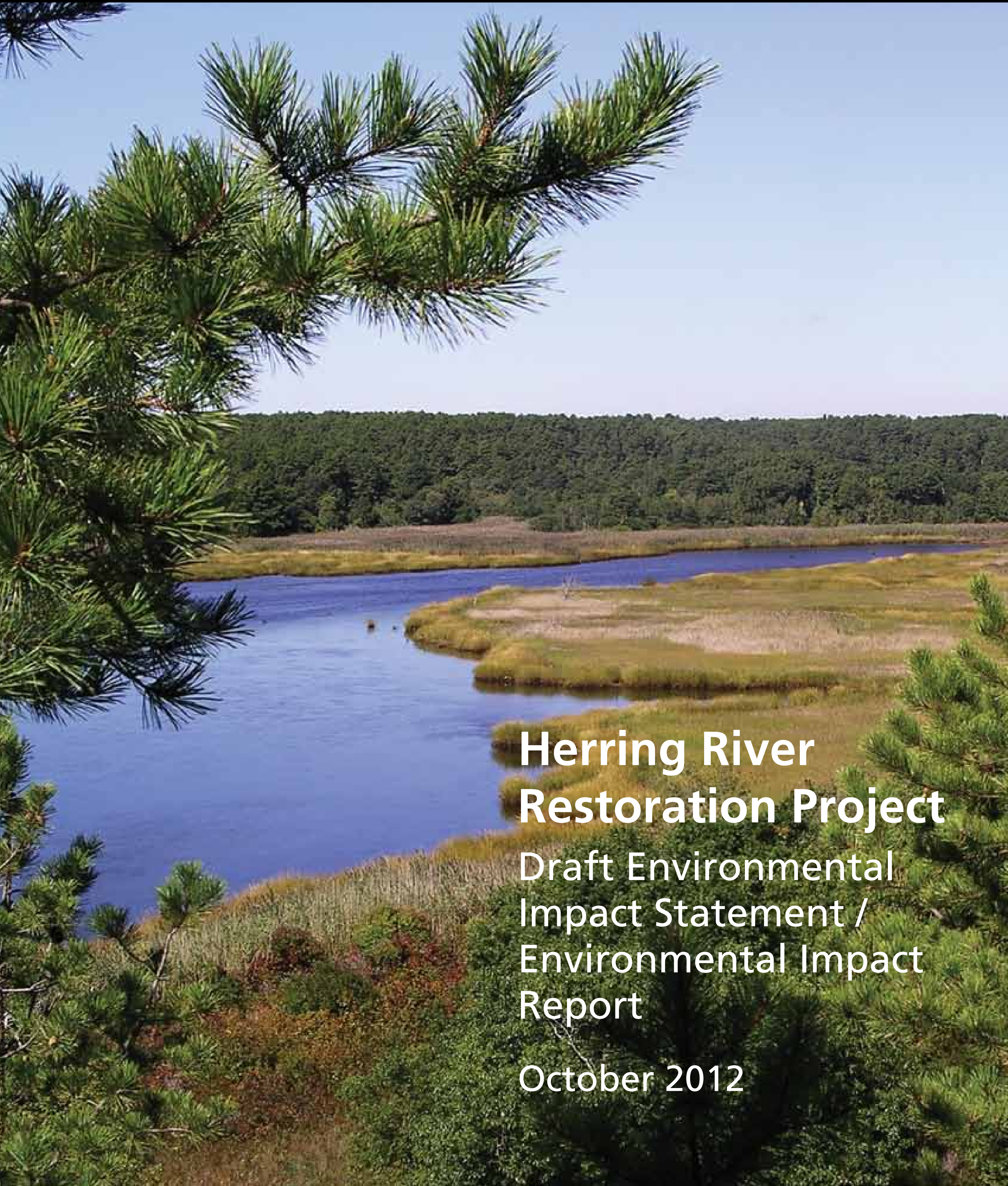
National Park Service
U.S. Department of the Interior
Cape Cod National Seashore

Town of Wellfleet
Town of Truro
Herring River Restoration Committee



Herring River Restoration Project

Draft Environmental Impact Statement / Environmental Impact Report

October 2012

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
AND HERRING RIVER RESTORATION COMMITTEE
HERRING RIVER RESTORATION PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT/ ENVIRONMENTAL IMPACT REPORT

This *Herring River Restoration Project, Draft Environmental Impact Statement/Environmental Impact Report* (draft EIS/EIR) evaluates alternatives for tidal restoration of large portions of the Herring River flood plain in and adjacent to Cape Cod National Seashore (the Seashore). The EIS/EIR assesses the impacts that could result from continuing current management (the no action alternative) or implementing any of the three action alternatives.

Three action alternatives have been developed for the restoration of the Herring River. These three alternatives are intended to represent a range of desirable endpoints to be achieved through incremental restoration of tidal exchange and adaptive management. The alternatives are distinguished primarily by the long-term configuration of a new dike and tidal control structure at Chequessett Neck Road and the resulting degree of tidal exchange. These alternatives represent the "bookends" of the minimum and maximum tidal exchange restoration necessary to meet project objectives, where alternative B achieves the minimally acceptable tidal restoration with the least impacts, and alternative D achieves the maximum practicable tidal restoration possible with more impacts, given the limitations of present day land use in the Herring River flood plain.

The Herring River flood plain is a large and complex area that has been impacted by more than 150 years of human manipulation, the most substantial being the construction of the Chequessett Neck Road Dike at the mouth of the river in 1909. Just as the current degraded state of the river is the combined effect of many alterations occurring over many years, restoration of the river will also require multiple, combined actions to return it to a more fully functioning natural system.

The review period for this document will end 60 days after publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register and publication of the availability of the EIR in the Environmental Monitor. During the 60-day comment period, comments will be accepted electronically through the NPS Planning, Environment and Public Comment website and in hard copy delivered by the U.S. Postal Service or other mail delivery service or hand-delivered to the address below. Oral statements and written comments will also be accepted during public meetings on the draft EIS/EIR. Comments will not be accepted by fax, email, or in any other way than those specified above. Bulk comments in any format (hard copy or electronic) submitted on behalf of others will not be accepted.

To comment on the DEIS, or for further information, visit http://parkplanning.nps.gov/caco or contact:

Cape Cod National Seashore and the Herring River Restoration Committee
Herring River Restoration Project, Draft EIS/EIR
99 Marconi Site Road
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The Secretary of Energy & Environmental Affairs accepts written comments on projects currently under Massachusetts Environmental Policy Act (MEPA) review. Comments may be submitted electronically, by mail, via fax, or by hand delivery. Please note that comments submitted on MEPA documents are public records.

On EIRs, any agency or person may submit written comments concerning the project, its alternatives, its potential environmental impacts, mitigation measures, and the adequacy of the EIR, provided that the subject matter of the comments are within the scope. For this project only, comments must be filed within 60 days of the publication of the availability of the EIR in the Environmental Monitor, unless the public comment period is extended.

The mailing address for comments on the EIR is:

Secretary Richard K. Sullivan, Jr.
Executive Office of Energy and Environmental Affairs (EEA)
Attn: MEPA Office
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EXECUTIVE SUMMARY

This *Herring River Restoration Project, Draft Environmental Impact Statement/Environmental Impact Report* (draft EIS/EIR) 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 National Park Service (NPS) Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-Making*, the Massachusetts Environmental Policy Act (MEPA), and the Cape Cod Regional Policy Plan.

This draft EIS/EIR evaluates alternatives for tidal restoration of large portions of the Herring River flood plain in and adjacent to Cape Cod National Seashore (the Seashore). The EIS/EIR assesses the impacts that could result from continuing current management (the no action alternative) or implementing any of the three action alternatives.

