
Chapter 2
Alternatives

CHAPTER 2: ALTERNATIVES

2.1 INTRODUCTION

The National Environmental Policy Act (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 Council on Environmental Quality (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 Massachusetts Environmental Policy Act (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.

Alternatives may originate from the proponent agency, local government officials, or members of the public. Alternatives may also be developed in response to comments from coordinating or cooperating agencies. With the exception of the no action alternative, alternatives must meet, to a large degree, the stated purpose and objectives for taking action and should not conflict with federal, state, or local laws, regulations, and policies or constraints identified during scoping.

This chapter provides a description of the alternatives being considered for the restoration of the Herring River estuary, including the no action alternative. The project alternatives include adaptive management strategies for varying degrees of tidal exchange, as well as infrastructure and flood mitigation elements. The design and construction elements of each of these alternatives are described in this chapter, and are analyzed in "Chapter 4: Environmental Consequences."

2.2 ALTERNATIVES DEVELOPMENT PROCESS

The Herring River Restoration Committee (HRRC) applied a systematic approach, as required by NEPA and MEPA, to the development of alternatives and mitigation strategies. This section provides a summary of the alternatives development process and the draft alternatives, which evolved through public input and multiple meetings with the HRRC.

Hydrodynamic modeling has been central to developing a range of potential restoration alternatives. Modeling has allowed for evaluation of specific questions about potential changes to surface water elevations, salinity levels, flow velocities, sediment transport, and potential impacts to low-lying properties within the Herring River estuary under a range of restoration scenarios. For detailed information about hydrodynamic modeling, see appendix B.

The alternatives analyzed in this Herring River Restoration Environmental Impact Statement / Environmental Impact Report (EIS/EIR) were screened for their ability to meet the project purpose and objectives for technical, logistical, and financial feasibility, and for their ability to avoid significant adverse impacts. This screening eventually resulted in three action alternatives, which were found to meet the purpose and objectives, to be feasible, and would result in clear differences in environmental outcomes. Thus, these alternatives constitute a reasonable range of alternatives for NEPA evaluation. These action alternatives are summarized in table 2-5 at the end of this chapter, and discussed in detail in sections 2.5 and 2.6.

Other alternatives or infrastructure options were dismissed from further consideration because they would not meet the purpose and need for action, are not feasible, or do not provide a substantial difference in environmental outcomes. These alternatives and the rationale for dismissal are described in detail in section 2.7.

2.2.1 Preliminary Alternatives – Conceptual Restoration Plan

The project team identified several preliminary project alternatives in early models and other studies (Roman 1987; Spaulding and Grilli 2001). Additional alternatives were formulated by the Herring River Technical Committee (HRTC) and studied in subsequent modeling efforts (Spaulding and Grilli 2005). The following range of preliminary alternatives was examined in the Conceptual Restoration Plan (CRP) (HRTC 2007):

- No Action: Retain existing tide gates and manage tides under existing conditions.
- Open existing culverts to their maximum (18-feet wide) extent.
- Build a replacement structure with an opening width of 100–130 feet, fitted with sluice gates to manage tides. Sub-options included:
  - Cast-in-place culverts.
  - Pre-cast arch spans.
  - A two-span bridge structure.
  - A trestle bridge structure.
- Build a bridge with no tidal control at Chequessett Neck, and establish tidal control structures at strategic upstream locations.

2.2.2 NEPA/MEPA Alternatives Development

Several additional project alternatives were introduced during public scoping in July 2008 (Federal Register notice August 21, 2008; MEPA #14272), which formally started the NEPA/MEPA processes. With feedback from state and federal agencies, including a draft EIR scope from MEPA (certificate dated November 7, 2008; notice in Environmental Monitor, November 22, 2008) and detailed comments from the Cape Cod Commission (CCC), the HRRC refined the project alternatives and impact topics. The MEPA certificate called for the EIS/EIR to evaluate the following:

- **No Action**—Existing tide gates would remain in place and tide levels would be managed under existing conditions.
- **Modified Tide Gate Control at Chequessett Neck Road**—Existing dike would be replaced with a new structure with an opening 100–130 feet wide consisting of culverts, arch spans, or

a bridge. The structure would be fitted with sluice gates to allow full tidal control and management.

- **Open Bridge with Upstream Tide Gate Controls**—An open bridge span would be constructed at the site of the Chequessett Neck Road Dike. The bridge would not have any tidal control. Tidal control would be established at upstream locations with several smaller structures to regulate the limit of tidal flooding.
- **Hybrid of Modified Tide Gate Control at Chequessett Neck Road with Upstream Tide Gate Controls**—A combination of controlling tides near the mouth of the river and at upstream locations.

The HRRC then conducted a two-day alternatives development workshop in September 2009. At this workshop, the HRRC reviewed the results of the hydrodynamic modeling, reviewed and refined the Statement of Purpose and Need for Taking Action, and reviewed NEPA and the National Park Service (NPS) Director's Order 12 guidance for alternatives development. The HRRC examined possible locations within the estuary where actions might be needed to achieve tidal restoration.

Based on the hydrologic modeling available at that time, the HRRC evaluated how different openings at Chequessett Neck Road would affect water surface elevations and salinity levels upstream of the dike. The HRRC developed a draft matrix to evaluate the many combinations of actions that could be used to achieve the project objectives.

After the two-day workshop, the HRRC continued alternatives development at subsequent meetings through 2009 and 2010. The alternatives matrix was revised by the HRRC to include only the options that are feasible for implementation and that address the purpose and objectives of the restoration effort. The draft alternatives and tidal flow diagrams were then presented to the Technical Working Group (TWG) (an advisory group made up of representatives of key federal, state, and regional regulatory agencies) for review and comment in 2010.

In the summer of 2010, the HRRC conducted informal public outreach to present the draft alternatives to the public. The Friends of Herring River sponsored a public meeting to present three proposed action alternatives:

- A single point of tide control at Chequessett Neck Road
- Full tide flow at Chequessett Neck Road with upstream tide controls at Mill Creek and Pole Dike Creek
- Multiple points of tide control within the estuary

These distilled the action alternatives into two broad options for tidal restoration through most of the Herring River flood plain, with specific options for Mill Creek. This has resulted in the three alternative restoration scenarios described in section 2.3.

2.2.3 Alternatives Refinement for the EIS/EIR

After refinement of the 2010 draft alternatives, additional hydrodynamic modeling was conducted to develop an understanding of the range of tidal influences, salinities, and sediment transport that could be expected under the range of proposed options. Initial modeling results were used to establish the range of tidal influences that could be expected and a lower and upper point of restoration potential. These benchmarks identified the range of desired high tide conditions as lying between 4.8 feet (the lowest mean high spring tide elevation in the Lower Herring River which would fulfill the minimum project objectives) and 7.5 feet (the highest 100-year storm driven tide in the Lower Herring River possible with a 165-foot-wide culvert at Chequessett Neck). These modeled tidal elevations were used to develop the three action alternatives described in this chapter.

In June 2011, the HRRC conducted a three-day Value Analysis/Choosing by Advantages workshop to compare and rank the benefits, impacts, and costs of the action alternatives (Kirk Associates 2011). This is a structured, comparative process used by the NPS and other agencies to assess the relative advantages of project components. Factors such as water quality improvements, acres of salt marsh and fish habitat restored, and private property impacts were used to compare the alternatives for the Herring River restoration project.

