4. PLAN FORMULATION AND ALTERNATIVES DEVELOPMENT

Planning for Federal water resources projects constructed by the USACE is based on The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (the Principles and Guidelines) (USWRC, 1983). The USACE Planning Guidance Notebook (ER 1105-2-100), which incorporates the Principles and Guidelines, provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation.

4.1 FEDERAL OBJECTIVE

Ecosystem restoration is a primary mission of the Corps' Civil Works program. The Corps' objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER) by increasing the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on improvements to habitat quality and/or quantity, and the benefits of ecosystem restoration projects can be quantified using acres, habitat units, or indexes (not monetary units). Ecosystem restoration plans are formulated and evaluated in terms of their net contributions to increases in ecosystem value (NER outputs).

4.2 STUDY GOALS, OBJECTIVES, AND CONSTRAINTS

After the problems and opportunities are defined (Chapter 2), the next task is to define the study planning objectives and the constraints that will guide efforts to solve these problems and achieve these opportunities. Planning objectives are statements that describe the desired results of the planning process by solving the problems and taking advantage of the opportunities identified. Constraints are restrictions that limit the planning process. Constraints that need to be considered include resource constraints, including focused value judgements over what environmental, fishery, and social impacts would be acceptable/unacceptable, and legal and policy constraints. Resource constraints are those associated with limits on knowledge, expertise, experience, ability, data, information, money and time. Legal and policy constraints are those defined by law, Corps policy and guidance. Plans should be formulated to meet the study objectives and to avoid violating the constraints.

Goals, objectives, and constraints for the GRR and SEIS were developed by the Project Delivery Team (PDT), consisting of the USACE-Baltimore District team and representatives from the MPA and natural resource agencies at the State and Federal level. The expansion study goals and objectives are consistent with the existing PIERP, and the concurrent, ongoing Federal DMMP and Mid-Chesapeake Bay Island studies.

4.2.1 Study Goals

The goals of the expansion study are:

- To investigate alternative modifications to the existing PIERP to increase the size of the habitat restoration and increase the opportunity for beneficial use of dredged material,

- Provide additional dredged material capacity to meet the annual placement needs and help offset the projected dredged material placement shortfall, as recommended in the Federal DMMP (2005),
- To evaluate elements that could be added to enhance the existing PIERP and the proposed expansion, such as recreational and educational resources,
- To assess additional components necessary for completion of the existing authorized project,
- To remain consistent with the success of the existing PIERP, and
- To build on lessons learned from the existing PIERP.

4.2.2 Study Objectives

The objectives of the study are intended to facilitate the completion of the project goals. The overall objectives of the expansion study were intended to be consistent with both the existing PIERP and the concurrent Mid-Chesapeake Bay Island Ecosystem Restoration Feasibility Study; and were meant to be flexible, measurable, attainable, and congruent.

The objectives of the expansion study are to:

- Restore and enhance marsh, aquatic, and terrestrial island habitat for fish, reptiles, amphibians, birds, and mammals;
- Protect existing island ecosystems, including sheltered embayments;
- Minimize impacts to existing fisheries nursery, feeding, and protective habitats;
- Increase wetlands acreage in the Chesapeake Bay watershed;
- Decrease local erosion and turbidity;
- Promote conditions to establish and enhance submerged aquatic vegetation;
- Promote conditions that support oyster recolonization;
- Minimize impacts to rare, threatened, and endangered species and their habitats;
- Minimize impacts to existing commercial fisheries;
- Minimize establishment of invasive species to maximum extent possible; and
- Optimize the site capacity for placement of dredged material.

4.2.3 Study Constraints

For developing alternatives for further consideration, the study team developed the following list of constraints and considerations for the expansion study:

<u>Socioeconomic</u>

- Avoid areas that would impose adverse socioeconomic impacts, especially those related to commercial and recreational fisheries and navigation.
- Avoid adverse impacts to surrounding public lands, infrastructure, and property.

<u>Environmental</u>

- Avoid quiescent areas in Poplar Harbor that were created as part of the Poplar Island EIS (USACE/MPA 1996).

- Minimize loss of shallow water habitat (SWH) (-6.5 ft MLLW and shallower) – SWH is important as nursery ground for many aquatic species and can support SAV.
- Minimize impacts to areas outside the footprint of the proposed project, such as impacts from sand borrow excavation and access channel dredging.

Engineering

- Avoid deep water (-12 ft MLLW or greater), to minimize the additional costs associated with constructing exterior dikes that are wider (to provide support) and require greater amount of armor stone (for increased protection).
- Provide sufficient capacity such that the future project (the existing PIERP plus the expansion) can accommodate up to 3.2 mcy of dredged material per year after Pooles Island closes in 2010.
- Allow for approximately 80 percent of the dredged material (majority of the capacity) to be placed into the upland cells.
- Restrict footprint to areas with suitable foundation material.
- Restrict borrow areas for dike construction to footprint of the project (specifically under the upland cells) and to access channel areas, to the maximum extent possible, to minimize disturbance of the Bay bottom.