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

BACKGROUND

Historically, the Herring River estuary and flood plain was the largest tidal river and estuary complex on the Outer Cape and included about 1,100 acres of salt marsh, intertidal flats, and open-water habitats (HRTC 2007). In 1909, the Town of Wellfleet constructed the Chequessett Neck Road dike at the mouth of the Herring River to reduce salt marsh mosquitoes. The dike restricted tides in the Herring River from approximately 10 feet on the downstream, harbor side, to about 2 feet upstream of the dike.

By the mid-1930s, the Herring River, now flowing with freshwater, was channelized and straightened. Between 1929 and 1933, developers of the Chequessett Yacht and Country Club (CYCC) constructed a nine-hole golf course in the adjoining Mill Creek flood plain. Several homes also have been built at low elevations in the flood plain.

By the 1960s, the dike tide gates had rusted open, increasing tidal range and salinity in the lower Herring River. This caused periodic flooding of the CYCC golf course and other private properties. In 1973, the Town of Wellfleet voted to repair the leaking tides to protect private properties. The Massachusetts Department of Public Works rebuilt the dike in 1974 (HRTC 2007). Following reconstruction, tidal monitoring showed that the Town had not opened an adjustable sluice gate high enough to allow the tidal range required by an Order of Conditions issued by the Conservation Commission. In 1977, control of the dike was transferred to the Massachusetts Department of Environmental Protection (MassDEP) so that increased tidal flow could be attained in the interest of restoration (HRTC 2007). Despite this, conditions in the estuary continued to degrade after the tide gates were repaired.

In 1980, a large die-off of American eel (*Anguilla rostrata*) and other fish focused attention on the poor water quality in the Herring River. The Massachusetts Division of Marine Fisheries and the NPS identified the cause of the fish kill as high acidity and aluminum toxicity resulting from diking and marsh drainage (Soukup and Portnoy 1986). The tide gate opening was increased to 20 inches in 1983. That year, Seashore scientists documented summertime dissolved oxygen depletions and river herring (*Alosa* spp.) kills for the first time (Portnoy 1991). The NPS then took steps to protect river herring by blocking their emigration from upstream ponds to prevent the fish from entering low oxygen waters (HRTC 2007).

Concerns about flooding of private properties and increased mosquito populations prevented the town from opening the tide gate further. NPS mosquito breeding research conducted from 1981 to 1984 found that although mosquitoes (*Ochlerotatus cantator* and *O. canadensis*) were breeding abundantly in the Herring River, estuarine fish, which are important mosquito larvae predators, could not access mosquito breeding areas because of low tidal range, low salinity, and high acidity (Portnoy 1984a). In 1984, the town increased the sluice gate opening to 24 inches, where it has since remained (HRTC 2007).

In 1985, the Massachusetts Division of Marine Fisheries classified shellfish beds in the river mouth as "prohibited" due to fecal coliform contamination. In 2003, water quality problems caused the MassDEP to list Herring River as "impaired" under the federal Clean Water Act (CWA) Section 303(d) for low pH and high metal concentrations. More recently, NPS researchers identified bacterial contamination as another result of restricted tidal flow and reduced salinity (Portnoy and Allen 2006).

In addition, concentrations of nitrogen and phosphorus in the sediments of Herring River have remained high. Although there is no documentation of specific anthropogenic or natural inputs, potential sources of excessive nutrients in the watershed include agriculture, fertilized lawns, the CYCC golf course, a nearby (Coles Neck) landfill, leaking septic systems, animal waste, and atmospheric deposition. The lack of tidal flushing has allowed nutrients to accumulate in the Herring River.

Pesticides have likely been used throughout the Herring River watershed, including long-term use for mosquito control. Pesticide concentrations (DDT and dieldrin) measured in the Herring River sediments downstream of the dike in 1969 (Curley et al. 1972) were found to be elevated, exceeding National Oceanic and Atmospheric Administration (NOAA) guideline values (Buchman 2008). However, samples analyzed for organics (including pesticides) from the Wellfleet Harbor by Hyland and Costa (1995) did not exceed NOAA guideline values. Quinn et al. (2001) analyzed the upper 2 cm of the marsh sediments at four stations upstream and downstream of the Chequessett Neck Road dike for polychlorinated biphenyls (PCBs), DDT, total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbons (PAHs). PAHs were found to be below the NOAA ERL (effects range low) guideline values, whereas PCBs and DDT were found to be above NOAA ERL guidelines.

Because tidal restrictions radically affect the process of sedimentation on the salt marsh, much of the diked Herring River flood plain has subsided up to 3 feet (Portnoy and Giblin 1997a). Coastal marshes must increase in elevation at a rate equal to, or greater than, the rate of sea-level rise in order to persist. This increase in elevation (accretion) depends on several processes, including transport of sediment and its deposition onto the marsh surface during high tides. This sediment transport must occur to promote the growth of salt marsh vegetation and gradually increase the elevation of the marsh surface. Diking has effectively blocked sediment from reaching the Herring River flood plain. In addition, drainage has increased the rate of organic peat decomposition by aerating the sediment and caused sediment pore spaces to collapse. All of these processes have contributed to severe historic and continuing subsidence in the Herring River's diked wetlands.

PURPOSE OF THIS PROJECT

The purpose of this project is to restore self-sustaining coastal habitats on a large portion of the 1,100-acre Herring River estuary in Wellfleet and Truro, Massachusetts. While the ecological goal is to restore the full natural tidal range in as much of the Herring River flood plain as practicable, tidal flooding in certain areas must be controlled to protect existing land uses. Where these considerations are relevant, the goal is to balance tidal restoration objectives with flood control by allowing the highest tide range practicable while also ensuring flood proofing and protection of vulnerable properties.

NEED FOR ACTION

The Herring River's wetland resources and natural ecosystem functions have been severely altered and damaged by 100 years of tidal restriction and salt marsh drainage. Adverse ecological impacts include the following:

- Tidal restriction (lack of tidal inflow and outflow)
- Plant community changes (including loss of salt marsh vegetation and increase in non-native, invasive species)
- Loss of estuarine habitat and degradation of water quality
- Alteration of natural sediment processes and increased salt marsh surface subsidence
- Nuisance mosquito production
- Impediments to river herring migration.

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OBJECTIVES IN TAKING ACTION

Objectives are "what must be achieved to a large degree for the action to be considered a success" (NPS 2011b). All alternatives selected for detailed analysis must meet project objectives to a large degree and resolve the purpose of and need for action. Objectives must be grounded in the enabling legislation, purpose, and mission goals of the Seashore, and must be compatible with the Seashore's General Management Plan direction and guidance, water resources plan, NPS *Management Policies 2006*, and/or other NPS management guidance. The NPS and Herring River Restoration Committee (HRRC) identified the following objectives for developing this draft EIS/EIR.

- To the extent practicable, given adjacent infrastructure and other social constraints, re-establish the natural tidal range, salinity distribution, and sedimentation patterns of the 1,100-acre estuary.
- Improve estuarine water quality for resident estuarine and migratory animals including fish, shellfish, and waterbirds.
- Protect and enhance harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Bay.
- Restore the connection between the estuary and the larger marine environment to recover the estuary's functions as (1) a nursery for marine animals and (2) a source of organic matter for export to near-shore waters.