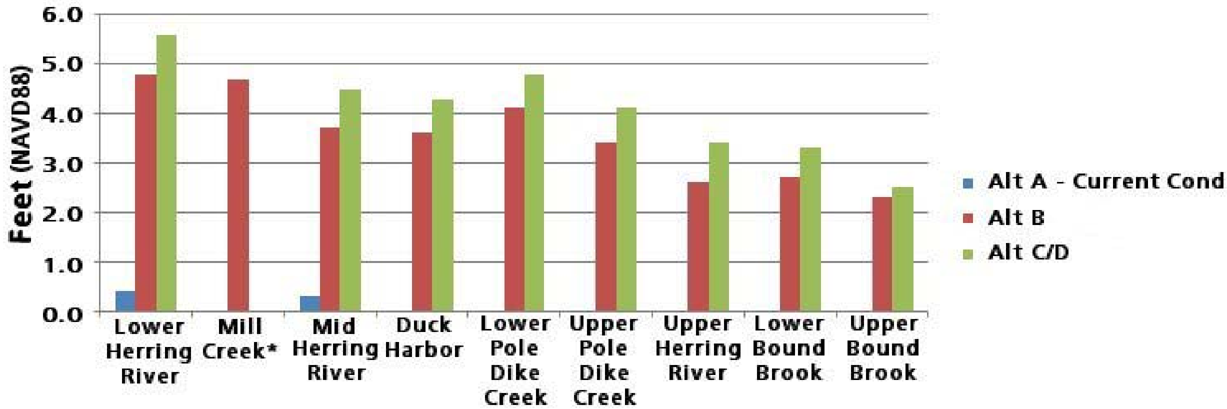
The Value Analysis/Choosing by Advantages process revealed that the greatest level of tidal restoration combined with the greatest level of low-lying property protection would be the most advantageous alternative for achieving the project objectives. The combination of these components is represented by alternative D (section 2.5.3), and is identified as the preferred alternative in this draft EIS/EIR.

Other alternatives or options for infrastructure components were determined not to meet the purpose and need, not to be feasible, or not to provide substantial variation in environmental impacts. These alternatives were dismissed from further consideration and the reasons for not considering them are described in detail at the end of this chapter (section 2.7).

2.3 OVERVIEW OF THE 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 end points 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.

Figure 2-1 provides a representative comparison of the anticipated tidal exchange levels for the different alternatives. Predicted water surface elevations during mean high spring tide are shown for the no action alternative (existing conditions) and for each of the action alternatives, as predicted by the hydrodynamic model. Implementation of any of the action alternatives does not necessarily imply that these exact water surface elevations would be achieved. Instead, they describe possible end points of incremental tidal restoration, while recognizing that, based on the results of adaptive management, the final degree of tidal exchange may lie somewhere between the bookend conditions identified in the action alternatives.



*Note: High tide in Mill Creek equivalent under alternative B and C; no tidal exchange in Mill Creek under alternative C.

FIGURE 2-1: MODELED MEAN HIGH SPRING TIDE ELEVATIONS OF THE HERRING RIVER RESTORATION ALTERNATIVES

2.3.1 OVERVIEW OF PROJECT COMPONENTS

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. Existing alterations and obstructions in the flood plain include more than 5 miles of roadway, an abandoned railroad embankment, several tidally restrictive culverts and berms, channelized stream reaches, and acres of invasive, non-native vegetation. There are multiple options for addressing each of these issues. Specifically, the major components and focus areas of the Herring River project are

- **Chequessett Neck Road Dike**—Reconstruction of the dike to allow greater tidal exchange is the primary element of the restoration project.
- **Mill Creek Sub-basin**—This is the sub-basin most affected by increased tidal influence, and has a number of private properties that could be subject to flooding without protective measures. The approach to flood protection in Mill Creek sub-basin is a primary distinction between the action alternatives.
- **Upper Pole Dike Creek Sub-basin**—Under certain restoration scenarios and tidal conditions, flood protection measures might be required in Upper Pole Dike Creek sub-basin.
- **High Toss Road**—The 5-foot diameter circular culvert at High Toss Road would need to be removed or enlarged to maximize tidal circulation upstream. The roadway itself would be impacted by restored tidal exchange and could either be elevated or removed to prevent this.
- **Pole Dike Creek, Old County, and Bound Brook Island Roads**—Culverts under these low-lying roads could need to be enlarged, if future monitoring shows the existing culverts are impeding tidal flows or altering other ecological processes. Road surfaces would need to be elevated or relocated to remain passable during high tides.

- **Management of Flood Plain Vegetation**—Measures would be considered to remove woody shrubs and trees that die during transition to a more saline and/or wetter environment.
- **Restoration of Tidal Channel Structure and Marsh Surface Elevation**—Measures would be taken to restore the natural configuration of tidal channels to maximize water circulation and promote elevation of subsided marsh surfaces.
- **Incremental Restoration and Adaptive Management**—Tidal restoration will be pursued gradually by opening a series of adjustable gates to slowly increase tidal range and salinity throughout the flood plain. An adaptive management plan, linking project objectives with monitoring data, will be used to guide tide gate management and other restoration actions, ensuring that informed decisions are made as the project is implemented.

2.4 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 (shown in figure 2-2), 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.

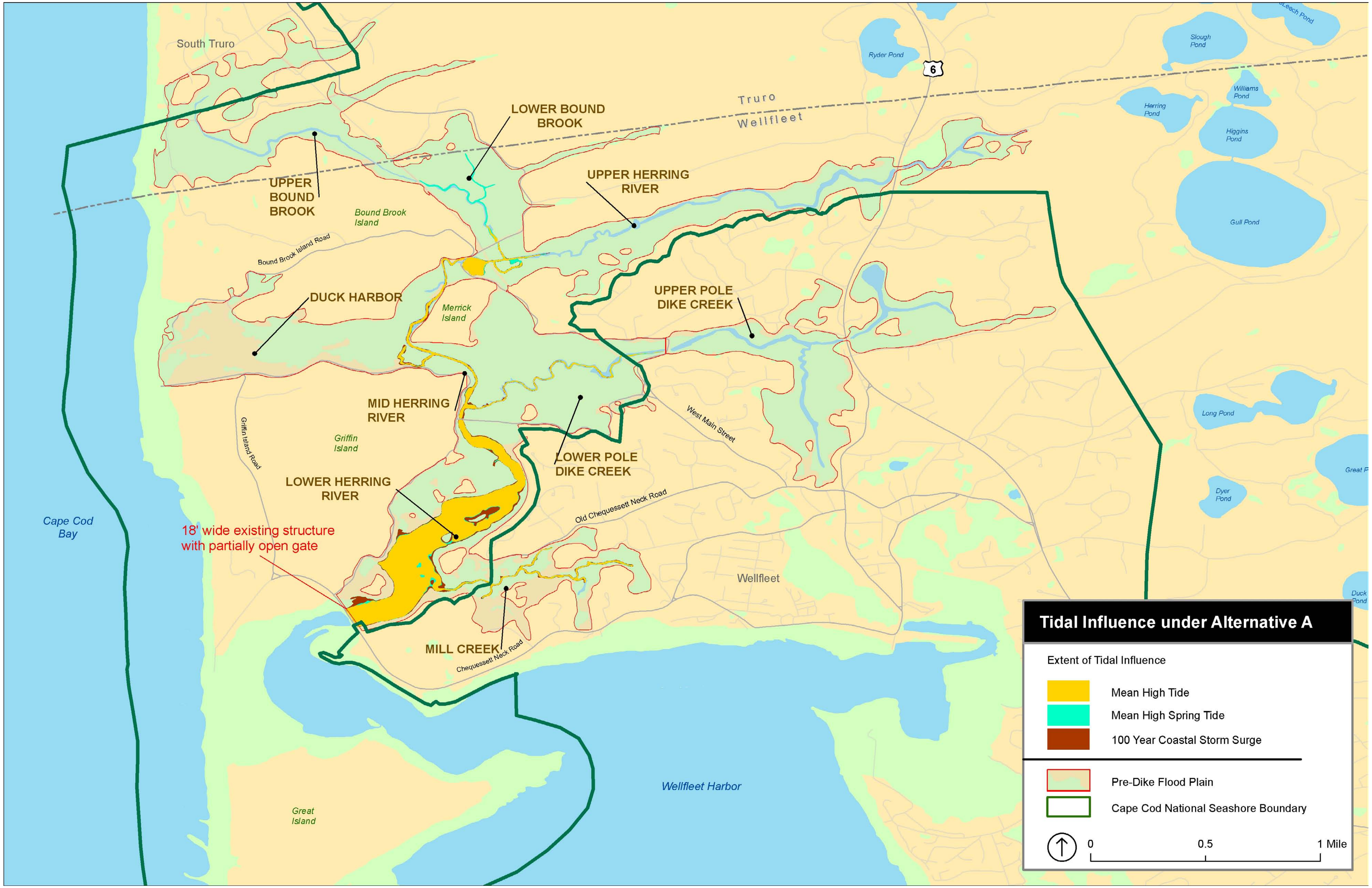


FIGURE 2-2: ALTERNATIVE A: NO ACTION – RETAIN EXISTING TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK

2.5 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." The following section contains a narrative description of the project elements unique to each action alternative.