Legal/Policy

- Avoid adverse impacts to threatened or endangered species.
- Increase placement capacity by 2010 to accommodate additional 1.2 mcy of dredged material currently going to Pooles Island [from 2 mcy (current capacity) to 3.2 mcy].
- Avoid cultural resource anomalies (and 300-ft buffers) to the north, south, and west (Figure 4-1).
- Avoid Natural Oyster Bars (NOBs) (Figure 4-1).

Public and Agency Concerns

- Avoid areas used extensively by commercial fishermen.
- Minimize negative impacts to local aesthetics.
- Minimize loss of SWH.
- Maintain at least 50 percent wetland habitat in expansion area.

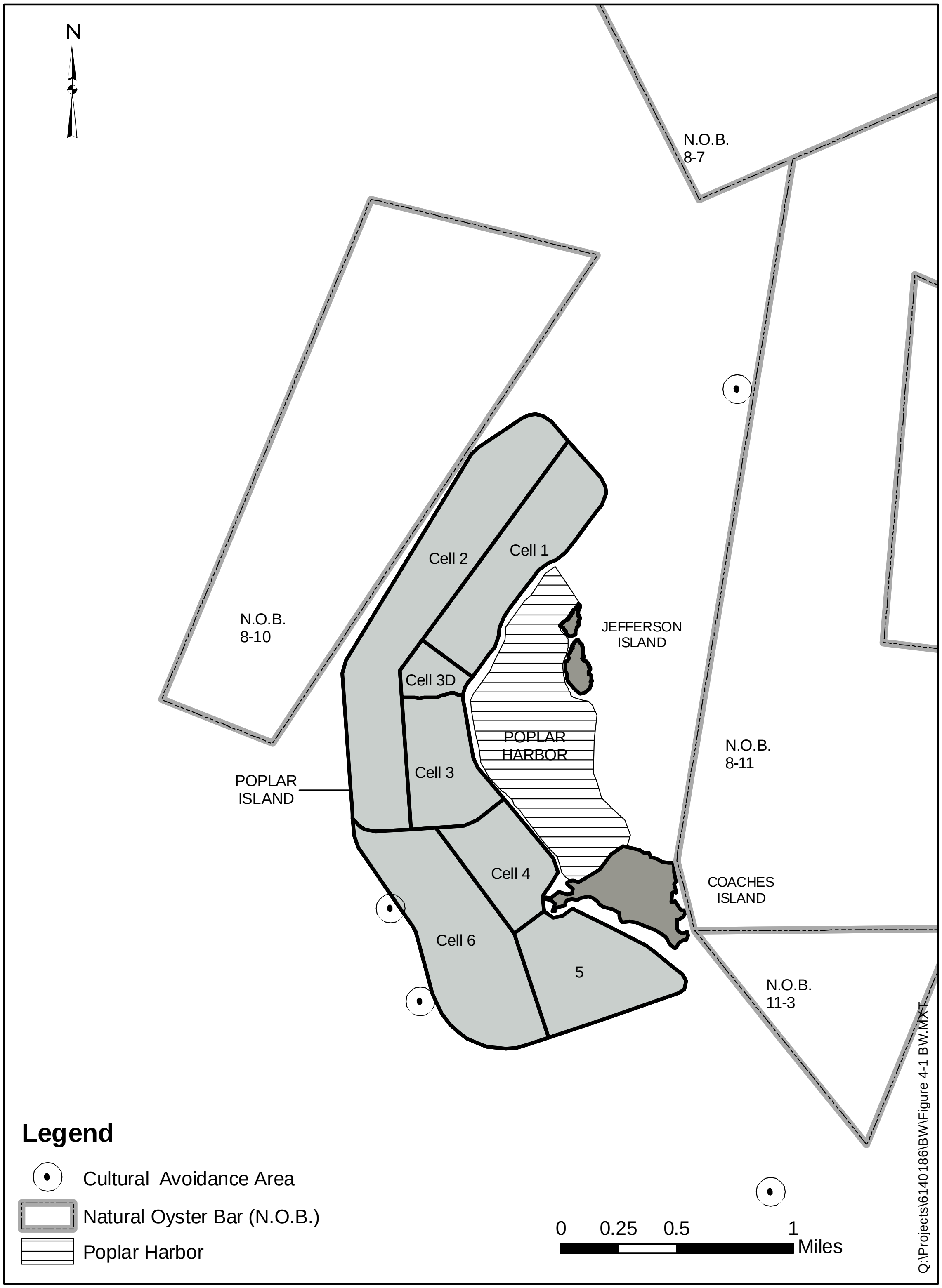


Figure 4-1. Existing Conditions at Poplar Island Environmental Restoration Project and Cultural Resource Avoidance Area

4.3 INVENTORY AND FORECAST

4.3.1 Existing Conditions

The next step of the Corps' planning process is to develop an inventory and forecast of critical resources (physical, demographic, economic, social, etc.) relevant to the problems and opportunities under consideration in the planning area. A quantitative and qualitative description of the current condition of these resources is made, and is used to define existing and future without-project conditions. This inventory of existing conditions was provided in Chapter 3.