- Remove physical impediments to migratory fish passage to restore once-abundant river herring and eel runs.
- Re-establish the estuarine gradient of native salt, brackish, and freshwater marsh habitats in place of the invasive non-native and upland plants that have colonized most parts of the degraded flood plain.
- Restore normal sediment accumulation on the wetland surface to counter subsidence and to allow the Herring River marshes to accrete in the face of sea-level rise.
- Re-establish the natural control of nuisance mosquitoes by restoring tidal range and flushing, water quality, and predatory fish access.
- Restore the expansive marshes and tidal waters that were once a principal maritime focus of both Native Americans and European settlers of outer Cape Cod in a manner that preserves the area's important cultural resources.
- Minimize adverse impacts to cultural resources during project construction and adaptive management phases.
- Minimize adverse impacts to surrounding land uses, such as domestic residences, low-lying roads, wells, septic systems, commercial properties, and private property, including the CYCC.
- Educate visitors and the general public by demonstrating the connection between productive estuaries and salt marshes and a natural tidal regime.
- Improve finfishing and shellfishing opportunities.
- Enhance opportunities for canoeing, kayaking, and wildlife viewing over a diversity of restored wetland and open-water habitats.

IMPACT TOPICS

Seashore staff, Wellfleet and Truro, members of the HRRC, and the public identified impact topics associated with tidal restoration in the Herring River. The full rationale for analyzing the following impact topics in detail is provided in chapter 1. These impact topics provide the organizational structure for the description of the affected environment in chapter 3 and the analysis of environmental consequences in chapter 4 of this draft EIS/EIR.

Salinity of Surface Waters

Increased tidal exchange and increased salinity levels affect species occurrence and distribution. Salt-intolerant vegetation in areas subject to frequent tidal inundation would be expected to die out, allowing colonization of tidal marsh species. In addition, support for estuarine fauna would also depend on salinity concentrations and water depths.

Water and Sediment Quality

One of the more important hydrologic functions of tidal flushing and wetlands is water quality improvement. Poor water quality in the river has led to fish kills and closure of shellfish beds at the river's mouth. Water quality parameters to be addressed in this draft EIS/EIR include dissolved oxygen, pH and sulfates, metal concentrations, nutrient levels, pesticides and other organic compounds, and fecal coliform.

Sediment Transport and Soils

Much of the tidal marsh plain of the Herring River upstream of the dike has subsided up to 3 feet below its pre-dike elevation and below the surface of existing salt marsh seaward of the dike. Restored tidal range would lead to higher sediment transport and deposition onto the wetland surface. Higher tidal velocities will increase the width and depth of tidal channels and the quantity of sediment mobilized in those channels. Tidal inundation of soils will initiate changes in terms of increased pore spacing, increased pH, and increased organic content.

Wetland Habitats and Vegetation

Wetlands in the project area would change from degraded habitats influenced by freshwater to tidal marsh habitats influenced by varying degrees of salt water. Increased tidal range would restore an estuarine salinity gradient and allow for colonization of native tidal marsh plants.

Aquatic Species

Improved water quality and increased salinity would increase the extent and value of the Herring River as a nursery for estuarine fish species, improve estuarine habitat conditions and access to spawning ponds for anadromous and catadromous fish, and increase habitat for shellfish and other invertebrates.

State-listed Rare, Threatened, and Endangered Species

Restoration of the Herring River estuary could beneficially or adversely impact several state-listed species and their habitats in the estuary, including American Bittern, Least Bittern, Northern Harrier, Eastern Box Turtle, Water-Willow Stem Borer, and Diamondback Terrapin.

Terrestrial Wildlife

Restoration of the Herring River estuary could beneficially or adversely impact birds, mammals, reptiles, and amphibians by affecting habitat conditions and habitat distribution.

Cultural Resources

Restoration of the Herring River estuary could impact pre-contact and post-contact archeological sites through direct disturbance and possibly through inundation. Some historic structure may also be affected. These cultural resources will be subject to ongoing site-specific evaluation as the project is implemented.

Socioeconomics

Social and economic conditions may also be affected by reducing nuisance mosquitoes, improving recreational and commercial shellfishing, improving finfishing, creating potential flood risk for low-lying roads and properties, opening scenic viewscapes, improving recreational access and quality, and improving regional employment conditions.

ALTERNATIVES

The NEPA requires federal agencies to consider and fully evaluate a range of reasonable alternatives that address the purpose of and need for the action. Reasonable action alternatives must be economically and technically feasible and demonstrate common sense. The CEQ regulations (40 CFR 1502.14) also require that federal agencies analyze a "no action" alternative; this alternative evaluates future conditions under existing management plans or practices and allows the public to evaluate what would happen if no project were implemented.

The MEPA (301 CMR 11.06 and 11.07) requires that the action proponent present a reasonably complete and stand-alone description and analysis of the project and its alternatives. Alternatives include 1) all feasible alternatives; 2) the alternative of not undertaking the project (no action) for the purpose of establishing a baseline in relation to which the alternatives can be described, analyzed, and potential environmental impacts and mitigation measures can be assessed; 3) an analysis of the feasible alternatives in light of the project objectives and the mission of participating agencies; 4) an analysis of the principal differences among the feasible alternatives under consideration, particularly regarding potential environmental impacts; and 5) a brief discussion of any alternatives no longer under consideration including the reasons for no longer considering these alternatives.

The project alternatives include adaptive management strategies for varying degrees of tidal exchange, as well as infrastructure and flood mitigation elements. How each of these alternatives meets the objectives of the EIS/EIR is detailed in "Chapter 2: Alternatives," table 2-4. The full range of impacts anticipated to result from implementation of the proposed alternatives is detailed in both table ES-1 and "Chapter 4: Environmental Consequences" of the EIS/EIR.

ELEMENTS COMMON TO ALL ALTERNATIVES

The following management actions are common to all alternatives. The HRRC will implement these actions upon adoption of the final Record of Decision (ROD) regardless of which alternative is adopted.

INCREMENTAL TIDAL RESTORATION AND ADAPTIVE MANAGEMENT

Since the early planning stages of the Herring River Restoration Project (HRRP), reintroduction of tidal influence has been understood as a long-term, phased process that would occur over several years. The key to restoration, and an element common to all action alternatives, is the construction of a new dike at Chequessett Neck Road with adjustable tide gates. Gradual opening of adjustable tide gates would incrementally increase the tidal range in the river. The primary reason to implement the project in this manner is to allow monitoring of the system so that unexpected and/or undesirable responses could be detected and appropriate response actions taken. In addition, the complexity of the proposed project also dictates use of an adaptive management approach. Among these are a large and divergent group of stakeholders, multiple and overlapping objectives, and the need for phased and recurrent decisions through an extended period of time.

Adaptive management is a formal, iterative process where (1) a problem is assessed, (2) potential management actions are designed and implemented, (3) actions and resource responses are monitored over time, (4) data are evaluated, and (5) actions are adjusted as necessary to better achieve desired management outcomes. Details of this process and its application to the Herring River project are described in "Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project.

MONITORING

Field monitoring is frequently used in ecological restoration to measure the success of restorative activities. When part of an adaptive management process, field monitoring needs to be carefully designed to measure progress toward objectives and assumptions built into conceptual models. In contrast to standard ecological monitoring and other data gathering efforts, monitoring for adaptive management is not carried out primarily for scientific interest. Instead, adaptive management monitoring studies are designed and carried out to specifically support management decision-making and assessment. Adaptive management monitoring could be a subset of a broader monitoring program, but adaptive management monitoring activities must be specifically tied to project objectives and be cost/time-efficient and sustainable for the duration of the adaptive management plan.

VEGETATION MANAGEMENT

The increased tidal exchange between the Herring River estuary and Cape Cod Bay would be achieved in incremental steps over a number of years and would change many characteristics of the flood plain. One of the most important, noticeable, and desirable changes would be to the composition of plant communities. There would be a transition from one set of plant community types to another as changes occur to environmental parameters, such as tidal range, frequency and duration of tidal flooding, soil saturation, and, most notably, salinity. Predominantly shrubland and woodland plant communities exist on areas of the river flood plain that were once vegetated with salt-marsh plants including salt meadow grass (*Spartina patens*), smooth cordgrass (*S. alterniflora*), black grass (*Juncus gerardii*), and spike grass (*Distichlis spicata*). Most woody plants will not tolerate flooding with salt water, however gradually these impacts occur, and flooding will likely result in many acres of standing dead trees and shrubs covering a large portion of the flood plain.