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

Chequessett Neck Road Dike

Following the "bookend" concept described in section 2.3, 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—see section 2.6). 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 (figure 2-3). 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 (table 2-1). 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 Chequessett Yacht and Country Club (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.

TABLE 2-1: ACRES OF RESTORED HABITAT, ALTERNATIVE B

Sub-basin	Tidal Creeks	Intertidal Accretion Zone	Intertidal Marsh	Transitional Zone	Total Acres Restored
Lower Herring River	33.0	0.0	117.3	2.4	152.7
Mill Creek* (option 1)	5.5	0.0	59.0	2.5	67.0
Mill Creek* (option 2)	5.5	5.5	42.8	2.6	56.4
Middle Herring River	10.5	1.7	72.9	1.4	86.5
Duck Harbor	6.0	32.8	41.8	24.7	105.3
Lower Pole Dike Creek	7.8	26.8	69.6	0.9	105.1
Upper Pole Dike Creek	17.8	16.4	77.5	17.1	128.8
Upper Herring River	17.2	39.6	40.1	22.4	119.3
Lower Bound Brook	4.3	10.8	51.1	6.3	72.5
Upper Bound Brook	4.8	0.0	35.7	21.0	61.5
Total (Option 1)	**106.9**	**128.1**	**565.0**	**98.7**	**898.7**
Total (Option 2)	**106.9**	**133.6**	**548.8**	**98.8**	**881.1**

Tidal Creeks: Sub-tidal habitat below modeled extent of Mean Low Water

Intertidal Accretion Zone: Subsided former marsh below modeled extent of Mean Low Water, expect to transition into Intertidal Marsh

Intertidal Marsh: Areas between modeled high extent of Mean Low and Mean High Spring Tides, includes Mud Flats, Low Salt Marsh, High Salt Marsh, and Brackish Marsh

Transition Zone: Areas above modeled highest extent of Mean High Spring tides, includes Brackish, Freshwater Marsh, and Wetland-Upland Border

*Mill Creek: Option 1 (relocation) and Option 2 (elevation) for affected portions of CYCC

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 (table 2-1).

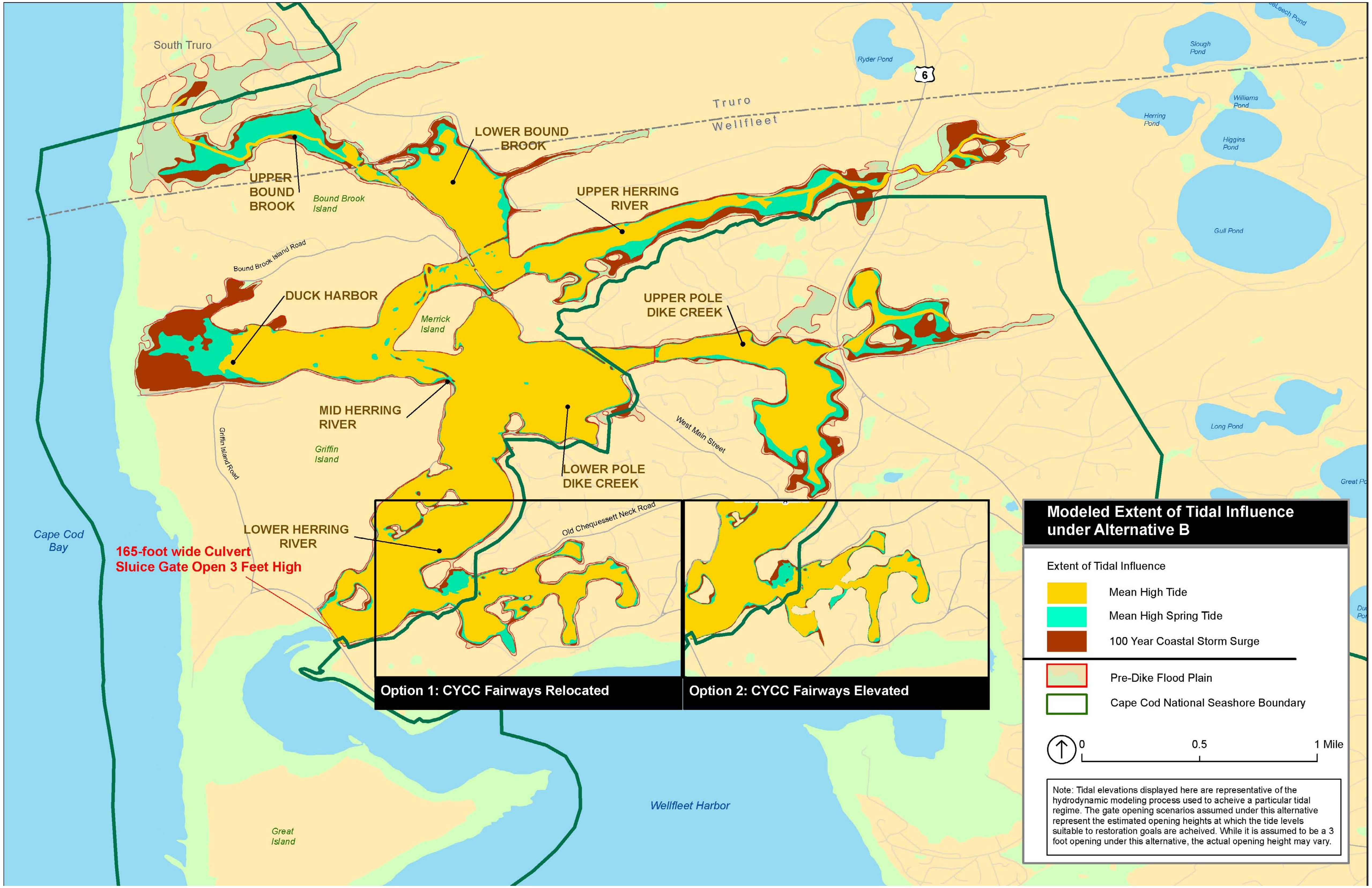


FIGURE 2-3: ALTERNATIVE B: NEW TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK – NO DIKE AT MILL CREEK

2.5.2 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 (figure 2-4). Following the "bookend" concept described in section 2.3, 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. Restored acreages from new tidal inundation are shown in table 2-2.

TABLE 2-2: ACRES OF RESTORED HABITAT, ALTERNATIVE C

Sub-basin	Tidal Creeks	Intertidal Accretion Zone	Intertidal Marsh	Transitional Zone	Total Acres Restored
Lower Herring River	33.0	0	130.0	2.4	165.4
Mill Creek	5.5	0	5.2	0.1	10.8
Middle Herring River	10.5	9.6	67.0	0.9	88.0
Duck Harbor	6.0	35.1	66.6	13.5	121.2
Lower Pole Dike Creek	7.8	42.7	55.2	0.9	106.6
Upper Pole Dike Creek	17.8	41.9	67.5	12.6	139.8
Upper Herring River	17.2	56.8	40.0	19.7	133.7
Lower Bound Brook	4.3	55.8	11.6	4.8	76.5
Upper Bound Brook	4.8	7.3	44.5	14.3	70.9
Total	**106.9**	**249.2**	**487.6**	**69.0**	**912.7**

Tidal Creeks: Sub-tidal habitat below modeled extent of Mean Low Water

Intertidal Accretion Zone: Subsided former marsh below modeled extent of Mean Low Water, expect to transition into Intertidal Marsh

Intertidal Marsh: Areas between modeled high extent of Mean Low and Mean High Spring Tides, includes Mud Flats, Low Salt Marsh, High Salt Marsh, and Brackish Marsh

Transition Zone: Areas above modeled highest extent of Mean High Spring tides, includes Brackish, Freshwater Marsh, and Wetland-Upland Border

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.