Through iterative review by the project team, the information developed during the inventory process was used to define and characterize the problems, opportunities, objectives, and constraints.

4.3.2 Expansion Study Components Not Subject to Plan Formulation

Several additional considerations (acceptance of dredged material from other channels) were studied as part of the GRR/expansion study, but were not subject to the screening and iterative evaluation of the plan formulation and impacts analysis. Summaries of the study results for these considerations are summarized in Sections 6.10 and included in the recommended plan (Chapter 6).

4.3.2.a Acceptance of Dredged Material from Other Channels Currently the PIERP authorization allows for acceptance of dredged material from the eight designated Chesapeake Bay approach channels to the Port of Baltimore (Figure 1-3); and congressional authorization would be required to accept dredged material from other channels. Specifically, accepting dredged material from the southern approach channels to the C&D Canal Approach Channels (from Pooles Island to the Sassafras River) (Figure 1-4) was considered for inclusion in the re-authorization of PIERP. Also included in the study was an evaluation of procedures for, and project constraints on, accepting dredged material from other small navigation projects (Federal, State and local channels). Although not included in the plan formulation, the potential to accept dredged material from additional channels at the PIERP was evaluated through agency consultation, the results and recommendations of which are summarized in Chapter 6.

4.3.2.b Environmental Enhancements To expand the benefits of the existing PIERP several environmental enhancements (Poplar Harbor protection, improvements to bird and fish habitat, and improvements to diamondback terrapin habitat) were also evaluated as part of the GRR/expansion study. A discussion of these study components is included in Chapter 6.

4.4 DEVELOPMENT AND SCREENING OF ALTERNATIVES

Alternative plans are formulated to identify specific ways to achieve planning objectives within constraints and, thereby, to solve the problems and realize the opportunities that were previously identified. An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to the planning constraints. A range of alternative plans is identified at the beginning of the planning process and screened and refined in subsequent iterations. Plans should be in compliance with existing statutes, administrative regulations, and common law or include proposals for changes as appropriate. Appropriate mitigation of adverse effects shall be an integral component of each alternative plan.

4.4.1 No-Action Alternative

The without-project condition (i.e., no expansion) is the existing built-out PIERP - 1,140 acres in size, with 50 percent uplands and 50 percent wetlands (Figure 4-1) as described in the 1996 EIS. The exterior perimeter dikes for the existing uplands cells at the PIERP are currently designed for a height of +20 ft MLLW, with a temporary dike height of +23 ft MLLW. The perimeter dikes for the wetland cells range from +8 to +10 ft MLLW. As described in Chapter 1, dredged material from the Upper Chesapeake Bay Approach Channels to the Port of Baltimore is being beneficially used to restore over 1,140 acres of wetland and upland habitat (Figure 1-3). The PIERP is planned to create approximately 50 percent wetland habitat (570 acres) and 50 percent upland habitat (570 acres). It is estimated that by 2014 PIERP will accept up to 40 mcy of dredged material for beneficial use.

4.4.2 Options for the Expansion

The expansion of the PIERP was one of a suite of alternatives recommended in the Federal DMMP (2005) to meet the projected dredged material capacity shortfall (Section 2.3.1). One objective for the design and development of the expansion components proposed for the PIERP was to increase the capacity and lengthen the site life of the existing project, such that PIERP could accommodate an annual inflow of approximately 3.2 mcy and provide a viable placement alternative until additional sites recommended in the Federal DMMP would be permitted, constructed, and available for placement. Three initial options for expansion were considered: 1) vertical expansion only, 2) lateral expansion only, and 3) lateral expansion plus vertical expansion.

