	S1 – Critically imperiled
Bolboschoenus fluviatilis	river bulrush	S2 – Imperiled
Geum laciniatum	rough avens	S1 – Critically imperiled
Sparganium eurycarpum	giant bur-reed	S3 – Watchlist, vulnerable

Source: NPS 2009f; Cartwright, pers. comm. 2013.

LEAST BITTERN

The least bittern (*Ixobrychus exilis*), considered a species of special concern by the Commonwealth of Virginia and the NPS, typically inhabits herbaceous or scrub-shrub wetlands, favoring marshes with tall emergent vegetation. Heavy growths of cattail, bulrush, bur-reed, and reeds are favored feeding sites, where the birds can forage in shallow water or along banks (NatureServe 2009).

The birds typically arrive at nesting grounds in April or early May. Peak nesting occurs from late May to early July, and birds leave breeding areas by September or October. Nesting usually occurs among dense, tall vegetation, including cattail, sedge, and bulrush. Nests are built over shallow water (0.3–3.3 feet [0.1–1.0 meter] deep) using the surrounding emergent vegetation to create a nesting canopy. Currently, there are fewer than six nesting birds at Dyke Marsh per year (NatureServe 2009; NPS 2009f), but they have been confirmed to be breeding in the marsh.

Loss of wetlands poses the most substantial threat to this species. Wetland losses are primarily caused by drainage, pollution, urbanization, agricultural practices, dredging, and siltation (resulting from erosion of farmlands and runoff containing insecticides). Marshland invasions by common reed and purple loosestrife may alter and degrade least bittern habitats as well (NatureServe 2009).

SWAMP SPARROW

The swamp sparrow (*Melospiza georgiana*) is a small perching bird that uses a variety of wetland habitats, including herbaceous and scrub-shrub wetlands (NatureServe 2009). Habitat requirements for this species include shallow, standing water; low, dense cover; and scattered, elevated perches. Swamp sparrows are ground and water feeders, and frequently forage on the water's edge (Wiland 2007). Swamp sparrows are uncommon in the marsh, particularly depending on the season. Single individuals have been confirmed (Cartwright, pers. comm. 2013), and breeding pairs have also been confirmed (FODM 2009, 2011; Johnston 2000; Cartwright, pers. comm. 2013). Breeding habitat for the swamp sparrow includes brackish and freshwater marshes, bogs, and swamps. Nests are sometimes built on the ground, but most are located above water (1.0 foot [0.3 meter]) in dense vegetation like cattails, grass, or sedge (NatureServe 2009; Wiland 2007).

Threats to the swamp sparrow are similar to those of the least bittern. The birds continue to be threatened by urban and suburban expansion. They are vulnerable to habitat loss through filling and draining of swamps, bogs, and marshes (Leberman 2008). Additional threats include tidal flooding, which reduces the reproductive success of the nesting birds (Eyler et al. 1999).

DAVIS' SEDGE

Davis' sedge (*Carex davisii*), which has been found in the park and for the first time in Virginia, is perennial and is typically found on calcareous soils in floodplain forests (the primary habitat in the northeast), dry to moist fields or woods, and alluvial meadows. This plant, which flowers from May to July, is native to eastern North America, ranging from eastern Canada, west to North Dakota, and south to Texas and Tennessee (Steury 2004; Thompson 2003). Many species rely on the seeds of this plant for food, including various insects and bird species (Hilty 2009).

Nonnative invasive species are opportunistic and have the potential to outcompete beneficial native species, such as Davis' sedge (NPS 2008b). In addition to nonnative species, habitat alteration and loss pose a great threat to this plant. Habitat alteration and loss result from river impoundment, habitat fragmentation and conversion, trash dumping, and human disturbance via off-road trails (Thompson 2003).

RIVER BULRUSH

River bulrush (*Bolboschoenus fluviatilis*), considered a dominant species in the existing marsh (NPS 2009f), is a common and important wetland plant found in dense colonies at the edges of marshes and along streams in shallow freshwater or mildly brackish wetlands (NHESP 2008; Runkel and Roosa 1999). This perennial sedge, which flowers from July to September, is found across southern Canada, south to Virginia, and west to California. Waterfowl and ducks use the seeds from this plant as a major source of food. In addition to providing cover for a variety of wetland animals, river bulrush is also used by muskrats to construct houses (NHESP 2008; Runkel and Roosa 1999).

Threats to river bulrush include habitat disruption, loss, and degradation. Other threats include fertilizers and septic systems, which can degrade water quality and possibly increase the success of many nonnative plant species that take over the species' habitat (NHESP 2008).

ROUGH AVENS

Rough avens (*Geum laciniatum*) is found in a wide range of habitats, including hardwood forests, limestone woodlands, muddy riverbanks, forested swamps, marshes, and roadsides. This perennial herb is found in most of the United States east of the Mississippi, and flowers from June to July with fruit developing from mid-July to mid-September (NYNHP 2009). At Dyke Marsh, rough avens grows against the edge of Haul Road and is being lost to succession as other plants around it mature and outcompete the rough avens (NPS 2009f).

GIANT BUR-REED

Giant bur-reed (*Sparganium eurycarpum*) grows on mud, sand, or gravel and can be found in shallow standing water, on the edges of streams and marshes, and in brackish swamps (NHDFL 2002; Runkel and Roosa 1999), and was found in Dyke Marsh during Natural Heritage Inventory surveys (Johnston 2000). This perennial aquatic herb is considered a good soil binder at marsh edges and along streams (Runkel and Roosa 1999). The plant flowers in early June with fruit developing from July to September (Runkel and Roosa 1999; NHDFL 2002). Bur-reed occurs throughout a large portion of North America, and provides food and shelter for a variety of wetland animal species (Runkel and Roosa 1999). Threats to giant bur-reed are similar to those for the plant species listed above, and include vegetation loss, poor water quality, and invasive nonnative species (NHDFL 2002).

ARCHEOLOGICAL RESOURCES

An archeological assessment of the Dyke Marsh vicinity was completed in 2009 (NPS 2009a). This study included a surface inspection of the upland areas adjacent to the marsh to look for indicators of that archeological resources might be present, the compilation of a detailed history of the property, and a review of the history of the marsh itself to gain an understanding of the potential for archeological sites in the area. Although an assessment was performed, no archeological survey was conducted, and no sites have been recorded in the marsh or on the adjacent upland areas. The assessment concluded with recommendations for a formal survey that would identify specific archeological sites at Dyke Marsh.

Based on studies of sea level rise in the Chesapeake estuary, the marsh was dry land until at least 6000 BC and probably until 3000 BC. Therefore, Paleo-Indian and Archaic period campsites may be present in the undisturbed portions of the marsh. Because no underwater prehistoric archeological sites have ever been found in the Potomac River, the existence of such sites is speculative, but the possibility of their presence cannot be discounted. Sites related to the use of the marsh after it was diked in the 19th century, such as hunting cabins or illegal taverns, might also be present. Where dredging has occurred, these sites have likely been destroyed. The upland areas adjacent to the marsh also have high potential for archeological sites, mostly for the Woodland Period, circa 1000 BC to AD 1600, and for the 19th century.

HISTORIC STRUCTURES AND DISTRICTS, AND CULTURAL LANDSCAPES

HISTORICAL BACKGROUND OF DYKE MARSH

During colonial times, Dyke Marsh was part of a plantation called West Grove (NPS 2009a). The owners, the West family, were prominent planters and associates of their neighbor George Washington. The marshland was actually not claimed during the initial patenting of land in the area. The claiming of land during the initial “land rush” period of the 1660s was based on highly inaccurate surveys, and in 1762, Colonel John West discovered that more than 1,000 acres around his home had never been claimed. He then patented 295 acres of the marsh and two other tracts.

The marsh remained part of West Grove until 1796, when the property was divided among four heirs and sold. After passing through the hands of speculators, the marsh and the rest of West Grove were acquired from 1811 to 1816 by Augustus J. Smith. The Fairfax County tax books show that by 1819, Augustus Smith owned approximately 1,322 acres located between the south bank of Great Hunting Creek and the west bank of the Potomac River. Smith was a physician by training and commanded in the Virginia militia during the War of 1812. His agricultural operations focused on livestock and dairying.

Another project of Smith's was the construction of a dike around the marsh. His intention was to turn the tidal marsh into a large meadow by excluding the waters of the Potomac. Smith expected that the proximity of his meadow to the Potomac River's shipping channel would allow seagoing vessels to unload cargo closer to the shore, turning the otherwise unusable marshland into a port. No information has been found indicating that ships used the area. Although his attempts to create a new port on the Potomac River had failed, Smith continued raising livestock in the newly claimed meadow. After his death, Smith's children put West Grove up for sale; the advertisement, published in the Alexandria Gazette on November 4, 1831, provides a good description of the property at that time:

> West Grove, residence of the late Col. Augustine J. Smith, for sale opposite Alexandria on Great Hunting Creek at its confluence with the river Potomac, extending and binding on both streams upwards of three miles and embracing one of the most extensive and valuable river bottoms and pocosins in this country. The pocosin has been recently reclaimed by the construction of a dyke with gravel brought from the hills, at great expense, by which it is perfectly secured from overflowing…upwards of 1,800 acres…includes two fisheries…the mansion house is large and convenient, situated within a few yards of a never failing spring of the finest water, near which is erected a large two story stone and brick dairy, the stream passing through it. Kitchen, smokehouse, quarters, blacksmith shop, all brick…large new barn, stables, corn house, carriage house, etc.…on the lower part of the farm, called Wigton, are…brick overseers house, orchard, etc.…(NPS 2009a)

Dyke Marsh remained part of farms owned by various families until 1891. During the 19th century the area's importance as a farming community declined, and instead it attracted residential and business development, as well as hunters and fishermen. The swamps and marshes along this stretch of the Potomac were sometimes called 'Hell Hole,' said by the Alexandria Gazette to be

> a grand and wild place, and, save for the miasma and mosquitos which reign there pre-eminent, would be a magnificent abode for those fond of following the pursuits of Nimrod and Walton (Virta 2012a).

Nimrod was the Biblical hunter, Walton the author of the *Compleat Angler*. Numerous small shacks were built along the river to shelter sportsmen, and stores were set up to cater to their needs.

The Potomac's banks also drew shadier characters. After the Civil War the city's authorities tried to crack down on the prostitution, gambling, and drinking that had burgeoned during the conflict. Some operators responded by embarking on house boats that could be sailed to other jurisdictions when law enforcement in one state or city grew troublesome. These "arks" often frequented the Virginia shore of the Potomac, since the state boundary between Virginia and Maryland ran along that bank. This probably included Dyke Marsh. Some of the 'fishermen's cabins' built out over the river, legally in Maryland but accessible only from Virginia, may have been houses of gambling or prostitution. During Prohibition, bootleggers used the same tactics, and there are numerous stories of illegal stills in the marshlands. In 1931 the Washington Post recounted the seizure of illegal liquor at Gus Quayle's "place" a on the dyke itself (Virta 2012a).

In 1891 the farm that included Dyke Marsh was purchased by agents of the New Alexandria Land and River Improvement Company. These developers planned to construct a new town, complete with streetcar service to Alexandria and Washington. The streetcar line was completed in 1892, but soon afterward the project was abandoned, a victim of the depression that gripped the country from 1892 to 1896. The New Alexandria Company lingered for a while but filed for bankruptcy in 1924. In 1929, trustees of the company sold property to the U.S. government for the construction of the Mount Vernon Memorial Highway. Much of the rest of the property, including the marsh, came into the hands of Bucknell University.

On December 21, 1929, Bucknell granted the U.S. government a 26-acre, 200-foot-wide tract for a right-of-way to construct the Mount Vernon Memorial Highway along the western edge of Dyke Marsh along the same route as the former Washington, Alexandria, and Mount Vernon Electric Railway.

M. B. Barlow, an Alexandria businessman, is credited with the original concept for a road from Washington to Mount Vernon in the late 1880s. Interest in the project declined with the construction of the Washington, Alexandria, and Mount Vernon Electric Railway. The number of visitors to Mount Vernon increased during the 1890s, most arriving by rail (NPS 1994). The concept of a parkway was revisited by the 1902 McMillan Commission, which stated that the palisades along the Potomac River from Great Falls to Mount Vernon should be safeguarded. It envisioned a parkway, the purpose of which would be recreation restricted to pleasure vehicles, “arranged with regard for scenery, topography, and similar features rather than for directness” (NPS 1994). Authorization for the highway was not received until 1928, spurred by the ever-increasing amount of motor traffic, poor road conditions, and, most importantly, the approaching bicentennial of George Washington’s birth in 1932. Three routes were studied, but the one selected followed the riverfront. The highway, built by the Bureau of Public Roads, was the first modern highway built by the federal government and was important in popularizing advanced highway engineering and landscape design features in parkways and highways throughout the country. In order to produce a seemingly natural landscape, unusual care was taken to wind the road around preexisting trees and use large native and nursery transplants. The completed road, extending 15.2 miles from the gates of Mount Vernon to Memorial Bridge in Arlington, was open by January 1932, although planting continued throughout the remainder of the year.

Throughout the planning and construction process, emphasis was put on purchasing land adjacent to the highway to protect the land from incompatible uses. Dyke Marsh’s woods, meadows, and marshlands were planned from the outset of the project to be a 500-acre bird refuge and wildlife sanctuary. The densely vegetated areas of Dyke Marsh and surrounding woodlands were part of the designer’s plans to manipulate motorists’ experience along the highway, alternating broad vistas with enclosed woodland corridors through selective cutting and planting (NPS 1994).

The creation of the George Washington Memorial Parkway was authorized by the Capper-Cramton Act; an “Act providing for a comprehensive development of the park and playground system of the National Capital.” The act stated the parkway was

> to include the shores of the Potomac, and adjacent lands, from Mount Vernon to a point above the Great Falls on the Virginia side, except within the city of Alexandria, and from Fort Washington to a similar point above the Great Falls except within the District of Columbia, and including the protection and preservation of the natural scenery of the Gorge and the Great Falls of the Potomac, the preservation of the historic Patowmack Canal, and the acquisition of that portion of the Chesapeake and Ohio Canal below Point of Rocks. (Capper-Cramton Act)

The bill also called for the transfer of the Mount Vernon Memorial Highway to become part of the George Washington Memorial Parkway (NPS 1996, Capper-Cramton Act).

The remainder of the Dyke Marsh property was not acquired by the federal government for another 30 years. In 1935, reeling from the Depression, Bucknell sold the marsh to the SSGC, who began dredging the marsh in the 1940s. The land was acquired by the NPS in 1960, but the agreement allowed Smoot to continue dredging for an additional 20 to 30 years. Dredging in the marsh continued until 1972. By that time, about half the marsh had been destroyed, and most of the dike had been removed.

Currently, the only visible remains of West Grove are two short sections of the old dike, along the south side. The location of the West Grove house is outside the project area, and no remains of any historic structures associated with that property are visible (NPS 2009a).

Present Conditions of the Historic District and the Dyke

Today Dyke Marsh is part of the George Washington Memorial Parkway, which is listed in the National Register of Historic Places (NRHP) as a historic district (NPS 1981; NPS 1995). The historic district is nationally significant under Criteria B and C. Under Criterion C, the district is significant for its landscape architecture as part of the long and continuous planning of the Washington, D.C., region. As a parkway, the district has several areas of significance: community planning and development, landscape architecture, transportation, commemoration, and preservation. The parkway was a product of master landscape architects such as Gilmore D. Clarke. The parkway also has significance as a means of conservation, protecting scenic and recreational resources from development along the river corridor.

Under Criterion B the historic district is significant for its commemorative association with George Washington and Clara Barton (for the Clara Barton Parkway in Maryland). The older Mount Vernon section and the upper parkway commemorate the life of Washington, who had a strong association with the Potomac River corridor and was responsible for the selection of the nation's new capital site.

The stretch of the parkway adjacent to Dyke Marsh preserves much of this original vision. Traffic flows unimpeded, as the original planners intended. The heaviest use of the parkway has become commuting, however, rather than its original intention for recreational use. The parkway there passes through an extensive complex of woodlands and marshes, which still draws birds and other wildlife. Dense trees screen the parkway from residential development on the inland side, contributing to an atmosphere removed from urban bustle.

The only remaining portions of the historical dike are located on the south side of Dyke Marsh, and are occasionally visible at low tide. No surveys have been completed on the conditions of these remaining portions of the dike. All other structures associated with 19th or early 20th century land uses are no longer extant. Other than the dike, there are no structures in the survey area.

CULTURAL LANDSCAPES

Dyke Marsh has not yet been formally identified as a cultural landscape, although it may qualify as a component landscape of the George Washington Memorial Parkway historic district. As defined by the NPS, a component landscape is "a definable physical area of a landscape that contributes to the significance of a National Register property, or, in some cases, is individually eligible for listing in the National Register" (NPS 1998b). A future cultural landscape inventory would be needed to formally identify the character-defining features of the Dyke Marsh landscape as they relate to the Mount Vernon Memorial Highway. The scenic qualities of the marsh area and the views to it from the parkway are noted in the NRHP nomination and cultural landscape report (NPS 1995; NPS n.d.c).

The cultural landscape report identifies the design principles, or the landscape features that defined the original design principles, that guided the planning of the Mount Vernon Memorial Highway: alignment, grading, planting, views, structures, and materials. South of Alexandria, the road was characterized by its horizontally and vertically curving alignment. This alignment allowed the road to follow the land's natural topography and controlled driving speeds, which were originally designed to be 35 miles per hour (mph). Median strips, wide lanes, and limited access were also designed to increase safety. Separated byways for horseback riding were planned to parallel the road, although only the section from Hunting Creek to New Alexandria was originally laid out. Although grading took place, transitions in grade were made with long vertical curves. Areas that were regraded were rounded for 10 feet to ease the transition between the new road and the existing topography.

Plantings along the parkway were to follow "the natural arrangement of native plants in large masses, in border plantations" (NPS n.d.c). These plantings were to screen objectionable views, emphasize important views, separate and accentuate pictures in the landscape composition, preserve open, unobstructed vision for traffic, and minimize maintenance. The overall effect was "to create a varied sequence of large bays and narrow corridors" achieved by new plantings and selective clearing (NPS n.d.c).

Views along the highway were to prepare the traveler headed south from Washington to Mount Vernon with views up, down, and across the Potomac River. Views were constructed through the plantings, which framed a succession of scenes.

Buildings and structures were designed especially for the highway, to include concession buildings at Mount Vernon, bus shelters constructed of stained timber, and rustic cedar lighting standards along the Mount Vernon Memorial Highway. Small-scale features included directional signs and guardrails that were designed to preserve the memorial character of the road (NPS n.d.c).

The Dyke Marsh section of Mount Vernon Memorial Highway provided natural views of the waterfront and the marsh. As such, existing plantings around the marsh were cleared as little as possible. Minor plantings were added to finish the edges between the road and existing woodland. Azalea species, St. John's wort (*Hypericum* spp.), and honeysuckle were used in large masses along the road, sometimes replacing the wood guardrail. Trees included hornbeam (*Carpinus caroliniana*), dogwood (*Cornus* spp.), and eastern redbud (*Cercis canadensis*). Small-scale features originally in the section included rustic guardrails and cedar light standards. Views from this section included a view across the river where the road widened to include an overlook turnout. (NPS n.d.c).

Present Conditions of the Cultural Landscape

The Dyke Marsh section of the parkway remained relatively unchanged until the 1984 Improvements Program. Circulation was modified with the improvement of the Morningside Lane intersection, which had become a major commuter traffic funnel. A deceleration lane was added for southbound traffic. New curbs, gutters, and underdrains were also constructed at that time. Other changes to the parkway included the removal of the cedar light standards, signs, and wood guardrails. The natural growth of the woodland edge has narrowed space and constricted views.

Other than the landscape features associated with the George Washington Memorial Parkway, the only cultural landscape elements in the survey area are the extant sections of the dike. Those are the only remaining structures in Dyke Marsh.

The marsh is visible from the parkway at certain points, as the parkway passes in and out of wooded areas. The parkway also passes over the marsh where Hog Island Gut extends to the west of the parkway, offering sweeping views of the marsh. The southern portion of the marsh is visible just north of the former promontory that was dredged. It is in this area that the remnants of the historic dike are located.

VISITOR USE AND EXPERIENCE

The George Washington Memorial Parkway links a group of parks and places that provide a variety of experiences to millions of people each year. These parks include historic sites and recreational areas, such as Jones Point Lighthouse within Jones Point Park, Riverside Park, Fort Hunt Park, and Mount Vernon. The parkway connecting these sites also provides visitors with an opportunity to travel to historic and recreational areas, as well as to natural areas such as Dyke Marsh, through a planned and landscaped road. The parkway is a component of the much larger system of parks, parkways, and playgrounds in the National Capital Region.

From a visitor use and experience perspective, one of the mission goals of the park is to provide a comprehensive park, parkway, and playground system in the National Capital region (NPS 2005b). As such, recreation becomes a fundamental element for the park units. As a scenic natural area, Dyke Marsh represents a relatively scarce resource in this highly urbanized location, both as an open green space and as a wetland area. In the project area, typical recreational uses include hiking, bird-watching, and nature study. Anglers also frequent the area, and enjoy fishing the deeper holes created by the dredging. Bicyclists and people walking their dogs also make use of the area on the multi-use trail alongside the parkway, along Haul Road, or on the lands around the edges of the marsh.

View along Haul Road

Belle Haven Marina, located adjacent to the northern edge of the marsh on NPS property, and operated by a concessionaire, provides boat storage, sailing instruction, and canoe and kayak rentals. Boating, including paddle sports, sailing, and some power boating, is a popular activity in the open waters near the marsh. The Mount Vernon Trail allows for access to Belle Haven Picnic Area, which is maintained by the NPS as a public use facility, allowing visitors to walk, jog, or bike from Mount Vernon to Theodore Roosevelt Island and alongside the marsh. The Belle Haven Picnic Area also allows for other passive recreation, including picnicking, bird-watching, walking, and nature study.

Recreational demand is high for the Mount Vernon Trail, Belle Haven Picnic Area, and the marina, whereas use within Dyke Marsh is modest in comparison. Dyke Marsh caters primarily to passive recreation. Although no specific visitor amenities are available at Dyke Marsh and no permanent NPS interpretive facilities are located in the marsh area, Sunday morning bird walks along Haul Road and the Mount Vernon Trail near the marsh are conducted by the Friends of Dyke Marsh organization. Also, periodic interpretation is provided by park staff, volunteers, and Friends of Dyke Marsh (NPS 2000b). Visitors typically use this area for studying the natural wetland environment, bird- and wildlife-watching, and nature study. Bulletin boards and waysides in this area provide information on various natural resources at Dyke Marsh. Use of the Dyke Marsh area for educational programs by local school systems is rapidly increasing, and the NPS has an active Parks-as-Classrooms Program that makes use of the marsh for this purpose.

This area is viewed as a national treasure because of its proximity to the nation's capital and a large urban/suburban population, because of its history, and because of its current potential for the provision of ecological services, recreational values, and educational opportunities. Because of its location and setting, there is an opportunity to enhance environmental education in the Dyke Marsh area. The park has several educational programs, including "Bridging the Watershed," and educational wayside exhibits proposed for the boardwalk at Dyke Marsh (NPS 2005b).

Visitation at George Washington Memorial Parkway generally has ranged between 6.8 million and 7.6 million visitors since 2000. In 2007, the park hosted 6,837,139 recreational visits, of which approximately 85 percent were local residents (Stynes 2011). In 2011, the park hosted 7,417,397 recreational visits (NPS 2012a). The traffic counts at Belle Haven Marina in 2011 included 251,986 vehicles. Assuming many of the visitors would be groups or families and a corresponding average of 2.6 visitors per car, this equals approximately 655,163 visitors to Belle Haven, or 8.8 percent of the park's total recreational visits (NPS 2012a). Based on the most recent Dyke Marsh and Belle Haven visitor survey, conducted in 1993 and discussed in the park's long-range interpretive plan, recreational visitors used the Mount Vernon Trail (55 percent), went to the Belle Haven Picnic Area (44 percent), visited the marina (31 percent), and walked the Dyke Marsh Trail (21 percent) (NPS 2005b). Ten percent of the visitors rented boats during their stays. If these percentages still hold, approximately 448,130 recreational visits to Dyke Marsh and Belle Haven Marina occurred in 2008, and approximately 44,813 visitors rented boats from the Belle Haven Marina, 246,471 hiked the trails in the area, and 197,177 visited the picnic area.

BELLE HAVEN MARINA

Belle Haven Marina is located at the northern part of Dyke Marsh and is approximately 2 miles south of Old Town Alexandria, an area composed of numerous retail outlets, restaurants, lodging, historical venues, and residential properties. Belle Haven Marina provides a place for the public to enjoy recreation on the waterways of the Washington metropolitan area. For over 50 years, Belle Haven Marina has served as a pleasure boat marina, providing opportunities for sailing instruction and catering to both visitors and the local community. The marina provides opportunities for adjacent communities to access the Potomac River and surrounding waterways in a largely urban environment. Visitors have the option at Belle Haven of launching their own boats or renting a boat to experience the Potomac River. They can also rent slips to store their boats to use at any time (NPS 2005a).

The Belle Haven Marina concession facility includes the following services (NPS 2009d):

- Single-lane boat ramp (for motorized boats)
- Boat rental
- Small craft (nonmotorized) boat launch and floating dock
- Wet storage – 59 wet slips
- Moorings – 35 located south and west of the marina
- Parking and dry storage – 15 permanent paved parking spaces and various informal grass and gravel parking spaces
- Marine pump-out station
- Comfort station
- Sailing school.

ADJACENT PROPERTY OWNERS AND THE MARINA

The area south of Dyke Marsh is characterized by mostly high-value homes and estates, many of which have docks. The NPS recently purchased land south of Dyke Marsh, the Crim property, which is part of the study area. The 5.7-acre Crim property at Dyke Marsh is the newest land acquisition for the George Washington Memorial Parkway, and includes both fast land and area over open water and marsh. This purchase completed the acquisition of land comprising the extent of the preserve, an acquisition process which began even before the establishment of Mount Vernon Memorial Highway in 1932. The purchase was made in 2008 at a cost of $37,250 (Feldman, pers. comm. 2009). Four adjacent properties with docks extend into the waters of the newly acquired tract. The park has not yet determined how it will address homeowners with docks that extend into parkland waters and how and when dock owners can maintain, repair, alter, or replace the docks (Feldman, pers. comm. 2009).

Dyke Marsh is adjacent to parkland to the north, bounded by the Belle Haven Marina, and by park-owned woodland and the parkway itself along much of the western edge of the marsh. However, Hog Island Gut crosses under the parkway, and the guts to the west of the parkway abut the land for residential apartments and condominiums, both garden-style and high-rise, as well as single-family residences. There is an elementary school in the vicinity as well.

Several channels that carry tidal flows branch out from the arms of the Hog Island Gut to the west of the parkway and run between buildings into the adjacent Belle View condominium community and the New Alexandria neighborhood to the north of Belle View. These communities sustained severe flooding in Hurricane Isabel in 2003 when water was pushed up the Potomac River, as well as the channels off the guts.

WASHINGTON GAS PIPELINE

Washington Gas has a revocable easement across the Potomac River that crosses the Dyke Marsh area in the vicinity of the historic promontory. There is a natural gas pipeline buried below the river bottom with the NPS permit issued to Washington Gas in 1961 (NPS 1961). Terms and conditions have been developed governing pile driving and other activities in the area of the pipeline (Washington Gas n.d).

PARK MANAGEMENT AND OPERATIONS

The following discusses the composition of the park staff responsible for various functions at the park, including the management of Dyke Marsh and the oversight of the Belle Haven Marina concession operation.

The Dyke Marsh area is serviced by staff from five of the park's divisions: the Cultural Resources Division, the Maintenance Division, the Interpretation Division, the Natural Resources Division, and the Park Police. The Natural Resources Division spends up to 20 percent of their time in the Dyke Marsh area, whereas the other divisions spend less time there, although the amount of time spent in the area varies depending on need and on responsibilities elsewhere in the park.

MAINTENANCE DIVISION

The Maintenance Division serves the entire park area, providing services to Dyke Marsh on an as-needed basis, and these services are limited to scheduled work order requests for routine and cyclical work. Upkeep of wayside and interpretive signs is the responsibility of park rangers. In addition, the Maintenance Division assists the with conducting emergency stabilization projects. Maintenance Division employees do not spend more than 20 percent of their time in the area during a typical week. This division conducts routine maintenance and upkeep for various facilities in the area, most notably Haul Road and its interpretive signs. This division also supports the Division of Technical Services with emergency stabilization as protection from storms, and coordinates with rangers 3 to 4 times per year to pick up trash after shoreline cleanups with volunteer groups (Bibbs pers. comm. 2013). Currently, no major ongoing maintenance activities are occurring in the Dyke Marsh area (Bibbs, pers. comm. 2013).

Interpretation, Recreation, and Resource Management Division

Interpretation Services

The park's interpretation services are divided into four sites or divisions that serve different areas of the park. The Dyke Marsh area is served by the park's Virginia District. This district is a division of Interpretation, Recreation, and Resource Management, which also includes Natural and Cultural Resource Management, as well as other visitor services. The Virginia District provides interpretation services to the area along the parkway corridor from its northern terminus at the I-495 Capital Beltway south to Mount Vernon, excluding Arlington House. The Arlington House, Great Falls, and Glen Echo / Clara Barton Parkway sites are served by other interpretive staff. The Virginia District has a total of three full-time, permanent employees, and two to three seasonal employees per year. These employees spend less than 20 percent of their time in the Dyke Marsh area (Werst, pers. comm. 2013).

Environmental education is an important part of current management policy at Dyke Marsh. Interpretation Division staff host watershed clean-up days, conduct curriculum-based programs for children, and oversee the bird walks conducted by the Friends of Dyke Marsh (NPS 2008a).

Currently, Dyke Marsh has one bulletin board, and has installed four interpretive and educational wayside exhibits that discuss marsh function, wildlife, and cultural resources. All of these have been installed along Haul Road, and support interpretive activities (Werst, pers. comm. 2013).

Cultural Resources Management Program

The Cultural Resources Management Program is involved with the identification, research, protection, and preservation of all cultural resource features of the George Washington Memorial Parkway, including the Dyke Marsh area. The Cultural Resources Management Division assists with prehistoric or historic education and outreach through efforts such as presenting talks on historical research. Primary educational programming is provided through the George Washington Memorial Parkway Interpretation and Education divisions. Two full-time, permanent employees work in the Cultural Resources Management Division, and they service the entire park, spending less than 10 percent of their time in the Dyke Marsh area (Virta pers. comm. 2013).

Natural Resources Management Program

The Natural Resources Management Program has three full-time, permanent employees who serve the entire park area, including Dyke Marsh. They spend approximately 20 percent of their time working in the Dyke Marsh area (Steury, pers. comm. 2009).

The Natural Resources Management Program is in charge of conducting on-the-ground management activities as they pertain to the Dyke Marsh's biological and geologic resources. One such activity is the control of nonnative plants, which includes applying herbicides and supervising volunteer groups to assist in the removal of nonnative plants. The division also manages the area's sedimentation/erosion tables, recording and storing data on the accretion or subsidence of the marsh (NPS 2008a).

The Natural Resources Division is responsible for managing the National Environmental Policy Act (NEPA) compliance associated with all restoration activities (Steury, pers. comm. 2009).

PARK POLICE

The Park Police serve the Dyke Marsh area on an as-needed basis. They patrol the area, respond to emergency calls, and limit the public's access to the marsh during the ecologically sensitive wren breeding season. Major issues associated with Dyke Marsh law enforcement include the poaching of turtles, bow hunting for fish, poaching of catfish, setting of trotlines, and setting of turtle traps, as well as illegal commercial trawl fishing and illegal waterfowl hunting within park boundaries. Current Park Police staffing is sufficient to meet the park's needs (Steury, pers. comm. 2009).

CONCESSION AT BELLE HAVEN MARINA

The concession that operates at Belle Haven Marina is described earlier in this chapter under the Visitor Use and Experience topic and is discussed here because restoring Dyke Marsh may affect the management and operation (and related revenues) of this concession.

Five marinas are located in the area surrounding Belle Haven Marina, two of which are along the parkway and host concession facilities (PwC 2003). Washington Sailing Marina can accommodate much larger boats than the Belle Haven Marina can and is the only other marina in the area providing sailing instruction and sailboat rentals, dry storage, and wet slips. However, Belle Haven has kayak and canoe rentals not provided elsewhere to the south of the District. Belle Haven has consistently maintained 100 percent occupancy levels for moorings and for wet and dry storage rentals (PwC 2003; Lebel, pers. comm. 2009).

The estimated revenues for the wet and dry storage options for Belle Haven Marina are provided in table 3-7. This assumes an average boat length of 22 feet and that monthly storage rates are received year-round.

TABLE 3-7. BELLE HAVEN MARINA REVENUE

Belle Haven Marina Operating Information	Rate[1]	Number[2]	Estimated Annual Revenue
Dry storage and moorings	$6/foot/month	35	$55,440
Wet slips	$8.25/foot/month	59	$128,502
Total			$183,942

[1] Rates provided by Belle Haven Marina (BHM 2009).

[2] Number of wet slips, dry storage, and moorings are provided by NPS 2009e.

The services provided by Belle Haven Marina are clearly in demand. There are few places to access the Potomac River on the Virginia side between Alexandria and Occoquan, and the marina provides these recreational opportunities (NPS 2009d). However, the marina is in need of extensive renovations.

Chapter 4:

Environmental Consequences

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

The "Environmental Consequences" chapter analyzes both beneficial and adverse impacts that would result from implementing any of the alternative elements described in chapter 2 of this draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement (plan/EIS). It is organized by resource topic and provides a standardized comparison among alternatives based on the topics discussed in chapter 1 and further discussed in chapter 3.

The chapter also presents a summary of laws and policies relevant to each impact topic, methods used to analyze impacts, and the analysis methods used for determining cumulative impacts. This plan/EIS addresses (in quantitative terms, to the maximum extent practicable) the direct and indirect potential environmental impacts from all aspects of the Dyke Marsh Wildlife Preserve (Dyke Marsh) restoration project. As required by the Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA), a summary of the environmental consequences for each alternative is provided in table 2-6, which can be found at the end of chapter 2.

SUMMARY OF LAWS AND POLICIES

Three environmental protection laws and their implementing policies guide the actions of the National Park Service (NPS) in the management of its parks and their resources—the Organic Act of 1916, NEPA and its implementing regulations, and the Omnibus Management Act. For a complete discussion of these and other guiding authorities, refer to the "Related Federal Laws, Policies, Regulations, and Plans" section in chapter 1. These guiding authorities are briefly described below.

The Organic Act of 1916 (16 USC 1), as amended or supplemented, commits the NPS to making informed decisions that perpetuate the conservation and protection of park resources unimpaired for the benefit and enjoyment of future generations. NEPA is implemented through regulations of the CEQ (40 CFR 1500–1508). The NPS has, in turn, adopted procedures to comply with these requirements, as found in Director's Order 12 (NPS 2011a) and its accompanying handbook (NPS 2001). The Omnibus Management Act (16 USC 5901 et seq.) underscores NEPA provisions in that both acts are fundamental to park management decisions. Both acts provide direction for connecting resource management decisions to the analysis of impacts and communicating the impacts of those decisions to the public, using appropriate technical and scientific information. Director's Order 12 provides a standard for best available information and a framework and process for evaluating the impacts of the alternatives considered in this plan/EIS.

METHODOLOGY FOR ASSESSING IMPACTS

The following elements were used in analyzing the potential effects of the alternatives on each resource category:

- General analysis methods as described in guiding regulations, including the context and duration of environmental effects.
- Basic assumptions used to formulate the specific methods used in this analysis.

- Methods used to assess significance of impacts.
- Methods used to evaluate the cumulative impacts of each alternative in combination with unrelated factors or actions affecting park resources.

These elements are described in more detail below.

GENERAL ANALYSIS METHODS

The analysis of impacts follows CEQ guidelines and Director's Order 12 procedures and is based on the underlying purpose, as stated in "Chapter 1: Purpose of and Need for Action," of developing and implementing actions for restoration and long-term management of the tidal freshwater marsh and other associated wetland habitats lost or impacted in the Dyke Marsh Wildlife Preserve (Dyke Marsh) on the Potomac River in Virginia. This analysis incorporates the best available scientific literature applicable to the region and setting, the species being evaluated, and the actions being considered in the alternatives. For each resource topic addressed in this chapter, the applicable analysis methods and assumptions are discussed.

HYDRODYNAMIC MODELING

As described in chapters 1 and 2, the anticipated outcome of the efforts to restore Dyke Marsh has been partially estimated using hydrodynamic modeling. A successful model provides information needed to meet the goals of a project. The model needs to be dynamic, capable of handling 2-way flows, and capable of determining change in water surface elevation over time.

HEC-RAS 1-dimensional hydrodynamic modeling and 2-dimensional Finite Element Surface Modeling System (FESWMS/SMS) modeling were used to understand what would happen hydrologically and hydraulically under each alternative, and how sediment would be transported through the marsh (see figures for the alternatives in chapter 2) (USACE 2010; USACE 2012a). The sediment transport process includes deposition (accretion) of sediment within the marsh and erosion of sediment from the marsh. The modeling also indicates where freshwater tidal marsh vegetation would colonize as the tidal plain elevation increases. These processes are described in detail in this chapter. Estimated acres of new wetland vegetation were also developed using model results and GIS.

ANALYSIS PERIOD

Goals, objectives, and specific implementation actions needed to restore Dyke Marsh are established for the next 15 years; therefore, the analysis period used for assessing impacts is up to 15 years. The impact analysis for each alternative is based on the principles of adaptive management, which would allow the NPS to change management actions as new information emerges from monitoring the results of restoration and management actions and ongoing research throughout the life of this plan.

GEOGRAPHIC AREA EVALUATED

Unless otherwise stated, the geographic study area (or area of analysis) for assessment of indirect and direct impacts includes the entirety of the original configuration of Dyke Marsh. The study area extends west to east, from the parkway to the eastern extent of the historic marsh, and north to south from the Belle Haven Marina to the area north of the private docks (figure 1-1). Some research topics (hydrology and sediment transport, surface water quality in the Potomac River, and floodplains) use a larger area of analysis, which considers the tidal channels that extend through the neighborhoods, and immediately adjacent land, upstream along the Potomac River to the confluence of Hunting Creek/Cameron Run with the Potomac River, and downstream to the Horticultural Society property where the Virginia/Maryland State line rejoins the banks of the Potomac River. The study area for these topics also includes the Potomac River and its shore on the Maryland side of the river between these upstream/downstream limits.

DURATION AND TYPE OF IMPACTS

Several basic assumptions are used for all impact topics (the terms “impact” and “effect” are used interchangeably throughout this document):

- *Short-term impacts*—Impacts associated with construction actions that are temporary and would not have long-lasting effects. These impacts could last several years, as construction could last multiple years, but they would not be permanent.
- *Long-term impact*s—Impacts that would last beyond the time when construction is complete, generally longer than three years and possibly lasting through the life of the plan, with potentially permanent effects.
- *Direct impacts*—Impacts that would occur as a direct result of NPS management actions.
- *Indirect impacts*—Impacts that would occur from NPS management actions and would occur later in time or farther in distance from the action.
- *Beneficial*—A positive change in the condition or appearance of the resource or a change that moves the resource toward a desired condition.
- *Adverse*—A change that degrades, or moves the resource away from a desired condition or detracts from its appearance or condition.

Direct and indirect impacts are addressed in the analysis, although they may not be specifically labeled as such.

ASSESSING SIGNIFICANCE OF IMPACTS

The impacts of the alternatives are assessed using the CEQ definition of “significantly” (1508.27), which requires consideration of both context and intensity:

1. Context—This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole.
2. Intensity—This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:
    a. Impacts that may be both beneficial and adverse. A significant effect may exist even if the federal agency believes that on balance the effect would be beneficial.
    b. The degree to which the proposed action affects public health or safety.
    c. Unique characteristics of the geographic area such as proximity to historic or cultural resources, parklands, prime farmlands, wetland, wild and scenic rivers, or ecologically critical areas.

d. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

e. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

f. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

g. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

h. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places (NRHP) or may cause loss or destruction of significant scientific, cultural, or historical resources.

i. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

j. Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment.

An assessment of significance of the impacts of the alternatives is provided in the conclusion section, which follows the analysis of impacts of the alternatives. The analysis of significance considered the factors identified above, where applicable, and also examined other factors such as how noticeable or how large in magnitude the impacts are overall; if the impact is a primary driver of other effects; if the resource affected is of regional or national importance; or if the resource is a rare or important component of the ecosystem or considered fundamental to the park.

CUMULATIVE IMPACTS ANALYSIS METHODS

The CEQ regulations to implement NEPA require the assessment of cumulative impacts in the decision-making process for federal projects. Cumulative impacts are defined as “the impact on the environment which results from the incremental impact of the action when added to other past, current, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions” (40 CFR 1508.7). As stated in the CEQ handbook, *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ 1997), cumulative impacts need to be analyzed in terms of the specific resource, ecosystem, and human community being affected and should focus on effects that are truly meaningful. Cumulative impacts are considered for all alternatives, including alternative A (no action).

Cumulative impacts were determined by combining the impacts of the proposed alternative with other past, present, and reasonably foreseeable future actions that would also result in beneficial or adverse impacts. The greater the impacts of the proposed alternative are, the greater the relative contribution to the cumulative impact. Therefore, it was necessary to identify those other actions at the parks and the surrounding areas (as appropriate) that could affect the various resources discussed in this plan and that are in addition to the actions already addressed within the alternatives.

The analysis of cumulative impacts was accomplished using four steps:

Step 1—Identify Resources Affected: identify resources affected by any of the alternatives.

Step 2—Set Boundaries: identify appropriate spatial and temporal boundaries for each resource.

Step 3—Identify Cumulative Action Scenario: determine which past, current, and reasonably foreseeable future actions to include for each resource. These actions are not only those within or undertaken by the park but also those actions by any entity that have had or will have an effect on the resources impacted by this plan.

Step 4—Cumulative Impact Analysis: determine the combined impact of the proposed alternative and the other identified actions of the cumulative scenario.

Table 4-1 summarizes the actions that were identified for the cumulative impact scenario for this plan, and additional information is provided in the following narrative for those projects not discussed elsewhere. The spatial boundaries vary, but the temporal boundaries for all impact topics except archeological resources, historic structures and districts, cultural landscapes, and visitor use and experience are back in time to the development of the golf course at Belle Haven Country Club (approximately late 1920s or early 1930s); and forward 15 years, the life of the plan.

Belle Haven Golf Course—The golf course, built in the 1920s or early 1930s, cleared land, hardened shorelines on Hunting Creek and resulted in more sediments and nutrients entering adjacent waters. The shorelines adjacent to the golf course are currently relatively natural and have riparian buffers.

Development of National Harbor—National Harbor is a relatively new mixed use development on the Maryland side of the river across from Dyke Marsh, just south of Woodrow Wilson Bridge. The development includes a waterfront hotel and convention center, marina, and shoreline hardened with riprap. Ferries to National Harbor run from Mount Vernon, Old Town Alexandria, and the Georgetown Waterfront. The Mount Vernon ferry passes Dyke Marsh several times a day. The boat is a single hull commercial vessel that can create wakes (Potomac River Boat Company 2013), but stays in the commercial channel that is closer to the Maryland shoreline near Dyke Marsh.

Replacement of Woodrow Wilson Bridge and associated wetlands mitigation—The Interstate-95 Woodrow Wilson Bridge over the Potomac River north of Dyke Marsh was replaced in the early 2000s, with the new bridge opening to traffic in 2006. As part of the project, interchanges and roads around the bridge were reconfigured. Approximately 25 acres of tidal and nontidal wetlands, and submerged vegetation were disturbed as part of the project. Wetlands mitigation included preservation or creation of 100 acres of wetlands in Virginia, Maryland, and the District of Columbia (Coastal Resource, Inc. n.d.; Bridge Pros 2003).