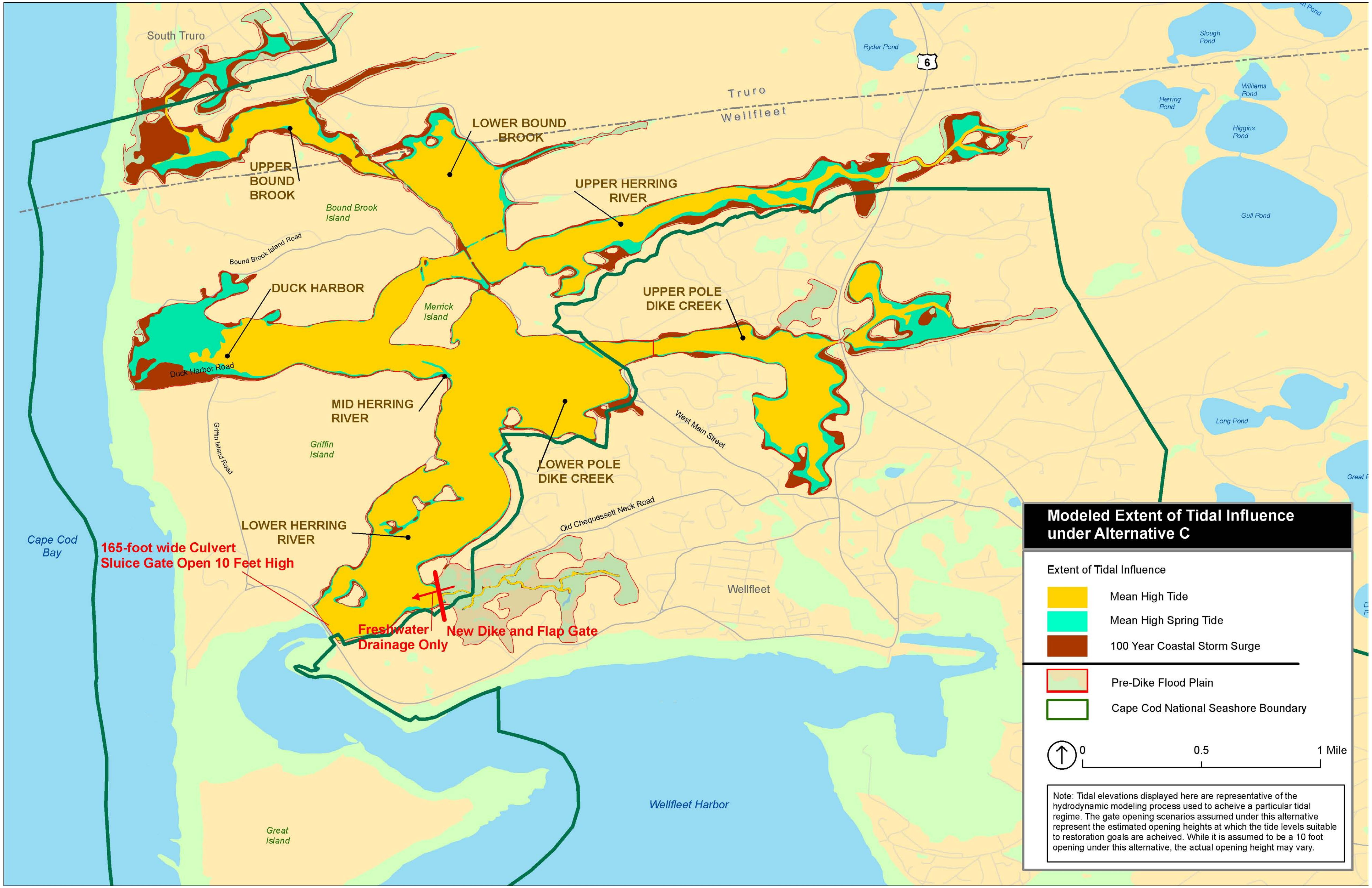


FIGURE 2-4: ALTERNATIVE C: NEW TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT EXCLUDES TIDAL FLOW

2.5.3 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 (figure 2-5). Following the "bookend" concept described in section 2.3, alternative D provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain (table 2-3). 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.

TABLE 2-3: ACRES OF RESTORED HABITAT, ALTERNATIVE D

Sub-basin	Tidal Creeks	Intertidal Accretion Zone	Intertidal Marsh	Transitional Zone	Total Acres Restored
Lower Herring River	33.0	0	130.0	2.4	165.4
Mill Creek* (option 1)	5.5	5.2	52.1	3.2	66.0
Mill Creek* (option 2)	5.5	5.6	44.2	2.4	57.7
Middle Herring River	10.5	9.6	67.0	0.9	88
Duck Harbor	6.0	35.1	66.6	13.5	121.2
Lower Pole Dike Creek	7.8	42.7	55.2	0.9	106.6
Upper Pole Dike Creek	17.8	41.9	67.5	12.6	139.8
Upper Herring River	17.2	53.0	40.0	19.7	129.9
Lower Bound Brook	4.3	55.8	11.6	4.8	76.5
Upper Bound Brook	4.8	7.3	44.5	14.3	70.9
Total (Option 1)	**106.9**	**250.6**	**534.5**	**72.3**	**964.3**
Total (Option 2)	**106.9**	**251.0**	**526.6**	**71.5**	**956.0**

Tidal Creeks: Sub-tidal habitat below modeled extent of Mean Low Water

Intertidal Accretion Zone: Subsided former marsh below modeled extent of Mean Low Water, expect to transition into Intertidal Marsh

Intertidal Marsh: Areas between modeled high extent of Mean Low and Mean High Spring Tides, includes Mud Flats, Low Salt Marsh, High Salt Marsh, and Brackish Marsh

Transition Zone: Areas above modeled highest extent of Mean High Spring tides, includes Brackish, Freshwater Marsh, and Wetland-Upland Border

*Mill Creek: Option 1 (relocation) and Option 2 (elevation) for affected portions of CYCC