4.4.2.a Vertical Expansion Only Vertical expansion of the existing PIERP would entail raising the existing upland cells (Cells 2 and 6) (Figure 4-2). Vertical expansion would not apply to the wetland cells. The existing upland cells are authorized to a final height of +20 ft MLLW. A permanent vertical raising of these dikes would be limited by the structural stability provided by the foundation materials. Based on the subsurface investigations, the maximum raising that could be accomplished is approximately 15-ft (to a final design elevation of +35 MLLW) because of slope stability limitations. Consequently, the vertical expansion was evaluated at 5-foot incremental increases in height, to a maximum final design height of +35 ft MLLW, for a total of three vertical expansion options: +25 ft MLLW, +30 ft MLLW, and +35 ft MLLW. To achieve the water drainage in the upland cells necessary for consolidation (during and after material placement), a temporary dike height 5-ft above the

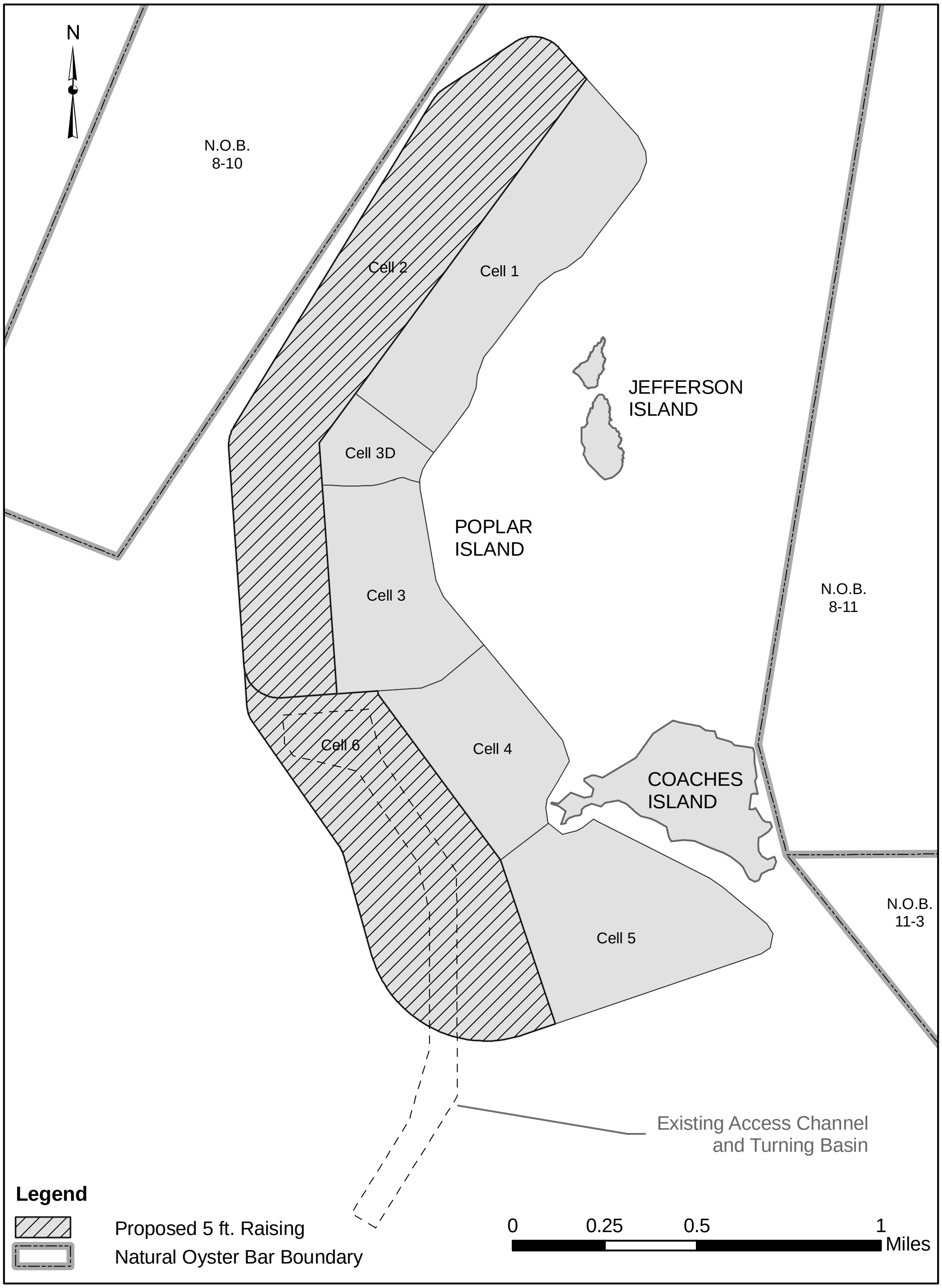


Figure 4-2. Vertical Expansion of Existing Upland Cells 2 and 6 at Poplar Island.

targeted final elevation is required to support topographic variation. For example, a temporary height of +40 ft MLLW would be required to achieve a final design height of +35 ft MLLW.