Vegetation Management Objectives

Management of flood plain vegetation, specifically the removal of shrubs and trees before salt water reaches them, would have the following objectives:

- Encourage re-establishment of tidal marsh.
- Remove woody debris that might impede fish passage.
- Remove large trees that will eventually die, topple and leave holes on the wetland surface where mosquitoes might breed.

Vegetation Management Options

Potential techniques for dealing with woody vegetation include cutting, chipping, burning, and targeted herbicide application. A combination of these techniques will be part of a flexible approach to vegetation management.

The vegetation management activities would consist of primary and secondary management techniques. Primary management is cutting of the vegetation. This would be accomplished with tools such as hand-held loppers, chain saws, mowers, brush hogs, or larger, wheeled or treaded machines that cut and chip.

Secondary management is the processing and removal of the biomass that has been cut. This would be accomplished by a number of techniques including the use of cut hardwood (i.e., as firewood), removal of wood chips, and burning brush and branches. Woody vegetation with diameters of 3 or more inches could be used for biofuel, either as chips or logs. Natural decomposition of dead woody material as a management technique would be considered in some areas of the restored Herring River flood plain. Appropriate options for smaller diameter cut woody vegetation would be developed. Access, substrate type, and other factors would need to be considered to determine the most appropriate vegetation management techniques for specific areas and conditions.

Vegetation management actions would be of the same type and would be implemented in an identical manner under each of the action alternatives; however the spatial extent and timing of when actions would be taken might vary. See “Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project” for a more complete discussion.

LOW-LYING ROAD CROSSINGS AND CULVERTS

Several segments of Pole Dike, Bound Brook Island, and Old County Roads, where they cross the main Herring River and tributary streams, are vulnerable to high tide flooding under the proposed restoration (ENSR 2007a). To prevent this, the road surfaces and culverts would need to be elevated or relocated. Preliminary engineering analysis shows that approximately 8,000 linear feet of road should be elevated to a minimum grade of 5.5 feet. Elevating these roads would also require widening the road bases and increasing culvert sizes. A second option for these road segments would be to relocate the alignment onto a nearby former railroad right-of-way. Preliminary engineering analysis shows this might be feasible with lower costs. Additional engineering studies and traffic analyses are needed to fully evaluate both of these options (CLE 2011).

RESTORATION OF TIDAL CHANNEL AND MARSH SURFACE ELEVATION

Although reintroduction of tidal exchange and salinity is the primary component and main driver for restoration of the Herring River flood plain, several other actions would likely be necessary to reverse other previous direct and indirect alterations of the system’s topography, bathymetry, and drainage capacity. Diking and drainage have caused subsidence of the former salt marsh by up to 3 feet in some locations, reaches of the river have been channelized and straightened, mosquito ditches have been created, and spoil berms have been left along creek banks (HRTC 2007). After tidal restoration is initiated, these factors could limit or delay progress toward meeting the project objectives by inhibiting circulation of salt water, preventing recolonization of tidal marsh vegetation, ponding fresh water, and expanding nuisance mosquito breeding habitat.

Several supplementary habitat management actions would be considered to address these issues. These actions and the conditions under which they would be employed are described and analyzed in detail in the project’s adaptive management plan. In summary, these potential actions include, but are not limited to the following:

- Dredging of accumulated sediment to establish a natural bottom of the Herring River channel at the appropriate depth and maximize ebb tide drainage.
- Creation of small channels and ditches to improve tidal circulation.
- Restoring natural channel sinuosity.
- Removing lateral ditch dredge spoil berms and other anthropogenic material on the marsh surface to facilitate drainage of ponded water.
- Applying thin layers of dredged material to build up subsided marsh surfaces.

UPPER POLE DIKE CREEK

Like Mill Creek, the Upper Pole Dike Creek sub-basin is mostly outside the Seashore boundary. It contains approximately 130 private parcels at least partly within the historic flood plain along with approximately 100 acres of degraded tidal wetlands that could be restored with reintroduction of tides. Hydrodynamic modeling shows that portions of these low-lying properties are low enough to potentially be affected by restored tides in the Herring River. However, only a few of these have structures that would be vulnerable to flooding. Any substantial flood impacts would be addressed on a property-specific basis or by restricting tide flow at Pole Dike Road with either the existing road culvert or a tide control gate. The extent and nature of these impacts and flood protection measures are described in "Chapter 4: Environmental Consequences."

PUBLIC ACCESS AND RECREATION OPPORTUNITIES

The Herring River estuary is included in the Seashore's natural zone, and is managed to protect natural processes with limited infrastructure. Given this National Seashore planning objective, it is anticipated that any development of public access points or visitor facilities would occur at the discretion of adjacent landowners or stakeholders, such as the Towns of Wellfleet and Truro, Wellfleet Conservation Trust, or the Friends of Herring River.

For example, the new Chequessett Neck Road Dike would be designed to include safe fishing access sites, and launches for canoes or kayaks could be provided at other points in the estuary. Walking trails could include access to the variety of habitats established by the restoration process. Over the long term, access to recreational shellfishing areas could also be considered once the shellfish resource is sustainable and capable of supporting harvest. The NPS would work with adjacent land managers by providing guidance on resource protection and interpretation.

ALTERNATIVE A: NO ACTION – RETAIN EXISTING TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK

NEPA and MEPA regulations require measuring all alternatives against a future condition without the project. In this case, no action means that the existing 18-foot-wide structure composed of two flap gates and an adjustable tide gate would remain in place, and no tidal restoration would occur. Although no changes to infrastructure would occur, it is important to emphasize that "no action" is not a steady state from an environmental perspective.

ACTION ALTERNATIVES

The three action alternatives are differentiated primarily by the extent of restored tidal range throughout the estuary. The beneficial and adverse impacts of all alternative elements, including elements common to all, are described and analyzed in detail in "Chapter 4: Environmental Consequences."

ALTERNATIVE B: NEW TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK – NO DIKE AT MILL CREEK

Following the "bookend" concept, alternative B provides the lowest high tide water surface elevations needed to achieve the project objectives. Under this alternative, a 165-foot-wide series of culverts with adjustable tide gates would be installed in the Chequessett Neck Road Dike to allow passage of Wellfleet Harbor tides (an element common to all alternatives). The tide gates would be opened gradually according to guidelines set forth in the Adaptive Management Plan with an objective to ultimately reach a mean high spring tide of 4.8 feet and 100-year storm driven tide of 6.0 feet in the Lower Herring River. These elevations reflect the maximum restoration possible without the need to install a secondary tidal control structure at Mill Creek to protect private properties and are based on the feasibility of addressing flood impacts within the Mill Creek sub-basin. Hydrodynamic modeling has demonstrated that a vertical tide gate opening of approximately 3 feet across the 165-foot culvert structure would result in this tidal regime. Tides in the upstream sub-basins would be lower because of natural tide attenuation.

This alternative would provide a uniform degree of restoration in all sub-basins and would not require the construction or cost of a dike at Mill Creek. Flood proofing actions undertaken throughout the estuary would be designed to accommodate 100-year storm driven tidal flooding up to 5.9 feet within the Mill Creek sub-basin and 5.3 feet in the Upper Pole Dike Creek sub-basin. The exact final maximum high tide elevations would be determined through the adaptive management process, but would not exceed these elevations.

Alternative B would require flood proofing measures for the CYCC golf course and other low-lying properties throughout the Herring River flood plain. Also, alternative B would forego the ability to pursue higher inundation levels in the estuary as part of an adaptive management process. This alternative would limit the total area of tidal wetland habitat that could be realized with tidal restoration.