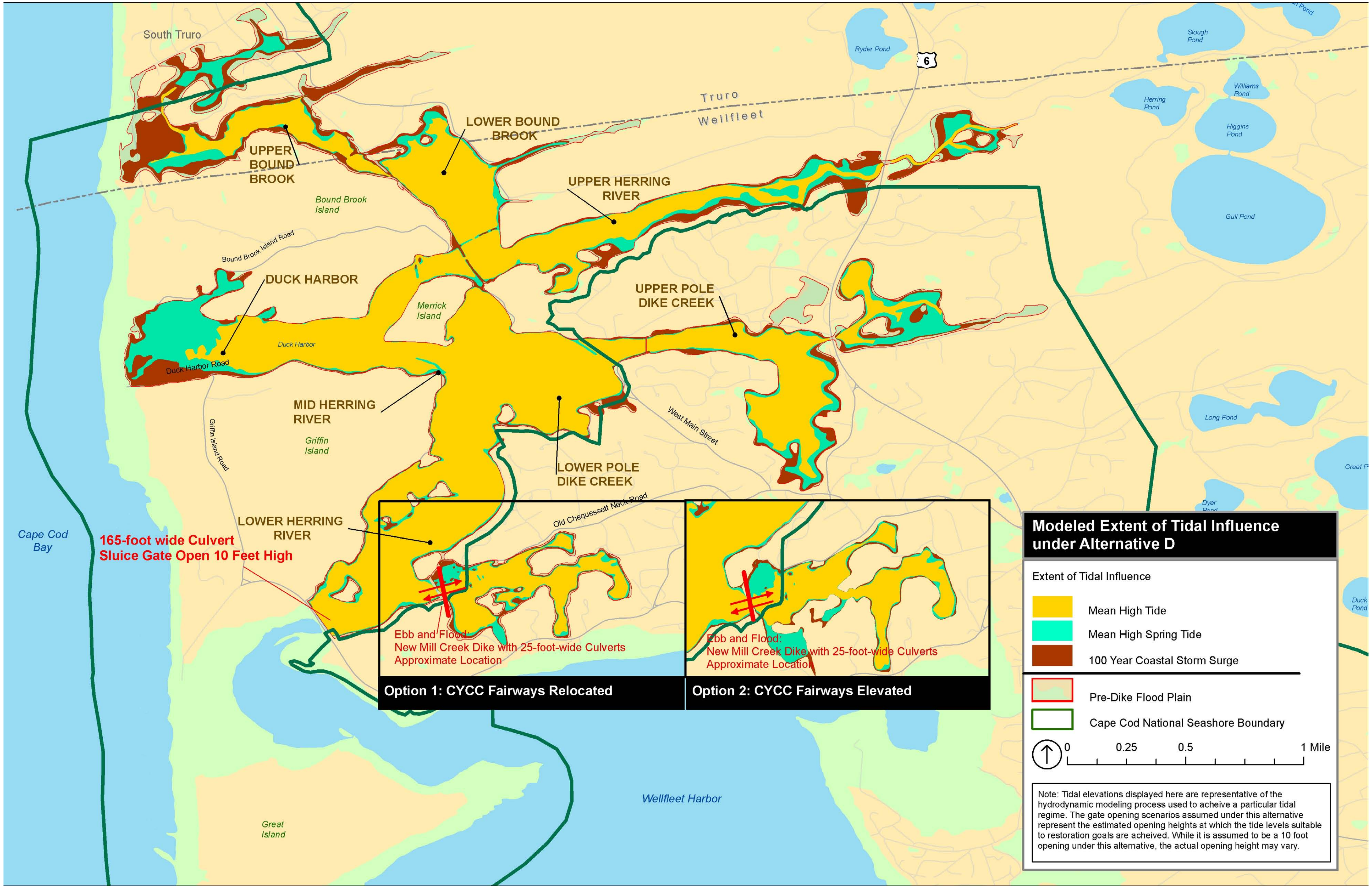


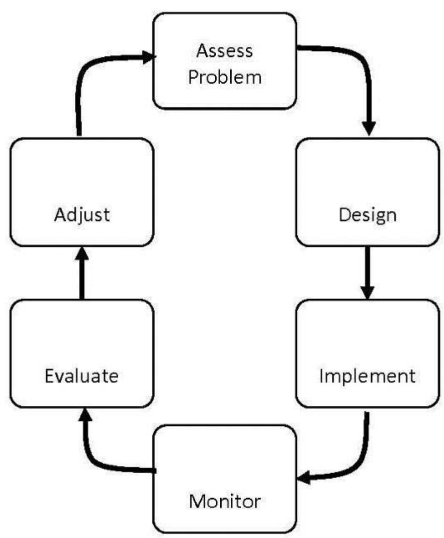
FIGURE 2-5: ALTERNATIVE D: NEW TIDAL CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT PARTIALLY RESTORES TIDAL FLOW

2.6 ELEMENTS COMMON TO ALL ACTION ALTERNATIVES

2.6.1 INCREMENTAL TIDAL RESTORATION AND ADAPTIVE MANAGEMENT

Since the early planning stages of the Herring River Restoration Project, 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 (DOI 2009) (figure 2-6). 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.”



Source: Williams et al. 2007

FIGURE 2-6: GENERAL ADAPTIVE MANAGEMENT PROCESS DIAGRAM

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.

2.6.2 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 three 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.

2.6.3 LOW-LYING ROAD CROSSINGS AND CULVERTS

High Toss Road

High Toss Road Culvert

The Herring River passes under High Toss Road, the second road that crosses the river, approximately one mile upstream from Chequessett Neck Road. The road is an earthen berm that was built across the salt marsh in the 19th century. The road is unpaved and infrequently traveled by vehicles, but can accommodate emergency vehicle access to Griffin Island. The river passes under the road at the western end through a 5-foot-diameter concrete culvert. Hydrodynamic modeling has shown that the culvert would cause a major restriction if tidal flow were increased at Chequessett Neck Road. The road would be overtopped daily by seawater under any restoration scenario and ebb tide drainage would be impeded by the causeway.

Complete removal of the tidal restriction at High Toss Road is a major component of the project under all action alternatives. Increased tidal exchange from a rebuilt Chequessett Neck Road Dike could be accommodated at High Toss Road by replacing the existing 5-foot-diameter concrete culvert with either a properly designed box culvert or an open channel. An open channel could include a small bridge spanning the river if pedestrian and/or vehicle access were continued. In either case, a tidal channel approximately 30 feet wide would be needed for adequate tidal water conveyance.

Further hydrodynamic modeling and analysis would be conducted to more precisely size this culvert or open channel. Direct and indirect impacts would be the same under each action alternative.

High Toss Road Flooding

Under all of the action alternatives, High Toss Road would be flooded at high tides greater than approximately 3 feet. Although replacement of the culvert, as described previously, is the only action necessary to allow unrestricted tidal exchange through the causeway, additional measures would be needed to address impacts to the road and causeway from increased tides in the Herring River. Options are

> **Elevate**—If full-time vehicle access to High Toss Road is deemed necessary the road surface must be elevated to prevent overtopping from increased Herring River tides. In addition, because the embankment would be subject to more frequent and higher water velocities and storm surges, stabilization of the side slopes would be needed to minimize erosion and undermining. Depending on the elevation of the final road surface, widening of the base might also be necessary, which would impact approximately 13,000 square feet of adjacent wetlands. In addition, if the High Toss Road culvert is replaced by an open channel, a bridge designed for suitable vehicle loading would be required.
>
> **Abandon and Remove**—Contingent on further public comment and consultation between the Town of Wellfleet and Cape Cod National Seashore (the Seashore), the length of road from Rainbow Lane to the parking area at Duck Harbor Road (approximately 1,000 feet) could be decommissioned and the causeway removed to the elevation of the surrounding wetland. If continued pedestrian and bicycle access is desired, a boardwalk could be constructed across the flood plain and river.

Periodic Closure

High Toss Road could remain at its current elevation with the understanding that low portions of the road would be impassable during at least some high tide periods. However, even if the elevation remained unchanged, the embankment side slopes would need to be stabilized as they would be subject to increased flow and velocity. In addition, if the High Toss Road culvert is replaced by an open channel, a bridge designed for suitable vehicle loading would be required.

High Toss Road as Temporary Bypass

Preliminary engineering analysis presented in the CRP demonstrated that complete closure of Chequessett Neck Road would substantially reduce construction time and costs for rebuilding the dike. If this becomes part of the proposed project, High Toss Road and Duck Harbor Road would need to be used as a detour during dike reconstruction. In this case, these two roads would require temporary improvements (surface grading, vegetation clearing) to accommodate traffic, including public safety vehicles. Town officials have also expressed a desire for a new water storage tank on the northern side of the Chequessett Neck Road Dike for enhanced fire protection on Griffin Island while the road is closed.

Pole Dike, Bound Brook, and Old County Roads

Recent survey data (ENSR 2007a) show that several segments of Pole Dike, Bound Brook Island, and Old County Roads, where they cross the main Herring River and tributary streams, are below 4 feet, making the roads vulnerable to high tide flooding under all action alternatives. To prevent this, the road surfaces would need to be elevated or relocated. Preliminary engineering analysis shows that approximately 4,175 linear feet of these roads could be affected by the highest tide of any given year. An additional 2,000 feet would be impacted by a 100-year storm surge. To prevent this and maintain safe travel along these roads they should be elevated to a minimum grade of 5.5 feet, 1 to 3 feet above the current grade, to prevent overtopping from storm driven tides in the Herring River (CLE 2011). Elevating these roads would also require widening the road bases, which would impact over 6,000 square feet of adjacent wetlands. 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 potentially less wetland impacts and lower costs. Additional engineering studies and traffic analyses are needed to fully evaluate both of these options (CLE 2011).