4.4.2.b Lateral Expansion Only Reconnaissance-level studies were conducted in 2002 and 2003 to examine the potential for lateral expansion of the current footprint of the existing project (EA, 2002e; E2CR, 2002; GBA, 2003; M&N 2002; M&N 2003). Alignments were developed to expand the existing footprint, and each alignment included the addition of both upland and wetland habitat. Alignments evaluated in the reconnaissance study were configured to maximize capacity, take into account construction constraints and avoid natural oyster bars and other known sensitive environmental resource areas. Alignments evaluated in the reconnaissance-level studies included footprint expansion to the north/northeast, south, and west, for a total of six alignments (Figures 4-3a through 4-3c). A seventh alignment (Alignment 7) that included footprint expansion to the north/northeast only (Figure 4-3d), was added during the early stages of the USACE-Baltimore's plan formulation process for the expansion study. In addition, an option to build a breakwater off the northeastern corner of Cell 1 was also considered (Alignment 8). The intent of the breakwater design was to provide protection to Poplar Harbor and Jefferson Island from wind-driven waves from the north-northeast and minimize the movement of sand that would fill in wetland openings along the western side of the project (Figure 4-3d).

4.4.2.c Lateral Expansion plus Vertical Expansion Also evaluated for the expansion study was a combination of a lateral expansion plus a vertical expansion. After initial screening processes were conducted to identify feasible lateral and vertical expansion components, an additional assessment of the various combinations of these options was conducted.

4.4.3 Additional Actions for Completion of Existing Project

The existing project is not yet completed, and site operations – dredged material placement and habitat development – are ongoing at the PIERP. Under the auspices of the GRR, USACE-Baltimore District assessed the current project and identified several additional actions required to complete the existing project. These actions were not specifically evaluated in the initial EIS for the existing project (USACE/MPA, 1996), and are, therefore, included in the GRR/SEIS (NEPA evaluation). These actions include:

4.4.3.a Raising the Existing Upland Dikes from +23 ft MLLW to +25 ft MLLW As noted above, a temporary dike height 5-ft above the targeted final elevation is required to support the water drainage in the upland cells necessary for consolidation (Appendix A, section 5.9). Currently, the final design height of the existing cells at the PIERP is +20 ft MLLW. In the EIS for the existing project (USACE/MPA, 1996), the upland dikes were limited to a temporary height 3 feet above the final design height of +20 ft MLLW (+23 ft MLLW). However, based on both the on-going site operations and studies conducted subsequent to the EIS, a temporary dike height of +25 ft MLLW is needed to achieve proper consolidation of the dredged material. Therefore, a design modification to raise existing upland dikes from +23 ft MLLW to +25 ft MLLW is evaluated in the expansion study.