DC Water Clean Rivers Project—DC Water is in the process of implementing infrastructure improvements to reduce or eliminate combined sewer overflow, which during heavy rain can discharge untreated sewage into the Anacostia River, Potomac River, and Rock Creek. Projects include construction of two large capacity tunnels, one of which is under construction. The tunnels will be able to hold stormwater during rain events and prevent overload of the system, contribute to green infrastructure initiatives that would reduce stormwater runoff volume at the source, and address water quality concerns. Ultimately, implementation of the Clean Rivers Project is expected to improve water quality in the Anacostia and Potomac, as well as Rock Creek, particularly by reducing bacteria loading improving dissolved oxygen levels (DC Water 2013).

Potomac Yards Metrorail Station—The Washington Metropolitan Area Transit Authority plans to open a new station in Alexandria near the Potomac Yards development on Route 1. NPS land in the George Washington Memorial Parkway may be part of the project. It is anticipated that the project area could impact archeological and other cultural resources, and mitigation for impacts to these resources could be necessary under Section 106 of the NHPA.

Arlington National Cemetery Expansion—The cemetery is planning to expand burial space onto land previously administered by the NPS. Through Section 106 consultation, it was determined that the project would result in an adverse effect to a portion of the wooded area that contributes to the NRHP listed Arlington House, the Robert E. Lee Memorial, which is administered by the George Washington Memorial Parkway. NEPA and NHPA compliance have been completed for this project, and the cemetery will likely proceed with construction within the year.

George Washington Memorial Parkway North Parkway Rehabilitation—Elements of the north parkway have deteriorated and require corrective treatment. George Washington Memorial Parkway is coordinating the treatment effort with the Federal Highway Administration. The Federal Highway Administration advocates the implementation of modern safety improvements into the project. This includes elements such as larger guide walls that could impact the historic integrity of the George Washington Memorial Parkway. Archeological resources could be impacted as well. An environmental assessment (EA) for this project is in process.

Arlington Memorial Bridge Rehabilitation—Components of the bridge have deteriorated to the point that corrective treatment is required. Some of the alternatives proposed have the potential to impact the historic character of the bridge and its visual appearance within the landscape of the George Washington Memorial Parkway. An EA is currently being developed to evaluate these alternatives.

Memorial Circle Safety Improvements—A road safety audit was conducted for Memorial Circle and its immediate vicinity. The audit proposed a number of modifications to the circle in order to address identified safety issues. Some of the proposed alternatives could result in conspicuous visual impacts to the historic George Washington Memorial Parkway. An EA is in planned to evaluate these alternatives.

External Projects—There are several high-rise development projects in planning stages or underway in Arlington County and Alexandria (including development in the vicinity of Potomac Yard independent of the proposed Metrorail station at that site) that will likely result in visual impacts to the George Washington Memorial Parkway.

TABLE 4-1. ACTIONS THAT CONTRIBUTE TO CUMULATIVE IMPACTS

Impact Topic	Spatial and Temporal Boundaries*	Past Actions	Present Actions	Future Actions (life of plan/EIS)
Hydrology and Sediment Transport	Spatial: Upstream from the Woodrow Wilson Bridge to southern edge of project	• Development of National Harbor • Replacement of Woodrow Wilson Bridge • Belle Haven Country Club Golf course	• No actions identified	• Potential dredging at Cameron Run/Hunting Creek
Soils and Sediments	Spatial: Hunting Creek to south side of project area on Virginia Side, downstream to the next tributary, Accotink/Pohick Creek on the Virginia side	• Construction of the Woodrow Wilson bridge • Development of the Belle Haven Country Club golf course (in the 1920s or 1930s) • Development of the Belle Haven Marina	• No actions identified	• Potential dredging at Cameron Run/Hunting Creek

Impact Topic	Spatial and Temporal Boundaries*	Past Actions	Present Actions	Future Actions (life of plan/EIS)
Surface Water Quality in the Potomac River	Spatial: Upstream to the northern District of Columbia / Maryland border, downstream to the next tributary (Accotink/Pohick Creek in Virginia)	• Development of National Harbor on Maryland side • Replacement of Woodrow Wilson Bridge • Belle Haven Country Club Golf course • Development of the Belle Haven Marina	• DC Water Clean Rivers Project	• DC Water Clean Rivers Project
Floodplains	Spatial: Upstream from the Woodrow Wilson Bridge to southern edge of project	• Wetland removal and mitigation associated with Woodrow Wilson Bridge construction • Belle Haven Country Club Golf course • Development of National Harbor on Maryland side	• DC Water Clean Rivers Project	• DC Water Clean Rivers Project
Vegetation and Wetlands	Spatial: Upstream to the District of Columbia, downstream to the next tributary (Piscataway Creek)	• Wetland removal and mitigation associated with Woodrow Wilson Bridge construction • Belle Haven Country Club Golf course Anacostia Wetland Project	• DC Water Clean Rivers Project	• DC Water Clean Rivers Project
Fish and Wildlife	Spatial: Upstream to the District of Columbia, downstream to the next tributary (Piscataway Creek) and across river to Maryland	• Development of National Harbor on Maryland side • Replacement of Woodrow Wilson Bridge	• No actions identified	• No actions identified
Species of Special Concern	Spatial: Upstream to the District of Columbia, downstream to the next tributary (Piscataway Creek) and across river to MD	• Woodrow Wilson Bridge replacement • Development of National Harbor on Maryland side	• No actions identified	• No actions identified

Impact Topic	Spatial and Temporal Boundaries*	Past Actions	Present Actions	Future Actions (life of plan/EIS)
Archeological Resources	Spatial: Extent of George Washington Memorial Parkway Temporal: Back to the replacement of the Woodrow Wilson Bridge (construction began in 2000) and forward 20 years or the life of the plan	• Woodrow Wilson Bridge replacement • New Parking lot at Mount Vernon	• No actions identified	• Potomac Yards Metro station • Land exchange at Langley Fork Park • Boathouse in George Washington Memorial Parkway in Arlington • George Washington Memorial Parkway North Parkway Rehabilitation • Memorial Circle Safety Improvements
Historic Structures and Districts, and Cultural Landscapes	Spatial: Extent of George Washington Memorial Parkway Temporal: Back to the replacement of the Woodrow Wilson Bridge (construction began in 2000) and forward 20 years or the life of the plan	• Woodrow Wilson Bridge replacement • New Parking lot at Mount Vernon • Designation of the Mount Vernon Parkway as a Historic District	• No actions identified	• Potomac Yards Metro station • Land exchange at Langley Fork Park • Boathouse in George Washington Memorial Parkway in Arlington • Arlington National Cemetery Expansion • George Washington Memorial Parkway North Parkway Rehabilitation • Arlington Memorial Bridge Rehabilitation • Memorial Circle Safety Improvements • External projects in Arlington and Alexandria adjacent to the parkway

Impact Topic	Spatial and Temporal Boundaries*	Past Actions	Present Actions	Future Actions (life of plan/EIS)
Visitor Use and Experience	Spatial: Viewshed from Dyke Marsh—up to the Woodrow Wilson Bridge, across the river and down to the inlet where Potomac River Waterfront Park is located north of Piscataway Creek Temporal: Back to the replacement of the Woodrow Wilson Bridge (construction began in 2000) and forward 20 years or the life of the plan	• Replacement of Woodrow Wilson Bridge • Development of National Harbor in Maryland	• No actions identified	• No actions identified
Adjacent Property Owners and the Marina	Spatial: Marsh and immediately surrounding areas and neighborhoods. Temporal: Back to the replacement of the Woodrow Wilson Bridge (construction began in 2000) and forward 20 years or the life of the plan	• No actions identified	• No actions identified	• No actions identified
Park Management and Operations	Spatial: Extent of George Washington Memorial Parkway	• No actions identified	• No actions identified	• No actions identified

*The temporal boundary for all impact topics is back in time to the development of the golf course at Belle Haven Country Club (approximately late 1920s or early 1930s); and forward 15 years (the life of the plan), unless otherwise noted.

IMPACTS OF THE ALTERNATIVES ON HYDROLOGY AND SEDIMENT TRANSPORT

GUIDING REGULATIONS AND POLICIES

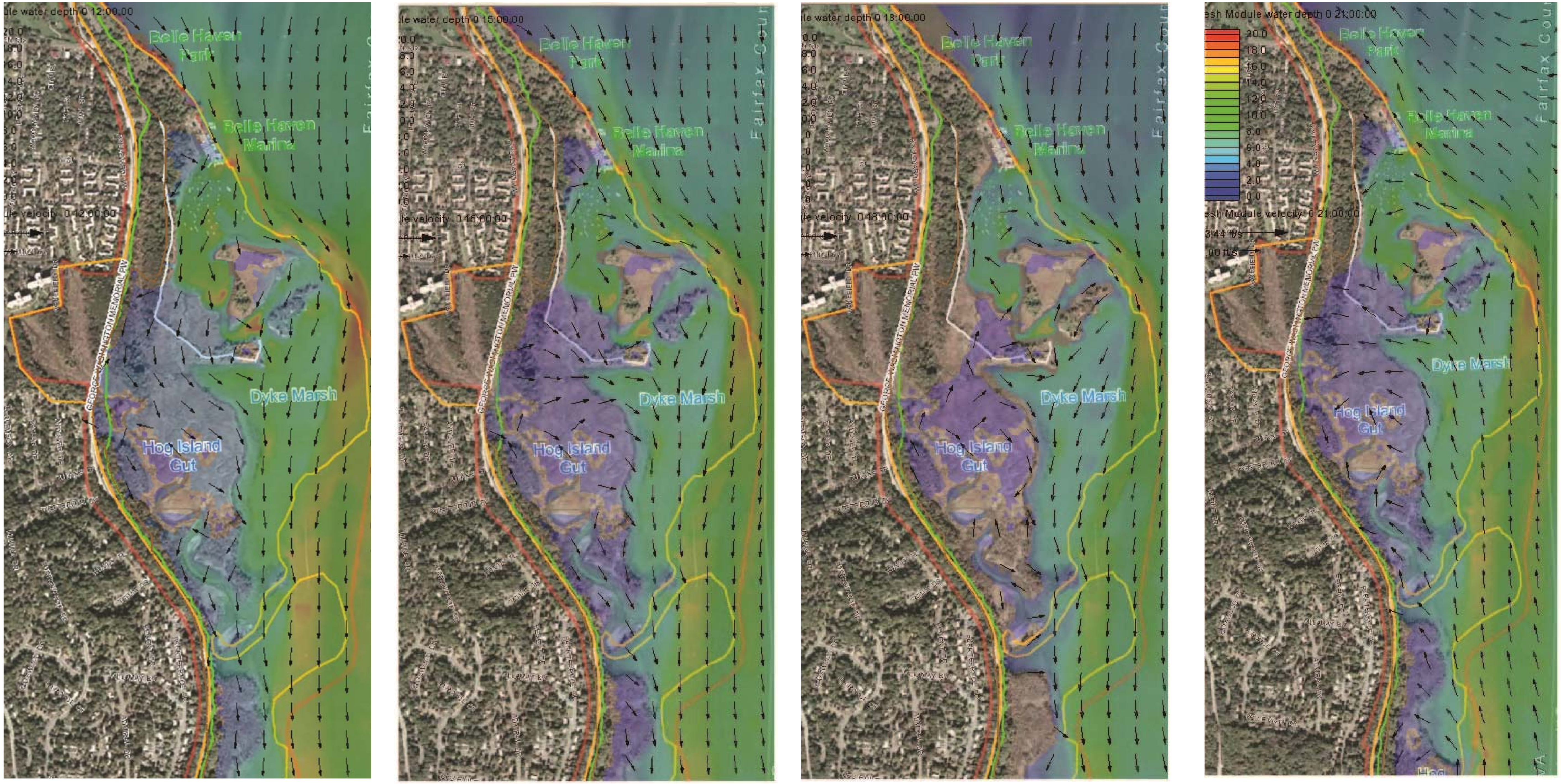
As discussed in chapter 1, the restoration is guided by NPS *Management Policies 2006*, specifically, “Chapter 4: Natural Resources,” which states that “the National Park Service will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks while providing meaningful and appropriate opportunities to enjoy them” (NPS 2006). Two instances that apply here in which the NPS would intervene in natural biological or physical processes are when it is directed to do so by Congress, which is the case with Dyke Marsh, and to restore natural ecosystem functions that have been disrupted by past or ongoing human activity. Dyke Marsh has been substantially altered by past dredging activity and is eroding. The NPS *Management Policies 2006* also direct the NPS to manage watersheds as complete hydrologic systems and manage stream processes, such as erosion and deposition that affect Dyke Marsh. Construction activities would be guided by state and federal laws, including the Clean Water Act (Section 404) and Section 9 of the Rivers and Harbors Act of 1899. The implementation of the project would follow in-water construction management practices required by the Virginia Department of Conservation and Recreation (VA DCR) in the Virginia Erosion and Sediment Control Manual (VA DCR 1992), and the Virginia Department of Game and Inland Fisheries (VDGIF) concerning construction in tidal waters.

METHODS AND ASSUMPTIONS

Success of the restoration relies on the ability to restore hydrologic conditions that would allow for and encourage sediment deposition and accrual in the marsh. The U.S. Army Corps of Engineers (USACE) characterized existing conditions in the marsh, and modeled anticipated future conditions in the marsh under both action alternatives. Analysis included 2-dimensional modeling using the FESWMS/SMS platform that characterized diurnal tides, the base flow of the Potomac River, and flow depths to understand how tidal flows affect the marsh currently and how they would affect the marsh under the different alternatives. This information was used to assess potential impacts including changes to flow, development of high or low energy areas that would result in erosion (in the high energy areas) or sediment accretion (in the low energy areas), and how that would affect the hydrologic processes and the overall restoration, along with information from a bathymetric study in 2009 (NPS 2009b); data from sediment transport modeling (USACE 2010); and information with the U.S. Geological Survey (USGS) study (Litwin et al. 2011) in which the authors measured existing erosion rates.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, no restoration efforts would occur and the marsh would continue to degrade. The existing marsh is not in a geologically sustainable state, and would “continue to be subjected to strong lateral shoreline erosion and stream piracy” (Litwin et al. 2011). Tidal freshwater marsh is a regionally threatened resource on the Potomac River and in nearby water bodies, making the adverse effects of the erosion of the marsh more acute. Sediments would continue to be carried past the marsh. The Litwin et al. study and the hydrologic modeling conducted for this restoration plan predicts that the current hydrologic situation would result in erosion in the marsh at a rate of 6–7.8 feet per year, and that there is little or no natural protection from erosion provided to Hog Island Gut (Litwin et al. 2011; USACE 2012a). Erosion of the gut is primarily the result of the removal of the promontory during dredging, which changed the hydrology of the area, and has allowed incoming tides and storm surges to flow more directly into Hog Island Gut. Erosion since the promontory was removed has further truncated the gut, and caused it to discharge to the south, which encourages incoming tides and flow from storms to flow into and out of the gut in a relatively straight line without attenuation from meanders in the channel, allowing tidal flows and storm surges to flow in and out of the gut with greater velocities. The higher velocities in the channel during tidal flows have eroded the channel banks, widening and straightening them, and this process would continue (Litwin et al. 2011). At the same time, with the promontory no longer in place, the undeflected flow on the outer edges of the marsh have caused erosion of the outer wall of the Hog Island Gut channel, narrowing the channel wall, to the point there are currently locations where the channel is in danger of being breached (Litwin et al. 2011). In addition, there are deep channels adjacent to the marsh that direct flow through the area at higher velocities that exacerbate erosion in the marsh. With no restoration efforts, relatively high energy conditions would continue to exist adjacent to the marsh allowing suspended sediments in the river to continue to be carried straight downstream past the marsh. There would continue to be relatively few, if any, places in the existing marsh that would provide the low energy conditions needed for sediments to settle out of the water column and accumulate on the river bottom (figure 4-1). The arrows on the images in figure 4-1 show direction of water flows during different tidal stages, and shading indicates relative depths. There would be no change to the hydrology or sediment transport in the Haul Road area. The area west of Haul Road would continue to be disconnected hydrologically from the rest of the marsh, and there would be no opportunities to reintroduce tidal flows into this area and restore it to the bottomland swamp forest that existed there previously, because the necessary hydrologic conditions that supported this forest, specifically periodic tidal influence, would not exist.



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Source: USACE 2012a

FIGURE 4-1. EXISTING FLOW CONDITIONS IN THE MARSH

Overall, under the no-action alternative, the existing erosive hydrologic processes created by past human disturbance would continue, river flow past the marsh would be undeflected by breakwaters (as compared with the action alternatives) (figure 4-1), and it is expected that the marsh would continue to erode noticeably, disrupting the organic mat under the marsh, and carrying sediments out of the marsh, with the potential that the marsh could disappear almost entirely with no intervention (Litwin et al. 2011).

Cumulative Impacts

Several past, present, and reasonably foreseeable future actions in the vicinity of Dyke Marsh have the potential to impact both hydrology and sediment transport in the marsh and the adjacent Potomac River. The construction of the new Woodrow Wilson Bridge in Alexandria in the 2000s, the development of the Belle Haven Golf Course early in the 20th century, and the development of Belle Haven Marina in the 1950s all affected the hydrology and sediment transport in the Potomac River and in Dyke Marsh, though most impacts were localized. The construction of the bridge, which included dredging and pile driving, has affected the hydrology by forcing water around the bridge piers. Also, flow velocities are higher in the narrower shipping channel where the water is deeper. The construction of the golf course has increased runoff and sediment deposition in Cameron Run and Hunting Creek. When coupled with upstream development along Cameron Run, this has resulted in sediments being transported from Cameron Run to the confluence with the Potomac River, where large mud flats are developing. That sediment is not being carried downstream in the direction of Dyke Marsh. Possible future dredging of the accumulating mudflats at the mouth of Cameron Run would affect hydrology and sediment transport including in Dyke Marsh. Dredging a channel in this area could temporarily allow additional sediment to flow from Cameron Run and Hunting Creek downstream toward Dyke Marsh and beyond, but the mudflats would continue to accumulate sediment and develop into vegetated wetlands. There are currently areas where vegetation has become established, and this would continue, even with dredging a small channel.

The development of the Belle Haven Marina altered the hydrology of Dyke Marsh by extending docks into the river and south toward the marsh, and through the maintenance of a navigation channel into the marina. There is noticeable sediment accumulation in the flats behind and west of the marina by the canoe launch, but the area where there is a deep dredging hole that has become the mooring area remains relatively deep, and there is no sediment accumulation in the mooring field area. The no-action alternative would contribute adverse effects to the overall beneficial and adverse cumulative effects in this area. This contribution would be appreciable, because of the marsh expected to be lost as a result of hydrologic change and erosion.

Conclusion

Under the no-action alternative, the existing flow regime would continue, and there would be continued erosion and loss of marsh over time. Without intervention, the marsh would disappear, and there would be no opportunity for beneficial hydrologic conditions or sediment accretion. Unique characteristics of the marsh, including its freshwater tidal wetlands and ecologically critical areas, would be lost. Hydrology and sediment transport are driving factors for wetland restoration and ecological changes in the marsh, so impacts on hydrology and sediment transport are of great importance. For these reasons, the impacts on hydrology and sediment transport under alternative A would be considered significant.

The no-action alternative would contribute adverse effects to the impacts of other past, present, and reasonably foreseeable projects in this area. This contribution would be appreciable because of the marsh expected to be lost as a result of hydrologic change and erosion.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Changes in Flow and Sediment Transport in the Main Marsh Areas

Both action alternatives include elements that create low energy areas in the marsh and reduce the velocity of currents that are currently causing erosion, especially in and along the tidal guts. The installation of a breakwater structure and placement of fill in the deep channels at the southern end of the existing marsh would dissipate wave and flow energy, and protect the mouth of Hog Island Gut. The breakwater structure mimics the function of the historic promontory, which would deflect both daily tidal and occasional storm wave energy from the long fetch to the south. Although there is a different location and length for the breakwater in each action alternative, the placement of the breakwater would redirect the flows around it from both directions, resulting in the creation of lower energy systems behind it. This reduction in energy would allow for and encourage sediment accretion (USACE 2012a) in the historic marsh areas. Filling the deeper channels with heavier and rougher material just upstream of the breakwater would start to remove the narrow raceway through which water is being directed at higher velocities, and would be expected to spread the flows more evenly across the river bottom and concentrate the line of fastest flow back into the main part of the river where it was historically. It is also likely that for a time, until other sediments settle on top of the fill, the rougher surface of the deep channel fill would also help slow the water energy due to the friction the rough surface would create (Litwin, pers. comm. 2011). However, the 2-D modeling showed that filling the channel to the 12-foot deep contour would not noticeably alter velocity vectors or their direction in the area, with the caveat that limitations to the model may have limited the ability of the model to recognize the benefits of the deep channel fill (USACE 2012a). The modelers also noted that filling the channels to 8 or 4 feet deep may also provide more noticeable benefits, but did not evaluate these scenarios. Erosive energy from higher velocity flows would be dissipated by the fill of the deep channels, contributing to the creation of low energy systems in the marsh, particularly around the mouth of Hog Island Gut. Where low energy areas are created, there is more likely to be sediment accretion, as sediments drop out of the flow and settle on the marsh or river bottom (Litwin, pers. comm. 2011).

The specific impacts would vary according to the placement of the breakwater and are discussed in the impact analysis for each alternative. However, by encouraging renewed deposition of sediment within the marsh area through the construction of the breakwater that resembles the historic promontory, some amount of sediments in the water column that have been flowing downstream unimpeded would be removed from the water column, and this may affect downstream areas where accretion of sediments is occurring. However, because the modeling stopped just south of Dyke Marsh, and did not extend downstream of Dyke Marsh, there are no data available to determine the downstream extent of the impacts of the predicted reduced sediment load on the areas where the suspended sediments are currently settling out. The flow trace study does show that it is likely that sediments would settle out immediately south of the breakwater in the southernmost wetlands, as occurred when the historic promontory was present, (figure 4-2), although the FESWMS/SMS model runs indicate that there is still a lot of flow around the breakwater, so sediments may not settle out (figure 4-3).

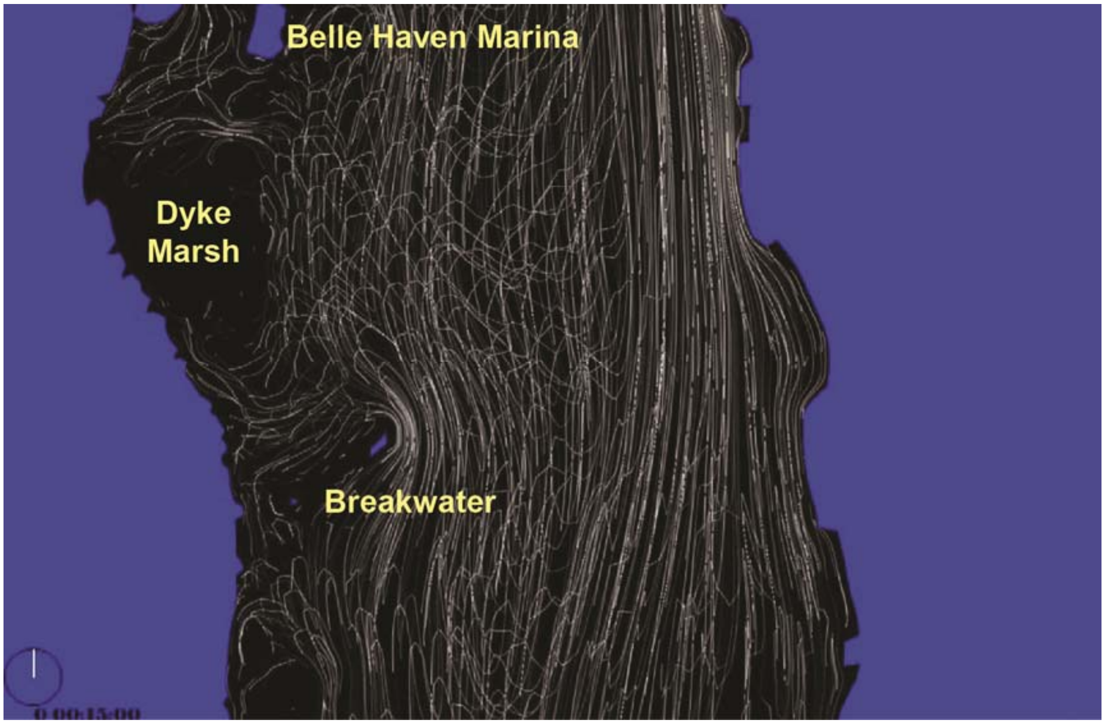


FIGURE 4-2. FLOW TRACE PATTERNS IN THE POTOMAC RIVER WITH A BREAKWATER

In addition, both action alternatives include the construction of new marsh surface using containment cells. The new marsh would change the hydrology and sedimentation patterns by creating friction and a rougher surface for water to flow over, generally slowing flows down in the marsh, and allowing for sediment accretion in some parts of the marsh. The use of natural and unhardened edges along the marsh would also result in beneficial impacts on hydrology and sediment deposition in the marsh by allowing natural and tidal flow over restored wetlands, impeded only by the plants themselves, and natural attenuation of flow velocities in and out of marsh. The result of this approach on hydrology and sediment in the marsh would be the establishment of a more natural flow regime in the marsh over the long term, with associated sediment deposition in the low energy areas to encourage marsh accretion.

Changes of Hydrology and Sediment Transport along Haul Road

Under both action alternatives, the creation of breaks along Haul Road would allow tidal flows to pass under the road and into the former bottomland swamp forest, along with sediment transfer associated with those tidal flows over the long term. The reconnections would allow tidal flows in the area, so that it would be inundated more frequently and more regularly with the tides. This change in hydrology would discourage continued establishment of nonnative and invasive plants in these areas by making conditions less suitable for the nonnative species and improving hydrologic conditions for native species found in bottomland swamp forests that grow well in regularly inundated conditions. The hydrologic reconnections would also result in improvements in floodplain values by improving bottomland floodplain forest habitat, and increasing floodplain capacity, all of which are discussed in other sections. Although the area in which the breaks would be placed is relatively sheltered, with lower flow velocities, there would still be some scour at the culverts or bridges where tidal flows are forced through. The modeling did not address this area, so the degree of scour cannot be predicted at this time. A scour analysis would be conducted during later stages of the design process to ensure scour would be minimized.

Impacts from Construction Activities

Under both action alternatives, the marsh would be reestablished using mostly large containment cells, with smaller, strategically placed containment cells, to complete the first phase of restoration. The cells would be designed to hold fill material until enough fill can be placed at a suitable elevation to support appropriate vegetation, and then settled so that plants can colonize or the area can be planted. Various best management practices (BMPs) or construction design approaches for the containment cells would prevent sediments from being lost from the containment cells during the fill process, but allow intertidal exchange once fill placement is complete. Intertidal exchange in the wetlands outside the containment cells would continue, although water would flow around the cells, and up Hog Island Gut. There would therefore be short-term effects on hydrology and sediment transfer related to construction. The cells would partially block or force redirection of flow to the existing marsh behind the containment structures while they are in place, and could force water along the back edges of the containment structures, creating friction and erosion at the edges. This would have localized adverse short-term effects on the marsh. There would also be some erosion along the outermost edge of the containment cell. However, containment structures would not block the entrance to Hog Island Gut under either of the action alternatives, and water would still flow into Hog Island Gut. The cells would create beneficial effects by sheltering the larger marsh from erosive storm waves while they are in place.

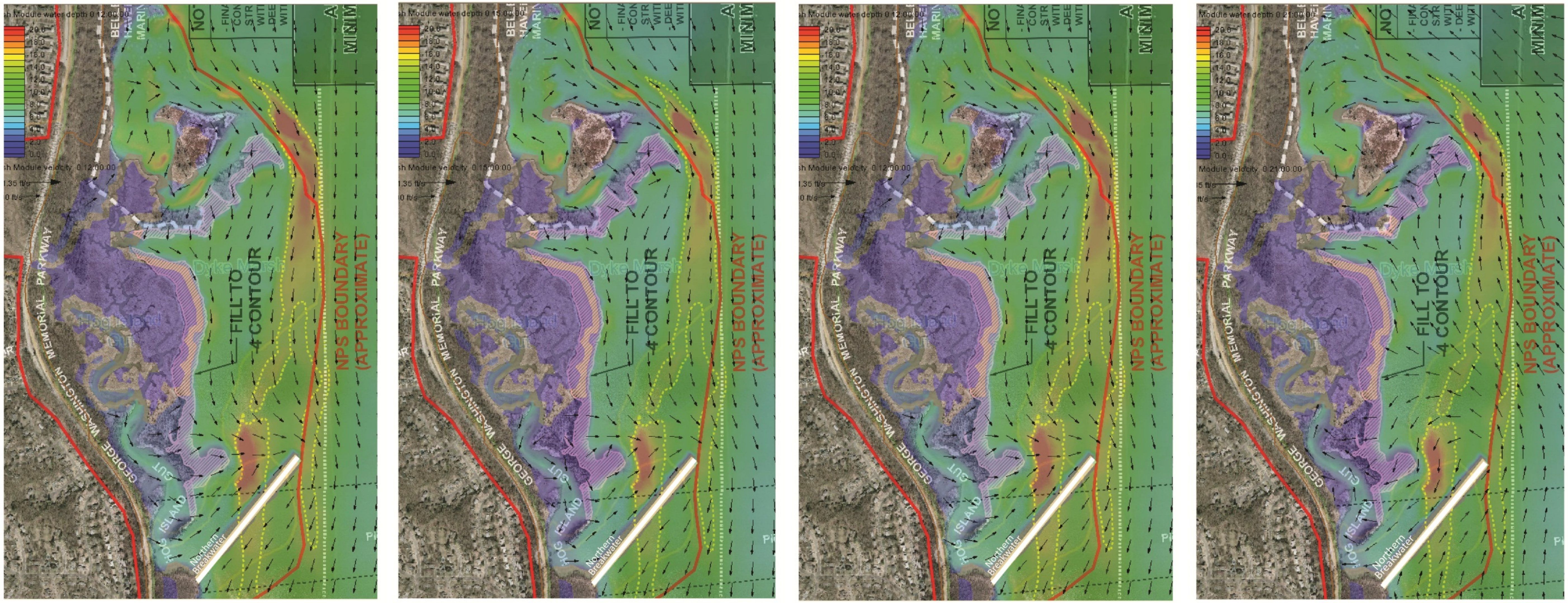
There would be no construction-related impacts on hydrology associated with constructing the breakwater.

Regardless of whether bridges or culverts are installed at the breaks in Haul Road, it is likely that a barrier would be placed along the shore while work is performed to prevent water from getting into the construction area. In addition, erosion and sediment control BMPs would be used to prevent accidental discharge of sediments into Dyke Marsh and the Potomac River during construction. Because there is no existing flow to the inland side of Haul Road, there would be no impacts on hydrology or sediment transport, specifically unanticipated delivery of sediment to the marsh and river, during construction.

IMPACTS OF ALTERNATIVE B

Under alternative B, the focus is on the most essential actions that would reestablish hydrologic conditions that shield the marsh from erosive currents and on protection of the Hog Island Gut channel and channel wall. The restoration activities would create beneficial hydrological and sediment deposition conditions that would promote successful marsh restoration over the long term. The breakwater under this alternative would be constructed at the northern edge of the historic promontory, adjacent to Hog Island Gut. The location of the breakwater would introduce a bend to the gut and cause it to empty to the north. This change in orientation for the outlet would greatly lessen and could even reverse the scour effect that is currently taking place in the southern-facing outlet.

Hydrodynamic modeling by the USACE (USACE 2012a) predicts that the breakwater would redirect flow in a way that would provide tidal resistance, disrupt the energy of the fetch from the south, and provide an adequate wave shadow to protect the mouth of Hog Island Gut and the wetlands on the southern end of Dyke Marsh from storms and higher energy waves. Restored marsh to the negative 4-foot contour would also help shelter the Hog Island Gut channel from destructive and erosive wave energy.



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Source: USACE 2012a.

FIGURE 4-3. ALTERNATIVE B FLOW PROJECTIONS IN DYKE MARSH

Figure 4-3 serves to illustrate the changes predicted by the model under this alternative. As compared with alternative A, in which erosion would continue, under alternative B, the marsh would stabilize. With both the breakwater and restored marsh area north of the breakwater, at high tide water would flow across the proposed marsh around Coconut Island at the north end of the marsh (see figure 2-7 in chapter 2 for the locations of the islands). At the receding mid-tide, flows would be pulled toward the southern end of the marsh in a low energy state that would promote deposition of sediments and marsh accretion in this area. Flows would be redirected around the breakwater at Angel Island at the mouth of Hog Island Gut. At low tide, the low energy flow would continue to be pulled into the south marsh, and flows at Coconut Island would no longer overtop the island, but would be redirected in a northerly direction. At mid-tide on the incoming tide, flows to the north would be pushed around the breakwater and up Hog Island Gut. A noticeable tidal lag would be created. Under normal conditions at all tidal stages, less water would flow over the top of the marsh, but would be directed into the marsh through Hog Island Gut and its tributaries (figure 4-3 shows flows during all four tidal stages). Approximately 70 acres of swamp forest wetlands, and vegetated high and emergent marsh would be created. Although there would be less marsh area restored than existed historically, hydrologic conditions would be similar to conditions before the historic promontory was removed. The flows would no longer be largely erosive, and there would be long-term benefits to the marsh, possibly allowing for natural accretion of marsh in the future (USACE 2012a). There would be a very small number of containment cells, and the placement of the cells would be designed to protect the channel walls of Hog Island Gut. The modeling shows a larger than desirable amount of water in the marsh at low tide, but the model was run before the design process. The final design would need to more carefully account for marsh elevations and sizing of the tidal guts so that a greater portion of the marsh is drier at low tide, and can support appropriate marsh vegetation. Design would also need to account for velocities at the outermost edge of the marsh so that the additional soils would not erode.

Construction-related impacts from the partial blockage of flows into the existing marsh by the containment structures would be as described in the section “Impacts Common to Both Action Alternatives,” but would be relatively small, given the scope of marsh restoration under this alternative.

Cumulative Impacts

The same past, present, and reasonably foreseeable projects that are discussed under the no-action alternative are considered under alternative B, and the impacts on hydrology and sediment transport in Dyke Marsh and the Potomac River from these projects would be the same. Alternative B would contribute beneficial impacts on hydrology and sediment transport to the beneficial and adverse impacts from other past, present, and reasonably foreseeable future projects. This contribution would be noticeable because most of the cumulative impacts from other actions are localized and have a limited effect on the hydrology and sediment transport in the immediate area of the marsh.

Conclusion

Several benefits to hydrology and sediment transport would result from alternative B. The most noticeable benefit would be from the construction of the breakwater. The breakwater is a fundamental design component of the restoration, and would allow beneficial changes to hydrology and sediment transport by shielding the marsh from storms, redirecting flows, and creating low energy areas in which sediment would settle out, accrete, and marsh areas could develop. Construction of the breakwater would result in localized, significant beneficial impacts on hydrology because it would restore natural hydrologic and sediment transport processes that were present in the marsh prior to the removal of the historic promontory. The establishment of these fundamental changes would also allow for measurable benefits to other key resources in the marsh.

The marsh restoration configuration for alternative B would create long-term benefits on hydrology and sediment transport by establishing restored wetlands areas and protecting Hog Island Gut, furthering the beneficial impacts created by the breakwater. Finally, the breaks in Haul Road would beneficially reintroduce tidal flows to areas west of Haul Road, resulting in beneficial impacts.

Construction would divert flows temporarily, creating some adverse impacts on hydrology and sediment transport within the marsh, but these impacts would not be significant, because they would not be very intense or of a large magnitude, and would be short-lived.

Alternative B would contribute mostly beneficial impacts on hydrology and sediment transport to the impacts of other past, present and reasonably foreseeable projects. The contribution would be noticeable, because most of the cumulative impacts from other actions are localized and have a limited effect on the hydrology and sediment transport in the immediate area of the marsh.

IMPACTS OF ALTERNATIVE C

Under alternative C, there would be a much greater extent of marsh restoration than under alternative B. The impacts from the initial phase of the restoration, in which wetlands would be restored to the negative 4-foot contour along the eastern edge of the marsh, would be similar to those impacts described under alternative B, because the configuration of the restoration would be similar. One noticeable difference between alternative B and the first phase of alternative C is the location of the breakwater, which would be in the southern location, and would have wetland cells to the north of it, simulating the historic extent of the promontory's land mass. Under alternative C, the breakwater alignment would be longer than the alignment under alternative B, and would therefore offer more overall protection to the marsh because it would deflect more waves from the south. Restoration would continue to the full extent of the marsh in future phases.

Overall, up to 245 acres of marsh and wetlands, including high marsh, emergent marsh, tidal guts, and areas of submerged aquatic vegetation (SAV), as well as bottomland swamp forest, could be restored under this alternative. The 245 acres includes the 20-acre optional cell by the marina, and an additional 16 acres of restoration south of the breakwater, as well as the area west of Haul Road. Tidal guts would also be cut into the restored marsh area in future phases, similar to historical flow paths, to allow crucial intertidal flows into the heart of the marsh.

Modeling indicates that the configuration of the breakwater under alternative C would function similarly to the breakwater proposed under alternative B, deflecting flows around the breakwater, and creating a low energy system in the area around Hog Island Gut, which would encourage sediment deposition in the southern end of the marsh and protect Hog Island Gut (USACE 2012a). The lower bend in the Hog Island Gut channel would be reestablished with the breakwater and restored wetland cells within the outline of the historic promontory forming a new channel wall, and its mouth would discharge in a more northerly direction around the restored wetlands recreating the extent of the promontory land mass. As under alternative B, the final design would need to more carefully account for marsh elevations and sizing of the tidal guts so that a greater portion of the marsh is drier at low tide, and can support appropriate marsh vegetation, as well as accommodate fluxes in groundwater levels during the tide cycle. Design would also need to account for velocities at the outermost edge of the marsh so that the additional soils would not erode. The current model, performed in the early stages of the design process, shows a high percentage of the marsh remains wet during low tide, although this is likely an anomaly of the model.

The southern alignment of the breakwater would initially provide less protection of Hog Island Gut than the northern alignment (Litwin, pers. comm. 2011), but mimics the historic promontory that previously existed there. The longer length of the breakwater would provide more protection of the marsh over the long term than the one proposed under alternative B. However, the proposed containment cell phasing would provide early protection until the marsh establishes itself. Either configuration of the breakwater would result in redirected flows and low energy areas that would protect Hog Island Gut from erosion.

The construction sequence would ensure that the breakwater and containment cells immediately adjacent to the existing terminus of Hog Island Gut would be constructed early in the process (see figure 2-9 for proposed phasing of containment cells). Therefore, the channel of the gut would be protected from high energy erosive flows, and the meanders would be restored so that scour in the gut channel would be minimized as early as possible in the construction sequence, and desirable lower energy hydrologic conditions would begin to be restored to the gut (figure 4-4).

Additionally, a new tidal gut would be constructed north of the new mouth of Hog Island Gut and due south of the terminus of Haul Road. The new tidal gut would empty in a southerly direction into an embayment formed at the mouth of Hog Island Gut. This new gut would help to distribute flows and sediments in the northern part of the main marsh.

Under alternative C, up to 245 acres of wetlands and marsh, including high marsh, emergent marsh, tidal guts, and SAV, could be created using large containment cells, although with the soft edge approach, the full extent of the outer containment cells and modeling shows that generally, flow would be directed around the breakwater as intended. At high tide, the marsh would be inundated, but flow in the marsh would primarily be limited to the tidal guts and around the marsh. An erosion hot spot could possibly develop near Coconut Island as a result of the redirection of strong flows. At mid-tide (receding), marsh areas would begin to drain, and there would be mixing in the embayment of outflow from both Hog Island Gut and the new tidal gut. At low tide, the marsh would continue to drain, there would be tidal resistance at Hog Island Gut, and a low energy area would be created in the embayment between the two tidal guts, protecting the marsh. The marsh would continue to drain through the tidal guts during the low-tide cycle. The modeling indicates that a shallow shelf is likely to develop at the outflow of Hog Island Gut; this shelf existed historically. At mid-tide on the incoming tide, model results indicate that the flow would be forced around the breakwater and associated wetlands, and up the tidal guts. The wetlands would be inundated. Small local depressions typical of marshes would be created once vegetation becomes established. (USACE 2012a)

The final design would need to carefully account for marsh elevations and sizing of the tidal guts so that a greater portion of the marsh is drier at low tide, and can support appropriate marsh vegetation. Design would also need to account for velocities at the outermost edge of the marsh so that the additional soils would not erode. However, under alternative C, the flows would be forced around the breakwater and around the restored wetlands and up the tidal guts.

Impacts related to cell design, and related to the introduction of breaks in Haul Road are discussed in the “Impacts Common to Both Action Alternatives” section.

Construction-related impacts would be as described under impacts common to all, but more far-reaching than under alternative B, because there would be a larger amount of marsh restored, and a larger number of containment cells would be used, around which water would need to flow to reach the existing marsh. The containment cells could reduce flows into the existing marsh, but would also protect it from erosion.

Cumulative Impacts

Impacts on hydrology and sediment transport from other past, present, and reasonably foreseeable future projects would be the same as discussed under the no-action alternative. Alternative C would contribute mostly beneficial long-term and some short-term adverse impacts to the other beneficial and adverse cumulative impacts. The contribution would be appreciable because the cumulative impacts of other past, present, and reasonably foreseeable projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative is relatively large.

Conclusion

There are longer term impacts common to both action alternatives that would result in beneficial impacts on both hydrology and sediment transport. The breaks in Haul Road would reintroduce tidal flows west of Haul Road. As with alternative B, the construction of the breakwater is a fundamental design component of the restoration, and would allow beneficial changes to hydrology and sediment transport by shielding the marsh from storms, redirecting flows, and creating low energy areas in which sediment would settle out, accrete, and marsh areas could develop. Construction of the breakwater would result in localized, significant beneficial impacts on hydrology because it would restore natural hydrologic and sediment transport processes that were present in the marsh prior to the removal of the historic promontory. The establishment of these fundamental changes would also allow for measurable benefits to other key resources in the marsh.

The marsh restoration configuration for alternative C would create long-term benefits for hydrology and sediment transport in the marsh. More wetland acreage (up to 245 acres) would ultimately be restored than under alternative B, and the first phase would establish restored wetlands areas to the negative 4-foot contour, thereby protecting Hog Island Gut, and increasing the beneficial impacts created by the breakwater.

Short-term construction impacts under alternative C would be similar to alternative B under phase one of the project. Impacts would be similar to, but of a slightly greater magnitude than those described under alternative B. Construction would divert flows around the containment cells temporarily, creating adverse impacts on hydrology and sediment transport, but impacts would not be significant.