These low-lying road segments also include three culverts on the mainstem of the Herring River, Pole Dike Creek, and Bound Brook. Hydrodynamic modeling indicates that leaving the culverts in their existing condition would result in little, if any, tidal restriction after tides are restored at Chequessett Neck and High Toss Road. Leaving them in place would result in almost identical circulation of tidal water in upstream portions of the flood plain than if they were replaced with larger culverts. However, to confirm these projections, water levels and tidal flow would be measured when restored tides begin to affect these locations. Culverts would need to be replaced if this monitoring demonstrates that enlarging the hydraulic capacity is necessary to improve tidal circulation. Replacement, and potential enlargement, of culverts would also be considered during additional design phases for road surface elevation and regrading, as described previously.

2.6.4 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.

2.6.5 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."

2.6.6 PUBLIC ACCESS AND RECREATION OPPORTUNITIES

As described in "Chapter 1: Purpose and Need," 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.

2.7 ALTERNATIVES OR ALTERNATIVE ELEMENTS CONSIDERED BUT DISMISSED FROM CONSIDERATION

2.7.1 REPLACE DIKE WITH BRIDGE AND FULLY RESTORE THE ENTIRE ESTUARY (NO CONTROL STRUCTURES)

Comments received through public scoping meetings held over the summer of 2008 reflected interest in replacing the Chequessett Neck Road Dike with a bridge to facilitate canoe and kayak passage, improve access for anadromous fish, and aesthetics. The hydrodynamic model was used to simulate the effect of completely removing the road crossing at Chequessett Neck. A fully open connection between the Herring River and Wellfleet Harbor would be as close to the original, pre-dike condition as could be achieved today, allowing maximal tidal circulation and sediment flux. However, because of the need for tidal control at least through the foreseeable adaptive management timeframe, and possibly much longer, construction of a bridge at Chequessett Neck Road was not considered practicable and was dismissed from further consideration. However, accommodations for fish passage, recreational boating, and aesthetics will be considered in design plans for the new dike.

2.7.2 FULLY OPEN THE EXISTING TIDE GATES

Earlier modeling studies (Roman 1987; Spaulding and Grilli 2001) evaluated the option of completely opening the existing three culverts in the Chequessett Neck Road Dike. The modeling showed that although this would result in a substantial increase in high tide heights and area of inundation upstream of the dike, the ebb tide drainage capacity of the dike would not increase, thereby increasing low tide heights. Opening the existing structure would actually decrease both the tidal range and flushing, while increasing the likelihood of harmful flooding. Because this outcome does not meet the project purpose and objectives, it has been dismissed from further consideration.

2.7.3 REBUILD THE DIKE WITH A TIDAL OPENING LESS THAN 165 FEET

Consideration has been given to the idea of deliberately undersizing a new Chequessett Neck Road Dike to diminish the range of Wellfleet Harbor tides allowed to pass into the Herring River. The underlying concept for this is that a passive tide control system could be designed that would allow normal monthly spring tides to propagate upstream but would also filter out higher tides caused by periodic astronomical events, coastal storm surges, and the impacts of sea level rise.

While this approach is technically feasible and has been successfully used at other tidal restoration projects, applying it at the Herring River could impose unnecessary constraints on the ability to manage tidal flows and sediment processes in keeping with the project's long-term goals and objectives. Changes to tidal hydrology resulting from sea level rise and other factors are uncertain and it is impossible to predict changes in land use within the Herring River estuary.

Additional modeling studies prepared for this project (Spaulding and Grilli 2005; WHG 2012) simulated new tidal inlets within the dike ranging from 30 to 300 feet wide. Results show that inlet widths less than 100 feet could improve the overall tidal range with higher high tides and lower lows, but the extent of salt water inundation of the flood plain remains muted. Although this could reduce the need for mitigation of adverse impacts in some locations, it precludes the minimally acceptable tidal exchange necessary to meet the project's restoration objectives. Therefore, this option was dismissed from further consideration.

2.7.4 Tidal Power Generation at the New Chequessett Neck Road Dike

During public scoping meetings in August and September 2008 several commenters advocated for inclusion of tidal power generation within a newly reconstructed Chequessett Neck Road Dike. These comments were also included in the MEPA certificate issued by the Massachusetts Executive Office of Energy and the Environment on November 7, 2008. This element would present a hazard to the key diadromous fish species targeted to benefit from the project and therefore is in direct conflict with the project objectives.

In addition, application of a basic equation for calculating potential kinetic energy from open flow channels (WHG 2009) to the Herring River shows that the relatively low flow volume and head differential at a new Chequessett Neck dike would be far too small to produce electricity at a scale that would justify the costs, complications, and increased environmental impact of a tidal power turbine. Therefore, this option was dismissed from further consideration.

2.7.5 Unrestricted Tide Flow at Chequessett Neck

The HRRC has considered a long-term outcome that would remove tidal control from the Chequessett Neck Road Dike and allow full, unrestricted tidal exchange between the river and Wellfleet Harbor. This alternative provides many ecological benefits, such as increased sediment deposition on the restored upstream tidal marsh during storm events, and has long-term operational advantages because after a period of incremental adjustments tide gates would no longer be needed and could be removed. Removal of tide gates would also ensure that the Herring River continues to flow freely into the foreseeable future since the mechanism for restricting tides would be eliminated. However, given the uncertainty about the impacts of tidal restoration and sea level rise and the relatively long period during which the incremental restoration and adaptive management process would occur, it was determined that a decision to allow removal of any tidal control structures could be considered in the future, but was beyond the planning horizon of this EIS/EIR.

2.8 CONSTRUCTION METHODS, TIMEFRAME, AND RESOURCE PROTECTION MEASURES

Standard construction methods and equipment would be used to construct the infrastructure needed to implement the action alternatives. Earth-moving equipment, graders, cranes, dump trucks, cement trucks, and other equipment would be operated and staged in the project area. Fill, armor stones, and other construction materials would also be staged in preparation for use. To the extent possible, previously disturbed areas would be used to stage equipment and materials. For dike construction, the sites would be de-watered using coffer dams and pumps, or other common methods for dike construction.

Preliminary engineering guidance suggests construction of the new dike at Chequessett Neck Road Dike would be expected to take approximately 12-18 months to complete. Elevation or changes to low-lying roads would take approximately 6-12 months to complete. At Mill Creek, the new dike (under alternatives C and D) would take approximately 6-12 months. It is likely that individual construction elements would be phased in over time and would not occur concurrently. Elevation construction of some of the roads that are in the more upstream reaches of the flood plain could be delayed or phased with the later incremental dike openings. All low-lying roads do not need to be elevated at the start of the incremental tidal restoration.

2.9 HOW ALTERNATIVES MEET OBJECTIVES

As stated in the "Chapter 1: Purpose and Need," all action alternatives selected for analysis must meet all objectives to a large degree. The action alternatives must also 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 and EIS/EIR (refer to "Chapter 1: Purpose and Need"). Alternatives that did not meet the objectives were not analyzed further (see section 2.7).

Table 2-4 compares how each of the alternatives described in this chapter would meet project objectives.

TABLE 2-4: COMPARISON OF HOW THE ALTERNATIVES MEET PROJECT OBJECTIVES

Objective	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Restoration Alternatives: B, C, and D
To the extent practicable, given adjacent infrastructure and other social constraints, re-establish the pre-dike tidal range, salinity distribution, and sedimentation patterns of the 1,100-acre estuary.	Alternative A would not meet this objective because restoration would not be undertaken. The Chequessett Neck Road Dike would continue to limit tidal influence in the estuary. Seawater would not reach areas upstream of High Toss Road. The Herring River flood plain would remain largely a freshwater system isolated from marine waters and lack of sediment availability would allow land subsidence to continue. The lowest reaches of the Lower Herring River would continue to receive some influence from tidally driven seawater.	The restoration alternatives would largely meet this objective by re-establishing the hydrologic connection between Wellfleet Harbor and the Herring River. Construction of a new Chequessett Neck Road Dike would allow long-term management of mean high spring tidal inundation levels to between 4.8 and 5.6 feet in the Lower Herring River. Tidal marsh restoration would occur over approximately 800 to 900 acres. A range of salinity concentrations – seawater to brackish to freshwater – would occur throughout the restoration area. Of the action alternatives, alternative D would best meet this objective by reintroducing tidal exchange and restoration processes to the greatest area.
Improve estuarine water quality for resident and migratory animals including fish, shellfish, and waterbirds.	Alternative A would only minimally meet this objective because limited tidal flushing and long residence times would contribute to poor water quality in the project area. The Herring River is currently listed on the Massachusetts 303(d) list for impaired water quality. Oxygen depletion, fish kills, high metals concentration, and fecal coliform contamination have all been issues in the Herring River flood plain, and this condition would continue. However, existing shellfishing activities would continue.	Under all restoration alternatives, water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to between 800 and 900 acres, and residence times would be reduced by a factor of 25. Regular tidal flushing would reduce nutrient concentration and bacteria counts, while changes in soil chemistry - from freshwater to saline – would eliminate metals contamination. Of the action alternatives, alternative D would best meet this objective by providing the greatest quantity of tidal exchange and water quality improvements.