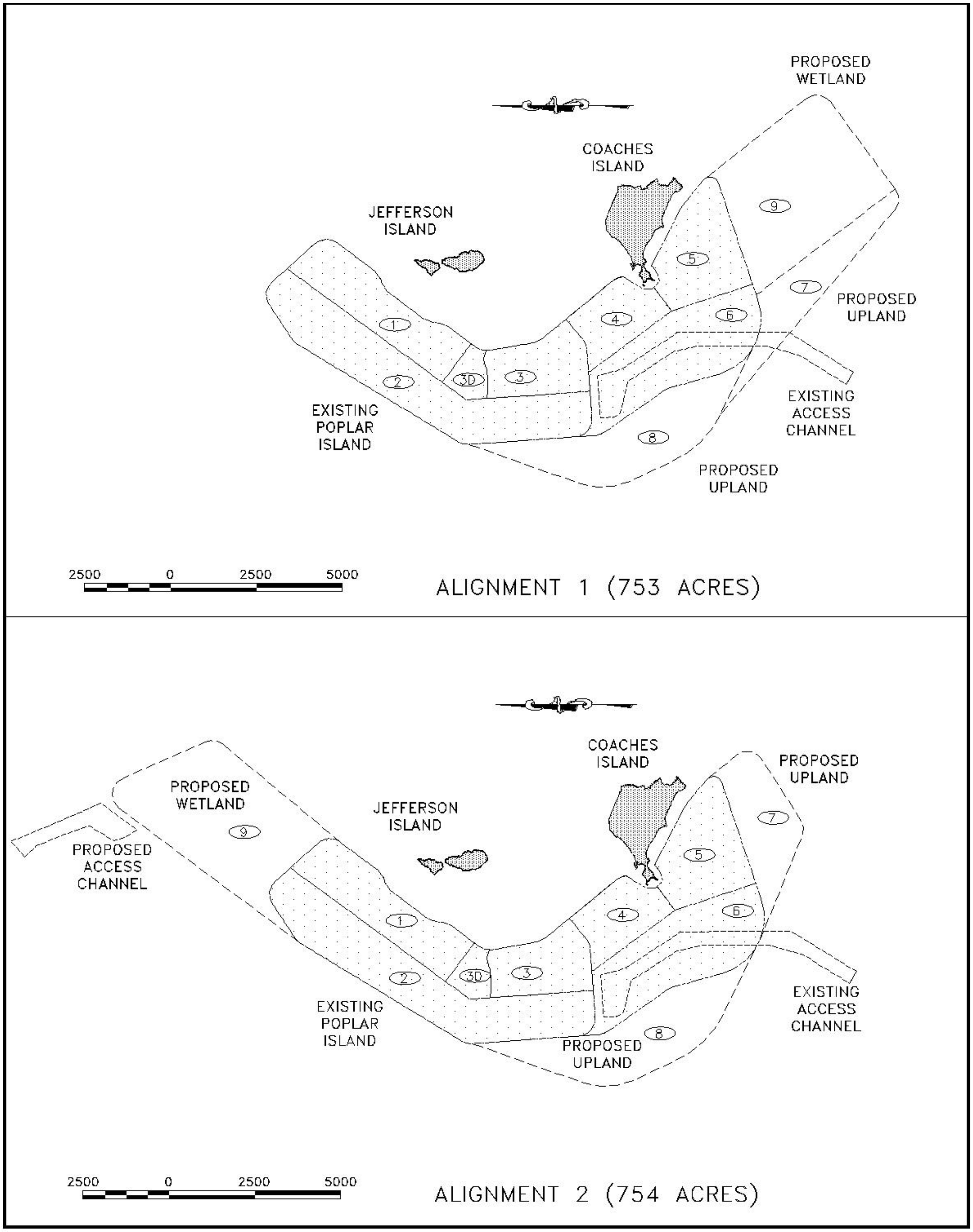


Figure 4-3a. Preliminary Alignments Considered During Scoping, Alignments 1 and 2