The contribution of the beneficial impacts of alternative C on Dyke Marsh and the Potomac River to the impacts from past, present, and reasonably foreseeable projects would be appreciable because the impacts of the other projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

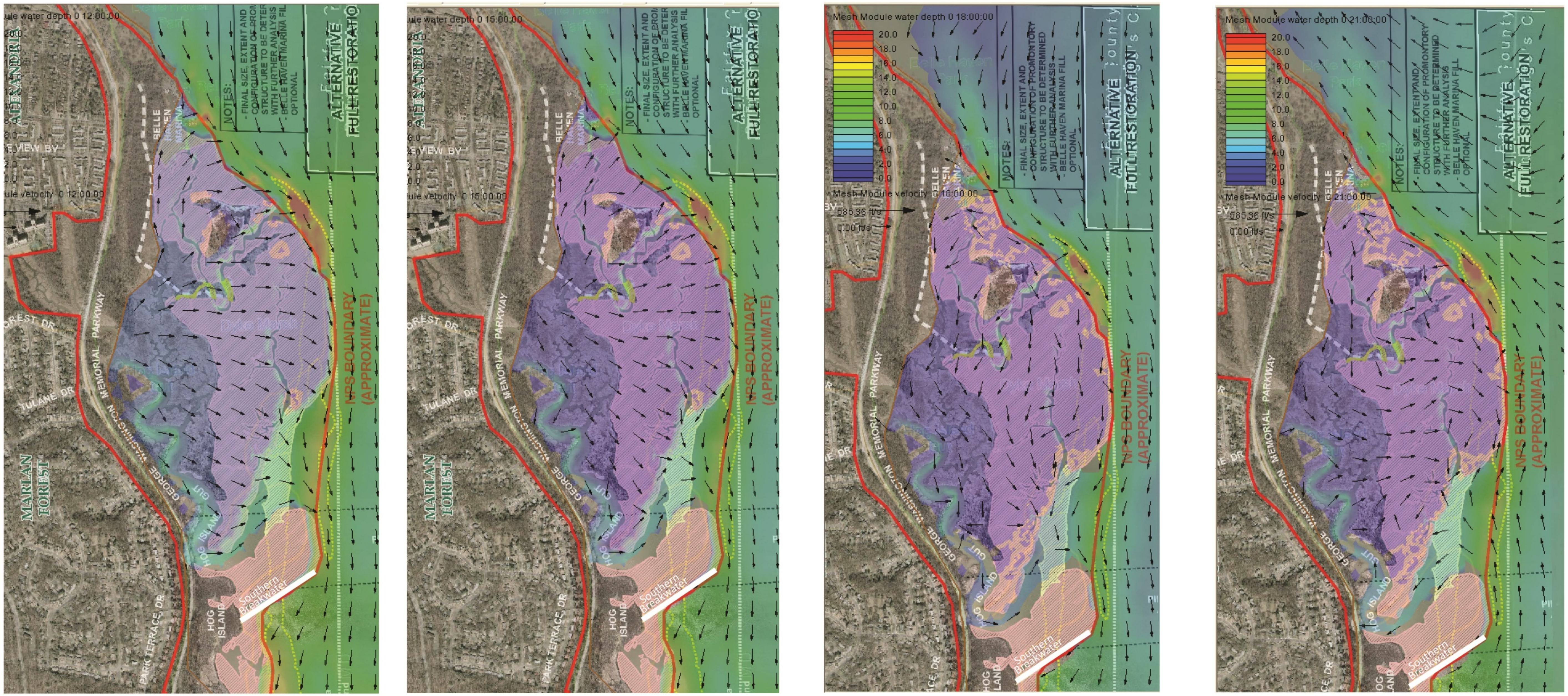

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FIGURE 4-4. PREDICTED FLOWS UNDER ALTERNATIVE C

IMPACTS OF THE ALTERNATIVES ON SOILS AND SEDIMENTS

GUIDING REGULATIONS AND POLICIES

The current restoration effort proposes several action alternatives to restore the eroding marsh and its associated processes and functions. Therefore, this restoration is guided by NPS *Management Policies 2006*, specifically the policies discussed in “Chapter 4: Natural Resources,” described in the “Impacts on Hydrology and Sediment Transport Section.” (NPS 2006). Two instances applicable to Dyke Marsh in which the NPS would intervene in natural biological or physical processes are when it is directed to do so by congress and to restore natural ecosystem functions that have been disrupted by past or ongoing human activity. Construction activities would be guided by state and federal laws, including the Clean Water Act (Section 404) and Sections 9 and 10 of the Rivers and Harbors Act of 1899. The implementation of the project would follow in-water construction management practices required by the VA DCR in the Virginia Erosion and Sediment Control Manual (VA DCR 1992), and the VDGIF concerning construction in tidal waters. Sediments would need to be tested to ensure they are clean and suitable for use as fill material in the project.

METHODS AND ASSUMPTIONS

Success of the restoration relies on the restoration of marsh conditions and processes such that these would allow for the retention of existing soils and encourage additional sediment deposition and accrual in the marsh supporting and enhancing appropriate marsh elevation and adjacent riverine bathymetry. Litwin et al. (2011) reports average vertical sediment accumulation rates of approximately 3.06 mm/year and 5.25 mm/year for Dyke Marsh. Several tests for sediment accumulation include the use of sediment collection tiles, graduated stakes, and surface elevation tables. The analysis of the impacts on soils and sediment is based on modeling and studies of existing soils and hydrological processes and their effect on the movement of sediment. Analysis included 2-dimensional hydrodynamic modeling using the FESWMS/SMS modeling platform that characterized the existing conditions in the marsh and anticipated future conditions in the marsh under the three action alternatives (USACE 2012a). Outputs are further characterized by daily tides, the base flow of the Potomac River, and flow depths to understand how tidal flows affect the marsh currently and how they would affect the marsh under the different alternatives. A second source included a USGS study (Litwin et al. 2011), which measured existing erosion rates, potential impacts including changes to flow, development of high or low energy areas that would result in erosion (in the high energy areas) or sediment accretion (in the low energy areas), and how that would affect the hydrologic processes and the overall marsh restoration. Additional information supporting the analysis included results from a bathymetric study in 2009 (NPS 2009b) and data from sediment transport modeling (USACE 2010).

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, no restoration efforts would occur and the marsh would continue to degrade under current conditions. The main impacts on soils and sediments would be due to erosive forces acting laterally on the shoreline and on the channel of Hog Island Gut (Litwin et al. 2011), and the lack of sediment accretion. Shoreline erosion is mainly due to the removal of the promontory and the deep dredge/scour channels on the riverbed adjacent to the eastern marsh shoreline; both are results of historic dredging operations. The Litwin et al. study and the hydrologic modeling conducted for this restoration plan predict that the current conditions would result in average shoreline marsh soil erosion of 6–7.8 linear feet per year (Litwin et al. 2011; USACE 2012a). Erosion of the gut is also primarily the result of the removal of the promontory during the historic dredging, which has allowed incoming tides and storm surges to flow more directly into Hog Island Gut, eroding the channel banks (i.e., widening and straightening them). Because there is little or no natural protection from erosion for Hog Island Gut, this process would continue under the no-action alternative (Litwin et al. 2011). In addition, there are deep channels, due to dredging and subsequent scouring, adjacent to the eastern marsh boundary that direct flow through the area at higher velocities that exacerbate erosion in the marsh. Furthermore, with no restoration efforts, these relatively high energy conditions would continue adjacent to the marsh allowing suspended sediments in the river to continue to be carried straight downstream past the marsh. There would continue to be relatively few, if any, places in the existing marsh that would provide the low energy conditions needed for sediments to settle out of the water column and accumulate on the river bottom (figure 4-2). Sediments would continue to be carried past the marsh without accreting and adding to the marsh area (figure 4-2). In summary, under the no-action alternative, it is expected that the marsh soils and sediments would continue to erode noticeably due to the existing erosive hydrologic processes created by past human disturbances, disrupting the organic mat under the marsh, and carrying sediments out of the marsh, leading to potential complete marsh disappearance with no intervention (Litwin et al. 2011).

In addition, there would be no change to the soils or sediment transport in the Haul Road area. The area west of Haul Road would continue to be hydrologically disconnected from the rest of the marsh, thereby continuing to impede sediment accretion in this area and the processes and conditions necessary for the development and upkeep of the hydric soils that previously supported a bottomland hardwood forest.

Cumulative Impacts

Other past, present, and reasonably foreseeable future actions in the vicinity of Dyke Marsh have the potential to impact soils and sediment in the marsh and the adjacent Potomac River. The construction of the new Woodrow Wilson Bridge in Alexandria in the 2000s, the development of the Belle Haven Golf Course in the early 20th century, and the development of Belle Haven Marina in the 1950s all affected the soils and sediment in the Potomac River and in Dyke Marsh; most impacts were localized although some impacts may have extended further downstream. The bridge construction included sediment disturbing activities, such as dredging and pile driving, which likely had local and possibly downstream effects on sediments depending on sediment transport. Construction disturbed tidal and nontidal wetlands, which may have led to longer term effects on sediments and sediment movement through the disturbance and the degradation of the sediment retention capabilities of the wetlands. The clearing and development of land for the golf course brought about increased runoff and sediment deposition in Cameron Run and Hunting Creek while increased urban development upstream on Cameron Run resulted in additional sediment being carried out of Cameron Run. The large amount of increased suspended sediments is settling out at the confluence with the Potomac River forming large mud flats. As a result, that sediment is not being carried downstream in the direction of Dyke Marsh for possible marsh accretion as might have occurred in the past. Possible future dredging of the accumulating mudflats at the mouth of Cameron Run would affect soils and sediment in the immediate in the area as well as in Dyke Marsh. Dredging a channel in this area could temporarily allow additional sediment to flow from Cameron Run and Hunting Creek downstream toward Dyke Marsh and beyond, but the process of sediment deposition and accumulation and mudflat formation would continue as would their development into vegetated wetlands. There are currently areas where vegetation has become established and sediment accretion would continue even with the dredging of a small channel. The development of the Belle Haven Marina altered soils and sediment of Dyke Marsh, changing the tidal creek outflow that previously existed south of the marina and through the maintenance of a navigation channel into the marina. There is noticeable sediment accumulation in the flats behind and west of the marina by the canoe launch but there is no sediment accumulation in the deep dredging hole used as a boat mooring area.

The no-action alternative would continue to contribute adverse impacts on soils and sediments in Dyke Marsh and the Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable future projects. The contribution would be appreciable because of the magnitude of the loss of soils in the marsh, and the relatively localized impacts from the other projects.

Conclusion

Under the no-action alternative, there would be continued erosion of wetlands soils and loss of marsh over time. Without intervention, the marsh would disappear, and there would be no opportunity for beneficial hydrologic conditions or sediment accretion to occur. This would result in a significant long term adverse effect because the soils needed to support the marsh would no longer be present.

The no-action alternative would continue to contribute adverse impacts on soils and sediments in Dyke Marsh and the Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable future projects. The contribution would be appreciable because of the magnitude of the loss of soils in the marsh, and the relatively localized impacts from the other projects.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Changes in Soils and Sediment in the Main Marsh Areas

All of the action alternatives include elements that directly and indirectly affect soils and sediments. Direct impacts on soils and sediment within the main marsh areas would be due to constructing the containment cells and the breakwater, and filling the deep dredge/scour holes at the southern end of the existing marsh. Indirect effects to soils and sediments due to the action alternatives include those from changes to hydrology and sediment transport, deposition, and erosion processes (discussed in detail in the hydrology and sediment transport analyses section).

Benthic sediment is sediment found on the river bottom.

Both action alternatives include the construction of new marsh surface using containment cells. The soils in the new marsh area would be different than the previously existing open water sediment habitat; the cells would create new marsh soils in an area that had been river bottom and benthic sediments. The composition of soils or gravel on the river bottom is unknown, but the sediments probably have some hydric characteristics, including being somewhat anoxic. The new marsh soils would have different elevations, chemical and physical characteristics, and hydric soil indicators than existing Dyke Marsh soils, but would become more hydric and similar to existing marsh soils over time as tides wet and rewet the marsh, and plant matter grows and decays in the restored marsh. The fill material would initially consist of clean dredge material combined with local river water to make placement of the material easier. The fill would likely be higher in mineral content than organic matter and would have an unknown nutrient concentration. As described in chapter 2, the fill would be placed to appropriate elevations to allow for native high and low marsh wetland vegetation growth. The fill material initially would likely not have hydric soil characteristics. These altered soil and sediment characteristics would have impacts on other resources such as flora, fauna, and hydrology and sediment transport (discussed in detail in the hydrology and sediment transport, vegetation and wetlands, fish and wildlife, and species of special concern resources analyses sections). The duration of these impacts depends on the specific condition and characteristics of the fill material used in the containment cells. It is assumed that over time the fill material soils would become more similar to existing marsh soils.

The impacts on river bottom sediment from the breakwater structure would likely be similar to those described for containment cells. The stone breakwater would cover an area of benthic sediments or deeper channel fill. Sediment function of the area under the breakwater would be lost, although the adjacent restoration in the footprint of the historic promontory would eventually become hydric and function as marsh soils. The fill in these cells would be placed to appropriate elevations to allow for native high and low marsh wetland vegetation growth. In addition, the fill material would have chemical and physical characteristics that differ than those of the benthic sediments.

The filling of the deep dredge channels would place new, heavier, and rougher material on top of sediments and gravel deposits, and could have different physical and chemical characteristics than the surrounding sediment. The characteristics of the new fill material and the characteristics of the existing river bottom in the deep channels are both unknown, although new fill would be clean, and existing deep channel bottoms is likely a mix of naturally occurring gravel and benthic sediments similar to those found outside the deep channels. The duration of these impacts on sediments would likely be longer than the construction period although this would depend on the exact fill material used. The sediments in these areas would likely be covered with finer material over time because rougher sediments tend to slow river flows allowing for sediments to settle out. Also the addition of this fill material would cause long-term impacts on the bottom contours and bathymetry of the channel.

As discussed in the “Hydrology and Sediment Transport” section, the addition of the breakwater would greatly reduce erosion in the marsh over the long-term.

Changes of Soils and Sediments along Haul Road

Under all the action alternatives, the creation of breaks along Haul Road would allow tidal flows to pass under the road and into the former bottomland swamp forest, along with sediment transfer associated with those tidal flows over the long-term. Soil and sediment impacts from these actions include the addition of natural sediments to the former wetland. The action of reestablishing tidal flow into the area would reintroduce periods of saturation and inundation necessary for the formation of hydric soils. Although the area was once a bottomland forested wetland, it has likely been cut off from the tidal water supply since the early 1970s when the road was constructed (Litwin et al. 2011). With regular hydrology, the soils could be saturated, flooded, or ponded for long enough during the growing season to develop anaerobic conditions in the upper part and be considered hydric soils. As the area receives natural hydrology and sediment inputs, the current invasive vegetation that does not tolerate these conditions would likely not survive, ultimately giving way to vegetation that thrive in these conditions. As native vegetation recolonizes, over time the organic content of the soil would increase as the vegetation dies, accumulates, and begins to decompose. The addition of hydrology and organic matter would assist in the development of soil characteristics necessary to support wetlands and wetlands functions in approximately 30 acres west of Haul Road. Potential scouring around the installed breaks could remove some soil in localized areas; however, appropriate design of the break structures and scour analysis during the design stage would help to minimize the amount of scour.

Impacts from Construction Activities

Under both of the action alternatives, the marsh would be reestablished using large and some smaller, strategically placed containment cells. The cells would be designed to hold fill material until enough fill can be placed to the correct elevation to support appropriate vegetation, and then plants could colonize or the area could be planted as the fill material within the cells settles. Intertidal exchange in the wetlands outside the containment cells would continue, although the cells would act as an obstruction and water would flow around the cells and up Hog Island Gut. Therefore, there could be short-term effects on sediment transfer and associated sediment erosion and deposition related to construction. While the cells are in place they would partially block or redirect flow to the existing marsh behind the containment structures. This could force water along the outermost and back edges of the containment structures, resulting in erosion and localized adverse short-term effects on the marsh and its soils. The cells would also create beneficial effects on soils by sheltering the existing marsh area and associated soils from erosive storm waves while they are in place. The construction of the breakwater, the breakwater containment cells, and the marsh restoration containment cells would impact the benthic sediments on which the construction materials are placed by covering them entirely. However, these impacts would be short term due to the ultimate creation of a new soil/sediment habitat within the containment cells. Design would accommodate ground water level fluxes within the containment cells. The construction of these structures could potentially have short-term adverse impacts on the adjacent sediments and soils through sediment disturbance due to equipment or construction methods. There is the potential for accidental discharge of sediments into the river in the case of an accident or structural failure of the containment cells. If a large amount of sediment were released, it could result in extremely turbid waters and related impacts on water quality and aquatic life (discussed in appropriate resource topic analyses) as well as downstream soil and sediment quality. However, the risk of such an event would be minimized by following requirements of permits and erosion and sediment control plans and in-stream BMPs outlined the Virginia Erosion and Sediment Control Handbook 1992. Some BMPs include turbidity curtains in the water and silt fences and erosion control blankets on the constructed surface.

Even if the fill material from the containment cells is not accidentally discharged, soil and sediment impacts could result from the type and physical and chemical characteristics of the fill material used. Soils within Dyke Marsh tend to be mainly fine-particles of silt or clay with 60–70 percent organic matter or more (Gee and Bauder 1986). If the fill material has different characteristics it could have an impact on the ability of the soil to support native vegetation and biota. The following soil features of the fill material that could have an impact include organic matter content, texture, nitrogen and metal concentrations, nutrient retention, and drainage capabilities (UMCES 2004). The consolidation rate of fill material soil could impact the stability and settling of the soil in the containment cells and thereby affect marsh elevation and vegetation (UMCES 2004). Specifications for fill characteristics and placement will be established for construction so that these impacts are minimized.

Construction activities related to creating breaks in Haul Road could have several impacts on soils. Soils would be compacted in a localized area around the break due to construction equipment and design requirements. Specifics of the break designs are unknown at this time but would likely require the addition of fill material in some places for grading purposes and soil removal at the breaks to achieve an appropriate elevation for successful tidal exchange. Furthermore, during construction activities to reconnect the two sides of Haul Road, erosion and sediment control BMPs would be used to prevent accidental discharge of sediments into Dyke Marsh and the Potomac River. The BMPs used would depend on the type of break (i.e., bridge or culvert) in Haul Road. Several examples that could be used include culvert inlet protection, a silt fence, or a turbidity curtain placed farther away at the marsh-water edge. BMPs would be consistent with the Virginia Erosion and Sediment Control Manual (VA DCR 1992).

IMPACTS OF ALTERNATIVE B

Under alternative B, the focus is on the most essential actions that would reestablish hydrologic conditions to shield the marsh from erosive currents and protect the Hog Island Gut channel and channel wall. The direct and indirect impacts on soils and sediments would be the same as those discussed in the section "Impacts Common to Both Action Alternatives." This alternative includes the installation of containment cells, a breakwater structure, and fill of the deep dredge channels. The difference in impacts on soils and sediments under this alternative is that the geographic extent of impacts is the smallest out of the two action alternatives. This alternative uses seven containment cells covering approximately 30-40 acres, in addition to the 30 acres behind Haul Road that would receive reintroduced tidal flows, for 70 acres overall. The cells under this alternative would not extend as far into the river as they would in alternative C. In addition, the breakwater structure would be placed at the northernmost extent of the historic promontory, which is different than the location in the other two action alternatives; therefore the impacts due to the installation of the breakwater would be localized to that area. The breakwater location would encourage sediment deposition and accretion in the area north of the breakwater. The action of filling of the dredge/scour hole is the same for both action alternatives and the impacts from the channel filling would be the same as those described in the section "Impacts Common to Both Action Alternatives." Any indirect effects to soils and sediments due to changes to hydrology and sediment transport, deposition, and erosion processes are discussed in the hydrology and sediment transport analyses section for alternative B. However, these impacts would likely be limited as compared to those under alternative C due to the limited geographic extent of the actions under this alternative. The hydrology and sediment processes would act on different locations than the other two action alternatives and these processes would result in soil and sediment impacts in those different locations. As described in detail in the hydrology and sediment transport section, processes include the decrease in erosive forces on the Hog Island Gut channel and outer channel walls and the shoreline of the main marsh as well as the increase in sediment accretion around Coconut Island and the main marsh shoreline.

Cumulative Impacts

The same past, present, and reasonably foreseeable future projects and their impacts on soils and sediments in Dyke Marsh and the Potomac River discussed under the no-action alternative would be considered for alternative B. Alternative B would contribute beneficial impacts on soils and sediments in Dyke Marsh and the Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable future projects. The contribution would be noticeable, because most of the cumulative impacts from other actions are localized and have a limited effect on the soils and sediment in the immediate area of the marsh.

Conclusion

Under alternative B, sediments on the river bottom would be replaced with fill that would eventually become wetland soils. The soils west of Haul Road would eventually be converted back to hydric soils. There are no significant ecological benefits from replacing one type of soil or sediment with another. Soil disturbance and river bottom compaction from construction activities would be both short and long term, and adverse, but relatively minor, and not significant.

Alternative B would contribute beneficial impacts on soils and sediments in Dyke Marsh and the Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable future projects. The contribution would be noticeable because most of the cumulative impacts from other actions are localized and have a limited effect on the soils and sediment in the immediate area of the marsh.

IMPACTS OF ALTERNATIVE C

Under alternative C, there would be a greater extent of marsh restoration than under alternative B, resulting in up to 245 acres of restored wetlands and marsh, including optional marsh restoration south of the breakwater and another optional area of containment cells in the area north of Dyke Island that is currently serving as the boat mooring area for the Belle Haven marina. The breakwater structure would be placed at the southern alignment of the historic promontory to protect Hog Island Gut, and that would be coupled with restored wetlands upstream of the breakwater that would simulate the historic extent of the land mass. Tidal guts would also be cut into the restored marsh area, similar to historical flow paths, to allow crucial intertidal flows into the heart of the marsh. The direct and indirect impacts on soils and sediments would be the same as those discussed in the section "Impacts Common to Both Action Alternatives" except for the differences discussed below. As with the alternative B, this alternative includes the installation of containment cells, a breakwater structure, and filling of the deep channels, and also includes creation of new tidal guts. The difference in impacts on soils and sediments under this alternative is that the geographic extent of impacts due to the containment cells is greater than those in alternative B. The cells cover similar area along the marsh shoreline as alternative B with the addition of cells in the southern marsh area adjacent to the breakwater structure in the upstream direction and all the cells extend out towards the river past the alternative B limit (i.e., the negative 4-foot contour) to the historic 1937 marsh limit adding up to 245 acres of wetland habitat. In addition, the breakwater structure is placed at the southernmost extent of the historic promontory which is a different location than alternative B. The action of filling of the deep channels is the same for both action alternatives and the impacts from filling the channels would be the same as those described in the section "Impacts Common to Both Action Alternatives." An additional difference under this alternative is the impact on soils and sediments due to the cutting of new tidal guts into the containment cells, which would disturb and remove higher soil to create benthic sediments in the new tidal gut channels.

Any indirect effects to soils and sediments due to changes to hydrology and sediment transport, deposition, and erosion processes are discussed in the hydrology and sediment transport analysis section. However these impacts would likely be more extensive than those described for alternative B due to the greater area restored. It is likely that there would be increased protection from erosive forces and therefore less sediment transport away from the marsh. The hydrology and sediment processes would act on different locations than under alternative B and these processes would result in soil and sediment impacts in different locations. As more fully discussed in the hydrology and sediment transport impact analyses section, the southern location of the breakwater would promote sediment deposition and accretion upstream of the breakwater and lead to the development of a shallow shelf at the Hog Island Gut outflow but could provide less protection for the gut until the completion of the containment cells adjacent to the breakwater. The placement and extent of the containment cells could limit the erosive forces at high tide to a localized area around Coconut Island, slow down receding tidal flows, and create a low energy deposition area between the two tidal guts at low tide. Construction-related impacts would be the as those described in the section "Impacts Common to Both Action Alternatives," but more extensive than under alternative B because of the larger amount of marsh and wetlands restored (70 acres versus up to 245 acres), the difference in breakwater installation location (southern versus northern location), and the creation of the tidal guts.

Cumulative Impacts

The impacts on soils and sediments in Dyke Marsh and the Potomac River from past, present, and reasonably foreseeable future projects would be the same as those discussed under the no-action alternative. Alternative C would contribute long-term beneficial impacts on soils and sediments in Dyke Marsh and the adjacent Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable projects. The contribution would be appreciable, particularly because the cumulative impacts are localized for the most part, and the scale of the Dyke Marsh restoration under this alternative is relatively large.

Conclusion

Impacts on soils and sediments under alternative C would be similar to but larger in scale than impacts under alternative B. Sediments on the river bottom would be replaced with fill that would eventually become wetland soils. The soils west of Haul Road would eventually be converted back to hydric soils. There are no significant ecological benefits from replacing one type of soil or sediment with another. Soil disturbance and river bottom compaction from construction activities would be both short and long term, and adverse, but relatively minor, and not significant.

Alternative C would contribute long-term beneficial impacts on soils and sediments in Dyke Marsh and the adjacent Potomac River to the mostly adverse impacts from other past, present, and reasonably foreseeable projects. The contribution would be appreciable, particularly because the cumulative impacts are localized for the most part, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

IMPACTS OF THE ALTERNATIVES ON SURFACE WATER QUALITY IN THE POTOMAC RIVER

GUIDING REGULATIONS AND POLICIES

NPS *Management Policies 2006* specifically addresses water quality in Section 4.6.3 (NPS 2006). The policy states:

> The pollution of surface waters and groundwater by both point and nonpoint sources can impair the natural functioning of aquatic and terrestrial ecosystems and diminish the utility of park waters for visitor use and enjoyment. The Service will determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside the parks. The Service will
>
> - Work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection for park waters;
> - Take all necessary actions to maintain or restore the quality of surface waters and groundwater within the parks consistent with the Clean Water Act and all other applicable federal, state, and local laws and regulations; and
> - Enter into agreements with other agencies and governing bodies, as appropriate, to secure their cooperation in maintaining or restoring the quality of park water resources.

Applicable state regulations include regulations and guidance that ensure construction activities minimize or prevent runoff of sediment and associated pollutants into the State's waterways. These regulations include the Virginia Erosion and Sediment Control Manual (VA DCR 1992).

METHODS AND ASSUMPTIONS

Potential impacts on water quality are based on impacts on the chemical, physical, or biological constituents of the water column, and an assessment of the processes that affect these constituents. The analysis of possible impacts on water quality was based on a review of existing literature and maps, information provided by the NPS and USACE, including the hydrodynamic modeling and the sediment flow modeling, as well as experience related to restoration of tidal freshwater marshes in the area, and professional judgment.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

As discussed in the analysis of impacts on hydrology in this chapter, the marsh would continue to erode under alternative A, carrying organic matter from the wetland root mats and sediment downstream as a result (Litwin et al. 2011). The sediment and any nutrients bound to the wetland root mats would be well-suspended around the marsh, given the results of sediment transport modeling, but it is unknown where suspended solids would settle out downstream along the Potomac River. Erosion at the marsh would contribute to turbidity and nutrient loads in the river and adversely affect downstream water quality, but given the size of the river, these impacts would not be particularly noticeable. Locally, incremental loss of marsh area would gradually decrease the ability of Dyke Marsh to filter pollutants and provide general water quality benefits to the river and immediately surrounding waters, benefits the marsh currently provides.

Cumulative Impacts

There are several past, present, and reasonably foreseeable future projects that have or may have impacts on water quality, including the replacement of the Woodrow Wilson Bridge in the 2000s, the development of the Belle Haven Golf Course in the early 20th century, and the National Harbor Development. Many of these projects have changed the shorelines and added sediments and sediment-bound nutrients to the water column in the river, although wetland mitigation for the bridge contributed beneficial impacts on water quality with many new acres of new wetlands and also provided permanent protection of wetlands that increased pollutant filtering in the Potomac River watershed. The DC Water stormwater storage tunnels and other actions to address stormwater and combined sewer overflow issues may have profound benefits on water quality in the Potomac River by reducing bacterial loads and large loads of other stormwater-related pollutants. Impacts from the marsh erosion would largely be localized. Therefore, the adverse impacts on water quality of continued and accelerated erosion of the marsh from the no-action alternative would be a noticeable but not appreciable contribution to the adverse and beneficial impacts on water quality from other projects.

Conclusion

Under the no-action alternative, erosion would continue and the marsh would eventually disappear. Marsh sediments would be carried downstream. Fewer wetlands would also decrease the filtering capacity of Dyke Marsh, lowering the ability of the marsh to provide water quality improvements locally. Similarly, the continued erosion of the marsh and reduction of floodplain function and values under alternative A would contribute noticeable adverse impacts to the overall cumulative impacts on water quality over time. Impacts would be long term and adverse, but given the overall volume and velocity of water in the Potomac River flowing by Dyke Marsh, the effects of the continued loss of marsh on water quality would be locally adverse but not significant because the impacts would be localized.

The adverse impacts on water quality of continued and accelerated erosion of the marsh from the no-action alternative would be a noticeable but not appreciable contribution to the impacts on water quality from other projects, because the impacts from the marsh erosion would largely be localized.

Impacts Common to Both Action Alternatives

Long-term Restoration-related Impacts

As discussed under the impacts on water quality under alternative A, wetlands filter nutrients and other pollutants in the water column of the Potomac River, and provide filtering for additional pollutants carried off from the land in stormwater. Increasing marsh acreage would increase the ability of the marsh to filter pollutants, fix nutrients and settle sediment, improving water quality in the river around the marsh under both action alternatives, although the extent would vary by alternative. Water quality parameters such as dissolved oxygen and turbidity might be expected to improve, based on pre- and post-construction monitoring at Kenilworth Marsh (Hamerschlag 1998). Other water quality parameters would be expected to stay relatively constant.

There would not be noticeable adverse impacts on water quality in the Potomac River as a result of reintroduction of intertidal flows west of Haul Road. Intertidal flows would now reach west of the road, connecting with land and soils that have not been regularly flooded in decades, but have not been disturbed, so they would have a limited ability to adversely affect water quality overall. However, it is likely that there would be some erosion or scour around the culverts or bridge pilings until a hydrologic equilibrium is established. This would result in a small amount of soils and sediments, and any bound nutrients or pollutants being carried into the marsh and river over the short amount of time after construction is complete. Whatever soluble pollutants are in the soil west of Haul Road could be transported into the river with the newly introduced intertidal flows.

Construction-related Impacts

Consistent with the Virginia Erosion and Sediment Control policies and regulations, construction would use BMPs such as silt fences around the construction area at the breaks in Haul Road, and would use practices for construction in waterways that are appropriate for the situation. The containment cells themselves serve as sediment control devices, but additional BMPs, such as sediment curtains, could be specified as necessary as the design and permitting process moves forward. In addition, fill materials for the breakwater (should the steel sheet piling with fill option be used), and for the containment cells for the restored wetlands would be tested to ensure they do not contain harmful pollutants, and would therefore not impact water quality.

IMPACTS OF ALTERNATIVE B

Because alternative B would involve the smallest amount of restored wetland acres (up to 70 acres), water quality impacts would be more limited in scale than under alternative C. There would be some water quality benefits from increased filtration of pollutants as a result of increased marsh acreage, and the overall rate of erosion would decrease or reverse over time.

Cumulative Impacts

The cumulative scenario is the same as discussed under the no-action alternative. Alternative B would contribute mostly localized long-term beneficial impacts on water quality in the marsh and the river to the adverse and beneficial impacts of other past, present, and reasonably foreseeable projects. The contribution would be only somewhat noticeable, given the localized nature of the impacts from alternative B and the impacts of many of the other projects.

Conclusion

Wetlands provide filters for nutrients and other pollutants, and marsh restoration under alternative B would provide local benefits to water quality by increasing marsh acreage, as opposed to degradation of water quality under the no-action alternative (alternative A). The scope of these benefits would be somewhat restricted under alternative B, because only 70 acres of wetland and marsh would be restored. The benefits would be mostly localized, and would not be particularly noticeable in the larger Potomac River system, given the overall large volume and velocity of water in the river. The beneficial impacts on water quality would not be significant.

Construction would cause short-term adverse impacts related to disturbing the sediments on the bottom, although BMPs would be used during installation to prevent water quality issues, and the containment walls would also prevent and minimize impacts. There would be some scour around the breaks in Haul Road, at least initially, but that would affect a small amount of soils. Construction impacts would be localized and would not be significant.

Alternative B would contribute mostly localized long-term beneficial impacts on water quality in the marsh and the river to the impacts of other past, present, and reasonably foreseeable projects. The contribution would be only somewhat noticeable, given the localized nature of the impacts from alternative B and the impacts of many of the other projects.

IMPACTS OF ALTERNATIVE C

Alternative C would restore noticeably more marsh than alternative B, up to 245 acres of various wetland habitats, and would therefore result in more benefits to water quality because most of the improvements to water quality would be the result of increased filtering capacity in the marsh. The increased filtering capacity of the additional marsh acres under alternative C could introduce noticeable, and localized long-term improvements in water quality in Hog Island Gut as well as the newly created tidal guts.

Cumulative Impacts

Cumulative Impacts would be the same as under alternative B. Implementation of alternative C would possibly contribute long-term beneficial impacts on water quality to the adverse and beneficial impacts of other past, present, and reasonably foreseeable projects. The contribution would be noticeable, but not appreciable, because the impacts from alternative C would still be mostly localized, even with the larger acreage of expansion.

Conclusion

The scope of these benefits to water quality under alternative C would be greater than but similar in nature to those under alternative B, because more acres of wetland would be restored. As with alternative B, the benefits would be noticeable, but not significant. They would be mostly localized, given the size of the Potomac River and the volume of water flowing by the marsh.

Similar to alternative B, construction would cause short-term adverse impacts related to disturbing the sediments on the bottom, although BMPs would be used during installation to prevent water quality issues, and the containment walls would also prevent and minimize impacts. There would be some scour around the breaks in Haul Road, at least initially, but that would affect a small amount of soils, and the adverse effects would not be large in magnitude. Impacts would not be significant, because they would be localized and of limited magnitude.

Implementation of alternative C would possibly contribute long-term beneficial impacts on water quality to the impacts of other past, present, and reasonably foreseeable projects. The contribution would be noticeable, but not appreciable, because the impacts from alternative C would still be mostly localized, even with the larger acreage of expansion.

IMPACTS OF THE ALTERNATIVES ON FLOODPLAINS

GUIDING REGULATIONS AND POLICIES

As discussed in chapter 1, the restoration is guided by NPS *Management Policies 2006*, specifically, “Chapter 4: Natural Resources,” which states that “the National Park Service will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks while providing meaningful and appropriate opportunities to enjoy them” (NPS 2006). Floodplain functions and values (store floodwaters, minimize erosion of adjacent soils, provide riparian habitat, etc.) are intrinsic to floodplains and cannot be easily duplicated or replaced. Certain portions of the Clean Water Act and the Rivers and Harbors Appropriation Act of 1899 also apply.

An Executive Order and an NPS Director's Order guide analysis of impacts on floodplains, including floodplain values and functions, apply:

- Executive Order 11988 directs all federal agencies to avoid long- and short-term impacts associated with occupancy, modification, and development of floodplains when possible.
- NPS Director's Order 77-2 implements Executive Order 11988 and established NPS policy to preserve floodplain values and minimize potentially hazardous conditions associated with flooding.

METHODS AND ASSUMPTIONS

Success of the restoration relies on the ability to restore hydrologic conditions that would allow for and encourage sediment deposition and accrual in the marsh, and could alter existing base flood elevations. The USACE modeling discussed under the impacts on hydrology sections anticipated future conditions in the marsh under the three action alternatives, including how the floodplain elevations would generally change. This information was used in the analysis, along with a qualitative analysis of how restored marsh would affect floodplain function and values. Scientific studies are cited to the extent possible when discussing changes to either floodplain function or values.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, although marsh would continue to erode, the base flood elevation would remain unchanged. However, the marsh itself would erode and shrink in size, reducing the assimilative capacity of the marsh to buffer the adjacent uplands from flood events (USEPA 1995), an important function of the floodplain. Haul Road would serve as a barrier to flood water and continue to prevent inundation in the area of the former bottomland floodplain swamp forest.

In addition to assimilative floodplain capacity, the most notable floodplain value in Dyke Marsh is habitat value. As the marsh erodes and shrinks, habitat value would also be reduced, as would the ability of the marsh to filter nutrients, and the quality of the scenic open space as a floodplain value would be lessened.

Cumulative Impacts

Past, present, and reasonably foreseeable future projects affecting the floodplain around Dyke Marsh include the wetland removal and mitigations projects associated with the Woodrow Wilson Bridge Construction, development of the Belle Haven Country Club Golf course, and the Clean Rivers Project under construction by DC Water. The wetlands mitigation projects associated with the bridge enhanced floodplain capacity along the Potomac River, by the creating and preservation of more wetlands than were impacted by the bridge. Development of National Harbor also affected the floodplain on the Maryland side of the Potomac River by hardening the shoreline, and therefore affects the floodplain function on the Virginia side. The Clean Rivers Project will indirectly improve floodplain capacity by storing potentially large volumes of stormwater and reducing flood volumes downstream. The continued erosion of the marsh and reduction of floodplain function and values under alternative A would contribute adverse impacts to the mostly beneficial cumulative impacts on floodplains from other projects over time. The contribution would be noticeable, and not appreciable, because the impacts from the erosion of the marsh would affect only the immediate vicinity of the marsh.

Conclusion

The continued erosion of the marsh under the no-action alternative would not change the base flood elevation, but would adversely affect floodplain functions and values, including the ability of the marsh to provide a buffer to the parkway and inland properties in storm conditions, and provide habitat for floodplain species of plants and wildlife. These impacts would be noticeable, but would affect only nearby properties, and the impacts would become evident slowly over time as the marsh erodes. Therefore the impacts would not be of a large enough magnitude to be significant.

The continued erosion of the marsh and reduction of floodplain function and values under alternative A would contribute adverse impacts to the mostly beneficial cumulative impacts on floodplains from other projects over time. The contribution would be noticeable, and not appreciable, because the impacts from the erosion of the marsh would affect only the immediate vicinity of the marsh.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

The restoration of marsh would have a variety of impacts on the immediately surrounding floodplains. Both alternatives would slightly increase the base flood elevation along the shoreline immediately adjacent to the marsh. Generally, increases in wetland acreage increase flood storage capacities in the floodplain, so all three alternatives would result in benefits to the floodplain in the adjacent parkland and community, although to varying extent. In addition, meanders and additional stream length would be restored to Hog Island Gut. The branches of the gut extend through the adjacent Belleview and New Alexandria neighborhoods that are largely within the 100-year floodplain. The additional length and meanders would reduce flow velocities and water volumes up the gut, in addition to adding more storage capacity, making it less likely for the channelized sections of the gut (channelized through the neighborhood outside the park boundaries) to flood, or lessen the severity of the flooding when flood events occur.

Construction of the breaks in Haul Road would provide direct benefits to the floodplain west of the roadway by restoring tidal flows. The land in this area is already in the floodplain, but is not as frequently inundated, and therefore does not support the bottomland floodplain forest that it once did. The base flood elevation in the area would change as predicted by the modeling (which varies by alternative). The impacts on the floodplain in this area would otherwise be the same for both action alternatives.

Construction-related impacts on the floodplain would be limited. Installation of the walls of the containment cells, particularly with the steel sheet piling that could be in place the longest, could displace water and potentially exacerbate flooding in the area while the containment cells are in place.

IMPACTS OF ALTERNATIVE B

Impacts on floodplains under alternative B would be the same as described above, but would affect the fewest acres of the action alternatives, and would represent a detectable improvement over alternative A. The models predict that the base flood elevation would increase approximately 0.10 foot (1.2 inches) (USACE 2013). There would be some increase in flood storage capacity and that capacity would likely increase to a limited degree over time. Habitat for marsh and floodplain fauna species would also be increased, and would likely continue to increase somewhat over time, as the breakwater would allow for accretion of sediments and slow expansion of marsh habitat.

Alternative B would result in the fewest construction-related floodplain impacts because the containment cells would be relatively small and narrow, and there would not be many of them.

Cumulative Impacts

The cumulative scenario of past, present, and reasonably foreseeable future projects is the same as under alternative A. Alternative B would contribute beneficial, but mostly localized impacts, as well as short-term adverse impacts to the mostly beneficial impacts of the past, present, and reasonably foreseeable projects, resulting in overall benefits to the floodplain in Dyke Marsh and on the Potomac River. The contribution of beneficial impacts from alternative B to the cumulative scenario would be noticeable, but not appreciable, because the impacts would be mostly localized. The contribution of the short-term impacts would be imperceptible.

Conclusion

Restoration of the marsh under alternative B would raise the base flood elevation by 1.2 inches, but would also increase marsh area that would provide a buffer to the parkway and inland properties during storm events, and could therefore lessen the severity of floods. Other floodplain functions and values would also be increased. The benefits from alternative B would reverse the adverse effects under alternative A. Although important, these benefits would not be large enough to be significant.

Alternative B would contribute beneficial, but mostly localized impacts to the mostly beneficial impacts of other past, present, and reasonably foreseeable projects, resulting in overall benefits to the floodplain in Dyke Marsh and on the Potomac River. The contribution of alternative B to the cumulative scenario would be noticeable, but not appreciable, because the impacts would be mostly localized.

IMPACTS OF ALTERNATIVE C

Impacts on floodplains under alternative C would be the similar to those described above for alternative B, but would affect a larger number of acres than under alternative B, as more wetlands would be restored. Although the models predict that the base flood elevation would ultimately increase up to 0.15 feet (1.8 inches) (USACE 2013), there would be a more noticeable increase in flood storage capacity than alternative B, and that capacity would likely further increase to a limited degree over time as more marsh builds naturally in the accretion areas behind the breakwater. Habitat for the marsh and floodplain species would be increased directly as the result of restoration construction, and would likely further increase somewhat over time because the breakwater would allow for accretion of sediments and slow expansion of marsh habitat.

Alternative C also would result in more construction-related floodplain impacts because the containment cells would be larger in size and more numerous, and they would cover a larger area overall, so more water would be temporarily displaced than under alternative B.

Cumulative Impacts

The cumulative scenario of past, present, and reasonably foreseeable future projects is the same as under alternative A. Similar to alternative B, alternative C would contribute beneficial, but localized impacts to the beneficial impacts from other projects, as well as short-term adverse construction related impacts. resulting in overall benefits to the floodplain in Dyke Marsh and on the Potomac River. The contribution from the long-term beneficial impacts would be noticeable, whereas the contribution from the short-term adverse impacts would be imperceptible.

Conclusion

Restoration of the marsh under alternative C would raise the base flood elevation by 1.8 inches, but would also noticeably increase marsh area. The increases in marsh areas under alternative C would provide a greater buffer from flooding to the parkway and inland properties during storm events than alternative B, and could therefore further lessen the severity of floods in areas near the marsh. Other floodplain functions and values would be increased. There would also be some short term adverse impacts on floodplain function and values as the result of the placement of the containment structures that could restrict the assimilative capacity of the existing marsh temporarily. Similar to alternative B, although the beneficial impacts would be important, and larger than under alternative B, these benefits and the short-term adverse impacts on floodplain function and values would be localized and relatively small. They would not be large enough in magnitude to be significant.

Alternative C would contribute beneficial, but localized impacts to the beneficial impacts from other projects, as well as short-term adverse construction-related impacts, resulting in overall benefits to the floodplain in Dyke Marsh and on the Potomac River. The contribution from the long-term beneficial impacts would be noticeable, whereas the contribution from the short-term adverse impacts would be imperceptible.

IMPACTS OF THE ALTERNATIVES ON VEGETATION AND WETLANDS

GUIDING REGULATIONS AND POLICIES

As stated in chapter 1 and above, the restoration is guided by NPS *Management Policies 2006*, specifically, “Chapter 4: Natural Resources,” which states that “the National Park Service will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks while providing meaningful and appropriate opportunities to enjoy them” (NPS 2006). The NPS has been directed by Congress to restore Dyke Marsh to its natural ecosystem functions, which have been disrupted by past and ongoing human activity. The NPS is also obligated under Director’s Order 77-1, Wetland Protection (NPS 2002) and its accompanying guidance (NPS 2011b), to implement Executive Order 11990, Protection of Wetlands,” first issued in 1977 by President Jimmy Carter. Director’s Order 77-1 mandates the NPS to achieve a goal of no net loss of wetlands within their resources; thus adopting a restoration program for Dyke Marsh would help to achieve that goal.

The NPS is obligated to minimize the harmful effects that nonnative invasive species have on their lands, under Executive Order 13112, Invasive Species, first issued by President Clinton in 1999. Under Executive Order 13112, federal agencies are to use the national-level invasive species management plan, created by the Invasive Species Council, to prevent the further spread of invasive species on federal lands.

Construction activities would be guided by state and federal laws, including the Clean Water Act (Section 404) and Section 9 of the Rivers and Harbors Act of 1899. The implementation of the project would require consultation with the VA DCR under its Virginia Water Protection Permit process and the Virginia Marine Resources Commission to address any potential impacts on the existing wetlands that may occur during construction.