Mill Creek Sub-basin

Under alternative B, the Mill Creek sub-basin would be left open to the Herring River, thereby subjecting the sub-basin to a limited tide regime controlled at Chequessett Neck Road Dike. However, the tide gates at Chequessett Neck Road Dike would remain partly closed to limit mean high water spring tides to a maximum of 4.8 feet and 100-year storm events to a maximum of 6.0 feet in the Lower Herring River. This would equate to a maximum mean high water spring tide elevation of 4.7 feet and a maximum 100-year coastal storm event elevation of 5.9 feet in Mill Creek. As a result, this alternative would not require the construction or cost of a dike at Mill Creek if flood protection measures are in place.

Chequessett Yacht and Country Club

Hydrodynamic modeling has shown that several areas of the CYCC golf course would be affected by inundation levels proposed under alternative B. There are two options for addressing the impacts to the CYCC:

- Relocate the affected portions of the facility to upland locations currently owned by the CYCC. This would involve clearing, grading, and planting of new golf holes and a practice area. Approximately 30 acres of long-term upland disturbance would be generated under this option. One fairway would not be able to be relocated because of its proximity to the clubhouse and would require filling and regrading.
- Elevate the affected portions of the facility by providing necessary quantities of fill, regrading, and replanting the areas. Initial design concept plans for this effort include approximately 150,000 cubic yards of fill and 32 acres of disturbance for grading and site preparation. Portions of five low-lying golf holes would be reconstructed to a minimum elevation of 6.7 feet, which is 2 feet above the mean spring tide in Mill Creek.

ALTERNATIVE C: NEW TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT EXCLUDES TIDAL FLOW

Chequessett Neck Road Dike

Like the other action alternatives, tide gates at a rebuilt Chequessett Neck Road Dike would be opened gradually and according to guidelines set forth in the Adaptive Management Plan. The objective for alternative C would be to fully open the gates to allow mean high water spring tides up to 5.6 feet and 100-year storm driven tides up to 7.5 feet in the Lower Herring River. Following the "bookend" concept, alternative C provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain; however, a tidal exclusion dike would be constructed at the mouth of Mill Creek in order to avoid flood impacts to low-lying private properties within this sub-basin. Tides in the upstream sub-basins would be lower because of natural tide attenuation. Mitigation actions undertaken throughout the remainder of the Herring River estuary would be designed to accommodate flooding up to these maximum tidal elevations.

Mill Creek Sub-basin

In contrast to alternative B, under alternative C a new dike at the mouth of Mill Creek would need to be constructed to *eliminate* tidal influence to the sub-basin. Based on the results of hydrodynamic modeling and preliminary consultation with the Federal Emergency Management Agency (FEMA), the minimum recommended crest height of this dike is 2 feet above the projected 100-year storm surge elevation, or 9.5 feet (based on the modeled prediction of the 100-year storm elevation of 7.5 feet in the Lower Herring River). Construction of this structure would require approximately 2,900 cubic yards of fill and would permanently impact 12,500 square feet of wetland. In addition, a construction work area encompassing approximately 105,000 square feet (2.4 acres) of vegetated wetlands would likely be required for dewatering and other associated work and would be impacted temporarily.

A one-way, flapper-style tide gate would need to be installed within the dike to allow freshwater to drain from the basin toward the Herring River while blocking seawater from passing upstream of the dike. Given the generally flat land surface of the flood plain and naturally occurring high water table, mechanical pumping may be necessary at times to facilitate freshwater drainage.

Chequessett Yacht and Country Club

Because a dike would eliminate tidal influence from the Mill Creek sub-basin, no additional flood protection measures would be required for CYCC or other Mill Creek properties.

ALTERNATIVE D: NEW TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT PARTIALLY RESTORES TIDAL FLOW

Chequessett Neck Road Dike

Like the other action alternatives, tide gates at a rebuilt Chequessett Neck Road Dike would be opened gradually and according to guidelines set forth in the Adaptive Management Plan. The objective for alternative D is to fully open the gates to allow mean high water spring tides up to 5.6 feet and 100-year storm driven tides up to 7.5 feet in the Lower Herring River. Following the "bookend" concept, alternative D provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain. Tides in the upstream sub-basins would be lower because of natural tide attenuation. With the exception of Mill Creek, flood protection actions undertaken throughout the estuary would be designed to accommodate flooding up to these maximum tidal elevations.

Mill Creek Sub-basin

Similar to alternative C, a new dike at the mouth of Mill Creek would need to be constructed under alternative D. However, under alternative D, the one-way flapper style tide gate would be replaced with an adjustable, two-way tide gate which would be managed to partially restore tidal flow to the sub-basin. Mean high spring tides would be limited to 4.7 feet and 100-year storm driven events to a maximum of 5.9 feet in Mill Creek. In contrast to alternative C, the same flood proofing measures and related costs specified under alternative B would be required for Mill Creek (e.g., golf course and private property flood proofing, and well relocation) as well as the cost of Mill Creek Dike construction.

Chequessett Yacht and Country Club

As described for alternative B, two options for protecting the CYCC golf course would be possible under alternative D: (Option 1) relocating portions of multiple low-lying golf holes to upland areas currently owned by the CYCC or (Option 2)elevating the affected areas in place by filling and regrading.

NPS AND HRRC PREFERRED ALTERNATIVE

To identify the preferred alternative, each alternative was evaluated based on its ability to meet the plan objectives (see "Chapter 2: Alternatives," table 2-4) and their potential impacts on the environment (see "Chapter 4: Environmental Consequences" of this document). An initial screening of the alternatives was accomplished by the project team through the Value Analysis/Choosing by Advantages process held June 1–3, 2011 (Kirk Associates 2011). The Value Analysis/Choosing by Advantages process considered the advantages of the three proposed action alternatives, including the Mill Creek options for alternatives B and D. Each of the three alternatives was evaluated against three factors:

- Restore natural and cultural resources.
- Improve operational efficiency, reliability, and sustainability.
- Enhance and maintain socioeconomic benefits.

The HRRC evaluated the benefit or "importance of advantage" for each of the alternatives. Not considering the cost, alternative D, with Mill Creek Option 2 which elevates the fairways and practice area at the CYCC, would provide the greatest importance of advantage based on benefit points. Relative initial cost estimates for the alternatives were developed and the relative benefits and costs of the alternatives were graphed. This cost-benefit ratio also showed that alternative D with Mill Creek Option 2, elevation of the CYCC golf course, would offer the best value, with the highest benefit to cost ratio. Thus, in the Value Analysis/Choosing by Advantages process, alternative D with elevation of the CYCC golf course was selected as the preferred alternative.

ENVIRONMENTAL CONSEQUENCES

For each impact topic, methods were identified to measure the change in the Herring River flood plain's resources that would occur with the implementation of each management alternative. Each management alternative was compared to baseline conditions (Alternative A: No Action) to determine the context, duration, and intensity of resource impacts. Table ES-1 summarizes the results of the impact analysis for the impact topics that were assessed. The full impact analysis is in "Chapter 4, Environmental Consequences."