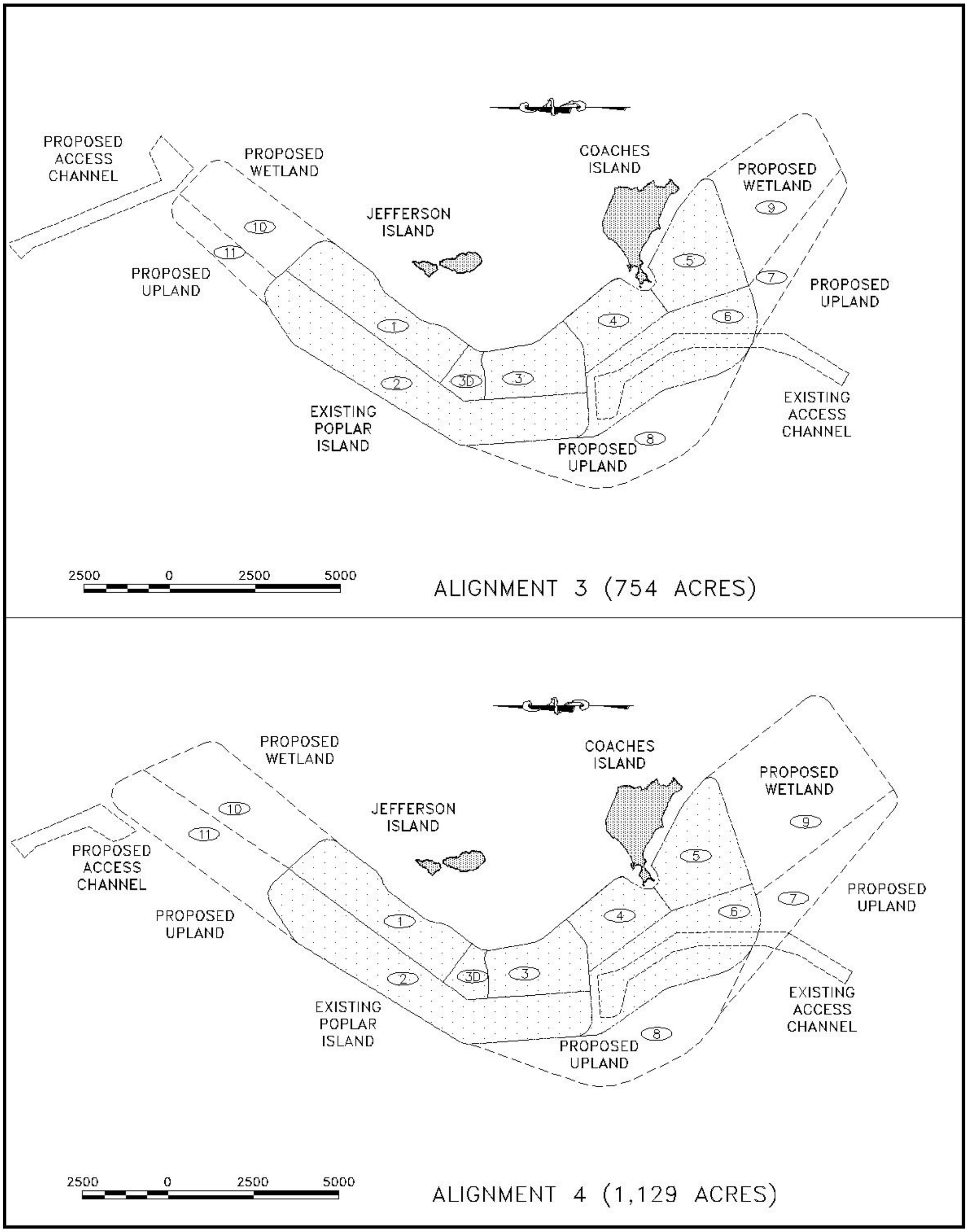


Figure 4-3b. Preliminary Alignments Considered During Scoping, Alignments 3 and 4

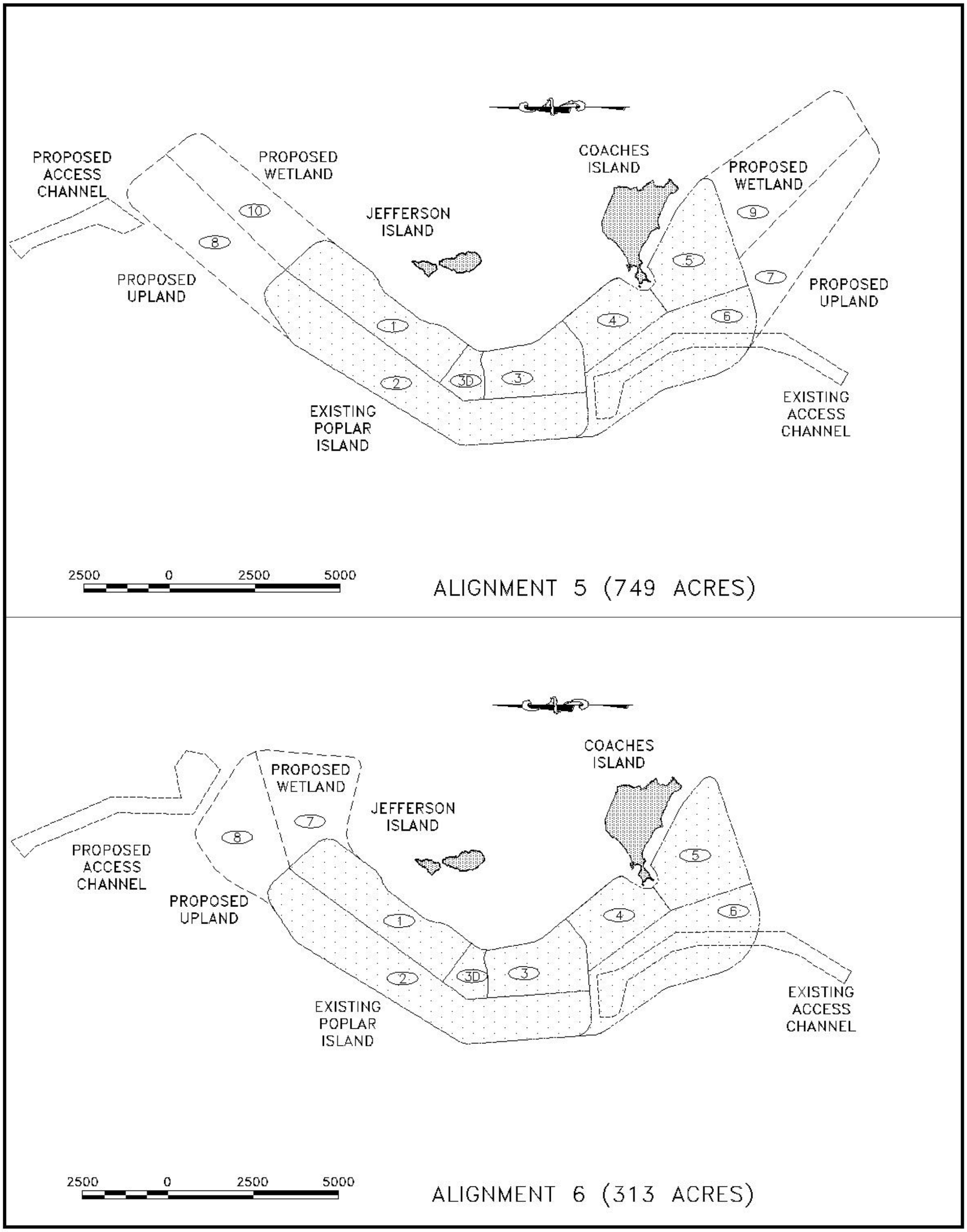


Figure 4-3c. Preliminary Alignments Considered During Scoping, Alignments 5 and 6