METHODS AND ASSUMPTIONS

Successful restoration of wetlands depends on the consistent accumulation of marsh soil, which is deposited from suspended sediment, and on the gradual buildup of organic matter. Additionally, the success of wetland restoration will be measured by the regeneration of wetland plant species across several elevation zones, including high marsh, emergent marsh, submerged areas, and forested swamps.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, no restoration efforts would occur and the marsh and its wetland vegetation would continue to degrade; however, the floodplain and swamp forest vegetation would remain relatively stable. Throughout its history, the floodplain forest in Dyke Marsh has remained relatively stable (NPS 1993); this is likely because these forests are not located in proximity to the erosive forces along the shoreline. As a result of the removal of the promontory during dredging, erosive forces increased along the eastern side of the marsh, which created marsh erosion in a landward direction (Litwin et al. 2011). Additionally, the removal of the promontory caused Hog Island Gut to lose its protection against surging tides; as a result, the mouth of Hog Island Gut has widened and has become more susceptible to continued erosion from stronger tidal waters entering. Because tidal waters flowing into and ebbing from Hog Island Gut are moving at an increased velocity, sediment that historically would have accrued in Dyke Marsh is leaving the system and entering the Potomac River. Therefore, as discussed under other resource topic analyses, there is a twofold loss of wetland soils; increased tidal velocity is causing marsh soils to erode and leave the marsh system, and sediment that would normally settle out from tidal waters is instead remaining in suspension. Under the no-action alternative these processes of erosion and sediment loss would continue (Litwin et al. 2011).

Based on photographic interpretation, Dyke Marsh is decreasing by approximately 0.75 acres per year (Litwin et al. 2011). The continuing loss of marsh would lead to the corresponding loss of wetland vegetation in Dyke Marsh. The acreage of low marsh communities, such as pond lily and pickerelweed tidal marshes, would continue to decrease, as would the communities of freshwater tidal high marsh. Species of concern such as river bulrush and giant bur-reed would be affected, and occurrences of these plants would decrease in the marsh. Under the no-action alternative, present communities of SAV could also be impacted. As the marsh erodes and releases sediment to the adjacent Potomac River, the resultant sediment could block sufficient light from reaching the SAV. However, as the marsh edge recedes, there is a potential for the SAV communities to reestablish themselves further landward. Although this may result in a temporary no net loss scenario for SAV, it is not sustainable for SAV or marsh vegetation.

The continuing loss of wetlands under the no-action alternative would remove the functions and values that wetlands provide as already discussed in the impacts on floodplains and water quality analyses. The majority of floodplain and swamp forest vegetation in Dyke Marsh would continue to remain relatively stable (NPS 1993). Construction of the Haul Road changed the hydrology of Dyke Marsh, because the area west of the Haul Road was cut off from the historic hydrology. As a result, the vegetation west of Haul Road has developed into a successional community with several nonnative invasive species (NPS 2009g). Under the no-action alternative, NPS would continue to remove invasive species either by hand or with approved chemical applications in this area.

Cumulative Impacts

Other past, present, and reasonably foreseeable future actions in the vicinity of Dyke Marsh have the potential to impact both wetlands and vegetation in the marsh and the adjacent Potomac River. The construction of the new Woodrow Wilson Bridge in Alexandria in the 2000s, the development of the Belle Haven Golf Course early in the 20th century, the development of the National Harbor in the 2000s, and the present DC Water Clean Rivers Project all affected wetlands, though most impacts were localized. The construction of the bridge affected wetlands and vegetation along the shore at both ends of the bridge. There was mitigation for wetland and vegetation disturbance. Hydrologic changes associated with the bridge did not exacerbate Dyke Marsh erosion and adverse effects on wetlands and vegetation in the marsh in any noticeable way, because higher flow velocities are directed into the shipping channel on the far side of the river from the marsh.

The construction of the golf course and the associated increased runoff and sediment deposition in Cameron Run and Hunting Creek, when coupled with the development upstream on Cameron Run, has resulted in sediments being carried out of Cameron Run and settling out at the confluence with the Potomac River, where large mud flats are developing; that sediment is not being carried downstream in the direction of Dyke Marsh, thus marsh erosion is attenuated due to lower deposition rates.

The development of the National Harbor in Prince Georges County, Maryland, has led to increased ferry traffic in the Potomac River (Potomac River Boat Company 2013). Although the ferries cross the river north of the marsh, or remain in the shipping channel as they head south to Mount Vernon, they can create wakes that can cause short-term increases in wave energy that can cause erosion on the edges of Dyke Marsh.

The no-action alternative would continue to contribute noticeable adverse effects on wetlands and vegetation in the marsh to the beneficial and adverse impacts from these other projects. The contribution of impacts from the no-action alternative would be appreciable because of the types of vegetation and the acreage affected.

Conclusion

The no-action alternative would result in erosion and disappearance of the marsh and its vegetation over time, including plants such as river bulrush that are species of concern. Additional impacts include reduced or eliminated functions and values that wetlands of Dyke Marsh provide. Erosion and disappearance of Dyke Marsh would result in significant adverse effects on vegetation and wetlands because tidal freshwater marsh is regionally threatened, and Dyke Marsh is important in a regional context. In addition, the river bulrush community is unusual, and there are very few tidal freshwater wetlands in this region, particularly with similar plant communities. Prevalence of the river bulrush is rare within Virginia, and it is a dominant component in the marsh.

The no-action alternative would continue to contribute noticeable adverse effects on wetlands and vegetation in the marsh to the impacts from other past, present, and reasonably foreseeable projects. The contribution of impacts from the no-action alternative would be appreciable because of the types of vegetation and the acreage affected.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Changes in Wetlands along Haul Road

Under all the action alternatives, the creation of breaks along Haul Road would allow tidal flows to pass under the road and into the former bottomland swamp forest, which would allow for the restoration of the bottomland swamp forest. The restored hydrology and sediment transfer would result in beneficial impacts on hydrology and sediment transfer in the area behind Haul Road because the breaks would allow past hydrologic conditions to be reestablished, and that would allow desirable ecologic conditions to be reestablished. The reconnections would discourage continued establishment of nonnative and invasive plants because repeated inundation favors the reestablishment of native plants over nonnative plants. The reconnections would also result in improvements in floodplain values, as described in the floodplains section.

Impacts from Climate Change

Impacts to vegetation in the marsh generally, and in the restored marsh specifically, can be expected over time, as water levels and/or salinity may change as a result of climate change. The marsh will be monitored as part of the adaptive management plan (see “Adaptive Management Approaches Included in the Action Alternatives” in chapter 2) and designed to be resilient to avoid adverse impacts to the marsh related to climate change.

Impacts from Construction Activities

Under all the action alternatives, the marsh would be reestablished using large containment cells and some smaller, strategically placed containment cells. The cells would be designed to hold fill material placed to the right elevation to support appropriate vegetation, and then settled so that plants can colonize or the area can be planted. Once fill has been placed, intertidal exchange and groundwater flows through the new marsh area would facilitate establishment of desired plant communities that are consistent with the existing marsh. Intertidal exchange in the wetlands outside the containment cells would continue, although water would flow around the cells, and up Hog Island Gut.

Under all of the alternatives, construction of new wetland areas would occur adjacent to existing marsh. The construction activity would take place from the water using barges, so there would be no impacts on existing marsh wetlands from construction equipment traversing the existing marsh. Construction would place containment cells abutting existing marsh which could prevent erosive forces from continuing to degrade their edges which could reduce erosion and fragmentation.

Construction of the breakwater would also affect subaqueous wetlands. Based on preliminary design, about 191 linear feet of breakwater would be placed in water that is 6 feet deep or shallower. Assuming that the breakwater would be 7 feet in elevation when the water is 6 feet deep, it is estimated that the base of the breakwater would be about 35-feet wide at the bottom. At that width, a 191-foot breakwater would cover approximately 0.15 acres of subaqueous wetlands.

During construction of the containment cells or breakwater, existing SAV could be displaced if they exist where the containment cells or breakwater are being placed. However, this would be a short-term impact for the containment cell construction areas, because SAV would be expected to recolonize the resultant new edge of the marsh (USACE 2013). The loss of subaqueous wetland in the footprint of the breakwater would be permanent, but minimal. In the event of an accidental sediment spill during construction, SAV could be impacted if the sediment plume blocks light from reaching the plants or if sediment settles from the water onto the plants. However, this situation is unlikely to occur because of erosion and sediment control plans and use of BMPs. Finally, no impacts on wetlands are expected from filling the deep channel in the eastern portion of the project area. No mapped marsh exists in that area and because the depth exceeds two meters, it is unlikely that SAV are present. SAV species generally grow in water that is less than two meters deep due to light requirements needed for photosynthesis (USEPA 1992).

Management of Nonnative Invasive Plant Species

Under all of the action alternatives, it is expected that the NPS would continue to monitor the presence of nonnative plant species and work to remove them from Dyke Marsh. The removal activities would include applying herbicides to eradicate *Phragmites*, purple loosestrife, and other nonnative invasive plant species; managing volunteers who physically remove nonnative plants and tag/cut plants for later application with NPS-approved herbicides; and removing nonnative plants and debris from the Haul Road area.

IMPACTS OF ALTERNATIVE B

Under alternative B, the focus is on the most essential actions that would reestablish conditions suitable for the creation of wetlands north of the historic promontory. The restoration activities would create beneficial hydrological and sediment deposition conditions that would promote successful marsh accretion and the establishment of wetland vegetation communities over the long term. A breakwater structure would be constructed on the south end of the marsh, in alignment with the northernmost extent of the historic promontory, and wetlands would be restored to wherever the water is less than 4-feet deep. This alternative would create approximately 70 new acres of various wetland habitats and allow the continued natural accretion of soils and establishment of wetlands given the new hydrologic conditions.

Based on the data presented in the hydrology section, a significant tidal lag would be created, which would slow the velocity of incoming tidal water. The effect would be that water that normally flows directly over the top of the marsh would be directed to the marsh through tributary channels of Hog Island Gut. Although not predicted by the flow models, this new hydrologic flow dynamic may decrease the amount of water that is reaching the northwestern portion of the existing marsh; if this were the case, and a portion of the marsh is cut off from its source of hydrology, it may be possible that areas within the existing marsh would be converted from wetlands dominated by obligate plant species to those that are more suited to a drier hydrologic regime. However, based on the hydrologic modeling, it is not expected that any areas would be cut off from a reliable hydrologic source (USACE 2012a). The proposed breaks in Haul Road are designed to address the concern that the northwestern area has lost its hydrologic connection. Impacts created by the breaks in Haul Road are discussed in the section “Impacts Common to Both Action Alternatives.”

Although the acreage of wetlands created under alternative B would be fewer than those that existed historically, the conditions that were conducive to creating the historic marsh would be restored, thus it is expected that steady accretion would occur and that wetland vegetation would colonize the expanding marsh soil. The success of wetland colonization is dependent upon the nature of plant propagation. Several revegetation approaches have been put forward, including seed dispersal and transplanting plugs. Seed dispersal is often successful; however, it is often more successful if the seeds are dispersed via water instead of by other forces such as wind (Neff and Baldwin 2005). Thus, it is important that hydrology be restored adequately so that flowing and ebbing water can disperse seeds throughout the newly created marsh.

Construction-related impacts from the partial blockage of flows into the existing marsh by the containment structures would be as described in the section “Impacts Common to Both Action Alternatives,” but would be relatively small, given the limited scope of marsh restoration under this alternative.

Cumulative Impacts

The projects and impacts on wetlands and vegetation in Dyke Marsh from past, present, and reasonably foreseeable future projects would be the same as those discussed under the no-action alternative. Implementation of alternative B would contribute beneficial long-term impacts to the mostly localized beneficial and adverse impacts of other projects, and would include benefits that help mitigate some of the adverse impacts from these other projects, such as protecting the marsh from erosive impacts of ferry wakes that can exacerbate erosion. The contribution would be noticeable, and not appreciable, because most of the cumulative impacts from other actions are localized and have a limited effect on the wetlands and vegetation in the immediate area of the marsh.

Conclusion

Alternative B would result in the creation of 70 acres of various wetland habitats, and would reverse the erosion and disappearance of the marsh described under alternative A. The new vegetation would protect existing marsh, including river bulrush and other unusual plants, in addition to increasing overall marsh acreage. There would be some adverse construction-related impacts that would be relatively small in magnitude. Because the new vegetation under alternative B would protect this important regional resource, the beneficial impacts would be significant.

In addition, the break in Haul Road and the resulting hydrologic reconnections would discourage continued establishment of nonnative and invasive plants because repeated inundation favors the reestablishment of native plants over nonnative plants, an important, but not significant effect.

Implementation of alternative B would contribute beneficial long-term impacts to the mostly localized impacts of other projects. The contribution would be noticeable, and not appreciable, because most of the cumulative impacts from other actions are localized and have a limited effect on the wetlands and vegetation in the immediate area of the marsh.

IMPACTS OF ALTERNATIVE C

Under alternative C, there would be a greater extent of marsh restoration than under alternative B, resulting in up to 245 acres of restored wetlands and marsh, including high marsh, emergent marsh, tidal guts, and areas of SAV, as well as bottomland swamp forest. The breakwater structure would be placed at the southern alignment of the historic promontory to protect Hog Island Gut, and that would be coupled with restored wetlands upstream of the breakwater that would simulate the historic extent of the land mass. Tidal guts would also be cut into the restored marsh area, similar to historical flow paths, to allow crucial intertidal flows into the heart of the marsh.

Impacts on wetlands and vegetation would be similar to those under alternative B. Under alternative C, up to 175 more acres of wetlands would be restored than under alternative B, which could extend into the river between approximately 400 feet and 2,000 feet from the current marsh edge (USACE 2013). Under alternative C, there would be an establishment of SAV between the break in the emergent marsh and the edge of the wetland cells; thus, not all of the created wetland area would be marsh. This scenario of extending the edge of the existing marsh much farther toward the water would probably impact the existing SAV, which are likely to be destroyed as their habitat is converted from open water to emergent marsh. However, because the overall area of restored marsh would exceed that of the present Dyke Marsh by up to 245 acres, there is the potential for an even greater area of SAV to develop upon completion of construction after restoration.

The restored hydrology under alternative C would allow the marsh to be entirely inundated at high tide. However, unlike under the current hydrology, areas of the marsh would be allowed to dry out at low tide, thus providing the necessary ecological conditions for high marsh and low marsh vegetation to colonize the formerly permanently inundated areas. High marsh vegetation is expected to grow in areas at least one foot above the typical water surface elevation, low marsh vegetation is expected to grow in areas between one foot and zero water surface elevation, and SAV are expected grow at a depth no deeper than five feet below water surface elevation (USACE 2013). Although high marsh and low marsh species can cross these depth zones, high marsh plants tend to perform better at higher elevations because the higher elevation provides their roots more oxygenated soil zones. Conversely, low marsh plants are better able to compete at lower elevations because of adaptations in their roots (Cronk and Fennessy 2001). In order to maintain this transition from marsh to SAV and avoid continuing erosion, a 20:1 slope gradient would be constructed at all edges (USACE 2013). The final design of the marsh would need to consider this and be refined from the current design so that the appropriate ratio of high marsh to emergent marsh is created.

Impacts related to cell design, and related to the introduction of breaks in Haul Road are discussed in the section “Impacts Common to Both Action Alternatives.”

Construction-related impacts would be as described under impacts common to all, but would be more far reaching than under alternative B, because there would be a larger amount of marsh restored and a larger number of containment cells would be used. The containment cells could reduce flows into the existing marsh but would also protect it from erosion.

Cumulative Impacts

Cumulative impacts on wetlands and vegetation would be the same as discussed under the no-action alternative. Alternative C would contribute long-term benefits to the beneficial and adverse impacts from other projects, including protection of the marsh from some of the erosive effects of other projects. The contribution of the beneficial impacts of alternative C on wetland restoration and vegetation colonization in Dyke Marsh would be appreciable, particularly since the cumulative impacts of other past, present, and reasonably foreseeable projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative is relatively large.

Conclusion

Like alternative B, alternative C would protect existing marsh and vegetation. It would also create up to an additional 175 acres of various wetland habitats (a total of 245 acres of restored wetlands and marsh). Alternative C would result in significant beneficial impacts both by protecting existing marsh and vegetation and restoring and increasing overall marsh acreage. Implementation of phase one would protect the existing marsh then allow additional restoration to move forward in the future. There would be some short-term adverse construction-related impacts that would be relatively small in magnitude. All of the beneficial impacts would be associated with the core purpose of the project. Similar to alternative B, because the new vegetation under alternative C would protect an important regional resource, the long-term beneficial impacts would be significant.

Also as with alternative B, the break in Haul Road and the resulting hydrologic reconnections would discourage continued establishment of nonnative and invasive plants because repeated inundation favors the reestablishment of native plants over nonnative plants.

Alternative C would contribute long-term benefits to the impacts from other projects, including protection of the marsh from some of the erosive effects of other projects. The contribution of the beneficial impacts of alternative C on wetland restoration and vegetation colonization in Dyke Marsh would be appreciable, particularly since the cumulative impacts of other past, present, and reasonably foreseeable projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

IMPACTS OF THE ALTERNATIVES ON FISH AND WILDLIFE

GUIDING REGULATIONS AND POLICIES

Servicewide NPS regulations and policies, including the NPS Organic Act of 1916; NPS *Management Policies 2006*; and the NPS Reference Manual 77, Natural Resource Management, direct national parks to provide for the protection of park resources. The Organic Act directs national parks to conserve wildlife unimpaired for future generations and is interpreted to mean that native animal life are to be protected and perpetuated as part of a park unit's natural ecosystem. Parks rely on natural processes to control populations of native species to the greatest extent possible; otherwise, they are protected from harvest, harassment, or harm by human activities. The NPS *Management Policies 2006* state that the NPS would maintain, as parts of the natural ecosystems of parks, all native plants and animals. The NPS Natural Resources Management Guidelines state, "the National Park Service will seek to perpetuate the native animal life as part of the natural ecosystem of parks" and that "native populations will be protected against…destruction…or harm through human actions."

The implementation of the project would follow in-water construction management practices required by the VA DCR in the Virginia Erosion and Sediment Control Manual (VA DCR 1992) and the VDGIF concerning the protection of fish and wildlife species during construction activities.

METHODS AND ASSUMPTIONS

Potential impacts on terrestrial and aquatic fish and wildlife and their habitats were evaluated based on known life histories and habitat requirements, and their past and present occurrence in the Dyke Marsh preserve. Information on habitat and occurrence within the Dyke Marsh preserve and potential impacts on species from the freshwater tidal marsh restoration efforts was acquired from park staff, available literature, and the discussions of subject matter experts during the science team meetings that were conducted for this restoration plan. The analysis also integrated the findings of the hydrodynamic modeling of the marsh and the surrounding area of the Potomac River under the different alternatives.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Terrestrial Wildlife

Under the no-action alternative, species present within Dyke Marsh, including species of concern, such as the least bittern and swamp sparrow (discussed in more detail in the species of concern section), would continue to occur, but would decrease over time because of the reduction of nesting and other suitable habitat. The tidal freshwater marsh, swamp forest, and floodplain forest habitats would continue to persist and provide habitat for amphibians, reptiles, birds, and mammals. However, the amount of tidal freshwater marsh habitat would continue to decline over time at a rate of approximately 6–7.8 feet per year due to erosion (Litwin et al. 2011; USACE 2012a).

Given the current decline in the marsh wren population at Dyke Marsh, with the continued erosion of the tidal freshwater marsh under the no-action alternative, enough habitat could eventually be lost that the marsh wren may eventually disappear from the marsh.

Aquatic Wildlife

As a tidal freshwater marsh, Dyke Marsh provides forage and spawning habitat for adult fish species, as well as nursery and refuge habitat for juvenile fishes (Mangold et al. 2004). The marsh also provides habitat for a variety of invertebrates, as described in chapter 3. Under the no-action alternative, Dyke Marsh would continue to provide suitable habitat for invertebrates, as well as juvenile and adult fish species. However, the amount of habitat available for use by invertebrates and fish species would continue to slowly decline over time with the loss of marsh due to erosion.

Cumulative Impacts

Other past, present, and reasonably foreseeable future actions in the vicinity of Dyke Marsh have the potential to impact both terrestrial and aquatic wildlife species in the marsh and the adjacent Potomac River. The construction of the new Woodrow Wilson Bridge in Alexandria in the 2000s and the development of National Harbor have adversely impacted fish and wildlife species in the vicinity of Dyke Marsh through the removal of SAV, wetlands, and benthic habitat, as well as the hardening of shoreline habitat. In the short term, contributions of adverse effects from the no-action alternative to the effects on terrestrial and aquatic fish and wildlife in the area from other projects would likely be imperceptible, but in the long term, with the continued erosion of the freshwater tidal marsh and loss of habitat, the no-action alternative would likely contribute a noticeable amount of adverse effects to the overall adverse cumulative effects on both terrestrial and aquatic fish and wildlife species in the area.

Conclusion

Alternative A would result in several long-term adverse impacts on fish and wildlife in the marsh. Dyke Marsh would continue to provide suitable habitat for invertebrates, as well as juvenile and adult fish species. However, the amount of habitat available for use by invertebrates and fish species would continue to slowly decline over time with the loss of marsh due to erosion. As the marsh erodes, habitat for marsh dwelling birds and wildlife would disappear, and many fish and wildlife species would decrease or disappear. Some of these species are species of concern; these species and other unusual species such as the marsh wren would be adversely affected. As a result of the loss of marsh under this alternative and the associated magnitude of adverse impacts on wildlife, impacts would be significant.

In the short term, contributions of adverse effects from the no-action alternative to the effects on terrestrial and aquatic fish and wildlife in the area from other projects would likely be imperceptible, but in the long term, with the continued erosion of the freshwater tidal marsh and loss of habitat, the no-action alternative would likely contribute noticeable adverse effects to the overall adverse cumulative effects on terrestrial and aquatic fish and wildlife species in the area.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Impacts from the Restoration of the Marsh

Under both action alternatives the construction of a breakwater in the vicinity of the historic promontory and filling of the deep channels that resulted from dredging would decrease water velocities and encourage sediment deposition, both of which would help protect Hog Island Gut and the existing marsh from further erosion (see “Impacts of the Alternatives on Hydrology and Sediment Transport”). This, along with the construction of new marsh surface using containment cells, would help preserve existing habitat and add new marsh. The sloping of the fill within the containment cells to promote a natural soft edge to the marsh would promote the growth of SAV habitat, although the amount of habitat marsh and SAV habitat added would vary depending on the alternative selected. New tidal guts would be cut into the restored marsh and allowed to grow naturally, providing additional marsh edge and channel habitat for species. In addition, all of the action alternatives would provide new tidal connections between the marsh and the back side of Haul Road, helping to reestablish floodplain swamp forest habitat for species to utilize. Overall, an increase in abundance for both terrestrial and aquatic fish and wildlife species would be expected under each of the action alternatives.

Terrestrial Wildlife—Amphibians and Reptiles

Dyke Marsh provides habitat for a variety of amphibians and reptiles. Protecting the existing marsh and constructing new marsh would provide additional habitat and forage for species such as the bull, green, and pickerel frogs; the American toad; the snapping, painted, red-bellied, red-eared, mud, and musk turtles; the ring-neck, black rat, northern water, and eastern garter snake; as well as other species that use the marsh habitat. Reconnecting the area behind Haul Road to tidal influence would enhance the floodplain swamp forest habitat for species such as the two-lined and redbacked salamanders; the American toad, the eastern gray treefrog, the green and pickerel frogs, the box turtle, the five-lined skink; and a variety of snakes and other species that use that habitat for foraging, refuge, and reproduction.

Terrestrial Wildlife—Birds

Tidal freshwater marshes harbor a high diversity of birdlife. Low marsh and adjacent mudflats are used by shorebirds (e.g., killdeer and spotted sandpiper), grasses and sedges characteristic of higher marsh elevations support an abundance of seed-eating species (e.g., blackbirds, sparrows, finches, wrens and others); tidal channels and pools provide habitat for shore birds (e.g., killdeer and spotted sandpiper); while waterfowl (e.g., wood duck and mallard) use open water areas in addition to the marsh surface itself Odem et al. 1984). Additionally, shrubs and trees found in the high marsh and along the upland-marsh ecotone provide habitat for a large number of arboreal birds (e.g., swallows, flycatchers, kingbirds, warblers and others) that can often be found feeding in or over the marsh as well (Odem et al. 1984).

Marsh restoration efforts would increase the amount of vegetated marsh habitat, as well as the amount of tide channels and mudflat habitat, providing additional forage habitat for species, including those such as the osprey that feed on fish in the marsh and peregrine falcons that feed upon small marsh birds. In addition to increased forage habitat, the restored marsh would also provide additional nesting habitat for those species that breed in the marsh. Species such as the red-winged blackbird, tree swallows, chipping sparrows, and American goldfinch are known to nest in tidal freshwater marshes (Odem et al. 1984) and have been recorded nesting at Dyke Marsh (Cartwright 2012).

Restoration efforts would also benefit the marsh wren and potentially help its population to grow. As noted previously, marsh wrens have a very narrow habitat preference (tall, dense, emergent vegetation adjacent to water) and as part of the restoration process, in addition to natural seed recruitment, the new containment cells could be planted with cattails, river bulrush, and wild rice, along with other plant species, depending on the ultimate approach to revegetation. These species of plants are the preferred nesting habitat of the marsh wren (Gutzwiller and Anderson 1987). Among other factors, nesting success in marsh wrens is dependent upon the density of other breeding marsh wrens and the distance between marsh wren nests and the nearest red-winged blackbird nest (Gutzwiller and Anderson 1987). Adult marsh wrens of both sexes destroy the eggs of other marsh wrens. As a result, typical territories for marsh wrens range from 0.3 to 0.7 acres (Gutzwiller and Anderson 1987). Red-winged blackbirds aggressively suppress the singing activities of marsh wrens, and therefore possibly reduce marsh wren reproductive success (Gutzwiller and Anderson 1987). As a result, adding more preferred marsh habitat under all of the action alternatives would increase the number of possible breeding territories for marsh wrens, although the number of possible nests and breeding territories would vary with the amount of new habitat created under the different alternatives.

Goose exclosures to prevent damage to wetland vegetation would be erected in the restored cells and would consist of string stretched between stakes at intervals to prevent geese from landing between them.

The string and stakes would be flagged so that they are visible by birds and other wildlife to prevent adverse impacts to other species. The exclosures have proven successful at Kingman Marsh on the Anacostia River (Hammerschlag et al. 2006). Their use at Dyke Marsh would allow the restored marsh to grow without the pressure of goose herbivory while providing habitat for birds and other wildlife. The exclosures would not affect other smaller bird species or types of wildlife, because they could fit between or under the exclosure strings, and the strings would be marked and flagged to deter wildlife from accidentally coming into contact with them.

Terrestrial Wildlife—Mammals

Habitat for resident mammal species of the marsh, including opossum, moles, mice, eastern cottontail, common muskrat, common raccoon, and others would expand, though the amount of additional habitat available for use would be dependent upon the amount of marsh to be restored under each action alternative. The restored marsh would provide increased foraging habitat in terms of invertebrates, fish, and marsh vegetation, while the surrounding forested habitat would continue to provide den sites and refugia.

Refugia are areas in which a population of organisms can survive through a period of unfavorable conditions.

Aquatic Wildlife—Fish

As noted earlier, Dyke Marsh provides suitable habitat as a nursery and refuge for small and juvenile fishes, including important species such as the anadromous American shad, blueback herring, and alewife, while also providing spawning and foraging habitat for adult fish such as largemouth bass, bluegill, and pumpkinseed, which are all important as recreational sport fish (Mangold et al. 2004). In general, restoration of the marsh and creation of new tidal guts would provide additional habitat for these uses resulting in long-term beneficial impacts on resident and transient fish species. However, as restoration of the marsh occurs, some short- and long-term adverse impacts would occur under both action alternatives.

In tidal freshwater marshes small species such as killifishes (e.g., mummichog and banded killifish) aggregate in the shallows along the marsh edge or in tidal creek channels during low tide and then move on to the marsh surface during high tide to seek refuge and feed (Odum et al. 1984). Species like the mummichog also use the marsh surface as a nursery area, depending on it for spawning and survival of juveniles (Kneib 1984). With marsh restoration and creation of new tidal guts, habitat for these resident species would increase and their populations would likely grow, providing additional forage for larger fish species such as largemouth bass, yellow perch, and white perch, as well as bird species that prey upon them such as herons. However, exactly how much habitat is actually available for use by the various fish species is dependent upon the amount of marsh restored under each action alternative and on its accessibility. The number and location of tidal creeks, marsh surface, water depth, and hydroperiod (length of time the marsh surface is inundated) all play key roles in determining how accessible the marsh surface is to various species and life stages of fish and would likely vary among the different action alternatives (Kneib and Wagner 1994; Minello et al. 1994; Peterson and Turner 1994; Rozas, McIvor, and Odum 1988).

Part of the design for marsh restoration entails creating a soft, natural edge to the marsh. To accomplish this, the fill material in the containment cells would be sloped so that water depths at the outer edge of the containment cell would not support emergent marsh vegetation. However, it is likely that SAV would become established in the deeper waters of the restored marsh edge. In studies of tidal freshwater marshes, densities of species such as killifish were found to be higher on vegetated marsh surfaces and in SAV habitats than over unvegetated bottom habitat (Castelloanos and Rozas 2001; Rozas and Odum

1987). The design of the marsh edge, which would likely help establish new SAV beds, would also benefit small fish such as spot-tail shiners, tessellated darters, and silversides, along with killifish and juveniles of other species that currently use the marsh habitat.

To attenuate water velocities and protect the marsh from wave energy, both action alternatives would include the construction of a stone breakwater in the vicinity of the historic promontory and the filling of the deep channels north of the promontory that are the result of past dredging. The holes and crevices between the rocks would provide some structured habitat for fish species to use as refuge.

The deep channels, which have depths of approximately 10 to 26 feet (Normandeau Associates 2009), would be filled with gravel or larger rock resulting in the loss of deep water habitat. Additionally, individual holes located closer to the marsh edge would also be lost as they would be filled in to create marsh habitat. However, the number and location of the deep holes to be filled would differ depending on the action alternative. While tidal freshwater fish species are more often associated with shallows and vegetation than with deeper channels, deep holes do provide refuge for larger fish such as catfish and striped bass (Odem et al. 1984). Also, while juveniles of the centrarchid family (sunfish, crappies, and bass) are most abundant in shallow water, larger adults can also be found in deeper water. Thus, filling the deeper holes for marsh habitat would result in the loss of important fish habitat and cause long-term adverse impacts. However, species would still be found in shallower waters within the park and there is other nearby deep water habitat in the Potomac River outside of the park boundaries that fish could also use.

As described in chapter 2, restoring the marsh would entail using a series of containment cells, which would be made from a variety of materials such as hay bales or coir biologs in shallow waters or sheet piling driven into the riverbed in deeper locations. While the sheet piling would be configured, cut, or perforated to allow intertidal and groundwater exchange once the fill has been placed within it, unimpeded tidal exchange in the vicinity of the containment cells would not occur until the restoration activities are complete and the sheet piling cut or driven into the river bed. The hay bales and biologs would also impede full tidal exchange with the marsh until they have biodegraded. As a result of the containment walls, access to the marsh surface by small fish such as the mummichog and banded killifish would be slightly reduced in the vicinity of the containment cells until the restoration process was complete resulting in some small short-term impacts. These fish species would, however, still have full access to the marsh surface via existing tidal guts or along the outer edge of the marsh where there are no containment cells. Additionally, the walls of the containment cells would also inhibit movement of the fish out of the marsh during the outgoing tide, potentially stranding individuals on the marsh at low tide and making them more vulnerable to predation by birds and mammals. The magnitude of the adverse impacts caused by the containment cells limiting fish access to the marsh surface would vary under each alternative and be dependent on the number and size of the containment cells being employed at any one time. Impacts would be minimized though through the phasing of restoration activities (i.e., not all containment cells would be put in place at once).

Restoration of Dyke Marsh would also include reestablishing hydrological connections to the inland side of Haul Road. Providing openings under Haul Road for tidal exchange to occur would open up potential habitat for fish species to utilize, resulting in long-term beneficial impacts.

Aquatic Wildlife—Invertebrates

Information about the macroinvertebrate community in Dyke Marsh is not well documented, but the marsh does contain over 300 individual species of arthropods, along with a variety of worms, mollusks, and insects (Barrows and Kjar 2003; UMCES 2004). Restoration of the marsh would make more habitat available including vegetated marsh, unvegetated tidal channels, and SAV for macroinvertebrates to colonize, increasing their abundance and providing more forage for fish and wildlife species that prey upon them. As mentioned earlier under Birds, resident Canada goose populations can cause damage to restored marshes through excessive herbivory, creating expansive unvegetated areas (Paul, Krafft, and Hammerschlag 2006). The loss of vegetation due to goose herbivory at Kingman Marsh in the Anacostia River estuary affected the macroinvertebrate community development in that restored marsh. Paul, Krafft, and Hammerschlag (2006) found that while the unvegetated mudflats actually supported a significantly greater density of macroinvertebrates (primarily chironomids [non-biting midges] and oligochaetes [aquatic and terrestrial worms]) the vegetated sites promoted a greater diversity of species. At Dyke Marsh, to prevent the loss of new vegetation due to grazing by resident Canada geese, goose exclosures would be employed. By helping to eliminate potential unvegetated areas due to goose herbivory, the exclosures would promote a more diversified macroinvertebrate community in the marsh.

Impacts from Construction Activities

To the greatest extent possible, access for construction under both action alternatives would be from the water using marine construction equipment with materials brought in by barge. This includes activities for constructing the breakwater in the vicinity of the historic promontory as well as the various containment cells for creating new vegetated marsh. In general, construction activities would have short-term adverse impacts on both terrestrial and aquatic fish and wildlife. Most impacts would be temporary displacement of wildlife resulting from noise and vibration disturbances. Additional impacts on aquatic species would include the potential burial or injury to less mobile species, and impacts from the resuspension of sediments and increased turbidity.

Terrestrial Wildlife

During construction of the new breakwater and the containment cells there would be localized, temporary adverse impacts on amphibians, reptiles, birds, and mammals in the vicinity of the construction. Species would be temporarily displaced from habitat in the area of the construction due to noise and vibration impacts. Because most species are highly mobile, mortality of terrestrial species would not be expected, as most species would just avoid the disturbed areas. With construction activities occurring from the water and only in those areas near the edge of marsh, wildlife located in the interior or landward edge of the marsh may not be impacted. Once construction is completed, species would be expected to readily recolonize the marsh.

Construction activities to reestablish the hydraulic connection to the inland side of Haul Road would occur on the road, which is already a disturbed area. Some minor clearing of vegetation including trees would likely be required. In addition to noise impacts temporarily displacing species from the localized area, some minor tree habitat would be lost as well. However, to mitigate any lost habitat, new native trees or possibly other appropriate native vegetation would be replanted in the disturbed area, resulting in long-term benefits.

To protect selected wildlife during certain times of year (e.g., breeding season) when species may be most sensitive to human activities (e.g., construction and land clearing activities), the VDGIF recommends certain time-of-year restrictions (VDGIF 2013). For example, for general migratory and resident songbirds, it is recommended to limit certain activities from March 15 to August 15 each year. The time-of-year restrictions are recommendations only to be considered as guidance for project planning purposes. Whether or not the restrictions pertain to a specific project depends on the type of work proposed, the location of the project relative to the resource area, and the timing and duration of the activity. Therefore, the NPS would consult with the VDGIF during the permitting process for the project to develop appropriate construction measures and timing of the project activities to mitigate any potential adverse impacts on terrestrial wildlife. However, given the potential adverse impacts on birds from construction noise, it is likely that construction activities would be required to be conducted outside of their breeding season.

Aquatic Wildlife

During construction of the new breakwater, filling of the deep channels, and construction of the containment cells there would be localized, temporary adverse impacts on fish and macroinvertebrate species in the vicinity of the construction. Fish species would be temporarily displaced from habitat in the area of the construction due to noise and vibration impacts from driving the sheet piling into the sediment. There could also be some mortality of sedentary and less mobile species (mainly macroinvertebrates such as mollusks, snails, arthropods etc.) and life stages through burial during placement of materials on the riverbed during construction of the breakwater, filling of the deep channels, and constructing and filling the containment cells.

Construction activities would likely temporarily resuspend sediments in the river in the vicinity of the marsh. Construction activities on Haul Road could cause sedimentation in the river through stormwater runoff. Sedimentation in the river can cause local turbidity levels to increase which can have adverse impacts on fish and other aquatic species. Many fish, such as sunfish, are visual feeders and increased turbidity levels can hinder feeding success (Henley et al. 2000). Other impacts that can be caused by increased turbidity include restricted habitat use and function through greater expenditure of energy, gill tissue damage and associated respiratory impacts, lowered oxygen levels, and in some cases mortality (Henley et al. 2000). Sedimentation may also smother spawning habitat, especially for substrate spawners. If sedimentation occurs after spawning, then oxygen supply to eggs and sac fry in the substrata may be decreased due to reductions in water circulation, increasing egg and larvae mortality.

In addition to fish, resuspended sediments settling to the riverbed can also reduce the available habitat for macroinvertebrates as it fills the interstitial spaces between coarse substrata material (Henley et al. 2000). Suspended sediments have also been shown to adversely affect the survival of freshwater mussels (Henley et al. 2000).

Any adverse impacts from sedimentation and increased water column turbidity would be temporary and minimal, because BMPs such as sediment curtains would be used to help contain resuspended sediments, and erosion and sediment control BMPs would be used along Haul Road to prevent runoff during construction in that area. Additionally, mobile species such as fish would likely flee the impacted areas to surrounding waters where feeding and other impacts would be less problematic. Once construction is completed, both fish and macroinvertebrates species would be expected to readily recolonize and use the affected areas.

To protect freshwater species during certain times of year when species may be most sensitive (e.g., spawning season) to human activities (e.g., construction and land clearing activities), the VDGIF recommends certain time-of-year restrictions for in-water work (VDGIF 2013). For example, to protect general warmwater species when they are spawning it is recommended to limit in-water work from April 15 to July 15; for anadromous fish the recommended timeframe is February 15 to June 30. The time-of-year restrictions are recommendations only to be considered as guidance for project planning purposes. Whether or not the restrictions pertain to a specific project depends on the type of work proposed, the location of the project relative to the resource area, and the timing and duration of the activity. Therefore, the NPS would consult with the VDGIF during the permitting process for the project to develop appropriate construction measures and timing of the in-water project activities to mitigate any potential adverse impacts on aquatic wildlife.

IMPACTS OF ALTERNATIVE B

Although the nature of the impacts described in the section "Impacts Common to Both Action Alternatives" are consistent for both alternatives, the magnitude of the impacts differ slightly depending on the alternative due to the amount of marsh to be restored.

Impacts from the Restoration of the Marsh

Terrestrial Wildlife

Under alternative B, approximately 70 acres of new marsh habitat would be restored, providing new habitat and long-term benefits for amphibians, reptiles, birds, and mammals that inhabit the marsh. However, the actual amount of vegetated marsh habitat created would be slightly less than 70 acres due to the sloped design within the containment cells to provide for a soft natural edge to the marsh. Impacts created from reestablishing the hydrological connection to the inland side of Haul Road are discussed in the section "Impacts Common to Both Action Alternatives" above.

Aquatic Wildlife

Under alternative B the 70 acres of restored marsh and wetlands would provide additional refuge, forage, and spawning habitat for fish and invertebrate species including some additional SAV habitat due to the sloped design within the containment cells. While deep water habitat would be lost through the filling of the deep channels, most other deep holes would remain intact since restoration activities would only take place in areas where the current water depth is 4-feet or less. Impacts created from reestablishing the hydrological connection to the inland side of Haul Road are discussed in the section "Impacts Common to Both Action Alternatives" above.

Impacts from Construction Activities

The nature of construction-related impacts under alternative B would be the same as described in the section "Impacts Common to Both Action Alternatives" above. The magnitude of the impacts, however, would be the least among the three action alternatives due to the more limited scope of the marsh restoration under this alternative.

Cumulative Impacts

The impacts on fish and wildlife in Dyke Marsh and the Potomac River from past, present, and reasonably foreseeable future projects would be the same as those discussed under the no-action alternative. Alternative B would contribute long-term beneficial impacts on wildlife in Dyke Marsh and the Potomac River to mostly localized but adverse impacts from other projects. The contribution would be somewhat noticeable, because it would increase the amount of available habitat to species in the local area.

Conclusion

Alternative B would increase wetland and marsh habitat by approximately 70 acres, potentially allowing for a corresponding increase in the number of species and larger population sizes over the long term. Although the marsh would be stabilized and additional acres of habitat would be added, there would not be enough ecological benefits to make the impacts significant.

Construction-related impacts would result from the use of marine equipment, and include temporary displacement of fish and wildlife as the result of construction noise and vibrations. Less mobile species of aquatic wildlife could be buried during the fill process. Restrictions on construction periods would likely be put in place per agreements with U.S. Fish and Wildlife Service (USFWS) and VDGIF to minimize adverse effects from vibration and construction noise on species of fish and wildlife that breed in the marsh. With BMPs and limits on construction during breeding periods, adverse construction impacts are not likely to be large enough to be significant under alternative B.

Alternative B would contribute mostly beneficial impacts on wildlife in Dyke Marsh and the Potomac River to the impacts from other past, present, and reasonably foreseeable future projects. The contribution would be somewhat noticeable because it would increase the amount of available habitat to species in the local area.

IMPACTS OF ALTERNATIVE C

Impacts from the Restoration of the Marsh

Terrestrial Wildlife

The nature of the impacts under alternative C would be the same as described in the section “Impacts Common to Both Action Alternatives,” but greater in magnitude than under alternative B. There would be a greater extent of marsh restoration than under alternative B, resulting in up to 245 acres of restored marsh and other wetland habitats, including high marsh, emergent marsh, tidal guts, and areas of SAV. Tidal guts would be cut into the restored marsh area, similar to historical flow paths, to allow crucial intertidal flows into the heart of the marsh providing additional channel habitat for foraging. Impacts created from reestablishing the hydrological connection to the inland side of Haul Road are discussed in the section “Impacts Common to Both Action Alternatives” above.

Aquatic Wildlife

Under alternative C, up to 245 acres of restored wetland and marsh would provide additional refuge, forage, and spawning habitat for both fish and invertebrate species allowing their populations to increase. At high tide, the marsh would be inundated allowing small fish species such as mummichogs and killifish to access most of the marsh surface. Although most impacts under alternative C would be beneficial, there would be some long-term adverse impacts due to the loss of deeper water habitat. Unlike alternative B, which would only restore marsh in waters less than 4-feet deep, marsh restoration under alternative C would extend out beyond the negative 4-foot contour, filling in some of the deep holes that are often used by fish. Some deep hole habitat north and west of Dyke Island and south of the new breakwater would remain, but most other deep holes would be filled and restored to marsh habitat. Additionally, the deep holes north and west of Dyke Island would also be lost to marsh restoration and if the option to restore marsh habitat south of the new breakwater is exercised, the deep hole habitat in that area would be lost. However, there are no species that exclusively use these holes, and there are other deep holes in the area. Impacts created from reestablishing the hydrological connection to the inland side of Haul Road are discussed in the section “Impacts Common to Both Action Alternatives” above.

Impacts from Construction Activities

The nature of construction-related impacts under alternative C would be the same as described in the section “Impacts Common to Both Action Alternatives” above. The magnitude of the impacts, however, would be greater than alternative B due to the number, size, and location of the containment cells that would be constructed.

Cumulative Impacts

The impacts on fish and wildlife in Dyke Marsh and the Potomac River from past, present, and reasonably foreseeable future projects would be the same as those discussed under the no-action alternative. Alternative C would contribute long-term beneficial impacts on wildlife to the mostly localized adverse impacts from other projects. The contribution would be appreciable, because the cumulative adverse impacts of other past, present, and reasonably foreseeable projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative is relatively large.

Conclusion

Alternative C would increase wetland and marsh habitat by up to 245 acres, following a smaller first phase that would stabilize and slightly increase overall marsh acreage, and create a greater habitat area, and would substantially increase the number of species and population sizes over the long term. The amount of new habitat and associated benefits would be measurable and potentially significant.