TABLE ES-1: SUMMARY OF THE IMPACTS OF THE ALTERNATIVES

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Salinity of Surface Waters	The existing Chequessett Neck Road Dike would continue to limit tidal influence in the estuary. Seawater would not reach areas upstream of High Toss Road. The lowest reaches of the Lower Herring River would continue to receive some influence from tidally driven seawater.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 4.8 feet and 100-year storm driven tide of 6.0 feet in the Lower Herring River. Salinity penetration would increase in most sub-basins.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 5.6 feet and 100-year storm driven tide of 7.5 feet in the Lower Herring River. A new dike managed to exclude tides would be constructed at the mouth of Mill Creek. Salinity penetration would increase in all sub-basins beyond that achieved in alternative B, but no change would occur in Mill Creek.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 5.6 feet and 100-year storm driven tide of 7.5 feet in the Lower Herring River. A new dike managed to control tides would be constructed at the mouth of Mill Creek. Salinity penetration would increase in all sub-basins to the same extent as alternative C, but salinity penetration in Mill Creek would be comparable to that of alternative B.
	Salinity ranges of specific sub-basins would be as follows (0 parts per thousand (ppt) = freshwater, ~35 ppt = seawater): • Lower Herring River: 0-26 ppt • Middle Herring River: 0 ppt • Upper Herring River: 0 ppt • Duck Harbor: 0 ppt • Lower Pole Dike Creek: 0 ppt • Upper Pole Dike Creek: 0 ppt • Lower Bound Brook: 0 ppt • Upper Bound Brook: 0 ppt • Mill Creek: 0 ppt	Salinity ranges of specific sub-basins would be as follows (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 22-29 ppt • Middle Herring River: 7-29 ppt • Upper Herring River: 0-1 ppt • Duck Harbor: 0-25 ppt • Lower Pole Dike Creek: 15-30 ppt • Upper Pole Dike Creek: 0-14 ppt • Lower Bound Brook: 2-24 ppt • Upper Bound Brook: 0-3 ppt • Mill Creek: 0-30 ppt	Salinity ranges of specific sub-basins would be as follows (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 25-30 ppt • Middle Herring River: 12-29 ppt • Upper Herring River: 0-17 ppt • Duck Harbor: 3-24 ppt • Lower Pole Dike Creek: 17-30 ppt • Upper Pole Dike Creek: 0-20 ppt • Lower Bound Brook: 7-27 ppt • Upper Bound Brook: 0-15 ppt • Mill Creek: 0 ppt	Salinity ranges of specific sub-basins would be as follows (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 25-30 ppt • Middle Herring River: 12-29 ppt • Upper Herring River: 0-17 ppt • Duck Harbor: 3-24 ppt • Lower Pole Dike Creek: 17-30 ppt • Upper Pole Dike Creek: 0-20 ppt • Lower Bound Brook: 7-27 ppt • Upper Bound Brook: 0-15 ppt • Mill Creek: 0-30 ppt

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Water and Sediment Quality	Lack of tidal flushing would continue to impact water and sediment quality by lowering the pH of porewater and surface water, leaching iron and aluminum, reducing summer dissolved oxygen concentrations to levels dangerous to fish and invertebrates, and concentrating fecal coliform.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to approximately 800 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to approximately 830 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates. No water quality improvements would occur to Mill Creek.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to 889 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates.
	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence Time under current conditions is approximately 200 days.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence time would be reduced to 8 days.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence time would be reduced to 6 days, but Mill Creek sub-basin would be excluded.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence Time would be reduced to 6 days.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Sediment Transport	Tidal flows would continue to be restricted by the existing Chequessett Neck Road Dike, limiting upstream sediment transport. Channel width, depth, and capacity would remain restricted. Insufficient delivery of sediment to marsh surfaces, pore space collapse, and decomposition of organic matter would cause continued subsidence of the marsh surface.	Enlarging the dike opening would result in accretion of sediment on the marsh. The degree and rate of sediment mobilization would be determined by the amount of tidal influence and rate of incremental opening of the tide gates. Restoration of marsh surface elevations may proceed for decades.	Same as alternative B.	Same as alternative B.
	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under current conditions: • Normal Tides: 56 acres • Storm Tides: 154 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative B: • Normal Tides: 144 acres • Storm Tides: 349 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative C: • Normal Tides: 156 acres • Storm Tides: 447 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative D: • Normal Tides: 156 acres • Storm Tides: 447 acres
Soils	The soils would continue to evolve as they have since the dike was built, as there would be no predicted changes in soil chemistry, structure, or organic content. Soil conditions would continue to reflect past adverse impacts of tidal exclusion.	Tidal restoration would result in estuary-wide, beneficial changes to hydric soils by increasing pore space, soil pH, and organic content as these soils are subjected to tidal inundation. Various local changes in soil texture are also expected as soils are subjected to different erosional and/or depositional forces that alter the sand, silt, or clay content.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Wetland Habitats and Vegetation	Degraded freshwater conditions would persist in over 1000 acres of former salt marsh habitats due to tidal restriction. The following habitat conditions are currently present in each sub-basin: • Lower Herring River: 162 acres degraded sub-tidal, salt marsh, brackish, freshwater, and woodland habitat • Middle Herring River: 89 acres degraded freshwater, woodland, and shrubland habitat • Upper Herring River: 147 acres degraded freshwater, woodland, and shrubland habitat • Duck Harbor: 129 acres degraded woodland, shrubland, and dune/heath habitat • Lower Pole Dike Creek: 109 acres degraded freshwater, shrubland, and woodland habitat • Upper Pole Dike Creek: 146 acres degraded freshwater, shrubland, and woodland habitat • Lower Bound Brook: 80 acres degraded freshwater, shrubland, and woodland habitat	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following sub-basin habitat conditions would exist after habitat transition is complete: • Lower Herring River: 150 acres tidally influenced sub-tidal and salt marsh habitat • Middle Herring River: 85 acres tidally influenced salt marsh habitat • Upper Herring River: 104 acres tidally influenced freshwater habitat • Duck Harbor: 81 acres tidally influenced brackish and salt marsh habitat • Lower Pole Dike Creek: 104 acres tidally influenced salt marsh habitat • Upper Pole Dike Creek: 108 tidally influenced freshwater and brackish habitat • Lower Bound Brook: 67 acres tidally influenced freshwater and brackish habitat • Upper Bound Brook: 39 acres tidally influenced freshwater habitat	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following sub-basin habitat conditions would exist after habitat transition is complete: • Lower Herring River: 156 acres tidally influenced sub-tidal and salt marsh habitat • Middle Herring River: 87 acres tidally influenced salt marsh habitat • Upper Herring River: 113 acres tidally influenced freshwater and brackish habitat • Duck Harbor: 107 acres tidally influenced salt marsh habitat • Lower Pole Dike Creek: 105 acres tidally influenced salt marsh habitat • Upper Pole Dike Creek: 125 acres tidally influenced freshwater, brackish, and salt marsh habitat • Lower Bound Brook: 71 acres tidally influenced freshwater, brackish, and salt marsh habitat	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following sub-basin habitat conditions would exist after habitat transition is complete: • Lower Herring River: 156 acres tidally influenced sub-tidal and salt marsh habitat • Middle Herring River: 87 acres tidally influenced salt marsh habitat • Upper Herring River: 113 acres tidally influenced freshwater and brackish habitat • Duck Harbor: 107 acres tidally influenced salt marsh habitat • Lower Pole Dike Creek: 105 acres tidally influenced salt marsh habitat • Upper Pole Dike Creek: 125 acres tidally influenced freshwater, brackish, and salt marsh habitat • Lower Bound Brook: 71 acres tidally influenced freshwater, brackish, and salt marsh habitat • Upper Bound Brook: 56 acres tidally influenced freshwater and brackish habitat