Objective	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Restoration Alternatives: B, C, and D
Protect and enhance harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Bay.	Alternative A would not meet this objective because the Herring River estuary would remain degraded with diminished abundance and diversity of shellfish species. Fecal coliform contamination would persist, as would the 90-acre shellfish harvest closure.	Under all action alternatives, increased salinity and improved water quality would provide substantially more habitat for locally important shellfish species within the Herring River estuary. As populations increase, juveniles may spread to and establish in Wellfleet Harbor. Of the action alternatives, alternative D would be expected to best meet this objective by providing the greatest quantity of tidal exchange and potential for increased populations and migration of shellfish.
Restore the connection with the 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.	Alternative A would not meet this objective because Herring River estuarine system would remain degraded with restricted access for and low abundance of locally important fish and shellfish species. The Chequessett Neck Road Dike would remain a hindrance to migratory fish passage, suitable habitat for juvenile fishes would be limited, and sediment and nutrients would remain trapped behind the dike.	Under all action alternatives, restored estuarine waters and formation of new tidal channels would provide substantially more habitat and access to upstream spawning and nursery habitats for both resident and transient fish species and shellfish, increasing their abundance. Although the new Chequessett Neck Road Dike would still present an impediment to sediment transport, nutrients and fine particles would move with the tides, both upstream into the sub-basins and downstream into Wellfleet Harbor. Of the action alternatives, alternative D would best meet this objective by providing the greatest quantity habitat and quantity of tidal exchange.
Remove physical impediments to migratory fish passage to restore once-abundant river herring and eel runs.	Alternative A would not meet this objective because Herring River estuarine system would remain degraded with restricted access for and low abundance of locally important anadromous and catadromous species. The Chequessett Neck Road Dike would remain a hindrance to migratory fish passage.	Under all action alternatives, restored estuarine waters and formation of new tidal channels would provide substantially more habitat and access to upstream spawning and nursery habitats for locally important anadromous and catadromous species, increasing their abundance. All restoration alternatives would include a new Chequessett Neck Road Dike that would provide adequate passage for herring and eels.
Re-establish native estuarine vegetative cover in place of the invasive non-native plants, freshwater wetland plants, and upland plants that have colonized most parts of the degraded flood plain.	Alternative A would not meet this objective because degraded freshwater wetland conditions would persist in over 1,000 acres of former salt marsh habitats due to tidal restriction. *Phragmites* and other non-native vegetation would persist and have the opportunity to spread in the project area.	Under all action alternatives, over the long term, extensive restoration of salt marsh vegetative communities would occur. Approximately 800 to 900 acres would be regularly inundated at a frequency to support growth of native, salt-tolerant wetland plants. However, conditions in upstream reaches of sub-basins would likely support transitional habitats and a border of persistent freshwater species. Of the restoration alternatives, alternative D would best meet this objective by providing the greatest acreage of vegetation change.

Objective	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Restoration Alternatives: B, C, and D
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.	Alternative A would not meet this objective because tidal flows would continue to be restricted, 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. Normal tides would continue to mobilize sediment over approximately 56 acres.	Under all restoration alternatives, the larger tide gate opening would support accretion of sediment on the marsh over decades. 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. Normal tides would mobilize sediment on between 144 and 156 acres, most of which would be deposited in upstream reaches. Of the action alternatives, C and D would best meet this objective by providing the greatest area of sediment mobilization.
Re-establish the natural control of nuisance mosquitoes by restoring tidal range and flushing, water quality, and predatory fish access.	Alternative A would not meet this objective because the absence of tidal flushing and predatory fish would persist. The Herring River would remain a productive mosquito habitat, particularly between High Toss Road and Route 6. The dominant mosquito species is *Ochlerotatus cantator.*	Under all restoration alternatives, 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. Of the action alternatives, alternative D would best meet this objective because 890 acres would be subject to saltwater influence.
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.	Alternative A would only minimally meet this objective because the 100-year old Chequessett Neck Road Dike would remain in place, with further degradation of the historic tidal marsh, absence of historically important aquatic species, and limited access for fishing and other recreational activities. Existing salt marsh areas in Lower Herring River would remain. However, there would be no impacts to cultural resources or archeological resources because existing conditions would be maintained.	Under all action alternatives, this objective would be partially met because tidal salt marsh would be restored, fish and shellfish populations would increase, and the open habitat type of the salt marsh would support greater access for fishing and recreation. However, there would be a potential for adverse effects to archeological resources in the area of potential effect (APE) from construction or other ground-disturbance. Higher tides would not affect archeological resources because inundation would be gradual. Erosion from increased tidal flows could affect transportation corridors across river channels, but these impacts would be mitigated by culvert replacement and other measures. Upland alteration to protect the CYCC golf course from flooding could result in disturbance of 5 to 30 acres of potentially sensitive cultural resources.

Objective	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Restoration Alternatives: B, C, and D
Minimize adverse impacts to surrounding land uses, such as domestic residences, low-lying roads, wells, septic systems, and private property, including the CYCC.	Alternative A would best meet this objective because tidal inundation levels and flood risk to adjacent landowners would not change. Properties in the project area would continue to be protected from inundation by the Chequessett Neck Road Dike. Individual properties may need to obtain flood insurance if the Chequessett Neck Road Dike is not upgraded to comply with FEMA design guidelines.	The restoration alternatives would meet this objective because of improved water management and control at the Chequessett Neck Road Dike and because affected properties would receive site-specific flood proofing measures. Under alternatives B and D, flood protection and drainage on the CYCC golf course would be improved by filling and elevating 8.3 acres of wetland or relocating vulnerable portions of the course. Between 7,400 and 9,400 feet of low-lying paved roadways would be improved and elevated above the flood plain. Of the action alternatives, alternative C would result in fewer impacts and flood mitigation requirements to surrounding land uses.
Provide a highly visible example of the values of estuarine habitat restoration and a rich and long-term opportunity to educate the public about the dependency of productive salt marshes on unaltered tidal exchange.	Alternative A would not meet this objective because restoration of the Herring River would not be undertaken.	The action alternatives would meet this objective by restoring tidal exchange over most of the historic marsh plain.
Restore the aesthetic appeal and accessibility of the open herbaceous marsh in place of existing scrub/shrub invasive species.	Alternative A would only minimally meet this objective because the current vegetative cover of forest and shrubs would persist over much of the Herring River flood plain. However, the aesthetic qualities of the existing marshes and woodlands would remain.	Over the long term, the restoration alternatives would result in improved aesthetic appeal by eliminating woody species, and opening the vista of the marsh plain. Intertidal habitats would vary by basin, but would be mostly open water, broad meadows, and salt water marshes. Wooded areas within the flood plain would decrease, reducing obstructions to viewscapes. Of the action alternatives, alternative D would best meet this objective because up to 890 acres would be returned to native habitat.
Improve finfishing and shellfishing opportunities.	Alternative A would only minimally meet this objective because recreational and commercial shellfish harvest would remain permanently closed over 90-acres immediately downstream of the Chequessett Neck Road Dike due to fecal coliform contamination. The finfish population in the Herring River would remain depauperate. However, current shellfishing and finfishing opportunities would continue.	The action alternatives would meet this objective because shellfish and finfish populations are expected to increase as habitat and water quality improve. Decreased fecal coliform levels would allow the closed area downstream of the Chequessett Neck Road Dike to be reopened to shellfish harvest; other areas of Wellfleet Harbor that are only conditionally opened could be opened year-round. Of the action alternatives, alternative D would best meet this objective by restoring the largest area and providing the greatest tidal exchange.