Construction-related impacts would result from the use of marine equipment, and include temporary displacement of fish and wildlife as the result of construction noise and vibrations. Less mobile species of aquatic wildlife could be buried during the fill process. Restrictions on construction periods would likely be put in place per agreements with USFWS and VDGIF to minimize adverse effects from vibration and construction noise on species of fish and wildlife that breed in the marsh. With BMPs and limits on construction during breeding seasons, adverse construction impacts are not likely to be significant despite the larger extent of restored wetland under alternative C.

Alternative C would contribute long-term beneficial impacts on wildlife to the mostly localized impacts from other past, present, and reasonably foreseeable future projects. The contribution would be appreciable because the cumulative adverse impacts of other projects are for the most part localized, and the scale of the Dyke Marsh restoration under this alternative would be relatively large.

IMPACTS OF THE ALTERNATIVES ON SPECIES OF SPECIAL CONCERN

GUIDING REGULATIONS AND POLICIES

Oversight of species of special concern is assumed by the Division of Natural Heritage in the VA DCR. Dyke Marsh restoration is guided by NPS *Management Policies 2006*, specifically, “Chapter 4: Natural Resources,” which states that “the National Park Service will strive to…protect the inherent integrity of the natural resources, processes, systems, and values of the parks…” (NPS 2006). Such resources include species of special concern.

METHODS AND ASSUMPTIONS

Success of the restoration relies on the ability to restore hydrologic conditions that would allow for and encourage sediment deposition and accrual in the marsh to support habitat for plant species of concern. Although successful habitat creation is dependent upon marsh accretion, proper propagation of selected plant species would increase the success of colonization by wetland plants, including species of concern.

Use of vegetation appropriate to the elevation (water depth) within the containment cells is an important component of the restoration process. Several options can be used, depending on factors such as available seed sources, type of wetlands desired in a cell, available plant material, and cost constraints. These options include allowing plants to establish naturally by seed or other propagates, seeding mudflats, or transplanting plugs of nursery plants. Revegetation activities could be conducted by NPS staff, contractors, or volunteers.

Potential impacts on bird species of special concern, as well as their habitats, were evaluated based on known life histories and habitat requirements, and their past and present occurrence in the Dyke Marsh preserve. Information on habitat and occurrence within the Dyke Marsh preserve and potential impacts on species from the freshwater tidal marsh restoration efforts was acquired from park staff, available literature, and the discussions of subject matter experts during the science team meetings that were conducted for this restoration plan. The analysis also integrated the findings of the hydrodynamic modeling of the marsh and the surrounding area of the Potomac River under the different alternatives.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Davis' Sedge

Under the no-action alternative, Dyke Marsh would continue to erode at its current or increased rate. As stated in the vegetation and wetlands sections in chapter 3 of this document, the current rate of erosion is having a greater impact on the marsh areas; however, because the floodplain forests are not adjacent to the Potomac River, they have not been affected by the river's erosive forces; thus, they have historically been relatively stable (NPS 1993). However, the construction of Haul Road hydrologically has constricted the floodplain forest behind Haul Road. As a result, normal dispersion of marsh plant seeds has been cut off to this area, which gives an advantage to nonnative and invasive plants to colonize the floodplain forest behind Haul Road and outcompete Davis' sedge (*Carex davisii,* S1 – critically imperiled). Under the no-action alternative, the floodplain swamp behind Haul Road would continue to be hydrologically restricted and habitat for Davis' sedge would continue to be lost.

Under all of the action alternatives, it is expected that the NPS will continue to monitor the presence of nonnative plant species and work to remove them from Dyke Marsh. The removal activities will include applying herbicides to eradicate *Phragmites*, purple loosestrife, and other nonnative invasive plant species; managing volunteers who physically remove nonnative plants and tag/cut plants for later application with NPS-approved herbicides; and remove nonnative plants and debris from the Haul Road area. These practices will minimize the loss of habitat for Davis' sedge mentioned in the preceding paragraph.

Rough Avens

Under the no-action alternative, the areas behind Haul Road would continue to be hydrologically restricted from the normal ebb and flow of the tides. As a result, normal dispersion of marsh plant seeds has been cut off to this area, which gives an advantage to nonnative and invasive plants to colonize the floodplain forest behind Haul Road and outcompete rough avens (*Geum lacinatum*, S1 – critically imperiled). Under the no-action alternative, the floodplain swamp behind Haul Road would continue to be hydrologically restricted and habitat for rough avens would continue to be lost.

River Bulrush and Giant Bur-reed

Under the no-action alternative, no restoration would occur and the marsh would continue to degrade at its current or accelerated rate. The continuing loss of marsh soils and the lack of new soils being formed from sediment deposition would lead to loss of habitat for existing communities of river bulrush (*Bolboschoenus fluviatilis, S2*– imperiled) and giant bur-reed (*Sparganium eurycarpum*, S3 – watchlist, vulnerable). Because these plants both function to bind marsh soil, loss of colonies of river bulrush and giant bur-reed would make adjacent parts of the marsh more vulnerable to erosion.

Least Bittern

Loss of habitat and degradation of habitat are considered the primary threat to the least bittern (*Ixobrychus exilis,* S3 – watchlist, vulnerable) (COSEWIC 2009), and under the no-action alternative tidal freshwater marsh habitat within Dyke Marsh would continue to decline over time at a rate of approximately 6–7.8 feet per year due to erosion (Litwin et al. 2011; USACE 2012b). This continued loss of potential nesting and forage habitat for the least bittern would result in long-term adverse impacts.

Swamp Sparrow

Loss of and degradation of habitat is a primary threat to the swamp sparrow (Leberman 2008); therefore, the continued loss of nesting and foraging habitat under the no-action alternative would result in long-term adverse impacts on the swamp sparrow (*Melospiza georgiana,* S1 for breeding– critically imperiled).

Cumulative Impacts

Other past, present, and reasonably foreseeable future actions in the vicinity of Dyke Marsh have the potential to impact plant and bird species of concern in the marsh and the adjacent Potomac River. The construction of the new Woodrow Wilson Bridge in Alexandria in the 2000s and the development of the National Harbor in the 2000s adversely impacted both bird species locally through the loss of wetlands and the hardening of shoreline habitat in the vicinity of Dyke Marsh. The no-action alternative would continue to contribute adverse effects on the three plant species of concern in the marsh to the adverse impacts from other projects. The contribution from the impacts of the no-action alternative would be appreciable because of the large acreage of marsh that would eventually be lost.

The loss of approximately 25 acres of tidal and nontidal wetlands habitat as part of the new Woodrow Wilson Bridge was mitigated through the creation of an additional 100 acres of wetland habitat in Virginia, Maryland, and the District of Columbia, which has likely benefited both species of birds regionally. In the short term, contributions from the no-action alternative to the cumulative effects on the least bittern and the swamp sparrow would likely be imperceptible, but in the long term, with the continued erosion of the freshwater tidal marsh and loss of habitat, the no-action alternative would likely contribute a noticeable amount of adverse effects to the overall cumulative effects on both species of birds in the local area. The construction of the bridge included dredging and pile driving and has affected the hydrology locally at the bases of the bridge structures by forcing the water around the bridge piers, and where the water is deeper, in the narrower shipping channel, flow velocities are higher. Increased flow velocities raise the erosion potential of Dyke Marsh; however, as stated above, these impacts are focused more on the open marsh rather than the floodplain forest.

In addition, the development of the National Harbor in Prince George’s County, Maryland, has led to increased ferry traffic in the Potomac River (Potomac River Boat Company 2013). Although the ferries operate mostly in the commercial channel, it creates wakes that can cause short-term elevations in water velocity that can cause erosion of the edges of Dyke Marsh; however, as stated above, these impacts are focused more on the open marsh rather than the floodplain forest.

The no-action alternative would also continue to contribute adverse effects on both bird species of concern in the marsh to the adverse effects from other projects. The contribution from these impacts would be noticeable because habitat for these birds would be decreased over time.

Conclusion

Under the no-action alternative, the floodplain swamp behind Haul Road would continue to be hydrologically restricted and habitat for Davis' sedge and rough avens would continue to be lost.

The continuing loss of marsh soils and the lack of new soils being formed from sediment deposition would lead to loss of habitat for existing communities of river bulrush and giant bur-reed. Because these plants both function to bind marsh soil, loss of colonies of river bulrush and giant bur-reed would make adjacent parts of the marsh more vulnerable to erosion. Continued loss of marsh would also result in loss of potential nesting and forage habitat for the least bittern and swamp sparrow, and would result in long-term adverse impacts for both species of birds.

Because it is expected that the marsh would completely erode over time and it provides important habitat for these state-listed species of concern, the adverse impacts on the river bulrush, giant bur-reed, and both bird species would be significant.

The no-action alternative would continue to contribute adverse effects on the three plant species of concern and both bird species of concern in the marsh to the adverse impacts from other projects. The contribution from the impacts of the no-action alternative would be appreciable because of the large acreage of marsh that would eventually be lost, and because habitat would be reduced.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Impacts from the Restored and Expanded Marsh

Under both action alternatives the construction of a breakwater in the vicinity of the historic promontory and the filling of the deep channels that resulted from prior dredging would decrease water velocities and encourage sediment deposition, both of which would help protect Hog Island Gut and the existing marsh from further erosion (see "Impacts of the Alternatives on Hydrology and Sediment Transport"). This, along with the construction of new marsh habitat using containment cells, would help preserve existing habitat, as well as add new marsh habitat. As part of the restoration process, in addition to natural seed recruitment, the new containment cells could be planted with cattails, river bulrush, and wild rice, along with other plant species, or other revegetation methods would be used. Cattail and bulrush are two species preferred by the least bittern for nesting (COSEWIC 2009), and cattails mixed with other vegetation, such as sedge, is some of the preferred nesting habitat for swamp sparrows (U.S. Forest Service n.d.). However, as discussed in detail in the section "Impacts of the Alternatives on Fish and Wildlife," grazing by resident Canada geese can greatly damage restored marsh vegetation. To prevent damage to new vegetation by geese, and protect habitat for plant and animal species of special concern, goose exclosures would be erected in the containment cells. The exclosures have proven successful at Kingman Marsh (Hammerschlag et al. 2006) and their use at Dyke Marsh would allow the restored marsh to grow without the pressure of goose herbivory while providing habitat for birds and other wildlife, including the least bittern and the swamp sparrow.

In addition to nesting habitat, restoring Dyke Marsh would also provide long-term beneficial impacts on the least bittern and swamp sparrow through increased foraging opportunities. Restoration of the marsh would provide habitat for and increase the population of small fish such as killifish, as well as frogs, and invertebrates which are all prey for the least bittern (Yolo Natural Heritage Program 2009). Insect populations would also increase, as would the availability of plant seeds, which are the main staples in the swamp sparrow's diet (U.S. Forest Service n.d.). The magnitude of the impacts, however, would vary by action alternative based on the amount of marsh habitat restored.

Changes in Wetlands along Haul Road

Under both action alternatives, the creation of breaks along Haul Road would allow tidal flows to pass under the road and into the former bottomland swamp forest, which would allow for the restoration of the bottomland swamp forest. The restored hydrology and sediment transfer would result in beneficial impacts on hydrology and sediment transfer in the area behind Haul Road because the breaks would allow past hydrologic conditions to be reestablished, and that would allow desirable ecologic conditions to be reestablished. The reconnections would discourage continued establishment of nonnative and invasive plants in the areas with restored hydrologic connection because of repeated inundation in which nonnative plants do not grow well, and the creation of conditions that would encourage reestablishment of native plants that prefer this type of habitat, including rough avens.

Because the bottomland floodplain swamp forest on the inland side of Haul Road does not provide habitat for the least bittern or the swamp sparrow, reestablishing the hydrological connection to the inland side of the road would not impact either the least bittern or the swamp sparrow.

Impacts from Construction Activities

Under both action alternatives, the marsh would be reestablished using mostly large and some smaller, strategically-placed containment cells. The cells would be designed to hold fill material until enough fill can be placed to the right elevation to support appropriate vegetation, and then settle enough that plants can colonize or the area can be planted. The containment cells would purposely prevent flow into the interior of the containment cells until the fill process is complete, and they are ready to be planted. Intertidal exchange in the wetlands outside the containment cells would continue, although water would flow around the cells, and up Hog Island Gut. Thus, there would be short-term adverse impacts on plant species of concern behind the cells because sediment transfer patterns would change. Normal flow of tidal water to the landward most area of the marsh would be restricted while the containment cells stabilize and planted with vegetation. However, the containment cells would not block the entrance to Hog Island Gut; therefore, water would still flow to the inside of the marsh, but the inside of the marsh may not experience as long an inundation period as before construction.

Construction of the breaks under Haul Road would be contained, to the extent practicable, to the footprint of Haul Road only. It would not be necessary to take construction equipment and machinery into the marsh or the forested area behind Haul Road; additionally, detailed surveys for species of concern would be performed prior to construction so that they may be avoided. Therefore, it is unlikely that there would be impacts on plant species of concern from these activities. However, it is expected that the construction activities along Haul Road would have short-term adverse impacts on the least bittern and the swamp sparrow due to noise and increased human activity.

There would be no construction-related impacts on plant species of special concern associated with the construction of the breakwater using armorstone because these activities would take place off land from barges.

Construction activities under both action alternatives would take place from the water, to the greatest extent possible, using marine construction equipment with materials brought in by barge. This includes activities for constructing the breakwater in the vicinity of the historic promontory as well as the various containment cells for creating new vegetated marsh. Temporary displacement of both bird species near the construction area would be likely. With construction activities being conducted from the water and only in those areas near the edge of marsh, individuals located in the interior or landward edge of the marsh may not be impacted. Once construction is completed, both bird species would be expected to readily recolonize the marsh. To prevent disturbance of the birds during their breeding seasons;

restrictions on construction activities would be put into place after consultation with VDGIF. Breeding season for the least bittern is approximately April through mid- to late-June (Yolo Natural Heritage Program 2009) and is mid-May through late-July for the swamp sparrow (U.S. Forest Service n.d.). The NPS would coordinate with the VDGIF during the permitting process for the project.

IMPACTS OF ALTERNATIVE B

Davis' Sedge

As stated above, both alternatives involve breaks in Haul Road, which would allow for tidal flows to pass under Haul Road to the former bottomland floodplain swamp forest. This activity would allow for ecological conditions more favorable for the development of suitable habitat for Davis' sedge; the restored hydrology would transport seeds of native species behind Haul Road, making them better able to compete with the current assemblage of invasive nonnative plant species. Under these conditions, there would be an increase in the preferred habitat of Davis' sedge. Under all of the action alternatives, the NPS would continue to eradicate nonnative invasive species, as mentioned under the no-action alternative subsection of this section.

As stated above, there is slight risk of impacts from the construction of the breaks in Haul Road to species of concern. If construction activity is allowed to occur off of Haul Road, existing populations of Davis' sedge could potentially be impacted if they are not properly identified prior to construction. It is assumed that the NPS would identify the populations of Davis' sedge prior to construction, place protective barriers around these populations, and alert construction crews to their whereabouts so that none of the existing populations of Davis' sedge would be impacted from construction activity. It is also assumed that construction of the breaks in Haul Road would take place exclusively from Haul Road and that BMPs, such as silt fencing, would be used if it is necessary to conduct construction activities in the forested area behind Haul Road. BMPs include protecting existing populations of Davis' sedge, as mentioned above, and preventing construction debris from entering into the floodplain forest by establishing silt fences and other erosion and sediment control measures.

Rough Avens

The population of rough avens identified in Dyke Marsh occur along Haul Road (NPS 2009f). Impacts on rough avens under alternative B, therefore, would be similar to those for Davis' sedge.

River Bulrush and Giant Bur-Reed

Under alternative B, approximately 70 acres of restored marsh and other wetlands would be created, including marsh north of the historic promontory. A breakwater structure would be constructed on the south end of the existing marsh, in alignment with the northernmost extent of the historic promontory, and wetlands would be restored to wherever the water is less than 4-feet deep. Marsh cells would be placed along the edge of the existing marsh; these cells would be planted with native wetland species that already exist in marshes of Dyke Marsh (USACE 2012a). Construction of the breakwater would attenuate the velocity of flowing tidal water, which would shield the marsh from erosive currents and protect the Hog Island Gut channel and channel wall. Decreasing the rate of erosion and attenuating the flow of tidal water would prevent stabilized soil from eroding and allow suspended sediment to accrete on the constructed marsh cells.

The construction of the breakwater along with the construction of the marsh cells would protect the existing habitat of the river bulrush and giant bur-reed, as well as provide new habitat for these species of concern. Because the roots of river bulrush and giant bur-reed provide a mechanism to stabilize marsh soils (Runkel and Roosa 1999), their success would increase the probability that more habitat would form under alternative B.

Construction-related impacts from the partial blockage of flows into the existing marsh by the containment cells would be as described in the section “Impacts Common to Both Action Alternatives,” but would be relatively small, given the more limited scope of marsh restoration under this alternative.

Least Bittern and Swamp Sparrow

While the nature of the impacts described in the section “Impacts Common to Both Action Alternatives” do not vary among the action alternatives, the magnitude of the impacts differ depending on the alternative due to the amount of marsh to be restored.

Under alternative B, approximately 70 acres of new marsh and wetland habitat would be restored, providing long-term beneficial impacts through the creation of new nesting and foraging habitat for both the least bittern and the swamp sparrow. However, the actual amount of vegetated emergent marsh habitat created would be slightly less than 70 acres due to the sloped design within the outermost containment cells to provide for a soft natural edge to the marsh.

Impacts from Construction Activities

The nature of construction-related impacts under alternative B would be the same as described in the section “Impacts Common to Both Action Alternatives” above. The magnitude of the impacts under alternative B would be the least among the action alternatives due to the more limited scope of the marsh restoration under this alternative.

Cumulative Impacts

The impacts on species of concern in Dyke Marsh from past, present, and reasonably foreseeable future projects on plant species and bird species of concern would be the same as those discussed under the no-action alternative. Alternative B would contribute long-term beneficial impacts on habitat for the plant and bird species of concern in Dyke Marsh to the mostly localized but adverse impacts of other projects. This contribution would be noticeable, because most of the cumulative impacts from other actions are localized and have a limited effect on the vegetation in the immediate area of the marsh, and implementation of alternative B would increase the marsh area overall and protect and stabilize the current marsh area. The alternative would also contribute some short-term adverse impacts to the overall scenario. Contribution of these short-term adverse construction-related impacts, with mitigation, would be imperceptible.

Conclusion

Restoration of marsh would provide additional nesting and foraging habitat for both the swamp sparrow and the least bittern, and increase acreage in which river bulrush and giant bur-reed could become established, resulting in long-term beneficial impacts. Approximately 70 acres of wetland and marsh habitat would be restored.

Reconnection of tidal flows west of Haul Road would discourage continued establishment of nonnative and invasive plants in the areas with restored hydrologic connection, and would create conditions that would encourage reestablishment of rough avens and Davis’ sedge. The NPS would identify the populations of Davis’ sedge and rough avens prior to construction, and protect the plants during construction activity.

Temporary displacement of both bird species near the construction area would be likely during construction. Both bird species would be expected to readily recolonize the marsh after construction was complete. To prevent disturbance of the birds during their breeding seasons, restrictions on construction would be put into place in consultation with the state.

The long-term benefits would be noticeable, but not large enough in magnitude to be significant. Because BMPs would be incorporated and there would be limitations on construction during breeding periods, impacts related to construction would be short-term adverse, but not significant.

Alternative B would contribute long-term beneficial impacts on habitat for the plant and bird species of concern in Dyke Marsh to the mostly localized adverse impacts of other projects. This contribution would be noticeable. The alternative would also contribute some short-term adverse impacts to the overall scenario. With mitigation, the contribution of these short-term adverse construction-related impacts would be imperceptible.

IMPACTS OF ALTERNATIVE C

Davis' Sedge

Impacts on Davis' sedge under alternative C would be the same as those under alternative B.

Rough Avens

Impacts on rough avens under alternative C would be the same as those under alternative B.

River Bulrush and Giant Bur-Reed

Under alternative C, there would be a greater extent of marsh restoration than under alternative B, resulting in up to 245 acres of restored wetland and marsh, including high marsh, emergent marsh, tidal guts, and areas of SAV, as well as new tidal guts to allow crucial intertidal flows into the heart of the marsh (USACE 2012a).

Under alternative C, the promontory mass would be reestablished as flows from the Hog Island Gut channel would be directed in a northerly direction around the wetlands. Similar to alternative B, the increased acreage of wetland cells would provide habitat for river bulrush and giant bur-reed. Although alternative C would restore nearly 175 more acres of wetlands and marsh, not all of that area would provide habitat for river bulrush or giant bur-reed as some of the area would be used for the restoration of SAV. River bulrush and giant bur-reed are capable of inhabiting areas that experience daily inundation; however, they cannot survive when permanently covered in water (Runkel and Roosa 1999; Gleason and Cronquist 1991). Thus, in permanently submerged areas on the edge of the resultant marsh, SAV species would potentially populate.

Construction-related impacts from the partial blockage of flows into the existing marsh by the containment structures would be as described in the section "Impacts Common to Both Action Alternatives," but would be relatively small, given the more limited scope of marsh restoration under this alternative.

Least Bittern and Swamp Sparrow

The nature of the impacts under alternative C would be the same as described in the section "Impacts Common to Both Action Alternatives," though there would be a greater extent of marsh restoration than under alternative B, resulting in up to 215 acres of restored marsh (excluding the wetlands west of Haul Road) extending from the breakwater to Dyke Island and east to the park property line as well as marsh restoration south of the breakwater and the optional area of containment cells in the area north of Dyke Island that is currently serving as the boat mooring area for the Belle Haven marina. As discussed under alternative B, due to the creation of a soft edge to the restored marsh, the actual amount of emergent vegetation in the restored marsh that could provide suitable nesting habitat for the least bittern and swamp sparrow would actually be less than the 245 acres. Overall, the creation of new nesting and foraging habitat would result in long-term beneficial impacts.

Impacts from Construction Activities

The nature of construction-related impacts under alternative C would be the same as described in the section “Impacts Common to Both Action Alternatives” above. The magnitude of the impacts, however, would be greater than alternative B due to the number, size, and location of the containment cells that would be constructed.

Cumulative Impacts

The impacts on species of concern in Dyke Marsh from past, present and reasonably foreseeable future projects on plant species of concern would be the same as those discussed under the no-action alternative. Alternative C would contribute long-term beneficial impacts on habitat for the plant and bird species of concern in Dyke Marsh to the mostly localized adverse impacts of other projects. The contribution would be noticeable, and possibly appreciable, given the greater extent of marsh restored under alternative C than alternative B. The contribution of short-term adverse construction impacts from this alternative would be more noticeable than under alternative B, but would still be imperceptible.

Conclusion

The impacts on Davis’ sedge and rough avens would be the same as under alternative B. The larger acreage restored under alternative C would provide similar benefits for the marsh plants river bulrush and giant bur-reed, and for both bird species, by increasing acreage in which the plants could occur, and by increasing nesting and foraging habitat. The magnitude of the benefits could result in these impacts being significant.

Construction impacts would be similar to those described under alternative B, although they would be more extensive, and would be temporary. Restrictions on construction periods would be put in place in consultation with VDGIF to avoid interference with breeding seasons. With these and other BMPs in place, construction impacts would not be significant.

Alternative C would contribute long-term beneficial impacts on habitat for the plant and bird species of concern in Dyke Marsh to the mostly localized adverse impacts of other projects. The contribution would be noticeable, and possibly appreciable, given the greater extent of marsh restored under alternative C than alternative B. The contribution of short-term adverse construction impacts from this alternative would be more noticeable than under alternative B, but would still be imperceptible.

IMPACTS OF THE ALTERNATIVES ON ARCHEOLOGICAL RESOURCES

GUIDING REGULATIONS

Impacts on archeological resources are regulated by the NEPA and Section 106 of the National Historical Preservation Act, as well as the Archeological Resources Protection Act of 1979 and the Antiquities Act of 1906.

METHODS AND ASSUMPTIONS

Fastland is land near water that is high and dry.

The George Washington Memorial Parkway which encompasses the Mount Vernon Memorial Highway, was conceived from its origin as having historical and natural components, connecting key historic sites along a route regularly traveled by George Washington, as well as creating a public park along the scenic Potomac River. Dyke Marsh is both a scenic natural resource and a surviving part of the historic landscape of Washington's era. The study area for the Archeological Resource Impact study is identical with the project area narrowly defined, that is, the marsh itself and the immediately surrounding areas that might be impacted by restoration efforts. Information on the archeological resources of the marsh comes from the Phase IA archeological study (Shellenhamer 2008). The most important archeological resource in the project area is the surviving remnant of the dyke that gave the marsh its name. The Phase IA study raised the possibility that undiscovered archeological sites from the Archaic or Paleoindian periods might be present in the undisturbed portions of the marsh, although no such drowned sites have been documented anywhere along the Potomac River. Prehistoric or historic period sites might also be present in the fastland portion of the project area behind Haul Road, and in other upland areas.

Analysis of possible impacts on archeological resources has been guided by the assumption that surviving, intact areas of marsh would be protected during construction.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, the marsh would continue to erode. This ongoing erosion would wash away or potentially damage the archeological resources of the George Washington Memorial Parkway. The short surviving section of the dyke that gave the marsh its name would be particularly threatened, and might be completely lost in a few decades. If any undiscovered archeological sites are present in the marsh, erosion would threaten them as well.

Cumulative Impacts of the No-action Alternative (Alternative A)

The impacts on archeological resources of past, present, and reasonably foreseeable projects, including the ongoing and future Potomac Yards metro station, George Washington Memorial Parkway North Parkway Rehabilitation, the land exchange at Langley Fork Park, and the Arlington boathouse, as well as the completed Woodrow Wilson Bridge replacement and associated work in Jones Point Park, have been, or are expected to be addressed through the Section 106 consultation process. Archeological survey has been or will be carried out as part of all of these projects, and measures to protect resources or mitigate disturbance have been or will be implemented. The no-action alternative would allow the marsh to continue to erode, threatening the surviving remnant of the dyke and any other archeological resources that might be present along the river's shoreline, and would contribute potential adverse effects to the effects of the other projects. This contribution would likely range from noticeable to appreciable.

Conclusion

Ongoing erosion would wash away or potentially damage known and unknown archeological resources of the George Washington Memorial Parkway. The short surviving section of the dyke that gave the marsh its name would be particularly threatened, as would other archeological resources that might be present in the marsh, but have not been discovered. Impacts from the no-action alternative (alternative A) would be unlikely to be significant, because it is anticipated that the park would review the condition of known archeological sites and implement a program to minimize the loss of integrity of sites threatened by erosion or other factors.

The no-action alternative would allow the marsh to continue to erode, threatening the surviving remnant of the dyke and any other archeological resources that might be present along the river's shoreline, and would contribute potential adverse effects to the effects of the other projects. This contribution would likely range from imperceptible to noticeable, depending on whether the dyke remnants are harmed.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Long-Term Impacts

The impact on archeological resources for both of the action alternatives would be the same, because the nature of the work is the same for both alternatives. The scale of the restoration under the two alternatives would not affect the impacts on archeology. The most important impact would be the positive one of stabilizing the marsh and reducing erosion, and therefore preventing unintentional exposure of unknown archeological resources in the marsh. Reducing erosion would protect any Paleoindian, Archaic, or historic sites that may be present in or adjacent to the marsh.

There are not expected to be impacts to archeological resources related to placing breaks in Haul Road, and reintroducing tidal flows to the area west of Haul Road. Tidal flows west of Haul Road would be low energy, and would not result in much, if any, erosion in areas that might contain archeological resources. Some erosion is possible at the breaks in Haul Road, but because the road itself is fill material, and engineering studies would minimize erosion through proper design, impacts on undiscovered archeological resources would not be likely to occur.

Construction-related Impacts

Construction of the new marsh areas would be done from barges to limit the impact on surviving areas of the marsh. This approach would also limit damage to any archeological sites within the marsh. Any archeological sites would already have been destroyed in any areas that have been dredged, and they would have probably have been severely disturbed under Haul Road (Shellenhamer 2008). Therefore, the areas where the soil would be impacted during construction are highly unlikely to contain any archeological remains (Shellenhamer 2008).

Since it is believed that past dredging activity would have destroyed archeological remains other than the dike remnants within the proposed construction areas, and construction methods would be used to protect the dike remnants, no archeological resources would be disturbed, and there would be no construction-related impacts on archeological resources.

Although there are no known archeological resources other than the dike remnants in and adjacent to the marsh, it is possible that archeological resources could be discovered during construction. If archeological resources are discovered during construction, all work in the immediate vicinity of the discovery would be halted until the resources can be identified and documented and an appropriate mitigation strategy can be developed. Consultation with the Virginia State Historic Preservation Office (SHPO), the NPS, and/or the NPS regional archeologist will be coordinated to ensure that the protection of resources is addressed. In the unlikely event that human remains, funerary objects, sacred objects, or objects of cultural patrimony are discovered during construction, provisions outlined in the Native American Graves Protection and Repatriation Act (25 USC 3001) of 1990 would be followed. In addition, fill material would come from approved sources, most likely river bottoms, and would not come from any areas with archeological potential. Protection of the dike remnants are discussed under the impacts to historic structures, districts and cultural landscapes.

Cumulative Impacts Common to Both Action Alternatives

The cumulative scenario discussed under alternative A would apply for both action alternatives, and impacts have been or will be identified, avoided, or mitigated under the Section 106 review process. The restoration of the marsh and reduction of erosion under both action alternatives would contribute beneficial impacts on archeological resources in the park to impacts from other projects by protecting the archeological resources in Dyke Marsh. The contribution would be appreciable.

Conclusion

Restoration activities under both alternatives would stabilize the marsh and substantially reduce erosion, which would therefore protect archeological resources in and adjacent to the marsh. The impacts would be the same for both alternatives. Introduction of low energy tidal flows west of Haul Road would not affect any archeological resources. Construction activities in the marsh would take place from the water and would not affect archeological resources, and construction to create breaks in Haul Road also would not affect archeological resources, because the road is built on fill material and archeological resources below the road would have been extensively disturbed in the past. Reducing the likelihood of erosion and unanticipated exposure and harm to archeological resources would be beneficial but not significant; erosion could still occur, and archeological resources could still be harmed or washed away in large storm events.

The restoration of the marsh and reduction of erosion under both action alternatives would contribute beneficial impacts on archeological resources in the park to impacts from other projects by protecting the archeological resources in Dyke Marsh. The contribution would be appreciable.

IMPACTS OF THE ALTERNATIVES ON HISTORIC STRUCTURES AND DISTRICTS, AND CULTURAL LANDSCAPES

GUIDING REGULATIONS

Impacts on historic resources are regulated by the NEPA and Section 106 of the National Historical Preservation Act.

METHODS AND ASSUMPTIONS

Dyke Marsh is part of the Mount Vernon Memorial Highway, which is part of the larger George Washington Memorial Parkway. Both roads are listed in the NRHP as historic districts (NPS 1981; NPS 1995). The historic district is nationally significant under Criteria B and C. Under Criterion C, the district is significant for its landscape architecture as part of the long and continuous planning of the Washington, D.C., region. The George Washington Memorial Parkway was conceived from its origin as having historical and natural components, connecting key historic sites along a route regularly traveled by

George Washington and creating a public park along the scenic Potomac River. Dyke Marsh fits into both categories, as both a scenic natural resource and a surviving part of the historic landscape of Washington's era. The study area for the Historic Structures and Districts Impact study includes the project area narrowly defined, that is, the marsh itself and the immediately surrounding areas that might be impacted by restoration efforts, as well as the adjacent sections of the Parkway from which the marsh might be visible.

Dyke Marsh has not yet been formally identified as a cultural landscape, although it may qualify as a component landscape of the Mount Vernon Memorial Highway and George Washington Memorial Parkway historic districts. As defined by the NPS, a component landscape is "a definable physical area of a landscape that contributes to the significance of a National Register property, or, in some cases, is individually eligible for listing in the National Register" (NPS 1998b). A future cultural landscape inventory would be needed to formally identify the character-defining features of the Dyke Marsh landscape as they relate to the Mount Vernon Memorial Highway cultural landscape or as they contribute to a separate independent cultural landscape. Regardless, the scenic qualities of the marsh area and the views to it from the parkway are noted in the National Register nomination and cultural landscape report (NPS 1981; NPS 1995; NPS n.d.c) and thus are important features of the parkway cultural landscape. None of the alternatives would disturb, and therefore would not have any impact on the plantings or other landscape elements along the Parkway.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, the marsh would continue to erode. Since the marsh is a feature of the historic landscape and a contributing element of the cultural landscape, present in George Washington's time and when the George Washington Memorial Parkway was created, its loss would be a measurable adverse impact on the George Washington Memorial Parkway historic district. Continued erosion of Dyke Marsh would therefore degrade the cultural landscape of the George Washington Memorial Parkway, and result in a long-term adverse impact on the historic districts and their component landscapes; an important scenic component of the landscape would disappear.

Cumulative Impacts of the No-action Alternative (Alternative A)

Other recent major projects undertaken along the Potomac in the vicinity of the George Washington Memorial Parkway, especially the construction of National Harbor and the new Wilson Bridge have had a noticeable impact on the George Washington Memorial Parkway by changing or impeding river views from the parkway and the shore adjacent to the marsh. Other projects, such as the land exchange at Langley Fork Park, the Potomac Yards Metro Station, George Washington Memorial Parkway North Rehabilitation project, Memorial Circle safety improvements and the proposed boathouse on parkway land in Arlington have the potential to affect the George Washington Memorial Parkway historic district overall. The effects of many of these projects on the historic district are not yet determined, but consultation with the SHPO is underway or will be conducted to identify these impacts and identify mitigation measures or ways to minimize and avoid impacts. Under the no-action alternative, Dyke Marsh would experience continued loss to erosion, and would contribute an adverse effect to the impacts of the other projects in the park. The contribution would therefore be appreciable, because the no-action alternative would result in the loss of a prominent landscape feature.

Conclusion

Erosion of the marsh under alternative A would result in long-term adverse effects under NEPA on historic districts and associated component landscapes, because a landscape feature important to the George Washington Memorial Parkway and Mount Vernon Memorial Highway would disappear. These impacts would be noticeable, and could rise to a level of significance because of the marsh's importance as a scenic feature in the historic district.

The no-action alternative would contribute an adverse effect to the impacts of the other projects in the park. The contribution would therefore be appreciable, because the no-action alternative would result in the loss of a prominent landscape feature.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Long-term Impacts

The main impact of all the action alternatives on the historic district and cultural landscape would be the positive effect of reducing or reversing the erosion of the marsh, as well as establishing additional marsh, moving the close in views from the parkway toward how they would have looked when the parkway was first constructed.

All of the action alternatives would also ultimately protect the surviving remnant of the original dyke through the reversal of erosion and restoration of marsh around the dyke remnant. In addition, all of the action alternatives would involve modifying Haul Road to allow water to pass through via culverts or boardwalk bridges similar to those found further down Haul Road and along the length of the trail along the parkway. Culvert structures, which are typically concrete boxes or pipes, could be a noticeable modern feature, depending on how they are installed and how large they are. Boardwalk bridges would be consistent with existing features on Haul Road and elsewhere in the park, and could represent a less noticeable visual intrusion than the culverts. However, Haul Road is not considered a significant landscape feature, and is not visible from the parkway, although they might be visible from the end of Haul Road in the marsh, so these impacts on both the historic district and the cultural landscape would be minimal.

The one new landscape feature proposed under all of the alternatives would be the armorstone breakwater constructed at the historic promontory, extending into the river near the southern edge of the marsh. This feature would represent an intrusion and change to the local landscape. The breakwater could be visible from close distances, and would be visible from the parkway and Mount Vernon Trail under alternative B. However, it would be low-profile, just tall enough to shield the marsh from waves during a storm and would not block views of the marsh from the park. Views of the breakwater would be shielded or completely obscured by restored marsh under alternative C, and would be further away from the point at which it would be visible from the parkway. It would not be visible from the south along the parkway.

Construction-related Impacts

Construction activities would result in short-term adverse impacts on the cultural landscape of the park. The containment cell structures, particularly those made of steel sheet piling, would be very visible in the near distance, and would disrupt the views beyond the natural marsh landscape. Construction barges would also be relatively noticeable in the middle distance, and would stay in place for days to months. The extent to which these construction features are noticeable would vary with each alternative and the level of restoration effort. Because there are other disturbances to views in the further distance (described under cumulative impacts), and there has long been substantial barge traffic on the river, the intensity of these short-term impacts would be mitigated to some extent.

Both action alternatives propose restoration in the immediate vicinity of the surviving dyke remnants. In the long term this would further protect the resource, but measures would have to be taken during construction to ensure that no damage is done to these dyke remnants. The greatest danger is that the dyke would be accidentally damaged by digging too close to its base, or by collisions with boats or barges. To prevent such damage, an exclusion zone would be established around the dyke, extending perhaps 10 feet from the feature, delineated by a high-visibility barrier such as snow fence with warning signs. Coupled with a verbal briefing of construction personnel, this would greatly reduce the likelihood of accidental impacts.

IMPACTS OF ALTERNATIVE B

Long-term Impacts

Alternative B would restore the fewest acres of marsh vegetation of all the action alternatives. However, this plan is intended to halt ongoing erosion of the marsh, and as such it would stabilize the historic landscape and protect the dyke remnants, resulting in long-term beneficial impacts. The stone breakwater would be visible from the opening in the parkway and Mount Vernon Trail near the turnaround/pulloff at the southern end of the marsh. Approximately 2 feet of breakwater would be visible immediately south of the opening in the view from the parkway, depending on the stage of the tide. There would be no vegetation in place to screen the view of the breakwater, so it would be an adverse effect on the historic viewshed.

Construction-related impacts would be the same as those described in the impacts common to all alternatives sections, although they would be smaller in scale than impacts under alternative C.

Cumulative Impacts of Alternative B

The same projects discussed in the cumulative impact analysis for alternative A have impacted or would impact historic district and cultural landscape of the George Washington Memorial Parkway under both action alternatives, by changing or impeding river views. Alternative B would contribute beneficial impacts to the impacts from the other projects by halting the erosion of Dyke Marsh and therefore limiting the deterioration of the landscape, but it would also contribute adverse effects to the viewshed, and would not mitigate the cumulative harm from the other projects that affect the viewshed. The contribution of beneficial impacts would be noticeable, and the contribution of adverse effects to the viewshed would range from noticeable to appreciable depending on the viewpoint and duration of the view (duration depends on whether the viewer is in the park or driving by).

Conclusion

Marsh restoration under alternative B would stabilize and restore the marsh, resulting in beneficial impacts on the historic landscape. The existing remnants of the dike would be protected by reduced erosion, and by measures put in place during construction. The breakwater would be constructed of large stones, and would therefore look somewhat natural, but it would be visible from the parkway, and would not be screened, resulting in adverse impacts on the historic landscape. Changes introduced to the landscape by the breakwater would be very noticeable and possibly significant, depending on the viewpoint and duration of the view.

Alternative B would contribute beneficial impacts to the adverse impacts on cultural landscapes and historic districts from the other projects by halting the erosion of Dyke Marsh and therefore limiting the deterioration of the landscape, but it would also contribute adverse effects to the viewshed. The contribution of the beneficial impacts would be noticeable, and the contribution of adverse effects to the viewshed would range from noticeable to appreciable depending on the viewpoint and duration of the view (duration depends on whether the viewer is in the park or driving by).

IMPACTS OF ALTERNATIVE C

Long-term Impacts

Alternative C envisages substantial restoration of the marsh vegetation, which would have a positive impact on the George Washington Memorial Parkway Historic District and its associated landscape. There would be an adverse long-term impact from the construction of the breakwater. However, the breakwater under alternative C would not be particularly noticeable because it would be a little over 500 feet south of the opening of the view near the parkway turnaround/pullout at the southern end of the marsh, and would also mostly be screened or obscured by marsh plantings once restoration is complete. The restoration of the marsh to much of its historic extent would be beneficial for the historic district, since visitors would see something much more like the historic state of the marsh at the time the parkway was created and earlier.

Construction-related Impacts

Construction-related impacts would be the same as discussed under impacts common to all, but would be greater in magnitude than under alternative B, because of the larger area of restoration. Dyke remnants would be protected.

Cumulative Impacts of Alternative C

Other recent major projects undertaken in the vicinity of the George Washington Memorial Parkway and their impacts are the same as discussed under alternative A. Restoration of Dyke Marsh under alternative C would contribute beneficial impacts on the cultural landscape and historic district to the adverse impacts of the other projects. The contribution would be appreciable, because erosion of the marsh would be prevented and the breakwater would not be highly intrusive.

Conclusion

Marsh restoration under alternative C would stabilize and restore a large area of marsh, resulting in beneficial impacts on the historic landscape. The existing remnants of the dike would be protected by reduced erosion, and by measures put in place during construction. The breakwater would be constructed of large stones, would be further south than the breakwater under alternative B, and would be developed into a wider promontory covered with marsh plantings, so it would not be particularly noticeable from the parkway. It would represent a minimal intrusion into the historic landscape, and the impacts would not be significant.

Restoration of Dyke Marsh under alternative C would contribute beneficial impacts on the cultural landscape and historic district to the adverse impacts of the other projects. The contribution would be appreciable, because erosion of the marsh would be prevented and the breakwater would not be highly intrusive.

IMPACTS OF THE ALTERNATIVES ON VISITOR USE AND EXPERIENCE

GUIDING REGULATIONS AND POLICIES

Enjoyment of park resources and values by the people of the United States is fundamental to the purpose of all national parks. The NPS is committed to providing appropriate, high-quality opportunities for the public to enjoy the parks. Because not all recreational activities are appropriate for each park, the NPS will encourage activities that are appropriate to the purposes for which the park was established, are appropriate to the unique park environment, will promote enjoyment through direct association with park resources, and can be sustained without causing unacceptable impacts on park resources or values (NPS 2006, Section 8.2).

Overall, the management of visitor use and experience, like all management decisions affecting the resources of a national park, is subject to the Organic Act. It is this foundational law that requires NPS to “provide for the enjoyment” of the national parks while also leaving them “unimpaired for future generations.” Where there is conflict between the public enjoyment of a park area and the conservation of a park value or resource, then “conservation is to be predominant” (NPS 2006, Section 1.4.3).

Appropriate uses within Dyke Marsh include boating activities at the Belle Haven Marina as well as passive recreation activities such as walking, running, biking, bird-watching, and nature study, as described in chapter 3.

METHODS AND ASSUMPTIONS

The Dyke Marsh restoration alternatives could impact the visitor experience by reducing or limiting the principle visitor uses during construction. When available, quantitative information was used to assess the overall change to any existing visitor use patterns or satisfaction levels. This assessment considers the availability of existing recreational opportunities, as well as the accessible areas, to assess the level of impacts for each action. Data used in this analysis, including visitor statistics, historic use patterns, and visitor use observations obtained from park rangers, is presented in chapter 3.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, no restoration would occur. Existing visitor use in the area would continue, mainly located along the Mount Vernon trail and within the Belle Haven Marina. Within the marsh, existing volunteer program activities associated with shoreline cleanup and the River Steward program would continue. Fishing, nature-viewing, kayaking, and canoeing could continue within the vicinity of the marsh, although the increasing open water areas would be more exposed to wind and currents over time, changing the nature of the experience from the water, and possibly decreasing the enjoyment for many users.

No manipulation of the marsh would occur other than emergency, safety-related, or limited improvements or maintenance actions and the marsh would continue to degrade. Without on-going maintenance, the southern portion of Haul Road where it extends into the marsh could potentially become submerged as the marsh erodes and disappears. This area is currently heavily used by birders. Should parts of Haul Road be lost, these visitors would no longer be able to use those parts of the trail, and would experience long-term noticeable impacts on the quality of their visitor experience. Visitor use would be noticeably impacted as visitor use in that area would be restricted, although changes to visitor use and experience would take place gradually.