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	• Upper Bound Brook: 113 acres degraded freshwater and shrubland habitat • Mill Creek: 72 acres degraded brackish, freshwater and woodland habitat and low-lying golf course	• Mill Creek: Golf course Option 1 (relocation), 60 acres tidally influenced salt marsh habitat, 30 acres upland disturbance; Golf course Option 2 (elevation), 53 acres tidally influenced salt marsh habitat, plus 5 acres upland disturbance	• Upper Bound Brook: 56 acres tidally influenced freshwater and brackish habitat • Mill Creek: 72 acres degraded brackish, freshwater and woodland habitat and low-lying golf course (no change from alternative A)	• Mill Creek: Golf course Option 1 (relocation), 60 acres tidally influenced salt marsh habitat, 30 acres upland disturbance; Golf course Option 2 (elevation), 53 acres tidally influenced salt marsh habitat, plus 5 acres upland disturbance (same as alternative B)
Aquatic Species	The Herring River estuarine system would remain degraded with diminished abundance of resident estuarine fish, marine migrant species, and macroinvertebrate species in the estuary, and limited use of fresh water spawning grounds by anadromous/catadromous species.	Restored estuarine waters and salt marsh would provide substantially more spawning and nursery habitat for both resident and transient fish species and for estuarine macroinvertebrates, increasing their abundance. Improved water quality and access to the head waters of the river would enlarge the river herring run.	Same as alternative B.	Same as alternative B.
	Total estuarine habitat would be limited to 70 acres within Lower Herring river.	Total estuarine habitat would increase to 790-800 acres.	Total estuarine habitat would increase to 822 acres.	Total estuarine habitat would increase to 878-885 acres.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
State-listed Rare, Threatened, and Endangered Species	Northern Harrier The 193-acre Typha-dominated nesting area in Bound Brook sub-basin would remain unchanged. Foraging areas would remain unchanged.	Northern Harrier 106 acres in Bound Brook would become tidally influenced, but with salinity near 0 ppt (freshwater), so nesting habitat would not be affected. Area of enhanced foraging habitat would increase by 393 acres.	Northern Harrier 127 acres in Bound Brook would become tidally influenced, Salinity in channels may reach about 20 ppt during storms, potentially reducing available nesting habitat. Area of enhanced foraging habitat would increase by 346 acres.	Northern Harrier Impacts on nesting habitat would be the same as alternative C. Area of enhanced foraging habitat would increase by 399 acres.
	American Bittern and Least Bittern Exact distribution and activity are not known. 242 acres of brackish and freshwater marsh habitat would remain available for bittern use.	American Bittern and Least Bittern 251 acres of fresh marsh in upper basins becomes tidally influenced, improving bittern habitat.	American Bittern and Least Bittern 294 acres of fresh marsh in upper basins tidally influenced, improving bittern habitat.	American Bittern and Least Bittern The impacts would be the same as alternative C, except that up to 53 acres of salt marsh would be restored in the Mill Creek sub-basin that is now dominated by non-native *Phragmites*.
	Diamondback Terrapin 13 acres of salt marsh habitat potentially used in Lower Herring River.	Diamondback Terrapin 393 acres of salt marsh would be restored in Lower Herring River, Mill Creek, Middle Herring River, Lower Pole Dike Creek.	Diamondback Terrapin 346 acres of salt marsh would be restored in Lower Herring River, Middle Herring River, Lower Pole Dike Creek.	Diamondback Terrapin 399 acres of salt marsh would be restored in Lower Herring River, Mill Creek, Middle Herring River, Lower Pole Dike Creek, Duck Harbor.
	Eastern Box Turtle Eastern box turtles would continue to occur in wooded upland areas in the project area and adjacent to the project area.	Eastern Box Turtle Eastern box turtles would be gradually displaced from 800-acre area influenced by mean high spring tide.	Eastern Box Turtle Eastern box turtles would be gradually displaced from 830-acre area influenced by mean high spring tide.	Eastern Box Turtle Eastern box turtles would be gradually displaced from 890-acre area influenced by mean high spring tide.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	<u>Water-Willow Stem-Borer</u> 174 *Decodon* stands are mapped in the project area (High Toss Road and above); the exact occupancy by stemborers is not known, but habitat conditions would remain unchanged.	<u>Water-Willow Stem-Borer</u> 103 stands in Lower Herring River, Middle Herring River, and Lower Pole Dike Creek likely affected by tidal water, but *Decodon* occurrence in 251 acres in upper sub-basins would potentially increase.	<u>Water-Willow Stem-Borer</u> 106 stands in Lower Herring River, Middle Herring River, and Lower Pole Dike Creek likely affected by tidal water, but *Decodon* occurrence in 294 acres in upper sub-basins would potentially increase.	<u>Water-Willow Stem-Borer</u> Impacts are the same as alternative C.
Terrestrial Wildlife	<u>Birds</u> Salt marsh species would remain limited to 13 acres in Lower Herring River. For other wetland species, 264 acres of freshwater/brackish habitat would remain available. For upland and other bird species, 723 acres of woodland, shrubland, and heathland habitat would remain in the project area.	<u>Birds</u> For salt marsh species, 393 acres of habitat would be restored in Lower Herring River, Mill Creek, Middle Herring River, and Lower Pole Dike Creek. For other wetland species, 407 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats.	<u>Birds</u> For salt marsh species, 346 acres of habitat would be restored in Lower Herring River, Middle Herring River, and Lower Pole Dike Creek. For other wetland species, 484 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats. No change would occur in Mill Creek.	<u>Birds</u> For salt marsh species, 399 acres of habitat would be restored in Lower Herring River, Mill Creek, Middle Herring River, Duck Harbor, and Lower Pole Dike Creek. For other wetland species, 491 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats.
	<u>Mammals</u> Mammals would remain widespread throughout the 1000+ acre project area.	<u>Mammals</u> Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	<u>Mammals</u> Most species would relocate to the estuary periphery and to the upper extents of the 830-acre area affected by mean high spring tide. No change would occur in Mill Creek.	<u>Mammals</u> Most species would relocate to the estuary periphery and to the upper extents of the 890-acre area affected by mean high spring tide.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	<u>Reptiles and Amphibians</u> Reptiles and amphibians would remain widespread throughout the 1000+ acre project area.	<u>Reptiles and Amphibians</u> Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	<u>Reptiles and Amphibians</u> Most species would relocate to the estuary periphery and to the upper extents of the 830-acre area affected by mean high spring tide. No change would occur in Mill Creek.	<u>Reptiles and Amphibians</u> Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.
Cultural Resources	No impacts to cultural resources or archeological resources would occur as a result of the no action alternative, as existing conditions would be maintained.	There is a potential for adverse effects to archeological resources in the APE from construction or other ground-disturbance. Additional archeological assessment would occur prior to construction. Higher tides would not impact archeological resources because any inundation would be gradual. Erosion from increased tidal flows could impact transportation corridors across river channels, but these impacts would be mitigated by culvert replacement and other erosion control measures. Depending on the golf course flood proofing option implemented, either 5 or 30 acres (approximately) of sensitive uplands could be disturbed.	Same as alternative B, but with approximately 30 additional acres under tidal exchange; no tidal influence or disturbance in Mill Creek.	Same as alternative B, but with approximately 90 additional acres of tidal exchange, including in Mill Creek. Depending on the golf course flood proofing option implemented, either 5 or 30 acres (approximately) of sensitive uplands could be disturbed.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Socioeconomics Nuisance Mosquitoes	The Herring River would remain a productive mosquito habitat, particularly between High Toss Road and Route 6. The dominant mosquito species is *Ochlerotatus cantator.*	A shift in species is expected as salinity is increased, with a long-term decline of freshwater and generalist species such as *O. cantator* and *O. canadensis*, with replacement by salt marsh mosquito species such as *O. solicitans* in the lower marsh. Because of the greater success in controlling this species, a decrease in the mosquito nuisance is expected. These impacts are expected in 801 restored acres.	The same species shift is expected as in alternative B. These impacts are expected in 830 restored acres. No changes would occur in Mill Creek.	The same species shift is expected as in alternative B. These impacts are expected in 890 restored acres.
Shellfishing	Recreational and commercial shellfish harvest would remain permanently closed immediately downstream of the Chequessett Neck Road Dike, due to fecal coliform contamination.	Shellfish populations and shellfish harvest are expected to increase. Decreased fecal coliform levels would allow the closed area downstream of the Chequessett Neck Road Dike to be reopened; other areas of Wellfleet Harbor that are only conditionally opened could be opened year-round.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Finfishing	No improvement to recreational or commercial finfishing would occur. Ongoing estuary degradation and obstructed access would contribute to continued regional population declines of estuary-dependent fisheries.	Improvements to habitat and water quality in the estuary and Wellfleet Harbor would benefit populations of finfish and commercial finfishing industries. Restoring connectivity with Wellfleet Harbor for the full range of fish species formerly found in the estuary would provide a corresponding improvement to the recreational fishery.	Same as alternative B.	Same as alternative B.
Low-lying Properties	Properties in the project area would continue to be protected from inundation by the Chequessett Neck Road Dike. Certain properties may need to obtain flood insurance if the Chequessett Neck Road Dike is not upgraded to comply with FEMA design guidelines.	Increased tidal exchange would result in beneficial and adverse impacts to low-lying properties. Beneficial impacts would include transition to open marsh and water vistas, potentially increasing property values. Adverse impacts could include flooding of low-lying structures and cultivated vegetation. Flood proofing measures would mitigate flood impacts. Compared to the other action alternatives, this alternative has the least impact in terms of the number of properties affected and the degree of impact.	The types of impacts are the same as alternative B. This alternative would have more impact in terms of the number of properties affected and the degree of impact than alternative B, but less than alternative D, because there would be no change in Mill Creek.	The types of impacts are the same as alternative B. This alternative would have more impact in terms of the number of properties affected and the degree of impact than alternatives B and C.