Objective	Alternative A: No Action – Retain Existing Tidal Control Structure at Chequessett Neck	Restoration Alternatives: B, C, and D
Enhance opportunities for canoeing, kayaking, and wildlife viewing over a diversity of restored wetland and open-water habitats.	Alternative A would only minimally meet this objective because public access points would remain unaffected and the physical character of the estuary would be unchanged. However, current recreational canoeing, kayaking, and wildlife viewing opportunities would continue.	The action alternatives would meet this objective because 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. The more open character of the estuary would support improved access and abilities to view native wildlife. Of the action alternatives, alternative D would best meet this objective by restoring the largest area of open-water habitats.

2.10 CONSISTENCY WITH THE PURPOSES OF NEPA

As required under CEQ regulations 40 CFR 1502.2(d), NEPA documents must include a section stating how each alternative analyzed in detail would or would not achieve the requirements of NEPA sections 101(b) and 102(1) of NEPA and other environmental laws and policies. In the Park Service, this requirement is met by (1) disclosing how each alternative, one of which is identified as the environmentally preferable, meets the criteria set forth in section 101(b) of NEPA; and (2) any inconsistencies between the alternatives analyzed in detail and other environmental laws and policies.

1. *Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.*

   Alternative A would not restore environmental conditions in the estuary, which is degraded due to diking, draining, and tidal restriction. This degraded environmental condition is expressed in the form of reduced salinity penetration, degraded water and sediment quality, closed shellfish beds, reduced distribution of salt marsh vegetation, obstructed fish migration, and lost habitat for diverse estuarine species. While current environmental laws provide some protection from additional environmental harm, without restoration future generations would inherit a substantially degraded estuarine environment. Alternative A, therefore, does not achieve criterion 1 to any great degree. Under each action alternative, environmental conditions would be substantially restored once the adaptive management process is complete. The majority of the Herring River flood plain would become tidally influenced, which would reverse the impacts of diking and draining. Penetration of saline water into the estuary would approximate pre-dike conditions. Increased flushing would improve water and sediment quality, allowing for the reopening of some shellfish beds in Wellfleet Harbor. The distribution of salt marsh vegetation would resemble pre-dike conditions, and substantial habitat for estuarine species would be restored. Future generations would inherit a substantially restored estuarine environment. Each of the action alternatives, therefore, achieve criterion 1 to a large degree, with alternative D achieving the most because the extent of tidal restoration is greatest.

2. *Ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.*

   Alternative A would retain the estuary's current scenic condition, which is shaped by upland and freshwater marsh vegetation, and which does provide a small measure of esthetic and cultural value. However, in most regards alternative A does not achieve criterion 2 due to poor water and sediment quality, degraded habitats, and closure of some shellfish beds. For all action alternatives, improved water quality, sediment quality, and salinity penetration would make the estuary more productive in terms of salt marsh vegetation; these improved habitat conditions would increase productivity for estuarine fish and shellfish species. Esthetic conditions would be improved for many residents and visitors as wooded areas give way to open views of the estuary. Potentially reduced mosquito hatches could also improve the estuary in an esthetic sense. The reopening of shellfish beds and increased shellfish productivity would enhance the role of the estuary for that culturally important aspect of the local economy. Each of the action alternatives, therefore, achieves criterion 2 to a large degree, with alternative D achieving criterion 2 the most because it would provide the greatest extent of restoration.

3. *Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.*

   While alternative A provides for a range of beneficial uses of the Herring River estuary, it does so by perpetuating degraded conditions that are themselves the unintended consequences of past diking, draining, and tidal restriction in the estuary and thus, does not achieve the goal of criterion 3. Each of the action alternatives would improve the condition and function of the estuary such that a wide range of sustainable, beneficial uses could be enjoyed over the long term without environmental degradation. These beneficial uses include recreational and commercial shellfishing, recreational finfishing, boating, and wildlife viewing. While the action alternatives would also result in increased flood risk for some private properties and low-lying road segments, beneficial use by residents is not precluded. The action alternatives would, therefore, achieve criterion 3 to a large degree. Of the action alternatives, alternative D would achieve criterion 3 the most because it would have the largest area of restoration over the long term and therefore provide the greatest benefit in terms of potential sustainable uses.

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 achieves criterion 4 to a small degree because it would not disturb cultural or historic resources; however, degraded environmental conditions would be perpetuated. Each of the action alternatives would restore tidal exchange and estuarine processes while mitigating impacts to cultural and historic resources that could result from higher tide levels, and therefore, achieve the goals of criterion 4 to a much larger degree, with alternative D achieving the most because it would provide the largest area of restoration over the long term.

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 does not achieve criterion 5 to any great degree because the current degraded condition of the Herring River estuary provides fewer amenities and contributes less to the standard of living of local residents than the estuary provided prior to diking, and less than it would provide after restoration. Each of the action alternatives would improve water quality and wetland function, increase aquatic life, reduce nuisance mosquitos, improve commercial and recreational shellfishing, improve landscape esthetics, and enhance recreation opportunities. The potential for tidal or storm surge waters to reach abutting properties would increase, but the NPS and HRRC are working with potentially affected property owners to develop site-specific flood mitigation measures for their property and structures. The action alternatives, therefore, achieve criterion 5 to a large degree because they would provide a broad range of amenities for the residents and visitors, and permit standard of living for the resident population.

6. *Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.*

   Alternative A partially achieves the goal of criterion 6 because it would not involve construction and, thus, would not use depletable resources; however, the existing degraded environmental conditions do not enhance the quality and quantity of locally important renewable resources such as shellfish and finfish. Each of the action alternatives would improve water quality and habitats for renewable shellfish and finfish resources. Construction of a new Chequessett Neck Road Dike (under all action alternatives), a new dike at Mill Creek (under alternatives C and D), changes to low-lying roads, and site specific flood mitigation measures would all consume depletable resources as part of the construction processes, but mitigation measures, including recycling, would reduce this depletable resource use to the maximum extent practicable. The action alternatives, therefore, achieve criterion 6 to a large degree.

2.11 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 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 (Q6a) 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."

Alternative D was identified as the environmentally preferable alternative because tidal restoration would be maximized. Construction could result in temporary adverse impacts, but in the long-term alternative D would substantially improve the biological and physical environment. Compared with the other action alternatives, a larger portion of the flood plain would be subjected to tidal influence, increasing salinity penetration, improving water and sediment quality, increasing the distribution of salt marsh vegetation, eliminating obstacles to fish migration, and providing habitat for diverse estuarine species. Although there could be some low-lying areas impacted by periodic flooding, these impacts can be effectively mitigated on a site-specific basis. Therefore, alternative D is considered to best protect, preserve, and enhance historic, cultural, and natural resources.

2.12 NPS AND HRRC PREFERRED ALTERNATIVE

To identify the preferred alternative, each alternative was evaluated based on its ability to meet the plan objectives (see 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.

2.13 SUMMARY AND IMPACTS OF THE ALTERNATIVES

The full range of impacts anticipated to result from implementation of the proposed alternatives is detailed in “Chapter 4: Environmental Consequences” of the EIS/EIR. A brief summary of these impacts is included in table 2-5.

TABLE 2-5: 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
	Water-Willow Stem-Borer 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.	Water-Willow Stem-Borer 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.	Water-Willow Stem-Borer 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.	Water-Willow Stem-Borer Impacts are the same as alternative C.
Terrestrial Wildlife	Birds 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.	Birds 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.	Birds 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.	Birds 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.
	Mammals Mammals would remain widespread throughout the 1000+ acre project area.	Mammals Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	Mammals 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.	Mammals 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
	Reptiles and Amphibians Reptiles and amphibians would remain widespread throughout the 1000+ acre project area.	Reptiles and Amphibians Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	Reptiles and Amphibians 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.	Reptiles and Amphibians 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.

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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.