Cumulative Impacts

Two past actions contribute to cumulative visitor use and experience impacts. The Woodrow Wilson Bridge was completed in 2006, replacing an existing bridge and slightly changing the viewshed from Dyke Marsh. Given the amount of development within the area, this change was likely not noticeable to visitors and did not change use patterns or existing experience. As a result of the bridge construction, 100 acres of wetlands were created or preserved within the metropolitan Washington region, providing visitors with more protected wetlands to enjoy within the region. A second completed project is the development of National Harbor across the Potomac River from Dyke Marsh. This development introduced another visual element for visitors along the Mount Vernon Trail and Bell Haven Marina and was noticeable, but not overly intrusive to visitor experience. Given the highly developed nature of this location, the two past projects resulted in an imperceptible impact on visitor use and experience. Alternative A would contribute long-term adverse impacts to the beneficial and adverse impacts of these cumulative projects. Because the changes would occur over a long period of time, the contribution would be imperceptible.

Conclusion

Marsh erosion would adversely alter visitor use and experience over time. Nature viewing would be altered and access to the marsh would decrease and disappear over time, including access to the end of the Haul Road trail, although visitors could still recreate in the area by boat, and the changes would be gradual. Opportunities for paddling and boating activities would still exist, but the area around the marsh would become more exposed to wind and currents as the marsh erodes, and there would be more open water. Because the changes would happen gradually, for most visitors, the changes would not be noticeable. For other users, such as bird watchers, the changes could represent a measurable adverse effect as opportunities decrease, and the number of species and number of individual birds decrease. Overall, the impacts on visitor use and experience would not rise to a level of significance.

Alternative A would contribute long-term adverse impacts to the impacts of other past, present, and reasonably foreseeable projects. Because the changes would occur over a long period of time, the contribution would be imperceptible.

Impacts Common to Both Action Alternatives

Both action alternatives include elements that create low energy areas in the marsh and reduce the velocity of currents that are currently causing erosion, and the creation of breaks along Haul Road. The installation of a breakwater structure and placement of fill in the deep channels at the southern end of the existing marsh would dissipate wave and flow energy, and protect the mouth of Hog Island Gut. As a result, Haul Road would be protected from erosion and require less NPS maintenance to maintain this location for visitor use. Kayakers and canoeists would likely be better able to access Hog Island Gut, providing an additional location for recreation.

The largest impact on visitor use and experience that is common to both action alternatives would occur during construction. Construction could last several years, depending on availability of fill material. While there would be limited construction equipment staging within the park, areas of visitor use may be closed during construction periods, such as the Haul Road. Portions of Haul Road would be closed during construction. Noise from construction equipment would likely temporarily displace wildlife and would impact those visitors who use the vicinity for nature-viewing. Although construction may last for an extended period of time, construction activities are likely to occur in discrete periods—during installation of containment cells, while fill is being placed, when planting occurs, if it occurs, and when containment cell materials are removed. In between these discrete periods, the containment cells would be visible, but there would be little construction noise and most areas would be open to visitors.

Along Haul Road, birders may alter their visitor use patterns during construction due to the reduced equality of their visitor experience. Bikers and hikers along the Mount Vernon Trail would likely continue to use the trail, but may not stop for wildlife viewing within that portion of the trail during construction. The Mount Vernon Trail would not be closed during construction, but may have occasional temporary closures if necessary to accommodate construction.

After construction is complete, visitors would experience beneficial impacts from the improved quality of the water, Hog Island Gut, and Haul Road, resulting in a better environment for wildlife viewing.

IMPACTS OF ALTERNATIVE B

Under alternative B, visitors would have the beneficial impact from the restoration of 70 acres of various wetland habitats in addition to the reduced erosion along Haul Road, as described in the section "Elements Common to Both Action Alternatives" in chapter 2. Restored marsh and wetlands would provide a healthier environment for wildlife and could provide visitors with improved wildlife viewing opportunities, although some people who fish could find the loss of some of the open water areas to be an adverse impact. The restored ecosystem would also provide expanded interpretive and education opportunities to visitors to learn about the wetland ecosystem. In place of the existing degrading marsh, visitors would be able to experience a healthier wetland ecosystem.

During construction, visitor experience would be negatively impacted, as described in the section "Elements Common to Both Action Alternatives" in chapter 2. Visitor access may be limited in particular locations and there would be increased noise levels, which would detract from the overall visitor experience. The trail along Haul Road would be closed during construction on the road.

The configuration of alternative B would not affect the use of the marina. Visitors would continue to be able to rent kayaks, canoes, and sailboats, and use the boat ramp, although access to the marsh would be restricted during construction.

Cumulative Impacts

Cumulative impacts under alternative B would be the same as described under the no-action alternative, with past projects resulting in small-scale adverse impacts on visitor use and experience. Implementation of alternative B would contribute mostly long-term beneficial and short-term adverse impacts to the overall adverse impacts of the cumulative projects. The contribution beneficial impacts would be noticeable. Contribution of adverse impacts would be imperceptible.

Conclusion

There would be some long term beneficial impacts on visitor use and experience related to experiencing improved wetland and marsh habitats and having more marsh to explore by paddle craft after restoration is complete. The largest impacts would occur during construction and would be adverse. Construction activity would be evident over an extended period of time, and parts of the park would be closed during construction. However, these impacts would be temporary and would not be significant. Long-term beneficial impacts on visitor use and experience would not attract enough additional visitation to make the impacts significant.

Implementation of alternative B would contribute mostly long-term beneficial and short-term adverse impacts to the overall adverse impacts of the cumulative projects. The contribution of beneficial impacts would be noticeable. Contribution of adverse impacts would be imperceptible.

IMPACTS OF ALTERNATIVE C

Impacts on visitor use and experience under alternative C would be the same as described under alternative B. An additional 175 acres of wetland area (245 acres total) would be restored under alternative C, providing a healthier ecosystem for visitors to enjoy under this alternative, resulting in a long-term beneficial impact on visitor experience as described under alternative B.

Because the restoration of cells adjacent to the marina would not be considered unless the marina concession were to become economically infeasible and were to close, there would be beneficial impacts on the experience of those visitors using the marina and its paddle craft by creating more marsh to access and explore. Although there would be less open water, the areas available to paddle would be more protected. Sailboats would continue to be able to access the docks and mooring areas, and the boat ramp would not be affected.

Similar to alternative B, there would be short-term impacts on visitor use and experience during construction, although construction could last for several years. It would be expected that these impacts would be greater under alternative C due to the larger area of disturbance and longer construction period, and could be very noticeable.

Cumulative Impacts

Cumulative impacts under alternative C would be the same as described under the no-action alternative, with past projects resulting in adverse impacts on visitor use and experience. Alternative C would contribute both short-term adverse and long-term beneficial impacts to the relatively small adverse cumulative effects. The contribution of both the beneficial and adverse impacts would be noticeable, because the impacts from C would be of a larger scale than the impacts from the cumulative projects.

Conclusion

Although there would be less open water to explore by boat, there would be long-term beneficial impacts on visitor use and experience related to experiencing improved wetland and marsh habitats and having more marsh to explore, including new tidal guts, by paddle craft after restoration is complete. Long-term beneficial impacts on visitor use and experience would not attract enough additional visitation to make the impacts significant.

As with alternative B, the largest impacts would occur during construction and would be adverse. Construction activity for future phases would cover a larger area than alternative B, and would be evident over a period of years. Impacts on the visitor use of the marina would be minimal, although access to the marsh by paddle craft would be limited. Parts of the park would be closed during construction, although the areas would change as work is completed and new cells or phases are started. Because construction-related impacts would occur over a period of years, and would be noticeable, impacts could be significantly adverse, although they would end once construction was complete.

Alternative C would contribute both short-term adverse and long-term beneficial impacts to the relatively small adverse cumulative effects. The contribution of the impacts would be noticeable, because the impacts from C would be of a larger scale than the impacts from the cumulative projects.

IMPACTS OF THE ALTERNATIVES ON ADJACENT PROPERTY OWNERS AND THE MARINA

METHODS AND ASSUMPTIONS

NPS *Management Policies 2006* do not directly address effects on adjacent land uses or property owners, but do mention cooperation and coordination with park neighbors in several areas (e.g., public participation, public involvement, and consultation). The purpose of this impact analysis is to assess the effects of the alternatives on the landowners surrounding Dyke Marsh. To determine impacts, the potential access and impacts from changing water levels and flood potential, as well as visual changes, were analyzed.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, there would be no impacts on adjacent landowners. Existing use levels, including the amount of traffic generated from the site, would continue. The NPS would continue to develop dock maintenance procedures in coordination with the four dock owners within the Crim property.

During severe storm events, it would be expected that flooding could continue to occur along the western portions of the Hog Island Gut, as was experienced during Hurricane Isabel. The docks and mooring field for the concessionaire-operated marina could also become more exposed over time, making it less pleasant or less functional to store boats or launch paddle craft.

Cumulative Impacts

No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

Conclusion

Alternative A would have minimal impacts on adjacent property owners and the marina. Erosion of the marsh would exacerbate flooding in adjacent areas, and over time, the marina could become more exposed, which could affect how much shelter the mooring field provides, and the ease of using the marina. Erosion of the marsh could also increase the amount of maintenance and protection needed on the parkway as the shoreline moves closer to it in the future. These impacts would be noticeable, but would not be a large enough magnitude to be significant.

No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

While the types of restoration activities that would occur under both action alternatives are the same, the impacts on adjacent landowners would vary by alternative. As a result, common elements other than construction impacts are described holistically under each alternative.

During construction, adjacent landowners may experience short-term adverse impacts from increased construction equipment in the project area. Impacts could include increased noise and large equipment in and out of the Dyke Marsh area. Construction equipment would be expected to operate within the current noise regulations, limiting hours of operation to normal daylight working hours. Construction impacts would be the same intensity for both alternatives, but would be longer in duration for alternative C as the restored area increases by alternative.

IMPACTS OF ALTERNATIVE B

The restoration of 70 acres of restored wetlands and marsh under alternative B would result in beneficial impacts on residential neighbors to the north and west of Dyke Marsh. The restored marsh, combined with the longer length of Hog Island Gut, would increase flood buffering and would provide a reduced probability for flooding during severe weather events. The reduced flood potential is described fully under the Floodplains section of this chapter.

Under alternative B, the NPS would be required to coordinate closely with Washington Gas so that construction would not damage the submerged gas line, which is very close to the northern breakwater alignment proposed under this alternative. Washington Gas has provided a list of mitigation measures, including specific requirements for pile driving and minimum distances to ensure that the northern promontory and sheet piling do not impact the gas line during construction. There would be no expected impacts on the gas line after construction is completed.

Under alternative B, the marsh and water depth south of the marsh are expected to remain very similar to existing water levels. Dock owners would be expected to be able to continue to use and maintain their docks as they do under to the no-action alternative.

The stone breakwater would introduce a new visual element to the project area and would have long-term visual impacts on adjacent properties. Under alternative B, the breakwater would be shorter and further from the landowners south of the project area than the breakwater proposed under alternative C, and would be a smaller visual impact for them than alternative C.

Alternative B does not include marsh restoration north of Dyke Island, so there would be no noticeable impacts on the marina and its concession operator. The marina and the mooring field would continue to be sheltered by the marsh to some extent.

Once restoration is complete, the marsh may attract an increase in waterfowl and hunters. There may be a slight increase in noise from hunting from existing duck blinds that would be closer to restored marsh areas than they currently are, which may negatively impact adjacent homeowners.

Cumulative Impacts

No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

Conclusion

Construction activities would affect adjacent landowners by increasing noise and large equipment in the Dyke Marsh area. The magnitude of construction-related impacts would be relatively small. Over the long term, alternative B could provide some additional buffering from flooding in the adjacent community, and provide some protection for the parkway itself. The breakwater would be visible from properties to the south but would be relatively distant from these properties. There may be increased noise during hunting season, although the restored marsh would still be relatively far from the property line, so hunting would not increase noticeably in adjacent waters. These impacts are all relatively small and would not be significant.

No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

IMPACTS OF ALTERNATIVE C

Impacts on adjacent landowners to the north and west of Dyke Marsh under alternative C would be expected to be similar to those described under alternative B. With a larger area of restoration (up to 245 acres), the marsh would have a larger flood storage capacity and, therefore, the reduction in flood potential would be greater than as described under alternative B, even though the base flood elevation would rise slightly. This greater reduction in flood potential would continue to result in long-term beneficial impacts on these adjacent landowners.

Under alternative C, the southern promontory location would be farther from the pipeline area, and would not result in adverse impacts on the Washington Gas pipeline. While measures to reduce vibration may still be required, there would be minimal impacts on the line during the construction period.

Alternative C would restore marsh closer to the marina, but would not exercise the option to fill cells adjacent to the marina unless the marina were to become economically infeasible and were to close for reasons unrelated to the marsh restoration, so the marina and its concessioner would not be noticeably or adversely affected by the restoration over the long term. Over the short term, there would be fewer or less attractive destinations for paddle craft renters from the marina during construction, but otherwise use of paddle craft, sailboats, and use of the boat ramp, the mooring field, or private slips would not be affected.

If the NPS were to restore marsh south of the breakwater, water levels to the south of the project area would be expected to become somewhat shallower over time, as sediments accreted in the restored marsh area and adjacent to it, as discussed in the hydrology section. However, water depths would not be anticipated to change enough to change the use of the existing docks south of Dyke Marsh.

Similar to alternative B, the rock breakwater options would introduce a new visual element to the project area and would have long-term visual impacts on adjacent properties. Under alternative C, the southern breakwater location would be used and therefore this visual element would be closer and more visible to the adjacent properties to the south.

Similar to alternative B, once restoration is complete, the marsh may attract an increase in waterfowl and hunters, as the marsh would be closer to the location of the permitted hunting blinds. There may be some increase in noise from hunting, which may negatively impact adjacent homeowners.

Cumulative Impacts

No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

Conclusion

Construction activities would affect adjacent landowners by increasing noise and large equipment in the Dyke Marsh area. The magnitude of construction-related impacts would larger than under alternative B. Over the long term, alternative C would provide noticeably more buffering from flooding in the adjacent community than currently exists, and would also provide some protection for the parkway itself. The breakwater would be visible from properties to the south and would be more visible than the breakwater proposed in alternative B, because it would be several hundred feet closer to the properties south of it. There may be noticeably more noise during hunting season with the extent of the restored marsh closer to the property line, making it more likely that waterfowl would be found closer to the property line and licensed hunting blinds. Sediment accretion in and adjacent to the restored marsh south of the breakwater could slightly affect the depth of the water under adjacent docks, but it would not be noticeable and would not affect the use of these docks. These impacts are all relatively minor and would not be significant.

No past, present, or future actions have been identified that would impact adjacent landowners. Therefore, no cumulative impacts are anticipated to occur to adjacent landowners as a result of this alternative.

IMPACTS OF THE ALTERNATIVES ON PARK MANAGEMENT AND OPERATIONS

GUIDING REGULATIONS AND POLICIES

As discussed in chapter 1, the restoration of Dyke Marsh is guided by NPS *Management Policies 2006*, specifically, "Chapter 4: Natural Resources," which states that "the National Park Service will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks while providing meaningful and appropriate opportunities to enjoy them" (NPS 2006). The NPS is intervening in natural biological and physical processes in Dyke Marsh both because it has been directed to do so by Congress and because it is restoring natural ecosystem functions that have been disrupted by past or ongoing human activity as directed under NPS *Management Policies 2006*.

METHODS AND ASSUMPTIONS

Success of the restoration of Dyke Marsh relies on the availability of park staff to actively manage for the restoration of the marsh. This includes staff management of not only the restoration but of the concessioners and visitor experience at the marsh as well. For the purpose of this analysis, park management and operations refers to the quality and effectiveness of the park staff to maintain and administer park resources and facilities and to provide for an effective visitor experience. Facilities included in this project include the Dyke Marsh and the sites within Marsh including Belle Haven Marina, Mount Vernon Trail, Haul Road, and the boardwalk at the end of Haul Road. Park staff who are knowledgeable of issues related to Dyke Marsh were members of the planning team that evaluated the impacts of each alternative. The impact analysis is based on the current description of park operations presented in "Chapter 3: Affected Environment" of this document. The proposed project has the potential to affect park management and operations after implementation through administrative and long-term operations and maintenance or life-cycle costs. It should be noted that staffing and funding levels associated with actions in the alternatives are difficult to project until final plans are completed.

IMPACTS OF THE NO-ACTION ALTERNATIVE (ALTERNATIVE A)

Under the no-action alternative, no restoration efforts would occur and the marsh would continue to erode. Current management of the marsh would continue, which includes providing basic maintenance related to Haul Road, control of nonnative invasive plant species, ongoing interpretive and environmental education activities, scientific research projects, boundary marking, and enforcement of existing regulations. No manipulation of the marsh would occur other than emergency, safety-related, or limited improvements or maintenance actions. The destabilized marsh would continue to erode at an accelerated rate (Litwin et al. 2011). It is likely that adverse impacts on park management and operations would be noticeable in the long term under this alternative as park activities such as research and educational activities would be impacted as the marsh erodes. Furthermore, it is anticipated that maintenance activities to Haul Road or the Mount Vernon Trail under this alternative would continue to increase in the long term in order to prevent or reduce the amount of erosion anticipated for these facilities.

The marina is currently at capacity and it is reasonable to expect that this condition would persist (Lebel, pers. comm. 2009). The Dyke Marsh area would continue to be serviced by staff from five of the park's divisions. The Natural Resources Division would continue to spend up to 20 percent of their time in the Dyke Marsh area. The mooring field and other parts of the marina could become more exposed over time and less appealing to marina users, and could therefore affect the ability of the marina concession to rent mooring spots.

Cumulative Impacts

No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.

Conclusion

Under the no-action alternative (alternative A), the marsh would continue to erode, which would result in decreased research and educational opportunities, and increased maintenance efforts to protect the parkway, Mount Vernon trail, and other facilities adjacent to the marsh. The marina is expected to continue to operate at capacity, but might experience a loss of revenue from decreased rentals of paddle craft over an extended period of time as the marsh erodes. The mooring field and other parts of the marina could become more exposed over time and less appealing to marina users, and make it more difficult for the marina concession to rent mooring spots. Increased maintenance would not likely become necessary for the next 15 years, however, and overall these impacts would not be significant.

IMPACTS COMMON TO BOTH ACTION ALTERNATIVES

Long-term Impacts from Adaptive Management Activities

Adaptive management would be used under all of the action alternatives to make adjustments to vegetation establishment, manage nonnative and invasive species throughout the marsh, and ensure restoration is successful. It is anticipated that park management and operations impacts would increase in magnitude as restoration acreage increases. This increase arises from park staff having to progressively monitor more marsh under each of these alternatives. Re-vegetation activities associated with newly created marsh land would be conducted by NPS staff, contractors, or volunteers. It is anticipated that the level of effort for NPS staff, contractors, or volunteers would increase in magnitude for alternative C, and would vary in intensity depending choice of labor for the re-vegetation activities. Use of volunteers would require the most coordination and staff time, while contractors would require the least staff time.

Changes to Park Management and Operations as a Result of Construction

In the short term, during construction, it is anticipated that some activities such as monitoring, data management, research, and law enforcement would be affected, and some of these activities, such as research, would likely be curtailed or refocused in the short-term due to interference by construction activities. In the long term, it is anticipated that these activities, in addition to invasive plant control and law enforcement activities, may increase in magnitude for alternative C, as more marsh area is created.

Under both of the action alternatives park management and operations would be impacted by the degree to which park staff are required to manage the Dyke Marsh area as it undergoes restoration. For instance, as hydrologic connections are reestablished to the inland side of Haul Road, some portions of this road may have to be closed, requiring staff time to ensure the construction area is well marked and that road closure signs remain visible, and are correctly placed. Additionally, it is anticipated that some impacts on park management and operations would occur as a result of park staff interacting with construction workers during the restoration of Dyke Marsh.

As construction would take place from the water to the greatest extent possible and material would be transported by barge and stored on the barges, there would be little, if any, need for staging areas on land in the park. Therefore, park management and operations activities on shore are not anticipated to be affected by a majority of the construction operations.

Under each of the alternatives the boardwalk at the end of Haul Road is expected to remain in place; however, park staff would likely have to close this off during the construction period due to the disturbances along Haul Road.

IMPACTS OF ALTERNATIVE B

Under this alternative, park management and operations may be affected by the establishment of approximately 70 new acres of various wetland habitats as well as the construction of a new breakwater and breaks along Haul Road. It is anticipated that adaptive management actions under this alternative would have less of an impact on park staff than alternative C in the long term. Furthermore, it is anticipated that this alternative would have the least impact on park staff conducting re-vegetation activities as this alternative has the smallest amount of new marsh being created. It is anticipated that over the long term, the area designated for research, maintenance, and educational activities would increase by the smallest amount relative to alternative C. Furthermore, it is anticipated that invasive plant control and law enforcement would be affected to the least degree under this action alternative relative to the other action alternatives. In the long term, it is anticipated that the amount of time and effort expended on these activities would increase due to the increase in marsh area and habitat for invasive plants. It is anticipated that research, maintenance, and educational activities would be refocused the least during construction of this alternative relative to the other action alternatives due to the relatively small area of new marsh being created.

Cumulative Impacts

No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.

Conclusion

Both action alternatives require the implementation of a monitoring program to ensure the restoration is successful, and increased management to ensure that geese exclosures and nonnative plant management are working. During construction, staff time would be required to interact with construction personnel, and research and educational activities might be refocused. Overall, the level of effort necessary to carry out the restoration actions under alternative B would not be of a magnitude that would be considered significant.

No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.

IMPACTS OF ALTERNATIVE C

Under this alternative, park management and operations may be affected by the establishment of up to 245 new acres of various wetland habitats as well as the construction of a new breakwater, breaks along Haul Road, and tidal guts that are cut into the restored marsh. The 245 acres includes options to restore an area currently serving as the mooring field for the Belle Haven Marina and an area south of the breakwater. The area serving as the mooring field for the Belle Haven Marina would only be filled in should the marina shut down; however, at this time, it is anticipated that the marina would continue its normal operations and that this option would not be exercised.

It is anticipated that adaptive management actions under this alternative would have a greater impact on park staff compared to alternative B in the long-term. Furthermore, it is anticipated that this alternative would have a greater impact on park staff conducting re-vegetation activities compared to alternative B because a larger amount of new marsh would be created under alternative C. It is anticipated that over the long term, the area designated for research, maintenance, and educational activities would increase by a larger amount than under alternative B. Furthermore, it is anticipated that invasive plant control and law enforcement would be affected to a higher degree under this alternative compared to alternative B. In the long-term, it is anticipated that the amount of time and effort expended on these activities would increase due to the increase in marsh area and habitat for invasive plants. It is anticipated that research, maintenance, and educational activities would be more than under alternative B during construction of this alternative relative to the other action alternatives due to the relative size of the new marsh being created.

Cumulative Impacts

No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.

Conclusion

Both action alternatives require the implementation of a monitoring program to ensure the restoration is successful, and increased management to ensure that geese exclosures and nonnative plant management is working. A greater amount of staff time would be required to interact with construction personnel under alternative C, and research and educational activities would be refocused. Overall, the level of effort necessary under alternative C would be much greater than under alternative B, but it would likely be spread out over time, and would be focused over short amounts of time and would therefore not be significant.

No past, present, or future actions have been identified that would impact park management and operations. Therefore, there would be no cumulative impacts on park management and operations from this alternative.

RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

NEPA regulations (40 CFR 1502.16) require an environmental impact statement (EIS) to consider the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. Special attention should be given to impacts that narrow the range of beneficial uses of the environment or pose a long-term risk to human health or safety.

Alternative A: No Action. NPS would not restore any marsh areas within Dyke Marsh. Current management of the marsh would continue, which includes providing basic maintenance related to Haul Road, control of nonnative invasive plant species, ongoing interpretive and environmental education activities, scientific research projects, boundary marking, and enforcement of existing regulations. There would be no manipulation of the marsh other than emergency, safety-related, or limited improvements or maintenance actions. The destabilized marsh would continue to erode at an accelerated rate. Since this is the environmental baseline and includes no restoration, no short-term impacts are expected. The long-term productivity of the park’s resources is expected to decline because the marsh would continue to degrade. Sediments would continue to be carried past the marsh. Erosion in the marsh would continue at a rate of 6–7.8 feet per year as there is little or no natural protection from erosion provided to Hog Island Gut (Litwin et al. 2011; USACE 2012a). With no restoration efforts, relatively high energy conditions would continue to exist adjacent to the marsh allowing suspended sediments in the river to continue to be carried straight downstream past the marsh. Habitat degradation would continue due to altered hydrology and would adversely impact management efforts for native species, wildlife, and special-status species, as well as threatening the surviving remnant of the dyke and any other archeological resources that might be present along the river's shoreline.

Alternatives B: Hydrologic Restoration and Minimal Wetland Restoration. The activities associated with the construction of a breakwater structure and containment cells, deep channel fill, establishment of natural edges on the outermost extent of the containment cells, reestablishment of marsh vegetation, and reintroduction of tidal flows to both sides of Haul Road and the installation of culverts or bridges would result in a number of impacts that would alter long-term uses of park resources. The short-term use for construction is essential to long-term productivity of the marsh. The installation of a breakwater structure and placement of fill in the deep channels at the southern end of the existing marsh would dissipate wave and flow energy, and protect the mouth of Hog Island Gut. The creation of breaks along Haul Road would allow tidal flows to pass under the road and into the former bottomland swamp forest, along with sediment transfer associated with those tidal flows over the long term. Establishing a natural edge would allow SAV to become established in the deeper waters riverward of the emergent marsh. Reintroduction of intertidal exchange west of Haul Road would encourage reestablishment of a floodplain swamp forest and facilitate the management of exotic and invasive vegetation species that have established in the area. Implementation of this alternative would create up to approximately 70 new acres of wetland habitat of various types, including approximately 25 acres of restored marsh, and allow the continued natural accretion of soils and establishment of wetlands due to the restored hydrologic conditions. All of these long-term impacts would affect resources and the uses of those resources by wildlife, visitors, and park personnel as well as influencing park operations and management in the long term.

Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative). Similar to Alternative B, impacts from proposed activities associated with the construction of a breakwater structure and containment cells, deep channel fill, establishment of natural edges on the outermost extent of the containment cells, reestablishment of marsh vegetation, and reintroduction of tidal flows to both sides of Haul Road and the installation of culverts or bridges would result in a number of impacts that would have short-term adverse effects, but would create long-term benefits. Under this alternative, up to 245 acres of various wetland habitats could be created. Similar to alternative B, all of these long-term impacts would affect resources and the uses of those resources by wildlife, visitors, and park personnel as well as influencing park operations and management in the long term.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

NEPA regulations (40 CFR 1502.16) require an EIS to address the irreversible and irretrievable commitment of resources caused by the alternatives. An irreversible commitment of resources is defined as the loss of future options. The term applies primarily to the effects of using nonrenewable resources (such as minerals or cultural resources) or resources that are renewable only over long periods (such as soil productivity). It could also apply to the loss of an experience as an indirect effect of a "permanent" change in the nature or character of the land. An irretrievable commitment of resources is defined as the loss of production, harvest, or use of natural resources; irretrievable resource commitments may or may not be irreversible. The following identifies commitments of resources that are either irreversible or irretrievable.

Under alternative A, the environmental conditions in Dyke Marsh would continue, including the potential for continued erosion in the marsh, leading to eventual disappearance of the marsh. Marsh erosion would be accompanied by habitat degradation and threats to historic resources. No manipulation of the marsh would occur other than emergency, safety-related, or limited improvements or maintenance actions and the marsh would continue to degrade and become smaller in size. As the marsh erodes, the end of Haul Road could be threatened, and the southern portion of the road could potentially become submerged. Should portions of Haul Road become submerged, visitors would no longer be able to use this location and would experience long-term noticeable impacts on the quality of their visitor experience. Visitor use would be noticeably impacted as visitor use in that area would be restricted. Impacts to these resources are irretrievable and would continue into the future under current management. However, restoration is based on the premise that current conditions are not irreversible. Restoration activities under alternatives B and C would create beneficial hydrological and sediment deposition conditions that would promote successful marsh restoration over the long term. Restoration of Dyke Marsh and the processes that support a freshwater tidal marsh would gradually restore the area's wetlands and ecosystem functions and processes, and repair damage from previous human uses and other continuing threats, such as alterations to the hydrology in the Potomac River and in nearby tributaries, and other effects from urbanization in the surrounding region.

UNAVOIDABLE ADVERSE IMPACTS

Alternative A: No Action. Implementation of alternative A would lead to unavoidable adverse environmental impacts. A decision by NPS to not restore the marsh would hinder regional restoration efforts and management of park resources. All resource areas would be adversely affected. The destabilized marsh would continue to erode at an accelerated rate, and would eventually disappear, adversely affecting hydrology and sediment transport, as well as soils and sediments, water quality, floodplains, vegetation, and wetlands. Archeological resources and other cultural resources, such as cultural landscapes, would be adversely affected by the erosion by increasing the potential that archeological resources along the riverbank could be exposed and harmed, and by altering the component landscapes of the historic districts. Marsh erosion would cause habitat degradation that would adversely impact management efforts for native species, fish and wildlife, and species of special concern by decreasing and eventually eliminating the habitat for these species. Visitor use and experience, park management and operations, and adjacent property owners and the marina would also be adversely affected by the disappearing marsh. Since no construction activities would be included in this alternative, there would be no construction-related impacts.

Alternatives B: Hydrologic Restoration and Minimal Wetland Restoration. Implementation of alternative B would lead to unavoidable adverse environmental impacts. Construction actions and reintroduction of intertidal flows across Haul Road would be accompanied by limited unavoidable short-term adverse impacts to hydrology and sediment transport, soils, water quality, vegetation, fish and wildlife, visitor use and experience, and adjacent landowners. In addition, intermittent adverse impacts to water quality could result have a limited ability to adversely affect water quality overall. However, it is likely that there would be some minimal erosion or scour around the culverts or bridge pilings until a hydrologic equilibrium is established. This would result in a small amount of soils and sediments, and any bound nutrients or pollutants being carried into the marsh and river over the short amount of time after construction is complete. Whatever soluble pollutants are in the soil west of Haul Road could be transported into the river with the newly introduced intertidal flows. Construction would use BMPs such as silt fences around the construction area at Haul Road, and would use practices for construction in waterways that are appropriate for the situation. The containment cells themselves serve as sediment control devices, but additional BMPs, such as sediment curtains, could be specified as necessary as the design and permitting process moves forward. In addition, fill materials for the breakwater (should the steel sheet piling with fill option be used), and for the containment cells for the restored wetlands would be tested to ensure they do not contain harmful pollutants, and would therefore not impact water quality.

Short-term adverse impacts to fish and wildlife species and species of special concern would be limited to the bird species and other fish and wildlife during the construction period. Impacts would be minimized by placing restrictions on when construction can occur to avoid construction during the birds' breeding periods.

Alternative C: Hydrologic Restoration and Fullest Possible Extent of Wetland Restoration (Preferred Alternative). Implementation of alternative C would lead to similar unavoidable adverse environmental impacts as under alternative B. Although construction actions and reintroduction of intertidal flows would support the long-term conversion of the project area to the desired marsh condition, they are accompanied by unavoidable short-term adverse impacts on hydrology and sediment transport, soil, water quality, vegetation, fish and wildlife, species of special concern, and visitor use and experience. Similar to alternative B, these impacts would be managed and mitigated by BMPs and other appropriate resource protection measures.

Chapter 5:

Consultation, Coordination, and Regulatory Compliance

CHAPTER 5: CONSULTATION, COORDINATION, AND REGULATORY COMPLIANCE

One intent of the National Environmental Policy Act (NEPA) is to encourage the participation of federal and state-involved agencies and affected citizens in the assessment procedure, as appropriate. This section describes the consultation that occurred during development of this draft Dyke Marsh Wetland Restoration and Long-term Management Plan / Environmental Impact Statement (plan/EIS), including consultation with scientific experts and other agencies. This chapter also includes a description of the public involvement process and a list of the recipients of the draft document.

HISTORY OF PUBLIC INVOLVEMENT

The public involvement activities for this plan/EIS fulfill the requirements of NEPA and National Park Service (NPS) Director's Order 12 (NPS 2011a).

THE SCOPING PROCESS

The NPS divides the scoping process into two parts: internal scoping and external or public scoping. Internal scoping involved discussions among NPS personnel regarding the purpose of and need for management actions, issues, management alternatives, mitigation measures, the analysis boundary, appropriate level of documentation, available references and guidance, and other related topics.

Public scoping is the early involvement of the interested and affected public in the environmental analysis process. The public scoping process helps ensure that people have an opportunity to comment and contribute early in the decision-making process. For this plan/EIS, project information was distributed to individuals, agencies, and organizations early in the scoping process and at a second meeting focused on conceptual alternatives, and people were given opportunities to express concerns, identify important issues, and provide input on the alternatives.

Taken together, internal and public scoping are essential elements of the NEPA planning process. The following sections describe the various ways scoping was conducted for this plan/EIS.

INTERNAL SCOPING

Internal scoping began November 14–15, 2007, with a meeting at Daingerfield Marina on the parkway in Alexandria, Virginia. During the two days of meetings, NPS employees reviewed background information on the marsh, discussed the NEPA and planning process, reviewed and confirmed the project purpose and need for action statements; identified issues and concerns (*problems to solve, opportunities to be taken*); and defined objectives for taking action (*what does the park hope to accomplish for the action to be successful?*). The group also began to analyze preliminary alternatives and data needs; identified interested and affected members of the public, and developed a plan for public involvement.

As discussed in "Chapter 1: Purpose of and Need for Action," the park convened a science team that evaluated scientific literature and provided input into the planning process.

PUBLIC SCOPING

Public Notification

A Notice of Intent to prepare an environmental impact statement (EIS) was published in the Federal Register on April 8, 2008 (Volume 73, Number 68).

A brochure was mailed on April 7, 2008, to the project's preliminary mailing list of government agencies, tribes, organizations, businesses, and individuals. The brochure announced public scoping meetings to be held in April 2008, summarized the purpose of and need for the plan, listed preliminary alternatives, provided background information on deer monitoring and research and findings at the parks, and presented instructions on how to comment on the plan.

A second brochure was prepared and mailed on April 24, 2012, to the project's mailing list, comprising the original preliminary list and those added after the first public scoping meeting. This brochure summarized the alternative concepts that the U.S. Army Corps of Engineers (USACE) had developed for the NPS.

Public Meetings

Public Scoping

On April 7, 2008, George Washington Memorial Parkway released the Public Scoping Newsletter for the plan/EIS for public review and comment. The public was invited to submit comments on the scope of the planning process and potential alternatives through May 23, 2008. During the scoping period, a public scoping meeting was held at Belle View Elementary on April 22. The meeting presented information about the development of the plan and planning processes. NPS staff was on hand to answer questions, provide additional information to workshop participants, and record their input.

Alternatives Scoping

The George Washington Memorial Parkway released a newsletter detailing four alternative concepts for the plan/EIS on April 24, 2012, and invited the public to attend a public meeting to learn more about these alternatives. A public scoping meeting was held on May 8, 2012, at the Washington Sailing Marina in Alexandria, Virginia, to review the additional research and alternatives developed by the USACE following more than a year's worth of modeling and research. The public comment period following this meeting was held open until June 20, 2012. At the meeting, representatives from NPS introduced the project and later discussed the NEPA process. Representatives from USACE presented the results of their research, results of research conducted by the U.S. Geological Survey (USGS), and four alternative scenarios for consideration in the plan/EIS. Comment cards were available, and attendees were also encouraged to submit comments online on the Planning, Environment, and Public Comment (PEPC) website at http://parkplanning.nps.gov/gwmp.

Public Comment

Public Scoping

During the initial public scoping period, nearly 300 pieces of correspondence were entered into the PEPC system either from direct entry by the commenter, or uploading of emails, faxes, and hard copy letters by NPS staff. Of the approximately 50 letters submitted from outside the region immediately surrounding

Dyke Marsh Wildlife Preserve (Dyke Marsh) (District of Columbia, Maryland, Virginia), concerns regarding hunting access in areas near Dyke Marsh were the almost exclusive topic of the communications. Among commenters from the District of Columbia, Maryland, and Virginia, the three topics that received the majority of the comments were expressions of support for the restoration of Dyke Marsh, concerns regarding the impact of the restoration on Belle Haven Marina, as well as concerns regarding continued access to hunting in areas near Dyke Marsh.

It should be noted that prior to the April 22 public scoping meeting, a notice was posted on the National Rifle Association's website stating there was going to be a meeting that evening with officials from the NPS and the Virginia Department of Game and Inland Fisheries (VDGIF) to discuss the future of hunting in the Dyke Marsh area. The inaccurate information contained in the notice generated national interest in the meeting and the process. Changing the current hunting opportunities available to the public outside of the marsh boundary is outside the scope of the plan/EIS and was not considered in this document.

Alternatives Scoping

Comments following the 2012 alternatives meeting primarily expressed support or opposition for the four alternatives, and also asked what the costs would be or expressed concern over likely project costs. Many commenters expressed concern that the project would cause the Belle Haven Marina to close or would restrict or reduce recreational access and opportunities in the marsh. Several commenters suggested approaches that would allow the marina to remain open and still allow for restoration. For example, several commenters suggested that alternative D should not include the option to fill the sailboat mooring area, and others suggested that the minimal or intermediate restoration alternatives would be more appropriate.

Several commenters also described the high-quality fishing grounds of the deeper holes in the marsh, and were concerned about the filling of these deeper areas. Other commenters were in favor of the restoration of wetland habitat for birds and other wetland-dwelling species.

AGENCY CONSULTATION

Consultation and coordination with several agencies has continued throughout the planning process for this plan/EIS. The Baltimore and Norfolk Districts of USACE, Virginia and Maryland agencies, and the Virginia State Historic Preservation Office (SHPO) have all been informed of the project and the process. Letters initiating consultation under Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act and/or requesting information or comments were sent to the agencies as described below. Copies of these letters and any responses are provided in appendix C.

U.S. FISH AND WILDLIFE SERVICE

As part of the planning process, a science team was convened to review information about the marsh and provide input to the process. This team included two U.S. Fish and Wildlife Service (USFWS) personnel who are very familiar with the marsh and surrounding habitat: John Gill, USFWS Maryland Fishery Resources Office, Biologist (who had completed wetlands restoration for local projects and a fish inventory of Dyke Marsh in 2001–2004); and Sandy Spencer, USFWS, Eastern Virginia Rivers National Wildlife Refuge Complex, Wildlife Biologist (Masters research at Dyke Marsh beginning in 1997). No federally listed species were identified during the discussions that addressed that subject.

A letter dated June 27, 2013, from George Washington Memorial Parkway was sent to reconfirm that information and to initiate informal consultation with the USFWS about the presence of federally listed rare, threatened, or endangered species in or near the parks. No response was received.

VIRGINIA STATE HISTORIC PRESERVATION OFFICE

A letter was sent in December 2009 from George Washington Memorial Parkway to the Virginia SHPO in accordance with Section 106 of the National Historic Preservation Act. The letter initiated consultation with the Virginia SHPO and provided information about the archeological assessment conducted at the marsh for this project. Virginia Department of Historic Resources responded on January 6, 2010, and stated that they found that the assessment provided a clear and thorough presentation of Dyke Marsh's archeological potential. They agreed that the proposed restoration should consider the preservation of the intact portions of the historic dikes located in the southeastern section of the marsh and that consideration should be given to avoidance of archeologically sensitive areas in planning the restoration. If avoidance is not possible, they stated that further identification efforts would be necessary to locate and evaluate any archeological sites that may be affected by the proposed restoration activities. The draft EIS has been provided to the Virginia SHPO to solicit comment and continue the consultation process.

VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION

A letter dated June 27, 2013, from George Washington Memorial Parkway was sent to the Section 7 coordinator for the Department about the presence of state rare, threatened, or endangered species in or near the parks. No response was received. The draft EIS has been provided to Virginia Department of Conservation and Recreation (VA DCR) for their review and comment.

VIRGINIA DEPARTMENT OF GAME AND INLAND FISHERIES

The VDGIF submitted a letter to the NPS on May 22, 2008, recommending further consultation with the agency concerning bald eagle habitat, anadromous fish habitat, and stating general support for the project. The draft EIS will be provided to VDGIF for their review and comment.

REGULATORY COMPLIANCE: PERMITS AND MITIGATION MEASURES

PROPOSED STRATEGY FOR REGULATORY PERMITTING

This section explains the proposed strategy for regulatory permitting over the duration of project implementation. The project would require coordinated permits multiple permits and approvals from federal, state, and county agencies. These approvals would need to encompass the project's several year implementation period and allow for flexibility if project needs extend beyond this time frame. Restoration activities would proceed in an incremental and phased approach that would be guided by, and adjusted in response to, the adaptive management plan.

VIRGINIA'S JOINT PERMITTING PROCESS

The Virginia Department of Environmental Quality administers the Virginia Water Protection Permit Program and associated compliance, which includes permits for activities such as dredging, filling, and excavating in open water, streams, and wetlands in Commonwealth waters. All permits are coordinated through the Joint Permit Application process, and submitted to the Department of Environmental Quality. The joint permit process allows for concurrent federal and state project review, and also includes compliance with Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbor Act, and water quality certification under Section 401 of the Clean Water Act. It also includes approval for sediment and erosion control planning, and other aspects of the construction process. The Fairfax County Wetlands

Board, and Virginia Marine Resources Commission will also be notified of the permit application. The county board and the commission have review and approval authority (VA DEQ 2012c).

A consistency determination to ensure federal projects are consistent with enforceable policies under Virginia's Coastal Zone Management Program, as mandated by the Coastal Zone Management Act of 1972, is also necessary. Applicable enforceable policies address fisheries management, subaqueous land management, tidal wetlands management, nonpoint and point source pollution control, air pollution control, and coastal lands management. Policies addressing shoreline sanitation and dunes management would not be applicable. Findings of consistency (either no effects or consistency determinations) are submitted to the Virginia Department of Environmental Quality (VA DEQ 2013).

No permitting would be required from the state of Maryland, but there would be consultation with the state of Maryland and they would be informed of the action and permit process. Actions in Virginia waters could affect water quality in Maryland waters.

LIST OF RECIPIENTS OF THE DRAFT PLAN/ENVIRONMENTAL IMPACT STATEMENT

Notification of the availability of this plan/EIS will be sent to the following agencies, organizations, and businesses, as well as to other entities and individuals who have submitted comments during scoping. In addition, hard copies of the document will be available for review at Park Headquarters, the Martha Washington Library, and the Sherwood Hall Library.