Resource	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Low-lying Roads	Present road conditions would persist under the no action alternative. None of the roads have serious flooding issues.	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 7,394 feet Sand/fire roads: 10,332 feet	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 8,694 feet Sand/fire roads: 10,332 feet	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 9,397 feet Sand/fire roads: 10,727 feet
Viewscapes	The current natural features and landscape character, and therefore viewscapes, would not change.	Long-term viewscape benefits would result from expanding intertidal habitat and open vistas. Intertidal habitats would vary by basin, but would be mostly open water, broad salt meadows, and salt water marshes. More native wildlife may also be observed. Wooded areas within the flood plain would decrease, reducing obstructions to viewscapes. In the short term, some dead or dying vegetation could reduce the quality of the viewscape until the transition is complete.	Same as alternative B, except that slightly more wooded area in the upper sub-basins would be removed, and Mill Creek sub-basin would be unaffected.	Same as alternative B, except that slightly more wooded area in the upper sub-basins would be removed.

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Recreational Experience and Public Access	Public access points would remain unaffected and the physical character of the estuary would be unchanged.	Some low-lying access points could be impacted in the short term, but in the long term these could be replaced with better access points. After restoration, there would be improvements to recreational shellfishing, finfishing, wildlife viewing, boating, and visual aesthetics. There would be no net loss in public access.	Same as alternative B, except that no change would occur in Mill Creek.	Same as alternative B.
Regional Economic Conditions	There would be no project expenditures. Current regional economic conditions and trends are expected to continue.	Regional economic conditions would benefit from engineering, construction, and related spending that would support jobs and increase economic activity.	Same as alternative B.	Same as alternative B.
Construction Impacts Chequessett Neck Road Dike	No construction would occur.	The Chequessett Neck Road Dike would be reconstructed, temporarily impacting approximately 103,200 square feet (2.4 acres) comprised of the current dike footprint and adjacent inter- and sub-tidal wetland areas.	Same as alternative B.	Same as alternative B.
Mill Creek Dike	No construction would occur.	No construction would occur.	This structure would require approximately 2,900 cubic yards of fill and would permanently impact 12,500 square feet of wetland. In addition, a work area of approximately 105,000 square feet (2.4 acres) of wetlands would be impacted temporarily for dewatering and other associated work.	Same as alternative C.

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High Toss Road		If the road is reconstructed above high tide line, there would be a permanent loss of approximately 13,000 square feet of vegetated wetland. Alternatively, if High Toss Road were removed, approximately 12,000 square feet of additional wetland area would be restored.	Same as alternative B.	Same as alternative B.
Pole Dike/ Bound Brook Island Roads		Elevating the roads above the 100-year storm elevation would fill approximately 4,000 square feet of adjacent wetlands. Elevating the roads above annual high water (AHW) would fill approximately 2,300 square feet.	Same as alternative B.	Same as alternative B.

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CYCC Golf Course Flood Proofing		Two options exist for flood proofing low-lying golf holes: Option 1 (relocation) and Option 2 (elevation). Under the relocation option, most of the low-lying golf holes would be relocated to an approximately 30-acre adjacent upland area. One hole would be elevated in its current location, resulting in a wetland loss of about 89,000 square feet. For the elevation option, approximately 360,000 square feet (8.3 acres) of wetland would be filled and elevated above the high tide line. Most of this wetland is now a developed part of the golf course. Fill may be generated from an approximately 5-acre borrow area on adjacent uplands for both options. The upland area is highly sensitive for pre-contact archeological resources.	No flood proofing measures are required.	Same as alternative B.
Residential Flood Proofing		Several low-lying residential properties could be impacted by restored tides, requiring actions such as constructing a small berm or wall to protect a residential parcel, adding fill to a low driveway or lawn, or relocating a well. Some of these actions may have limited wetland impacts.	No flood proofing measures are required in Mill Creek. In other areas, impacts would be similar to alternative B.	Same as alternative B.

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Secondary Restoration Actions / Minor Road Improvements		These actions may include direct vegetation management, sediment management, channel improvements, and planting of vegetation. Impacts are expected to include work within wetland areas to remove trees and shrubs, dredge and/or deposit of sediment, excavation or fill of channels, and other actions to improve tidal circulation. Some actions may include access for heavy equipment.	Same as alternative B, except that no restoration would occur in Mill Creek.	Same as alternative B.

Contents

Appendices

Figures

Tables

Acronyms and Abbreviations

ACEC	areas of critical environmental concern
AHW	annual high water
APE	area of potential effect
BMP	best management practice
BVW	Bordering Vegetation Wetlands
CCC	Cape Cod Commission
CCMCP	Cape Cod Mosquito Control Project
CEQ	Council on Environmental Quality
CRP	Conceptual Restoration Plan
CWA	Clean Water Act
CYCC	Chequessett Yacht and Country Club
CZM	Coastal Zone Management
DDT	dichlorodiphenyltrichloroethane
DRI	Development of Regional Impact
EFH	essential fish habitat
EIR	environmental impact report
EIS	environmental impact statement
EIS/EIR	Herring River Restoration Environmental Impact Statement / Environmental Impact Report
ENF	environmental notification form
ERL	effects range low
ERM	effects range median
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HRRC	Herring River Restoration Committee
HRRP	Herring River Restoration Project
HRTC	Herring River Technical Committee
LCS	List of Classified Structures
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MHW	mean high water
MLW	mean low water
MOU	Memorandum of Understanding
National Register	National Register of Historic Places
NEPA	National Environmental Policy Act
NHESP	Natural Heritage and Endangered Species Program
NHPA	National Historic Preservation Act of 1966

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PA	programmatic agreement
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEPC	Planning, Environment, and Public Comment
PEL	probable effects level
ROD	Record of Decision
Seashore	Cape Cod National Seashore
SHPO	State Historic Preservation Officer
TEL	threshold effects level
THPO	Tribal Historic Preservation Officer
TPH	total petroleum hydrocarbons
TWG	Technical Working Group
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service