Virginia Congressional Delegation:

- Senator Mark Warner
- Senator Tim Kaine
- Representative James P Moran
- Representative Gerald Conolly

Federal Agencies:

- National Park Service
  - National Capital Parks – East
  - Chesapeake and Ohio Canal National Historical Park
  - National Mall and Memorial Parks
  - Potomac Heritage National Scenic Trail
- U.S. Environmental Protection Agency, Headquarters and Region 3
- U.S. Department of Agriculture, National Resources Conservation Service, Virginia
- U.S. Fish and Wildlife Service, Chesapeake Bay Field Office
- U.S. Fish and Wildlife Service, Northeast Region
- U.S. Fish and Wildlife Service, Virginia Field Office

State Legislative Delegation (State Legislative Delegation (Virginia):

- Barbara Comstock, State Delegate
- Scott Surovell, State Delegate
- K Robert Krupicka, Jr., State Delegate
- Adam P Ebbin, State Senator
- Janet Howell, State Senator
- Toddy Puller, State Senator

State Agencies:

- Virginia Department of Conservation and Recreation
- Virginia Department of Game and Inland Fisheries
- Virginia Department of Historic Resources
- Maryland Department of Natural Resources
- Maryland Department of the Environment

Local Governments and Regional Authorities:

- Metropolitan Washington Council of Governments
- Northern Virginia Regional Commission
- Northern Virginia Soil and Water Conservation District
- City of Alexandria, VA
- Fairfax County, VA

Organizations and Agencies:

- American Sportfishing Association
- Audubon Naturalist Society
- The Audubon Society of Northern Virginia
- Friends of Dyke Marsh
- Friends of Little Hunting Creek
- Isaac Walton League of America, Inc.
- Alice Ferguson Foundation
- APVA – Preservation Virginia
- Fairfax County Federation of Citizens Associations
- Interstate Commission on the Potomac River Basin
- Mount Vernon Council of Citizens' Associations
- Mount Vernon Ladies Association
- National Trust for Historic Preservation
- National Wildlife Federation
- National Aquarium - Baltimore
- National Audubon Society
- National Parks Conservation Association
- Northern Virginia Conservation Trust
- Porto Vecchio Condominium Association
- Ski Club of Washington DC
- Sierra Club, Mount Vernon Group
- The Nature Conservancy
- Virginia Native Plant Society
- Virginia Society of Ornithology
- Washington Gas Company
- Wellington Civic Association
- Wessynton Marine Association
- Westgrove Citizens Association

SCIENCE TEAM MEMBERS

Name	Title	Organization / Location
Andrew Baldwin, Ph.D.	Professor, Department of Environmental Science and Technology	University of Maryland - Department of Environmental Science and Technology
Rebecca Beavers, Ph.D.	Coastal Geologist	NPS Geologic Resource Division, Natural Resource Program Center
Bob Blama	Project Manager	USACE
Doug Curtis	Regional Hydrologist	NPS-NCR- Natural Resources and Science
Katia Engelhardt, Ph.D.	Wetland Ecologist and Professor	University of Maryland Center for Environmental Studies (UMCES) Appalachian Laboratory, Frostburg, MD
John Gill	Biologist	USFWS Maryland Fishery Resources Office
Richard Hammerschlag, Ph.D.	Biologist (now retired)	United States Geological Survey
Michael Martin	Hydrologist	NPS Washington Support Office Water Resources Division
Eric Oberg	Biologist	NPS George Washington Memorial Parkway
Diane Pavek, Ph.D.	Research Coordinator and Botanist	NPS-NCR- Natural Resources and Science
Walter Priest	Habitat Restoration Specialist	National Oceanic and Atmospheric Administration, Restoration Center
Charles Roman, Ph.D.	Ecologist	NPS, University of Rhode Island Bay Campus
Vincent Santucci	Chief Ranger, Natural and Cultural Resource Interpretation	NPS George Washington Memorial Parkway
Dan Sealy	Deputy Chief of Natural Resources and Science (now retired)	NPS-NCR- Natural Resources and Science
Jim Sherald, Ph.D.	Chief of Natural Resources and Science (now retired)	NPS-NCR- Natural Resources and Science
Sandy Spencer	Wildlife Biologist	USFWS, Eastern Virginia Rivers National Wildlife Refuge Complex
Melissa Stedeford	EIS Manager for Dyke Marsh	NPS Environmental Quality Division
Brent Steury	Natural Resource Program Manager	NPS George Washington Memorial Parkway
Joel Wagner	Hydrologist	NPS Washington Support Office Water Resources Division

LIST OF PREPARERS

Name	Title	Education/Responsibility	Experience (years)
National Park Service			
Gregory Anderson	Cultural Resources Specialist, George Washington Memorial Parkway	BS Anthropology Provided technical review and input of cultural resources sections of the environmental assessment (EA)	6 years with NPS
Doug Curtis	Hydrologist, NPS—National Capital Region	AA Forestry and Engineering; BS Environmental Engineering; MS Water Resources Engineering Provided technical input and review on hydrology	13 years with state of Maryland 20 years with NPS
Joel Gorder	Regional Environmental Coordinator, National Capital Region	BS Biology; MURP, Planning Responsible for NEPA compliance and regional review of document. Responsible for NEPA compliance and technical review of document	19 years, 3 years with NPS
Marian Norris	Aquatic Ecologist, NPS — National Capital Region and Northeast Region	BS Biology and Environmental Science; MS Ecology and Evolution Provided technical review of draft EIS and authored adaptive management plan	22 years with water resources monitoring
Diane Pavek	Research Coordinator and Botanist, NPS — National Capital Region Network	BS Botany and Zoology; MS and PhD Botany Provided technical input and review; prepared adaptive management plan	22 years in botany; 13 years with NPS
Thomas Sheffer, AICP	Planner, George Washington Memorial Parkway	BS Natural Resource Recreation; MURP, Planning Provided review	3 years with NPS
Melissa Stedeford	Project Manager, Environmental Quality Division	B.S. Environmental Science; M.S. Environmental Science NPS Project Manager responsible for NEPA policy, guidance, and technical review	9 years with NPS
Brent Steury	Natural Resources Program Manager / Biologist, George Washington Memorial Parkway	BS Marine Science Provided technical input and review; prepared adaptive management plan	18 years with NPS
Matthew R. Virta	Cultural Resources Program Manager, NPS-George Washington Memorial Parkway	BA Anthropology (Archeology); MAA Applied Anthropology (Archeology) Responsible for cultural resources review	30 years in Archeology/Cultural Resources Management, 25 years with NPS
Louis Berger Group			
Allison Anolik	GIS Specialist	BA Geography Responsible for Mapping and Graphics	7 years
John Bedell, Ph.D.	Principal Archeologist	PhD History; MA History; BA History Cultural Resources	24 years

Name	Title	Education/Responsibility	Experience (years)
Holly Bender, Ph.D.	Economist	BA Political Science and Economics; PhD Mineral Economics Adjacent Property Owners and the Marina (affected environment)	14 years
Rudi Byron, AICP	Environmental Planner	Visitor Use and Experience; Adjacent Property Owners and the Marina (affected environment)	8 years
Chris Flannagan	Wetlands/Soil Scientist	BS Botany; BS Soil and Water Conservation; MS Soil Science; Responsible for Vegetation and Wetlands (environmental consequences), Plant Species of Concern (environmental consequences)	15 years
Erin Hagan	Environmental Scientist	BA Biology, MEM Conservation Science Responsible for Soils (environmental consequences)	8 years
Charles LeeDecker, RPA	Senior Archeologist	BA Anthropology; MA Anthropology Archeological reconnaissance study in support of NEPA	35 years
Josh Schnabel	Environmental Planner	BA Sociology; MA Geography; Soils (affected environment), Vegetation, Fish and Wildlife (affected environment), Species of Concern (affected environment)	8 years
Spence Smith	Marine Scientist	BS Zoology; MA Biology-Marine Biology Concentration Deputy Project Manager, Phase 2 Fish and Wildlife (environmental consequences; species of concern); Quality Review Phase 3	17 years
Margaret Stewart	Senior Planner	AB Growth and Structure of Cities Program; MRP Land Use and Environmental Planning Deputy Project Manager, Ph 2, 3; Responsible for project management, water resources, and science team facilitation	18 years
Nancy Van Dyke	Senior Consultant	BA Biology and Geography; MS Environmental Sciences Berger Project Manager Responsible for project management (Ph 3) and Quality Review (Ph 1 and 2).	32 years
Julia Yuan	Senior Environmental Scientist	BS Environmental and Forest Biology/Forest Resources Management MPS Forest and Natural Resources Management Responsible for Quality Control review of environmental consequences	12 years

Name	Title	Education/Responsibility	Experience (years)
Christopher Dixon	Environmental Planner	BSES Environmental Economics and Management; MURP; MBA Responsible for Park Operations and Management (environmental consequences)	3 years
The Final Word			
Juanita Barboa	Technical Editor – The Final Word	BS Technical Communication Responsible for editing document	24 years
Sherrie Bell	Technical Editor – The Final Word	Business Management Certificate from New Mexico State University Responsible for formatting and editing document	24 years
US Army Corps of Engineers (USACE)			
Robin Armetta	Environmental Protection Specialist Project Manager	BA Environmental Studies Development/evaluation of alternatives and preliminary design	3 years USACE 3 1/2 years Maryland Environmental Service
Stacy Barron	Project Manager (former)	BS in Civil Engineering Development/evaluation of alternatives and preliminary design	21 years
RK&K, LLP, Consultant to USACE			
Brian Finerfrock, PE	Water Resource Engineer	BS Civil Engineering, Coastal Engineering Certificate, Professional Engineer (VA, NC) Hydraulic modeling and alternatives development	10 years Civil Engineering; 4 years with RK&K
Kirk Value Planners, a subsidiary to Kirk Associates			
Steve Garrett, CVS	Principal and Value Analyst	B. Arch. Architecture Facilitator for Choosing by Advantages / Value Analysis workshop	20 years

PROJECT SUPPORT

- Ben Helwig, formerly Chief of Lands and Planning, NPS, George Washington Memorial Parkway
- Jon James, Deputy Superintendent, George Washington Memorial Parkway
- Carol Pollio, Chief of Natural Resources and Science, National Capital Region

References, Glossary, and Index

REFERENCES

Barrows, E.M., and D.S. Kjar

2003 "Biodiversity Database of the Washington, D.C., Area." Accessed October 30, 2009, at http://biodiversity.georgetown.edu.

Belle Haven Marina (BHM)

2009 Belle Haven Marina Website. Accessed August 24, 2009, at http://saildc.com.

Bibbs, E.

2013 Email from Eric Bibbs, George Washington Memorial Parkway, to Margaret Stewart, Louis Berger Group regarding Maintenance Division activities related to Dyke Marsh. October 17, 2013.

Bies, B., and M. Virta

2009 Personal communication between Brandon Bies and Matthew Virta, National Park Service, George Washington Memorial Parkway, and the Louis Berger Group, Inc., July 27, 2009.

Bishaw, A. and J. Semega

2008 Income, Earnings, and Poverty Data from 2007 American Community Survey: American Community Survey Reports. August 2008.

Booth, G.

2006 "A Sanctuary Amid the Sprawl." *Virginia Wildlife.* October 2006.

Bureau of Labor Statistics (BLS)

2012a Labor Force Statistics from the Current Population Survey. Accessed August 1, 2012, at http://data.bls.gov/PDQ/servlet/SurveyOutputServlet;jsessionid=a230f6986a9c7a657562.

2012b Local Area Unemployment Statistics. Accessed August 1, 2012, at http://www.bls.gov/data/.

Cartwright, L.

2004 "Breeding Bird Survey for Dyke Marsh Wildlife Preserve." Unpublished data.

2012 Breeding bird survey: results of the 2012 Dyke Marsh breeding bird survey. Accessed at: http://www.fodm.org/reports.htm. Accessed on June 7, 2013.

2013 Email from Larry Cartwright, Friends of Dyke Marsh, to Brent Steury, NPS concerning breeding occurrences of Swamp Sparrows in Dyke Marsh. July 17, 2013

Castellanos, D.L. and L.P. Rozas

2001 Nekton use of submerged aquatic vegetation, marsh, and shallow unvegetated bottom in the Atchafalaya River Delta, a Louisiana tidal freshwater ecosystem. Estuaries 24: 184-197.

Cavey, Joseph F., Brent W. Steury, Erik T. Oberg

2013 Leaf Beetles (Coleoptera: Bruchidae, Chrysomelidae, Orsodacnidae) from the George Washington Memorial Parkway, Fairfax County, Virginia. *Banisteria*, Number 41, pages 71-79. Virginia Natural History Society.

Chesapeake Bay Program

2000 *Chesapeake 2000*. Annapolis, Maryland. June 28, 2000.

2013 "Draft Chesapeake Bay Watershed Agreement (Abridged Version for Early Stakeholder Input)." Working Draft (7-9-2013).

Chesapeake Materials, LLC

2013 Products page. Accessed online at http://www.chesapeakematerials.com/products/products.htm on April 8, 2013.

Cleary, E.C., and R.A. Dolbeer

2005 *Wildlife Hazard Management at Airports: A Manual for Airport Personnel*. United States Department of Transportation Federal Aviation Administration and United States Department of Agriculture, Washington, D.C.

Coastal Resources, Inc.

n.d. "Woodrow Wilson Bridge Project" page. Accessed June 5, 2013 at http://coastal-resources.net/index.php/projects/woodrow-wilson-bridge-project/.

COSEWIC

2009 COSEWIC assessment and update status report on the Least Bittern *Ixobrychus exilis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 36 pp.

Council on Environmental Quality (CEQ)

1981 "Forty Most Asked questions Concerning CEQ's National Environmental Policy Act Regulations." Federal Register 46(55):18026–38. Available at: http://ceq.eh.doe.gov/nepa/regs/40/40p.3.htm.

1997 Considering Cumulative Effects Under the National Environmental Policy Act. Council on Environmental Quality. January 1997.

County of Fairfax

2010 "FEMA Special Flood Hazard Areas." Map Panel 93-2. Accessed October 1, 2012, at http://www.fairfaxcounty.gov/gis/DMV/Default.aspx.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe

1979 *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Cronk J. and S. Fennessy

2001 Wetland Plants: Biology and Ecology. CRC Press 463 pages.

District of Columbia Water and Sewer Authority (D.C. Water)

2013 "Clean Rivers Project News." DC Clean Rivers Project, April 2013.

Engelhardt, K.A.M., and A.H. Elmore

2007 *Should We Restore Dyke Marsh? A Management Dilemma Facing George Washington Memorial Parkway, Final Report*. Appalachian Laboratory, University of Maryland Center for Environmental Science. Frostburg, Maryland. July 2005.

Engelhardt, K.A.M., S.W. Seagle, and K.N. Hopfensperger

2005 *Should We Restore Dyke Marsh? A Management Dilemma Facing George Washington Memorial Parkway, Final Report*. Appalachian Laboratory. University of Maryland Center for Environmental Science. Frostburg, Maryland. July 2005.

Eyler, T.B., R.M. Erwin, D.B. Stotts, and J.S. Hatfield

1999 "Aspects of Hatching Success and Chick Survival in Gull-billed Terns in Coastal Virginia." *Waterbirds* 22(1): 54–59.

Fairfax County, Virginia

2012 "Emerald Ash Borer Trapping in Fairfax County" Webpage. Accessed November 14, 2012 at http://www.fairfaxcounty.gov/dpwes/environmental/eab_trap.htm.

Federal Emergency Management Agency (FEMA)

1990 Flood Insurance Rate Map. Fairfax County, Virginia. Community Panel 5155250137D.

Federal Leadership Committee for the Chesapeake Bay

2009 Habitat and Research Activities to Protect and Restore Chesapeake Bay Living Resources and Water Quality: a Revised Report Fulfilling Section 202g of Executive Order 13508. November 23, 2009. U.S. Department of the Interior and U.S. Department of Commerce.

2010 Executive Order 13508: Strategy for Protecting and Restoring the Chesapeake Bay Watershed. May 12, 2010. U.S. Department of the Interior and U.S. Department of Commerce.

Feldman, D.

2009 Email from Debbie Feldman, NPS, to Holly Bender, the Louis Berger Group, Inc. August 31, 2009.

Fernald, R.T.

2008 Letter from Raymond Fernald, Manager, Nongame and Environmental Programs, Virginia Department of Game and Inland Fisheries, to GWMP Superintendent concerning consultation. May 22, 2008.

Finerfrock, B.

2013 Telephone conversation between Brian Finerfrock, RK&K, and contractor for USACE, concerning cutting of tidal guts and that the hydrodynamic model shows the marsh would remain wet under alternatives c and d. May 29, 2013.

Friends of Dyke Marsh (FODM) Website

2007 "Bird Surveys and Mission Statement: Beltsville, Maryland." Accessed December 2007 at http://www.fodm.org/default.htm.

Friends of Dyke Marsh (FODM)

2009 Breeding Bird Survey. Accessed July 28, 2009, at http://www.fodm.org/Dyke%20Marsh/updated.htm.

2011 Breeding Bird Survey. Accessed April 10, 2012, at http://fodm.org/reports.htm.

2012 Bird List. Accessed December 20, 2012 at http://www.fodm.org/updated.htm.

2013 Marsh Life. Accessed at: http://www.fodm.org/marshbio.htm. Accessed on June 7, 2013.

Gee, G.W., and J.W. Bauder

1986 Particle-size Analysis. P.383-411. In A.L. Page (ed.) Methods of soil analysis, Part 1, Physical and mineralogical methods. Second Edition, Agronomy Monograph 9, American Society of Agronomy, Madison, WI.

Gleason, H. and A. Cronquist

1991 Manual of Vascular Plants of Northeastern United States and Adjacent Canada, second edition. The New York Botanical Garden, Bronx, New York

Gutzwiller, K.J. and S.H. Anderson

1987 Habitat suitability index models: marsh wren. U.S. Fish and Wildlife Service Biological Report 82(10.139). 13 pp.

Hammerschlag, R.

1998? Ten Years of Anacostia Water Quality Data (1988-1997); Five Years Pre and Post Kenilworth Marsh Reconstruction. US Geological Survey, Patuxent Wildlife Research Center. NOTE: There is not date on this document.

2007 Personal communication between Richard Hammerschlag, U.S. Geological Survey, and the Louis Berger Group, Inc., November 14–15, 2007.

Hammerschlag, R.S., A.H. Baldwin, C.C. Krafft, K.P. Neff, M.M. Paul, K.D. Brittingham, K. Rusello, and J.S. Hatfield

2006 Final Report: Five years of monitoring reconstructed freshwater tidal wetlands in the urban Anacostia River (2000-2004). USGS Patuxent Wildlife Research Center Laurel, Maryland. 101 pp.

Harper, J.D., and F.D. Heliotis

1992 "Dyke Marsh Hydrologic Model." George Mason University, Fairfax, Virginia.

Henley, W.F., M.A. Patterson, R.J. Neves, and A.D. Lemly

2000 Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. *Reviews in Fisheries Science* 8:125-139.

Hilty, J.

2009 “Davis’ Sedge, *Carex davisii*.” *Illinois Wildflowers, 2002–2009*. Accessed August 4, 2009, at http://www.illinoiswildflowers.info/grasses/plants/davis_sedge.htm.

Hopfensperger, K. N.

2007 *Effects of Annual and Perennial Community Dynamics on Tidal Freshwater Marsh Ecosystem Functioning*. University of Maryland. Program of Marine, Estuarine, and Environmental Science.

Hopfensperger, K.N., K.A.M. Engelhardt, and S.W. Seagle

2006 “The Use of Case Studies in Establishing Feasibility for Wetland Restoration.” *Restoration Ecology* 14(4): 578–586. December 2006.

Interstate Commission on the Potomac River Basin (ICPRB)

2007 *Total Maximum Daily Loads of Polychlorinated Biphenyls (PCBs) for Tidal Portions of the Potomac and Anacostia Rivers in the District of Columbia, Maryland, and Virginia*. ICPRB Report 07-7. Prepared by H. C. Haywood and C. Buchanan. Rockville, Maryland. October 2007.

Interagency Workgroup on Wetland Restoration (IWWR)

2003 *An Introduction and User’s Guide to Wetland Restoration, Creation, and Enhancement*. National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and Natural Resources Conservation Service.

Johnston, D.W.

2000 “The Dyke Marsh Preserve Ecosystem.” *Virginia Journal of Science* 51:223–271.

Kneib, R.T.

1984 Patterns in the utilization of the intertidal salt marsh by larvae and juveniles of *Fundulus herteroclitus* (Linnaeus) and *Fundulus luciae* (Baird). *Journal of Experimental Marine Biology and Ecology*. 83: 41-51.

Kneib, R.T., and S.L. Wagner

1994 Nekton use of vegetated marsh habitats at different stages of tidal inundation. *Marine Ecology Progress Series* 106: 227-238.

Krakow, J.L.

1993 National Register of Historic Places Nomination, George Washington Memorial Parkway. On file. George Washington Memorial Parkway Headquarters. McLean, Virginia.

Lebel, S.

2009 Personal communication between Steve Lebel, NPS, and Holly Bender, the Louis Berger Group, Inc. August 20, 2009.

Leberman, R.C.

2008 "Swamp Sparrow (*Melospiza georgiana*)." *2nd Pennsylvania Breeding Bird Atlas, 2004–2008*. Carnegie Museum of Natural History. Accessed August 4, 2009, at http://www.carnegiemnh.org/atlas/media/accounts/390-91_SWSP.pdf.

Lichvar, R.W.

2013 The National Wetland Plant List: 2013 Wetland Ratings. *Phytoneuron* 2013-49:1-241. Published 17 July 2013. ISSN 2153 733X.

Litwin, R.

2011 Email from Ron Litwin, USGS, to Brent Steury, NPS-George Washington Memorial Parkway; Stacy Underwood, U.S. Army Corps of Engineers-Baltimore District, and Dottie Marshall, NPS-George Washington Memorial Parkway, transmitting comments from Ron Litwin, Milan Pavich, and John Smoot (USGS) on draft alternatives. July 22, 2011.

2013 Email from Ron Litwin, USGS, to Glenda Booth, Friends of Dyke Marsh concerning clarification of cited ages of dyke marsh. January 11, 2013.

Litwin, R., and M. Pavich

2009 Presentation by Ron Litwin, U.S. Geological Survey, and Milan Pavich, U.S. Geological Survey, at the alternatives development meeting, May 12, 2009.

Litwin, R.J., J.P. Smoot, M.J. Pavich, H.W. Markewich, E. Oberg, B. Helwig, B. Steury, V.L. Santucci, N.J. Durika, N.B. Rybicki, K.M. Engelhardt, G. Sanders, S. Verardo, A.J. Elmore, and J. Gilmer

2011 *Analysis of the Deconstruction of Dyke Marsh, George Washington Memorial Parkway, Virginia: Progression, Geologic and Manmade Causes, and Effective Restoration Scenarios*. U.S. Geological Survey Open-file Report 2010-1269.

Litwin, R.J., J.P. Smoot, M.J. Pavich, E. Oberg, B. Steury, B. Helwig, H.W. Markewich, V.L. Santucci, G. Sanders

2013 Rates and Probable Causes of Freshwater Tidal Marsh Failure, Potomac River Estuary, Northern Virginia, USA. Wetlands. SWS. DOI 10.1007/s13157-013-0461-6. October 3, 2013.

Mangold, M.F., R.C. Tipton, S.M. Egler, and T.M. McCrobie

2004 *Inventory of Fish Species within Dyke Marsh, Potomac River (2001–2004)*. U.S. Fish and Wildlife Service, in conjunction with Maryland Fishery Resources Office. Annapolis, Maryland.

Minello, T.J., R.J. Zimmerman, and R. Medina

1994 The importance of edge for natant macrofauna in a created salt marsh. Wetlands 14: 184-198.

National Oceanic and Atmospheric Administration (NOAA)

2000 “Rising Seas: Maryland Managers Pursue Higher Ground.” Coastal Services March/April 2000. National Oceanic and Atmospheric Administration Coastal Services Center, Charleston, South Carolina. Accessed October 28, 2009, at http://www.csc.noaa.gov/magazine/2000/02/rising_seas.html.

National Park Service (NPS)

n.d.a Director’s Order 77: *Natural Resource Protection*. In development.

n.d.b Reference Manual 77: *Natural Resource Management*. In development.

n.d.c *Cultural Landscape Report, Mount Vernon Memorial Highway*. Volume One: History. Volume 2: Documentation. National Capital Region, National Park Service, U.S. Department of the Interior. Prepared by EDAW, Inc. (probably in 1992).

1961 Letter from William M. Haussmann, Acting Chief, Division of Design and Construction, National Capital Parks, to Washington Gas Light Company, concerning permit and right of way for gas pipeline through Dyke Marsh

1977 *Dyke Marsh Environmental Assessment*. National Capital Region. George Washington Memorial Parkway. May 1977.

1981 National Register of Historic Places Nomination, Mount Vernon Memorial Highway. On file. George Washington Memorial Parkway Headquarters. NRHP # 81000079. McLean, Virginia.

1991 Registration Form, National Register of Historic Places: Parkways of the National Capital Region, 1913 – 1965. NRHP #64500086. Signed November 12, 1994.

1993 *A Historical Delineation of the Dyke Marsh Vegetation*. Prepared by D. Kelso, Z. Xu, G. Marcella, and L. K. Thomas, Jr.

1994 *George Washington Memorial Parkway, along Potomac River from McLean to Mount Vernon, VA, Mount Vernon, Fairfax County, VA*. National Park Service, U.S. Department of the Interior. Prepared by the Historic American Engineering Record.

1995 Registration Form, National Register of Historic Places: George Washington Memorial Parkway. NRHP # 95000605. Signed April 24, 1995.

1996 George Washington Memorial Parkway Administrative History. Prepared by Barry Mackintosh.

1998a Director’s Order 28: *Cultural Resource Management*. June 11, 1998.

1998b *Guide to Cultural Landscape Reports: Contents, Process, and Techniques*. National Park Service, U.S. Department of the Interior. Prepared by Robert Page, Cathy A. Gilbert, and Susan Dolan.

2000a Director’s Order 47: *Soundscape Preservation and Noise Management*. December 1, 2000.

2000b *Raised Boardwalk and Improvements to Wildlife Viewing Areas at Dyke Marsh Environmental Assessment*. George Washington Memorial Parkway. April 2000.

2001 Director’s Order 12 Handbook: *Conservation Planning, Environmental Impact Analysis, and Decision Making*.

2002 Director’s Order 77-1: *Wetland Protection*. October 30, 2002.

2003 Director's Order 77-2: *Floodplain Management*. September 8, 2003.

2005a *Belle Haven Marina Draft Environmental Assessment / Assessment of Effect*. George Washington Memorial Parkway. August 12, 2005.

2005b *George Washington Memorial Parkway Long-range Interpretive Plan*. Prepared by the Department of Interpretive Planning Harpers Ferry Center and George Washington Memorial Parkway. November 2005.

2006 National Park Service *Management Policies 2006.*

2008a "Dyke Marsh Wetland Restoration and Long-Range Management Plan / Environmental Impact Statement." Display board for use in Public Scoping Open House. National Park Service, George Washington Memorial Parkway, Virginia.

2008b "George Washington Memorial Parkway: Dyke Marsh Wildlife Preserve." Accessed July 8, 2009, at http://www.nps.gov/gwmp/dyke-marsh.htm.

2009a Final Report: *Archeological Assessment for Dyke Marsh Preserve*. George Washington Memorial Parkway, Virginia. Prepared by The Louis Berger Group, Inc. January 2009.

2009b Final Report: *Observations of Erosion and Deposition in Dyke Marsh Preserve Alexandria, Virginia, 1992 to 2009*. George Washington Memorial Parkway, Virginia. Prepared by Normandeau Associates Inc. June 2009.

2009c *Draft Interim Guidance: Considering Climate Change in National Park Service NEPA Analysis*. February 2009.

2009d *Dyke Marsh Wetland Restoration and Long-range Management Plan / Environmental Impact Statement: Summary of Alternatives Development Meeting*. George Washington Memorial Parkway, Virginia. May 12–13, 2009.

2009e "Annual Park Visitation." NPS Public Use Statistics Office. Accessed August 18, 2009, at http://www.nature.nps.gov/stats/park.cfm.

2009f *Final Report: Dyke Marsh Wetland Restoration and Long-range Management Plan / Environmental Impact Statement*. Science Team Summary. George Washington Memorial Parkway, Virginia.

2009g NPS National Capital Region Vegetation Classification and Mapping Project, 2009.

2010a Monthly Report for January 2010. National Park Service Count Station for George Washington Memorial Parkway at Hunting Creek – South of Alexandria.

2010b Monthly Report for July 2010. National Park Service Count Station for George Washington Memorial Parkway at Hunting Creek – South of Alexandria.

2011a Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision Making*.

2011b National Park Service Procedural Manual #77-1: Wetland Protection

2012a "Annual Park Visitation." NPS Public Use Statistics Office. Accessed July 19, 2012, at http://nature.nps.gov/stats/park.cfm?parkid=292.

2012b "Mount Vernon Trail Information" Web page. Accessed October 1, 2012 at http://www.nps.gov/gwmp/mvt-safety.htm.

Natural Heritage Endangered Species Program (NHESP)

2008 "River Bulrush, *Bolboschoenus fluviatilis* (Torr.) Sajak." Massachusetts Division of Fisheries & Wildlife. Westborough, Massachusetts. Accessed August 5, 2009, at http://www.mass.gov/dfwele/dfw/nhesp/species_info/nhfacts/bolboschoenus_fluviatilis.pdf.

Natural Resource Conservation Service (NRCS)

2009a Farmland Protection Policy Act. Accessed November 13, 2008, at http://www.nrcs.usda.gov/programs/fppa/.

2009b Web Soil Survey for Dyke Marsh area. Accessed July 22, 2009, at http://websoilsurvey.nrcs.usda.gov/app/.

National Vegetation Inventory (NVI)

2009 "Freshwater Tidal Mixed High Marsh." Description and profile.

NatureServe

2009 NatureServe Explorer: An Online Encyclopedia of Life [web application]. Accessed July 31, 2009, at http://www.natureserve.org/explorer. Last updated February 6, 2009.

Neff, K. and A. Baldwin

2005 Seed Dispersal Into Wetlands: Techniques and Results for a Restored Tidal Freshwater Marsh. *Wetlands*, Vol. 25, No. 2, June 2005, pp. 392–404.

New Hampshire Division of Forests & Lands (NHDFL)

2002 "Rare Plants of New Hampshire: Larger Bur-reed." New Hampshire Natural Heritage Program, Concord, New Hampshire. Accessed August 5, 2009, at http://www.nhdfl.org/library/pdf/FS-LargerBur-Reed.pdf.

New York Natural Heritage Program (NYNHP)

2009 "Rough Avens (*Geum virginianum*)." *NYNHP Conservation Guide*. Accessed August 5, 2009, at http://www.acris.nynhp.org/report.php?id=9297.

Normandeau Associates

2009 Dyke Marsh Potomac River 2009 water depths at mean low water. Unpublished data.

Odum W.E., T.J. Smith III, J.K. Hoover, and C.C. McIvor

1984 The ecology of tidal freshwater marshes of the United States east coast: a community profile. U.S. Fish Wildlife Service. FWS/OBS-83/17. 177 pp.

Paul, M., C. Krafft, and D. Hammerschlag

2006 Avian comparisons between Kingman and Kenilworth marshes, Final Report 2001-2004. USGS Patuxent Wildlife Research Center Beltsville, Maryland.

Pavek, D.

2013 Email communication from Diane Pavek, NPS, to Margaret Stewart, Louis Berger Group, concerning reasons the original EA was not completed. September 26, 2013.

Peterson, G.W., and R.E. Turner

1994 The value of salt marsh edge vs. interior as a habitat for fish and decapod crustaceans in a Louisiana salt marsh. *Estuaries* 17: 235-262.

Potomac River Boat Company

2013 " Sighseeing Tours"Webpage. Accessed June 5, 2013 at http://www.potomacriverboatco.com/mount-vernon-cruise.php.

PricewaterhouseCoopers, LLC (PwC)

2003 *Belle Haven Marina Market Analysis for Marina and Support Facilities*. April 2003.

Rozas, L.P. and W.E. Odum

1987 Fish and macrocrustacean use of submerged plant beds in tidal freshwater marsh creeks. *Marine Ecology Progress Series* 38: 101-108.

Rozas, L.P., C.C. McIvor, and W.E. Odum

1988 Intertidal rivulets and creekbanks: Corridors between tidal creeks and marshes. *Marine Ecology Progress Series* 47: 303-307.

Runkel, S.T. and D.M. Roosa

1999 *Wildflowers and Other Plants of Iowa Wetlands*. University of Iowa Press, Iowa.

Searcy, K.

n.d. *The Floodplain Forest*. Accessed July 28, 2009, at http://www.bio.umass.edu/biology/conn.river/fpforest.html.

Shellenhamer J.

2008 *Archeological Assessment for Dyke Marsh Preserve, George Washington Memorial Parkway, Fairfax County, Virginia.* Prepared for the National Park Service, Denver Service Center, by the Louis Berger Group Inc.

Spencer, S.C.

2000 "Population Abundance and Habitat Requirements of the Marsh Wren (*Cistothorus palustris*) at Dyke Marsh National Wildlife Preserve." Master's thesis, George Mason University, Fairfax, Virginia.

Steury, B.W.

2004 "Carex davisii, Noteworthy collection from Virginia." *Castanea* 69(3): 241–242.

2009 Telephone conversation between Brent Steury, NPS, and Landon Vine, the Louis Berger Group, Inc. July 27, 2009.

2010 Rare Sedge Discovered in Dyke Marsh. The Marsh Wren. Friends of Dyke Marsh, Spring 2010.

2011 "Additions to the vascular flora of the George Washington Memorial Parkway, Virginia, Maryland, and the District of Columbia." *Banisteria* 37:3-20.

2013 Email from Brent Steury, George Washington Memorial Parkway, to Margaret Stewart, Louis Berger Group, regarding costs of the no action alternative. September 18, 2013.

Stynes, D.J.

2011 *Economic Benefits to Local Communities from National Park Visitation and Payroll, 2009.* Department of Community, Agriculture, Recreation and Resource Studies. Michigan State University and National Park Service Social Service Program.

Teague, J.

2012 Email from Judy Teague, NatureServe, to Brent Steury, NPS, on description of vegetation communities in Dyke Marsh. July 27, 2012.

Thompson, E.

2003 Carex davisii *Schwein. & Torr. (Davis' sedge) Conservation and Research Plan for New England*. New England Wild Flower Society. Framingham, Massachusetts. Accessed August 4, 2009, at http://www.newenglandwild.org/docs/pdf/Carexdavisii.PDF.

Titus, J.G., K.E. Anderson, D.R. Cahoon, D.B. Gesch, S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams

2009 *Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region, Synthesis and Assessment Product 4.1*. Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. January 2009.

United States Army Corps of Engineers (USACE)

1987 *Corps of Engineers Wetland Delineation Manual*. Environmental Laboratory. Vicksburg, Mississippi.

1998 *Geotextile Tube Structures for Wetland Restoration and Protection.* WRP Technical Note HS-RS-3.2. January 1998.

2010 "Dyke Marsh Tidal Modeling Technical Memorandum, Potomac River Hydrologic Evaluation," in *Dyke Marsh Compendium Phase 1(2009-2010)*. Prepared by RKK Associates for the U.S. Army Corps of Engineers.

2012a "Dyke Marsh Restoration Project Potomac River 2D Hydrodynamic Modeling, January 2012," in *Dyke Marsh Compendium Phase 2 (2011- 2012)*. Prepared by RKK Associates for the U.S. Army Corps of Engineers.

2012b Wetland Indicator Status Atlantic Gulf Coastal Plain.

2012c "Dyke Marsh Restoration Project Team Presentation materials from February 15, 2012 meeting with NPS, USACE, and other stakeholders. Prepared by RKK for the USACE.

2013 Dyke Marsh Restoration Project Design Technical Memorandum, Phase 3. March 2013. Prepared for the USACE Baltimore District by RK&K.

U.S. Census Bureau

2000a "City of Alexandria." 2000 Census, Demographic Profile Data. Accessed August 1, 2012, at http://censtats.census.gov/cgi-bin/pct/pctProfile.pl.

2000b "Fairfax County." 2000 Census, Demographic Profile Data. Accessed August 1, 2012, at http://censtats.census.gov/cgi-bin/pct/pctProfile.pl.

2000c “Virginia.” 2000 Census, Demographic Profile Data. Accessed August 1, 2012, at http://censtats.census.gov/cgi-bin/pct/pctProfile.pl.

2000d “United States.” 2000 Census, Demographic Profile Data. Accessed August 1, 2012, at http://censtats.census.gov/cgi-bin/pct/pctProfile.pl.

2010a “City of Alexandria.” 2010 Census, DP-1: Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data. Accessed August 1, 2012, at http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

2010b “Fairfax County.” 2010 Census, DP-1: Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data. Accessed August 1, 2012, at http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

2010c “Virginia.” 2010 Census, DP-1: Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data. Accessed August 1, 2012, at http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

2010d “United States.” 2010 Census, DP-1: Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data. Accessed August 1, 2012, at http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

United States Department of Agriculture-Animal and Plant Health Inspection Service (USDA-APHIS)

2012 “Cooperative Emerald Ash Borer Project.” Map of EAB Detections. November 1, 2012. Accessed November 14, 2012 at http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/NewCountyDetectionMap.pdf.

United States Environmental Protection Agency (USEPA)

1992 Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis

1995 *America’s Wetlands: Our vital link between land and water.* Office of Water, Office of Wetlands, Oceans and Watershed. EPA 843-k-95-001.

2009 “Ecosystems Research.” Ecological Services Research Program Web page. Accessed July 22, 2009, at http://epa.gov/ord/esrp/.

United States Fish and Wildlife Service (USFWS)

2000 National Wetland Inventory Data Mapper. Accessed August 4, 2009 at http://wetlandsfws.er.usgs.gov/imf/sites/NWI_CONUS/CONUS_metadata/topoq24.htm.

U.S. Forest Service

n.d. Swamp sparrow (*Melospiza Georgiana*). Northeastern Research Station A.O.U. No. 584.0. p. 348.

United States Geological Survey, National Wetlands Research Center (USGS)

2008 “About Wetlands.” National Wetlands Research Center Web page. Accessed July 22, 2009, at http://www.nwrc.usgs.gov/wetlands.htm.

2012 “USGS Current Water Data for Dist. of Columbia.” National Water Information System: Web Interface. Accessed August 02, 2012, at http://waterdata.usgs.gov/dc/nwis/rt.

University of Maryland Center for Environmental Science (UMCES)

2004 “Summary of Informational Workshop for Dyke Marsh Preserve.”

2007 “Climate Change Will Impact Global River Flow, Scientists Warn.” *Science Daily* October 13, 2007. Accessed October 30, 2009, at http://www.sciencedaily.com/releases/2007/10/071012105820.htm.

Virginia Department of Conservation and Recreation (VA DCR).

1992 Virginia Erosion and Sediment Control Handbook, Third Edition.

Virginia Department of Environmental Quality (VA DEQ)

2008 Virginia Water Quality Assessment: 305(b)/303 (d) Water Quality Integrated Report to Congress and the EPA Administrator for the Period January 1, 2001, to December 31, 2006. Richmond, Virginia. October 2008. Available online at http://www.deq.state.va.us/wqa/ir2008.html.

2012a “2012 Draft Recreation Use Map Service.” Available online at http://www.deq.virginia.gov/mapper_ext/default.aspx?service=public/2010_ADB_Recreation.

2012b *Virginia Draft 305(b)/303(d) Water Quality Integrated Report to Congress and the EPA Administrator for the Period January 1, 2005, to December 31, 2010*. Richmond, Virginia. March 2012. Available online at http://www.deq.state.va.us/Portals/0/DEQ/Water/WaterQualityAssessments/IntegratedReport/2012/ir12_Integrated_Report_All_Draft.pdf.

2012c A Public Guide to the Wetland Permitting Process in Virginia. Office of Wetlands and Stream Protection. December 2012.

2013 “Federal Consistency Information Package. “Accessed October 24, 2013 at http://www.deq.virginia.gov/Programs/EnvironmentalImpactReview/FederalConsistencyReviews.aspx.

Virta, M.

2012a “The Cultural History of Dyke Marsh: An Overview of Human History and Interaction in One of the Washington, DC Region’s Largest Freshwater Tidal Wetlands.” Presented November 14, 2012 at the Friends of Dyke Marsh November Meeting At the Huntley Meadows Park Visitor Center

2012b Personal communication between Matthew Virta, NPS-GWMP and Margaret Stewart, Louis Berger Group, regarding inclusion of cultural landscapes as an impact topic. July 30, 2012.

2013 Email from Matthew Virta, Cultural Resources Program Manager, NPS, George Washington Memorial Parkway, to Margaret Stewart, Louis Berger Group, concerning the park’s Cultural Resources Management Program. October 22, 2013.

Washington Gas

n.d. “Pile Driving Nearby Steel Transmission Main.”

Werst, L.

2013 Email from Lee Werst, Chief Ranger, George Washington Memorial Parkway, to Margaret Stewart, Louis Berger Group, confirming information on interpretation services division. October 17, 2013.

Wiland, L.

2007 “Swamp Sparrow, *Melospiza georgiana*.” *Migratory Birds of the Great Lakes*. University of Wisconsin Sea Grant. Accessed August 4, 2009, at http://www.seagrant.wisc.edu/birds/swamp_sparrow_intro.html.

Williams, B.K., R.C. Szaro, and C.D. Shapiro

2007 *Adaptive Management: The U.S. Department of the Interior Technical Guide.* Adaptive Management Working Group, U.S. Department of the Interior, Washington, D.C.

Xu, Z.

1991 *Final Report on Inventories of Plant Species and Communities in Dyke Marsh, Alexandria, Virginia*. George Mason University, Fairfax, Virginia.

Yolo Natural Heritage Program

2009 Draft Species Accounts: least bittern (*Ixobrychus exilis*).

GLOSSARY

adventitious roots—roots that develop in an unusual place, such as the trunk.

benthic sediment—Bethnic sediment is sediment found on the river bottom.

coir biologs—tubes or logs made of coir or coconut fiber bound by high strength twisted coir netting that provide attenuation of wave energy in shallow places; over time, the logs will degrade.

containment cells—a containment cell is an structure placed in the open water that allows for fill to be placed inside to raise the elevation of the river bed.

fastland—fastland is land near water that is high and dry.

geotextile tubes—geotextile tubes are large tubes made from high strength fabric filled with sand slurry; they can be several hundred feet in length, and several feet in diameter.

hydroperiod—length of time the marsh surface is inundated.

obligate wetland indicator plants—Obligate wetland indicator plants are those plants that almost always occur in wetlands.

refugia— refugia are areas in which a population of organisms can survive through a period of unfavorable conditions.

thalweg— Thalweg is the line defining the lowest points along the length of a river bed or valley.

tidal guts—tidal guts are stream-like features found in tidal marshes formed by advancing and receding tides.

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Appendices

APPENDIX A: ADAPTIVE MANAGEMENT

DRAFT DYKE MARSH MONITORING PLAN TO SUPPORT ADAPTIVE MANAGEMENT APPROACH TO ASSESSING THE SUCCESS OF MARSH RESTORATION

PROJECT PURPOSE

The purpose of this project is to restore a destabilized, eroding marsh. The National Park Service (NPS) and U.S. Army Corps of Engineers have congressional mandates to restore the historic marsh. Using the steps outlined above, this section describes the elements to be included in the development of the adaptive management plan.

SAMPLING DESIGN

Monitoring will determine factors contributing to the success or failure of the restoration, justify adaptive management actions, and allow for the better understanding of factors contributing to marsh loss throughout Dyke Marsh. Key processes shaping the marsh include hydrodynamic forces, vegetation, and sediment accretion and erosion (Darke and Megonigal 2003). Marsh surface elevation, vegetation, and hydrology are closely linked. Monitoring of hydrology, elevation and accretion, and vegetation at the treatment and reference marshes will be conducted prior to restoration and will continue for at least 10 years after restoration. The monitoring program is managed and implemented by NPS. In a successful restoration, vegetation in the newly created marsh should be approximately the same as what is currently in the existing marsh, invasive nonnative species would be removed upon discovery, and the breakwater would work according to the hydrologic models and would allow for low energy areas in the marsh that would encourage accretion (NPS 2013).

This monitoring plan employs a Before, After, Control, Impact sampling design (Stewart-Oaten et al. 1986; Stewart-Oaten et al. 1992; Underwood 1992; Smith et al. 1993; Stewart-Oaten 2003; Rafferty et al. 2011; Turner et al. 2013a). The Before, After, Control, Impact design examines the before (pre-construction baseline) and after (post-construction) condition of the restoration site and compares a control (reference site) with the impact site (restoration site) (Turner et al. 2013a). Before and after sampling will determine how the restoration process changed the site through time from its historical condition (Turner et al. 2013a). Baseline elevation data are currently available for sediment erosion tables Sediment Elevation Table (SET) and LIDAR. Vegetation data at Dyke Marsh has been gathered by several investigators from 1991 to the present (Xu 1991; Hopfensperger and Engelhardt 2008). Numerous surveys of vegetation exist, as well as bathymetric studies and complete elevation surveys of the marsh.

The placement of dredge material and any planting is the “impact” and a nearby reference marsh that has not been recently disturbed is the “control.” The control marsh is representative of the target condition. Control and impact sampling differentiate effects of restoration actions from natural variability, stochastic events, and underlying regional trends such as sea level rise increasing water levels. A control site with identical conditions to the restoration site is not typically available. Therefore, the term reference site is used to describe areas near the restoration but not part of the area directly affected by the restoration project. The restoration and reference sites are typically monitored with similar intensity to allow for direct comparison of the different monitoring samples (Turner et al. 2013a).

Cells will be filled to elevations designated in the design plan. Knowledge of the sediment dynamics will be incorporated in restoration design. The elevations of the marsh will be dynamic. Physical gradients and marsh vegetation influence the maintenance of marsh elevation. This is where climate change impacts occur and need to be monitored. Sea level rise will obliterate the marsh if elevations are not dynamic; the system must be accreting more than the water level is rising. Lateral erosion is intrinsic to marshes and part of their dynamic processes (Temmerman et al. 2003). Within this category there are a number of marsh features that can be measured, such as accretion rates, elevation change, and elevation of channels (NPS 2013).

An ideal reference marsh would be (1) located in the same region so that they shared broad scale environmental factors; (2) managed by the NPS so that decisions, relations, and processes would be similar and relevant to establishing feasibility; and (3) tidal wetland systems similar to the ecosystem. It was determined that the marshes of Piscataway Park are the best for control and reference monitoring since they meet the three criteria and are also within the same tidal area of the Potomac River.

Reference Marsh

The park will confer with National Capital Parks – East before establishing the marsh as a reference for the restoration of Dyke Marsh. There are 50 vegetation plot Global Positioning System (GPS) points in Piscataway Park. LIDAR was flown in 2008. SETs will need to be added to the marsh and sampling design established.

Study Area

Dyke Marsh, George Washington Memorial Parkway, Virginia and Piscataway Marsh, National Capital Parks – East, Maryland

Sampling Frequency and Replication

Final temporal and spatial design of sampling will depend on the restoration design and process. Monitoring of marsh restorations to direct adaptive management should continue for at least 10 years following completion of the restoration, and preferably for decades (Mitsch and Wilson 1996). There should be a timeframe component to the success criteria because marsh characteristics will change over time, especially during the first few years. It can take a number of years for channels and elevations to stabilize (NPS 2013).

SAMPLING METHODS

Hydrology (Water Level)

Hydrology and duration of flooding are important indicators to be monitored, because the data collected may reveal the causes behind changes in vegetation over time and will allow the restoration team to determine how to adjust the restored system. For example, if soils become too anaerobic and that corresponds to frequent flooding, then the team may take steps to change the flooding regime. The duration or percent of time that the marsh is flooded (frequency), and not the depth of the flooding, is the best indicator of the vegetation that will become established (NPS 2013).

A continuous water level recorder consisting of a data logger and pressure transducer is present at the Belle Haven Marina. Additional continuous water level loggers may be installed along each transect and at the existing SET locations. All loggers could be set to record at the same time every hour, providing an hourly inundation map of the marsh.

Geomorphology (Elevation and Erosion/Accretion)

Monitoring geomorphology includes measurements of accretion, elevation change, channel development, and topography. Measuring elevation and accretion can be used to determine if the marsh is keeping up with sea level rise. For elevation, there can be a range of elevations, and presumably there will be a gradient of elevations in the restored marsh. The differences in elevation will dictate plant community and diversity, which will determine the quality of habitat for marsh wildlife. It is also important to establish heterogeneity in elevation. A way to monitor elevation is to get photo-documentation of shrubs from shallow to deep water. The design plan will include a view of the different elevation zones that the restoration team will try to create, and monitoring of elevation and hydrology should follow that plan.

Monitoring will occur with repeated elevation measurements (NPS 2013). It is also important to look at channel development to ensure it is not eroding. In terms of topography, horizontal accretion may also be monitored. A topographic map will be generated for Dyke Marsh, and it was suggested that a tide gauge be placed in the vicinity of the marsh (NPS 2013).

Accretion

Sediment accretion is measured using marker horizons and either cryogenic corers or the “marsh plug” method. Both these techniques are described in detail at the USGS Patuxent Wildlife Research Center SET web site http://www.pwrc.usgs.gov/resshow/cahoon/. Start time of SET installation and sampling will depend on settlement of the dredge slurry material. Initially the SET and accretion may be sampled four times per year, which may be reduced to twice per year as the marsh develops. For robust statistical analysis of the SET, readings across a full 20-year tidal pattern are necessary.

Elevation

Marsh sediment elevation change is measured using SETs (Cahoon et al. 2000; Cahoon et al. 2002a; Cahoon et al. 2002b; Cahoon and Lynch 2010). A millimeter scale may be required to measure the marsh’s response to sea level rise which SETs provide.

Existing 9 SETs in Dyke Marsh were installed following standard peer-reveiwed methods as described by Cahoon and others (Cahoon et al. 2000; Cahoon et al. 2002 a; Cahoon et al. 2002b; Cahoon and Lynch 2010). The tables are currently read twice a year, following standard methods (Cahoon et al. 2000; Cahoon et al. 2002a; Cahoon et al. 2002b; Cahoon and Lynch 2010). Data are maintained by National Capital Region Inventory and Monitoring Network and Northeast Coastal and Barrier Inventory and Monitoring Network. Analyses and reports are forthcoming. SET already exist in the marsh and will continue to be monitored National Capital Region Inventory and Monitoring Network, and Northeast Coastal and Barrier Inventory and Monitoring Network. The park will be given the data annually.

Currently, Dyke Marsh has baseline elevation mapping and hypsography.

Soils

The dredge material characteristics will be evaluated by U.S. Army Corps of Engineers, including toxin levels, particle size analysis, and consolidation rates before restoring the site. There is a danger of contaminated fill, depending on where dredging occurs.

Salinity

Some tidal freshwater wetlands are seasonally pulsed with salinity (during dry summer months), which can have effects on vegetation. Currently, the salt wedge is 36 miles (58 km) south of Dyke Marsh. The upstream movement of the salt wedge in the Potomac River is a strong possibility with sea level rise and climate change. Continuous logging conductivity meters are already deployed at Piscataway Park on the Potomac River in Maryland and Fort Hunt on the Potomac River in Virginia downstream of Dyke Marsh. It may be useful to install an additional logger in Dyke Marsh.

Vegetation

Sampling design in Dyke Marsh would consist of a series of transects from upland to the water's edge. Transects would be extended out to water's edge as the marsh is expanded during the phased restoration. Sampling will occur at the current nine SET locations and along with additional transects beginning in the upland area and extending towards the river inserted as needed. Traditionally, marsh sampling runs from the water to the upland, but due to the phased construction of the marsh, it is better to extend the transects at the water's edge as cells are added. Additional transects will be added as marsh restoration proceeds. Effective sample size can be determined through a combination of consideration of power analysis for change detection and consideration of the scale of the restoration, the amount of variability across the site and practical limits of cost and labor (Turner et al. 2013b).

The locations of each transect and of plots along each transect will be established by a random-systematic design. To monitor plant community changes over time baseline latitude, longitude and elevation measurements will be made using survey grade GPS to achieve cm scale accuracy. Data points are taken from the marsh until there is a shift in the primary or secondary species present. GPS will be used to mark the location and elevation of plant community changes along transects. Using the data from previous years, each transect will be revisited in subsequent years and major changes in plant communities will be documented (Kreeger et al. 2012).

Suggested variables to measure for the plant community assemblage are species present, invasive species, percent cover by species, and stem height for the first 25 stems and light intensity at the sediment surface was recorded. When present, the extent of invasive nonnative species and state rare river bulrush will be GPS mapped.

Data Management, Analysis, and Reporting

There needs to be a plan for long-term data management for all areas monitored. One searchable database for all the monitoring data is needed for George Washington Memorial Parkway. Data collection, management, analysis and reporting will follow the National Capital Region Inventory and Monitoring Network data management plan where applicable (geographic information system (GIS), GPS, metadata, NPS reporting standards, upload of databases and documents to Integrated Resource Management Applications) which can be found here:
http://science.nature.nps.gov/im/units/ncrn/data_management.cfm

Monitoring the restoration and reference sites with the same methods, intensity, and frequency allow for paired comparison of the trajectories of the restored and reference site. However, the lack of replicates for either site can be problematic (Turner et al. 2013b). Conquest (2000) provides some guidance on how to deal with this statistically.

Hydrology (Water Level)

Management Action

This is not monitored at many restoration sites, although it is a major marsh feature.

Action Thresholds

Inundation at key vegetation community interfaces does not support desired species.

Management Responses

Adjust marsh elevation or remove obstacles to flow.

Geomorphology (Elevation and Erosion/Accretion)

Management Action

All of the projects that involved dredge material placement conducted studies on some dredge material characteristics including toxin levels, particle size analysis, and consolidation rates before restoring the site. After restoration, Poplar Island did not study the dredge material consolidation rates, which would have been helpful. Elevations at Kenilworth Marsh restoration were higher than desired, which may have enhanced the spread of invasive nonnative species. Measured components of soils may include organic matter content and metal content (NPS 2013).

Action Thresholds

Are marsh elevations maintained over time?

Can sediment accretion rates maintain the biodiversity of the marsh?

Management Responses

Use adaptive management to gain management experience regarding the elevation of the new marsh. Adaptive adjustments to monitoring metrics and management responses will be made based on information gained through surveillance and the effects of management actions on marsh biodiversity.

Salinity

Management Action

Follow marsh restoration design plan. Conductivity and salinity are mathematically related. Measuring conductivity serves as a surrogate for salinity.

Action Thresholds

Conductivity above--uS/cm indicates salinity that would impact vegetation community.

Management Responses

Adjust expectations for community composition of Dyke Marsh. It will not resemble the historic marsh in species composition.

Vegetation

Management Actions

Measurements include species composition, species richness, cover, and invasive nonnative species abundance. The list of perennial species should be similar to those of reference sites, but there may be differences in relative abundance. For example, there may be more cattail in the restored area of Dyke Marsh when compared to the existing marsh. It is also important to have annual species as part of the vegetation index. Plant cover is a good index of production and of ecosystem function. The NPS should use the existing marsh as reference for invasive nonnative species because a restored wetland may not remain free of nonnative species, and the nonnative species content may never fall below that of the existing marsh (NPS 2013).

Storm surge (wind-induced waves) can start erosion in the marsh and create abrupt edges or cleared mudflats unprotected by vegetation. Further vegetation-sediment destabilization feedback can occur by excessive herbivory by geese, for example. Fenced exclosures will be used in Dyke Marsh to prevent herbivory by geese, for example, in low elevation areas, especially mudflats.

The colonization of newly created wetlands will occur within the first growing season of substrate creation. Following restoration plan design, available cells will be planted if funding allows as soon as elevation goals are reached and slurry has consolidated. If funds are not available, it is anticipated that plants will start growing during the first growing season from seedbank and other propagules. Many plants use vegetative reproduction, e.g., rhizomes, once they are established. This will promote a heterogeneous restored wetland and reduce the likelihood of invasive nonnative species establishing. Tidal creeks and guts are major sources of plant propagules.

Action Thresholds

What is the change in vegetation over time? Will species richness of the newly created marsh match the older established marsh?

Management Response

The species mix should remain approximately 98 percent native. Restoring the tidal freshwater marsh and associated habitats may take a long time, possibly as much as 30 years. If species that are dominant in the old marsh are missing, George Washington Memorial Parkway may want to plant those species into the restoration area and find out whether propagules are present. Species richness should be similar to the reference site.

Action Threshold

Will problem areas with no or low plant establishment be vulnerable to nonnative invasive species?

Management Response

When invasive nonnative species are present, they must be a high priority for removal. Replanting the area after control treatments of exotics may be necessary. Implement design and management measures to manage the spread of nonnative invasive plants. Treat invasive nonnative species three times per year, especially when invasive exotic plants are vulnerable or before fruiting. Assess and monitor the effectiveness of treatment within each treated area and retreat as needed. Replant as needed. Protect from herbivores.

Action Threshold

Does the distribution of state rare plants expand into new areas of the marsh?

Management Response

Assisting the recovery of special status and other species through the restoration of ecosystem function and associated habitats. State imperiled river bulrush (*Bolboschoenus fluviatilis*, G5, S2) may move to newly created habitat, depending on marsh elevation. It is distributed within the existing Dyke Marsh and is likely to propagate downstream into newly created marsh.

LITERATURE CITED

Cahoon, D.R. and J. Lynch

2010 Surface Elevation Table (SET). USGS.

Cahoon, D.R., P.E. Marin, B.K. Black, and J.C. Lynch

2000 A method for measuring vertical accretion, elevation, and compaction of soft, shallow-water sediments. *Journal of Sedimentary Research* 70:1250-1253.

Cahoon, D.R., J.C. Lynch, P. Hensel, R. Boumans, B.C. Perez, B. Segura, and J.J.W. Day

2002a A device for high precision measurement of wetland sediment elevation: I. Recent improvements to the sedimentation-erosion table. *Journal of Sedimentary Research* 72:730-733.

Cahoon, D.R., J.C. Lynch, B.C. Perez, B. Segura, R. Holland, C. Stelly, G. Stephenson, and P. Hensel

2002b A device for high precision measurement of wetland sediment elevation: II. The rod surface elevation table. *Journal of Sedimentary Research* 72:734-739.

Conquest, L.L.

2000 Analysis and Interpretation of Ecological Field Data Using BACI Designs: Discussion. *Journal of Agricultural, Biological, and Environmental Statistics* 5:293-296.

Darke, A.K. and J.P. Megonigal

2003 Control of sediment deposition rates in two mid-Atlantic Coast tidal freshwater wetlands. *Estuarine, Coastal and Shelf Science* 57:255–268.

Hopfensperger, K.N. and K.A.M. Engelhardt

2008 Annual species abundance in a tidal freshwater marsh: Germination and survival across an elevational gradient. *Wetlands* 28:521-526.

Kreeger, D., A. Padeletti, and L. Whalen

2012 Development and Implementation of an Integrated Monitoring and Assessment Program for Tidal Wetlands: Final report for U. S. Environmental Protection Agency. PDE Report No. 12-03, Partnership for the Delaware Estuary.

Mitsch, W.J. and R.F. Wilson

1996 Improving the success of wetland creation and restoration with know-how, time, and self-design. *Ecological Applications* 6:77-83.

National Park Service (NPS)

2013 Draft Dyke Marsh Restoration EIS. National Park Service, Washington, DC.

Rafferty, P., J. Castagna, and D. Adamo

2011 Building partnerships to restore an urban marsh ecosystem at Gateway National Recreation Area. *Park Science* 27:34-41.

Smith, P.E., D.R. Orvos, and J. Cairns

1993 Impact assessment using the before-after-control-impact (BACI) model: concerns and comments. *Canadian Journal of Fisheries and Aquatic Sciences* 50:627-637.

Stewart-Oaten, A

2003 On rejection rates of paired intervention analysis: comment. *Ecology* 84:2795- 2799.

Stewart-Oaten, A., J.R. Bence, and C.W. Osenberg

1992 Assessing effects of unreplicated perturbations: no simple solutions. *Ecology* 73:1396-1404.

Stewart-Oaten, A., W.W. Murdoch, and K.R. Parker

1986 Environmental Impact Assessment: “pseudoreplication” in time? *Ecology* 67:929-940.

Temmerman, S., G. Govers, P. Meire, and S. Wartel

2003 Modeling long-term tidal marsh growth under changing tidal conditions and suspended sediment concentrations, Scheldt estuary, Belgium. *Marine Geology* 193:151–169.

Turner, K., J.Y. Takekawa, I. Woo, C. Ellings, B. Root, and J.E. Takekawa

2013a Monitoring Design: Before-After Control-Impact. Tidal Marsh Monitoring Handbook. USGS.

2013b Tidal Marsh Monitoring Handbook: Monitoring Design: Data Analyses and Management. USGS.

Underwood, A.J.

1992 Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology* 161:145-178.

Xu, S.

1991 Final report on inventories of plant species and communities in Dyke Marsh, Alexandria, Virginia. George Mason University, Fairfax, Virginia.

ACRONYMS

GIS	Geographic Information System
GPS	Global Positioning System
NPS	National Park Service
SET	Sediment Elevation Table

APPENDIX B: BREEDING BIRD SPECIES

Species	Common Name
Confirmed Breeding Species	
Branta canadensis	Canada Goose
Aix sponsa	Wood Duck
Anas platyrhynchos	Mallard
Pandion haliaetus	Osprey
Haliaeetus leucocephalus	Bald Eagle
Zenaida macroura	Mourning Dove
Otus asio	Eastern Screech-Owl
Melanerpes carolinus	Red-bellied Woodpecker
Picoides pubescens	Downy Woodpecker
Myiarchus crinitus	Great Crested Flycatcher
Tyrannus tyrannus	Eastern Kingbird
Vireo gilvus	Warbling Vireo
Cyanocitta cristata	Blue Jay
Corvus ossifragus	Fish Crow
Tachycineta bicolor	Tree Swallow
Stelgidopteryx serripennis	N. Rough-winged Swallow
Hirundo rustica	Barn Swallow
Poecile carolinensis	Carolina Chickadee
Baeolophus bicolor	Tufted Titmouse
Thryothorus ludovicianus	Carolina Wren
Cistothorus palustris	Marsh Wren
Polioptila caerulea	Blue-gray Gnatcatcher
Turdus migratorius	American Robin
Dumetella carolinensis	Gray Catbird
Sturnus vulgaris	European Starling
Setophaga petechia	Yellow Warbler
Protonotaria citrea	Prothonotary Warbler
Cardinalis cardinalis	Northern Cardinal
Agelaius phoeniceus	Red-winged Blackbird
Quiscalus quiscula	Common Grackle
Icterus spurius	Orchard Oriole
Icterus galbula	Baltimore Oriole
Carpodacus mexicanus	House Finch

Species	Common Name
Spinus tristis	American Goldfinch
Passer domesticus	House Sparrow
Sitta carolinensis	White-breasted Nuthatch
Setophaga americana	Northern Parula
Progne subis	Purple Martin
Molothrus ater	Brown-headed Cowbird
Probable Breeding Species	
Empidonax traillii	Willow Flycatcher
Passerina cyanea	Indigo Bunting
Geothlypis trichas	Common Yellowthroat
Contopus virens	Eastern Wood-Pewee
Vireo olivaceus	Red-eyed Vireo
Melospiza melodia	Song Sparrow
Emphidonax virescens	Acadian Flycatcher
Ixobrychus exillis	Least Bittern
Possible Breeding Species	
Butorides virescens	Green Heron
Accipiter cooperii	Cooper’s Hawk
Troglodytes aedon	House Wren
Mniotilta varia	Black-and-White Warbler
Seiurus aurocapilla	Ovenbird
Parkesia motacilla	Louisiana Waterthrush
Piranga olivacea	Scarlet Tanager
Archilochus colubris	Ruby-throated Hummingbird
Bombycilla cedrorum	Cedar Waxwing
Toxostoma rufum	Brown Thrasher
Piplio erythrophthalmus	Eastern Towhee
Buteo jamaicensis	Red-tailed Hawk
Charadrius vociferous	Killdeer
Actitis macularia	Spotted Sandpiper
Coccyzus americanus	Yellow-billed Cuckoo
Chaetura pelagica	Chimney Swift
Ceryle alcyon	Belted Kingfisher
Picoides villosus	Hairy Woodpecker
Colaptes auratus	Northern Flicker
Sayornis phoebe	Eastern Phoebe
Corvus brachyrhynchos	American Crow

Species	Common Name
Mimus polyglottos	Northern Mockingbird
Spizella passerina	Chipping Sparrow
Present Breeding Species	
Cygnus columbianus	Tundra Swan
Phalacrocorax auritus	Double-crested Cormorant
Ardea Herodias	Great Blue Heron
Ardea albus	Great Egret
Cathartes aura	Turkey Vulture
Aythya valisineria	Canvasback
Larus delawarensis	Ring-billed Gull
Larus argentatus	Herring Gull
Larus marinus	Great Black-backed Gull
Columba livia	Rock Pigeon
Coragyps atratus	Black Vulture
Pluvialis squatarola	Black-bellied Plover
Hydroprogne caspia	Caspian Tern
Sterna forsteri	Forster’s Tern

APPENDIX C: AGENCY CONSULTATION LETTERS

United States Department of the Interior

NATIONAL PARK SERVICE
George Washington Memorial Parkway
c/o Turkey Run Park
McLean, Virginia 22101

H 4217 (GWMP-Dyke Marsh)

Ethel Eaton, Senior Policy Analyst
Division of Resource Services and Review
Virginia Department of Historic Resources
2801 Kensington Avenue
Richmond, VA 23221

Re: Dyke Marsh Restoration Archeological Assessment

Dear Ms. Eaton:

Please find enclosed for your records the archeological report entitled Archeological Assessment for Dyke Marsh Preserve, George Washington Memorial Parkway, Fairfax Count, Virginia. This report will serve as part of the documentation required under Section 106 of National Historic Preservation Act of 1966, as amended (NHPA Section 106) for the proposed undertaking consisting of the restoration of Dyke Marsh. Previous correspondence to your office has included the notification of scoping for the project provided in April of 2008 in the form of the Dyke Marsh Public Scoping Newsletter. It is anticipated that an Environmental Impact Statement (EIS) will be prepared for this undertaking and that this will serve to help fulfill federal agency responsibilities under NHPA Section 106 per 36 CFR Part 800.8(c).

Hopefully you'll agree that the enclosed report proves satisfactory in the reporting of the archeological potential of Dyke Marsh and meets NHPA Section 106 documentation requirements. As always, we appreciate the assistance your office provides in such matters.

Sincerely,

DP Marshall

Dottie P. Marshall
Superintendent

enclosure

bcc:

GWMP-Files w/o
GWMP-Project Files w/o
IRRM-Files w/o
IRRM-Compliance Coordinator w/o
IRRM-M. Virta w/o

COMMONWEALTH of VIRGINIA

Department of Historic Resources

2801 Kensington Avenue, Richmond, Virginia 23221

L. Preston Bryant, Jr.
Secretary of Natural Resources

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Director

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January 6, 2010

Dottie P. Marshall, Superintendent
National Park Service
George Washington Memorial Parkway
Turkey Run Park
McLean, Virginia 22101

Re: Dyke Marsh Wetland Restoration and Long Term Management Plan
DHR File No. 2009-1849

Dear Ms. Marshall:

Thank you for providing us with a copy of the document titled *Archeological Assessment for Dyke Marsh Preserve, George Washington Memorial Parkway, Fairfax County, Virginia.* The assessment was prepared in January 2009 for the referenced project by Jason Shellenhamer *et. al*. of The Louis Berger Group, Inc. in January 2009

I am pleased to inform you that we find that the assessment provides a clear and thorough presentation of Dyke Marsh's archeological potential. Based upon the information presented we concur with the consultant's recommendations as stated in Section IV, page 36, of the document. We agree that the proposed restoration should consider the preservation of the intact portions of the historic dikes located in the southeastern section of the marsh. We also agree that the entire upland or fast land should be considered sensitive for the presence of Native American sites dating from the past 5, 000 years. In addition Paleoindian and Archaic Period camp sites may be present in the undisturbed portions of the marsh. For this reason consideration should be given to avoidance of archeologically sensitive areas in planning the restoration. If avoidance is not possible, we agree that further identification efforts will be necessary to locate and evaluate any archaeological sites that may be affected by the proposed restoration activities.

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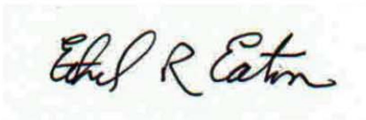
Tidewater Region Office
14415 Old Courthouse Way
2nd Floor
Newport News, VA 23608
Tel: (757) 886-2807
Fax: (757) 886-2808

Roanoke Region Office
1030 Penmar Avenue, SE
Roanoke, VA 24013
Tel: (540) 857-7585
Fax: (540) 857-7588

Northern Region
Preservation Office
P.O. Box 519
Stephens City, VA 22655
Tel: (540) 868-7029
Fax: (540) 868-7033

If you have any questions concerning our comments, please do not hesitate to contact me. We look forward to working with you on this project.

Sincerely,



Ethel R. Eaton, Ph.D., Senior Policy Analyst
Division of Resource Services and review

c. Matthew Virta. Cultural Resource Manager

Administrative Services 10 Courthouse Ave. Petersburg, VA 23803 Tel: (804) 862-6416 Fax: (804) 862-6196	Capital Region Office 2801 Kensington Office Richmond, VA 23221 Tel: (804) 367-2323 Fax: (804) 367-2391	Tidewater Region Office 14415 Old Courthouse Way 2nd Floor Newport News, VA 23608 Tel: (757) 886-2807 Fax: (757) 886-2808	Roanoke Region Office 1030 Penmar Avenue, SE Roanoke, VA 24013 Tel: (540) 857-7585 Fax: (540) 857-7588	Northern Region Preservation Office P.O. Box 519 Stephens City, VA 22655 Tel: (540) 868-7029 Fax: (540) 868-7033

COMMONWEALTH *of* VIRGINIA

L. Preston Bryant, Jr.
Secretary of Natural Resources

Department of Game and Inland Fisheries

Robert W. Duncan
Executive Director

May 22, 2008

Superintendent
George Washington Memorial Parkway
700 George Washington Memorial Parkway
Park Headquarters, Turkey Run Park
McLean, VA 22101

RE: Dyke Marsh Preserve
Restoration & Long-Term
Mgt. Plan/ EIS scoping
ESSLog # 25162

Dear Superintendent:

We have reviewed the National Park Service's (NPS) letter notice of development of an Environmental Impact Statement (EIS) to evaluate the potential environmental and social impacts of the restoration and long-term management of Dyke Marsh Preserve (Preserve). Upon review of the relevant information and our attendance at the public scoping meeting held on April 22, 2008, we offer the following comments and recommendations. The Virginia Department of Game and Inland Fisheries (VDGIF), as the Commonwealth's wildlife and freshwater fish management agency, exercises full law enforcement and regulatory jurisdiction over those resources, inclusive of State or Federally *Endangered* or *Threatened* species, but excluding listed insects. We are a consulting agency under the U. S. Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et *seq.*), and we provide environmental analysis of projects or permit applications coordinated through the Virginia Department of Environmental Quality, the Virginia Marine Resources Commission, the Virginia Department of Transportation, the U. S. Army Corps of Engineers, and other state or federal agencies. Our role in these procedures is to determine likely impacts upon fish and wildlife resources and habitats, and to recommend appropriate measures to avoid, reduce, or compensate for those impacts.

Upon review of our data for the presence of listed wildlife resources, it has been determined that although no state Threatened bald eagle nesting locations are documented on or immediately adjacent to the Preserve, Dyke Marsh serves as an important foraging area for this species. We recommend that all restoration and management activities initiated on the Preserve are performed in a manner protective of this species and in enhancement of foraging habitat. We recommend

4010 WEST BROAD STREET, P.O. BOX 11104, RICHMOND, VA 23230-1104
(804) 367-1000 (V/TDD) ***Equal Opportunity Employment, Programs and Facilities*** **FAX (804) 367-0405**

Superintendent
05/22/2008
Page 2 of 3

that the NPS coordinate closely with Jeff Cooper, VDGIF Region V Wildlife Diversity Biologist, at 540-899-4169 regarding the protection of bald eagles on this site.

In addition, the Potomac River has been designated a Confirmed Anadromous Fish Use Area. Anadromous fishes use the Potomac River in this area mainly as a migratory pathway during late winter into late spring for movement to spawning grounds. We recommend that all marsh and shoreline activities be performed in a manner protective of this resource. We support activities aimed at improving water quality, reducing sedimentation, and restoring spawning and nursery habitats for all aquatic species, including anadromous fishes. We recommend coordination with John Kauffman, VDGIF Region V Fisheries Manager, at 434-296-4731 regarding the protection and enhancement of these resources.

Although it is difficult for us to make specific comments about restoration and management activities at Dyke Marsh until specific projects are developed and proposed, we generally support the restoration of marsh and wetland habitats at this Preserve. We support the beneficial use of any clean dredge spoil from the area for use at this site. We are happy to assist the NPS in restoration and management efforts at Dyke Marsh and recommend continued coordination with our agency regarding future projects.

VDGIF supports the continuation of waterfowl hunting opportunities in and around the Preserve. The floating blind program that has been in operation in the public waters off of Dyke Marsh for over 15 years appears to be successful and has not resulted in any reported accidents or injuries to hunters or the public. We support the continuation of hunter access at the Marina. We believe it is very important that hunters be allowed the opportunity to carry cased shotguns from their cars to the marina area. We recommend consideration of expanding hunting opportunities and access on the Preserve and are willing to assist the NPS in these efforts.

Dyke Marsh Preserve is a very important wildlife viewing site. The Preserve features a well-developed wetland forest, expansive mudflats, and vistas of the Potomac River. Over 300 species of birds have been seen at this park. The Preserve's juxtaposition to the Potomac River and urban environments makes it an oasis for wildlife enthusiasts. Dyke Marsh Preserve is included in the VDGIF's Virginia Birding and Wildlife Trail as site 2 on the Mason Neck Loop. The site includes a trail that runs through the forested wetlands and mudflats that provides visitors the opportunity to view eagles, foraging shorebirds, and waterfowl, as well as spring and fall migrant songbirds. We support maintenance of this site and the expansion of wildlife viewing opportunities within the Preserve. We would be happy to assist the NPS in identifying new opportunities for wildlife viewing at Dyke Marsh.

We recommend continued coordination with our agency regarding the management of wildlife on the Preserve, access to the Preserve for hunting and wildlife watching, and the avoidance and minimization of impacts upon wildlife and their habitats during specific restoration or management projects. As stated above, we are willing to assist the NPS in efforts to enhance wildlife habitats and manage wildlife resources under our jurisdiction. Please do not hesitate to contact us if we can be of further assistance.

Superintendent
05/22/2008
Page 3 of 3

Thank you for the opportunity to provide input on the development of the EIS. Please contact me or Amy Ewing 804-367-6913 if we may be of further assistance.

Sincerely,

Raymond T. Fernald, Manager
Nongame and Environmental Programs

Cc: Robert Duncan, VDGIF
David. Whitehurst, VDGIF
Gary Martel, VDGIF
Bob Ellis, VDGIF
Dee Watts, VDGIF

United States Department of the Interior

NATIONAL PARK SERVICE
George Washington Memorial Parkway
c/o Turkey Run Park
McLean, Virginia 22101

IN REPLY REFER TO:
N1621 (GWMP)

June 27, 2013

Section 7 Coordinator
U.S. Fish and Wildlife Service
Virginia Field Office
6669 Short Lane
Gloucester, VA 23061

To Whom It May Concern:

This letter serves as notification we have begun the National Environmental Policy Act (NEPA) process and are proposing to have an Environmental Impact Statement (EIS) available for public and regulatory review in the near future. In addition, this letter serves as a record the National Park Service (NPS) is initiating Section 7 Consultation with your agency pursuant to the requirements of the 1973 Endangered Species Act, as amended. In order to comply, we are requesting information concerning threatened or endangered species documented or reasonably suspected within 0.5 miles of the project site, which is depicted on the enclosed map.

As part of our planning process, a science team was convened to review information about the marsh and provide input to the process. This team included two United States Fish and Wildlife Service (USFWS) personnel who are very familiar with the marsh and surrounding habitats: John Gill, USFWS Maryland Fishery Resources Office, Biologist (who completed wetlands restoration for local projects and helped with fish inventory of Dyke Marsh in 2001-2004) and Sandy Spencer, USFWS, Eastern Virginia Rivers National Wildlife Refuge Complex, Wildlife Biologist (Masters research at Dyke Marsh beginning in 1997). No federally listed species were identified during the discussions that addressed that subject.

The NPS are aware of breeding bald eagles in the general vicinity, but only as transients within Dyke Marsh. The USFWS (Mangold, 2004) conducted a fish survey in Dyke Marsh between 2001 and 2004 but did not find any evidence of Shortnose or Atlantic Sturgeon. Should you know of or come across any other resource constraint that may be a possible planning issue, please do not hesitate to contact us.

We anticipate no significant environmental impacts associated with the project and look forward to receiving any guidance or comments you may have regarding the process or the project itself.

Dyke Marsh is located along the Potomac River in Fairfax County, Virginia. The proximity of the area, just one mile south of the Nation's Capital, Washington, D. C., makes Dyke Marsh a popular destination for visitors seeking natural solitude in an urbanized landscape. Although the 1937 marsh consisted of 184 acres, sand and gravel mining operations between 1940 and 1970 and subsequent erosion have reduced the marsh to its current size of approximately 60 acres. A USGS study (open-file report 2010-1269) available online, has shown that since the dredging stopped, the marsh has continued to erode, with an average loss of nearly 0.8 acres per year since 1972. In 1974, congress passed Public Law 93-251, mandating the restoration of Dyke Marsh. The EIS in development will propose four alternatives for the restoration of Dyke Marsh, including a no action alternative. Three alternatives propose stabilization and protection of the existing marsh, while restoring various acreages within the footprint of the historic marsh. The goal of this project is to develop an Environmental Impact Statement for Dyke Marsh that will provide the opportunity to fulfill our Congressional mandate while protecting the current marsh that still provides habitat for many species of plants and animals.

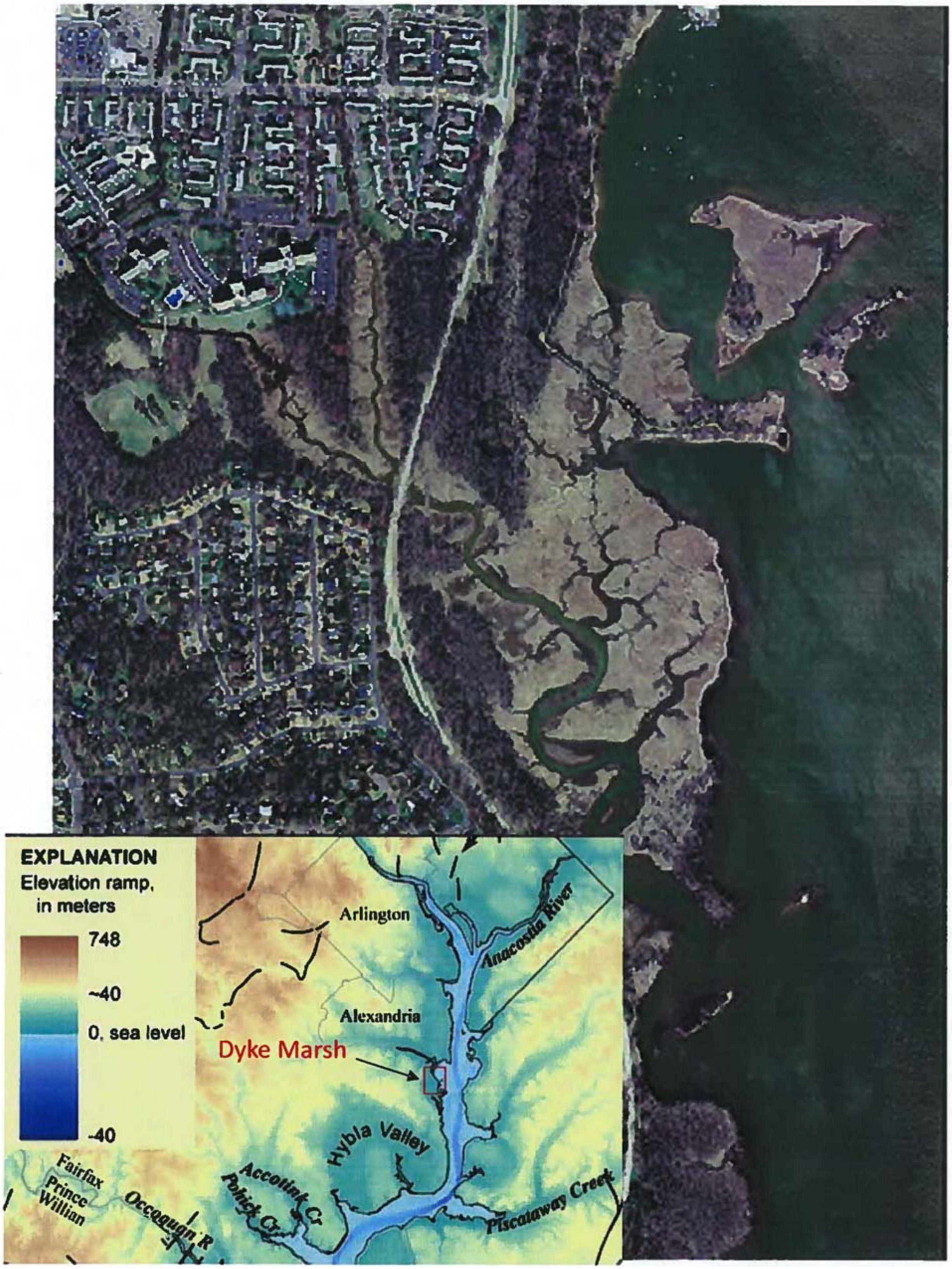
Thank you for your anticipated assistance with this matter. If you need additional information or have any questions regarding this request, please contact me at (703) 289-2500.

Sincerely,

Alexcy Romero
Acting Superintendent

bcc:

GWMP Files
GWMP IRRM Steury


EXPLANATION
Elevation ramp, in meters
748
~40
0, sea level
-40
Arlington
Anacostia River
Alexandria
Dyke Marsh
Hybla Valley
Fairfax
Prince William
Occoquan R
Accotink Cr
Pohick Cr
Piscataway Creek

United States Department of the Interior

NATIONAL PARK SERVICE
George Washington Memorial Parkway
c/o Turkey Run Park
McLean, Virginia 22101

IN REPLY REFER TO:
N1621 (GWMP)

June 27, 2013

Rene Hypes
Section 7 Coordinator
Department of Conservation and Recreation
Division of Natural Heritage
217 Governors St. 3rd Floor
Richmond, VA 23219

Dear Ms. Hypes:

This letter serves as notification we have begun the National Environmental Policy Act (NEPA) process and are proposing to have an Environmental Impact Statement (EIS) available for public and regulatory review in the near future. In addition, this letter serves as a record the National Park Service (NPS) is initiating Section 7 Consultation with your agency pursuant to the requirements of the 1973 Endangered Species Act, as amended. In order to comply, we are requesting information concerning state rare, threatened or endangered species documented or reasonably suspected within 0.5 miles of the project site, which is depicted on the enclosed map.

We are aware of breeding bald eagles in the general vicinity, but only as transients within Dyke Marsh. The US Fish and Wildlife Service (Mangold, 2004) conducted a fish survey in Dyke Marsh between 2001 and 2004 but did not find any evidence of Shortnose or Atlantic Sturgeon. The NPS knows of breeding populations of Least Bittern in the marsh as well as four species of state listed plants (*Carex davisii*, *Geum laciniatum*, *Schoenoplectus fluviatilis*, and *Sparganium eurycarpum*). We also know of historical records for *Carex decomposita* and Allegheny woodrat (*Neotoma magister*). Should you know of or come across any other resource constraint that may be a possible planning issue, please do not hesitate to contact us. We anticipate no significant environmental impacts associated with the project and look forward to receiving any guidance or comments you may have regarding the process or the project itself.

Dyke Marsh is located along the Potomac River in Fairfax County, Virginia. The proximity of the area, just one mile south of the Nation's Capital, Washington, D. C., makes Dyke Marsh a popular destination for visitors seeking natural solitude in an urbanized landscape. Although the 1937 marsh consisted of 184 acres, sand and gravel mining operations between 1940 and 1970 and subsequent erosion have reduced the marsh to its current size of approximately 60 acres.

A United States Geological Survey (USGS) study (open-file report 2010-1269) available online, has shown that since the dredging stopped, the marsh has continued to erode, with an average loss of nearly 0.8 acres per year since 1972. In 1974, congress passed Public Law 93-251, mandating the restoration of Dyke Marsh. The EIS in development will propose four alternatives for the restoration of Dyke Marsh, including a no action alternative. Three alternatives propose stabilization and protection of the existing marsh, while restoring various acreages within the footprint of the historic marsh. The goal of this project is to develop an Environmental Impact Statement for Dyke Marsh that will provide the opportunity to fulfill our Congressional mandate while protecting the current marsh that still provides habitat for many species of plants and animals.

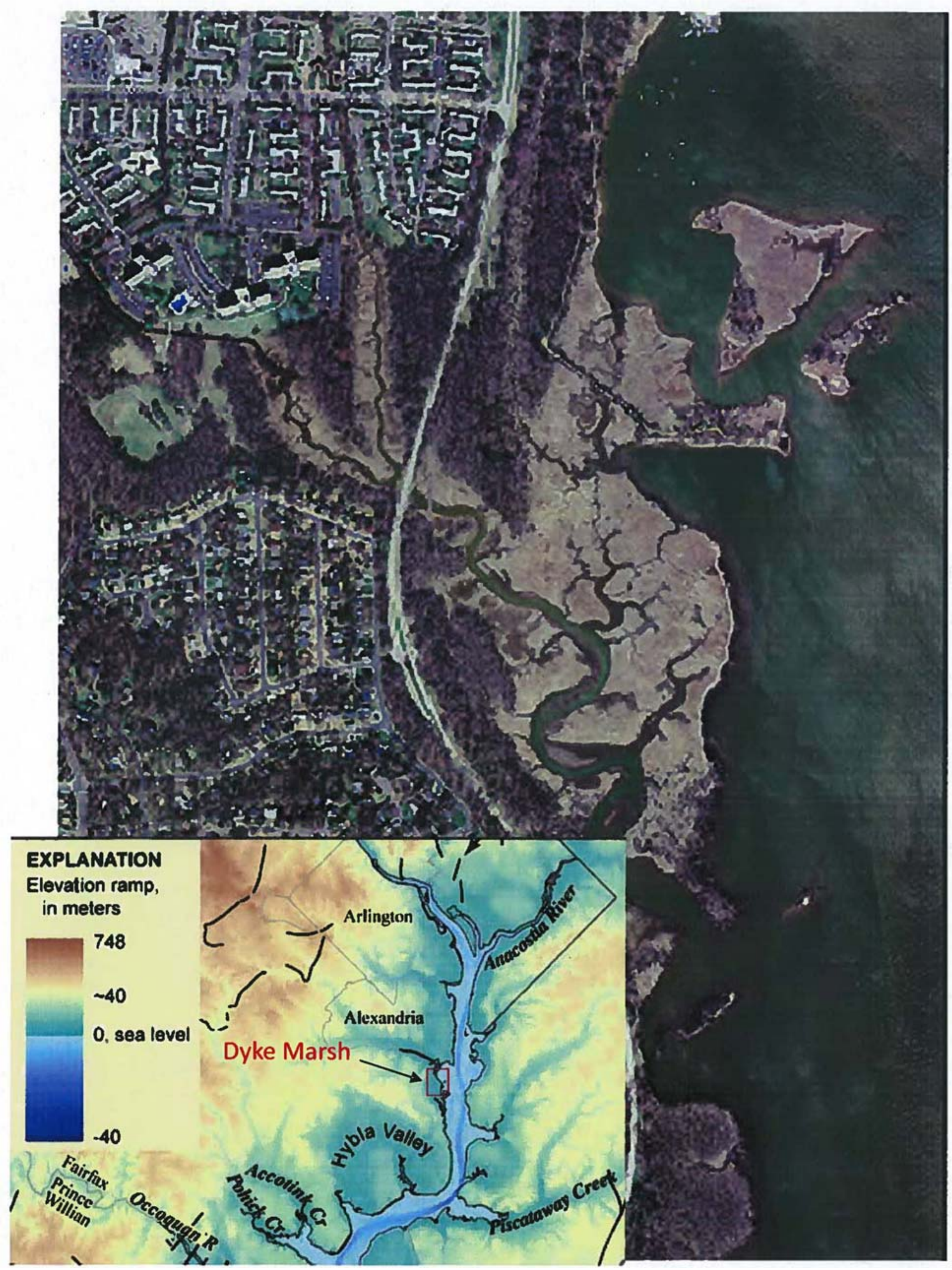
Thank you for your anticipated assistance with this matter. If you need additional information or have any questions regarding this request, please contact me at (703) 289-2500.

Sincerely,

Alexcy Romero
Acting Superintendent

bcc:

GWMP Files
GWMP IRRM Steury


EXPLANATION
Elevation ramp, in meters
748
~40
0, sea level
-40
Arlington
Alexandria
Anacostia River
Dyke Marsh
Hybla Valley
Accotink Cr
Pohick Cr
Piscataway Creek
Occoquan R
Fairfax
Prince William

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historic places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

(January 2014)

United States Department of the Interior · National Park Service