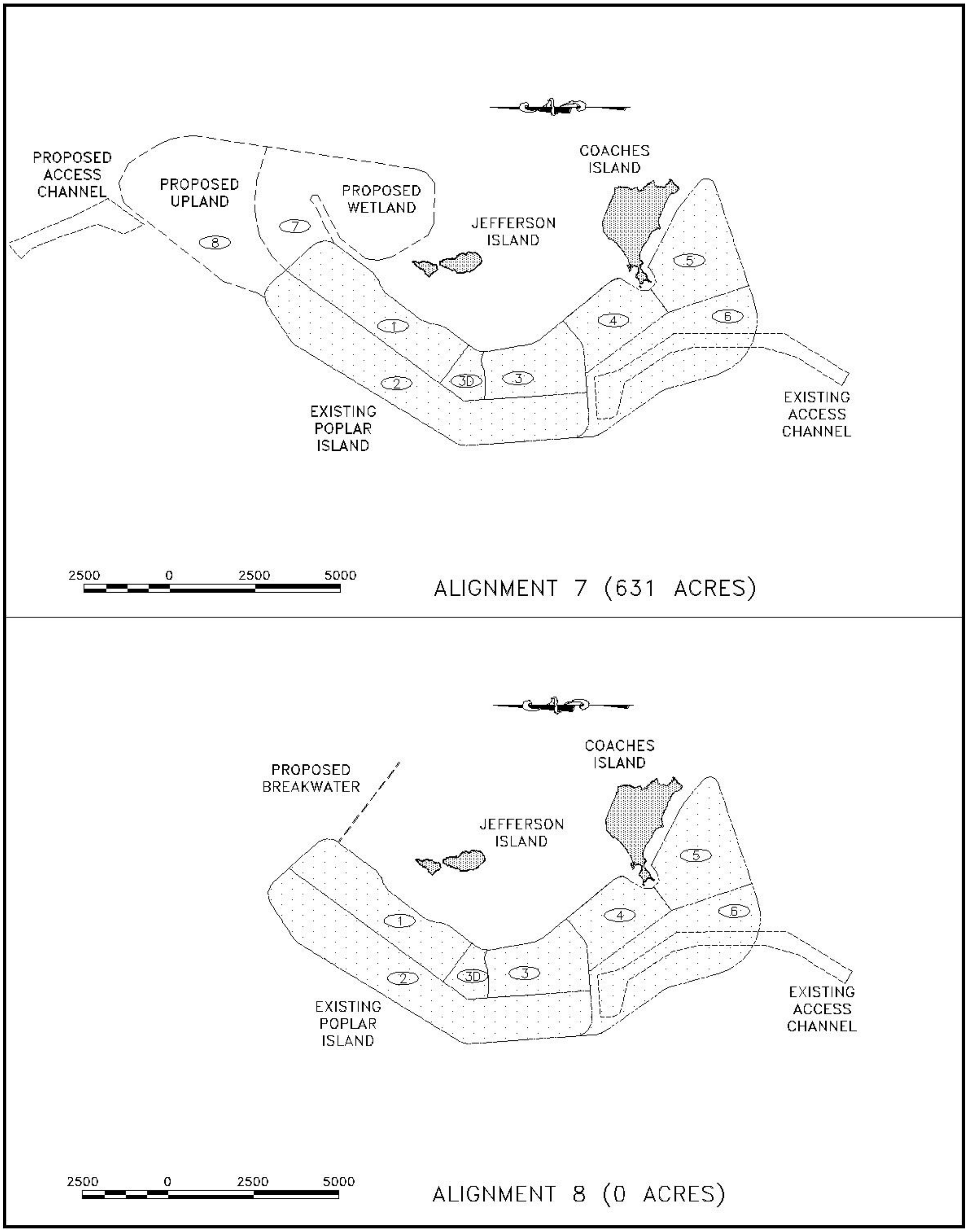


Figure 4-3d. Preliminary Alignments Considered During Scoping, Alignments 7 and 8

4.4.3.b Cell 6 Closure and Additional Cell Activities The construction of the PIERP is not complete, and Cell 6 is currently an open water basin with free, unrestricted tidal exchange with the Chesapeake Bay. The actions associated with the Cell 6 closure include: relocation of the existing access channel opening at the southern end of Cell 6, dredging of a turning basin, sand borrow excavation from Borrow Areas F and G, and raising the Cell 6 perimeter dike to elevation +23 ft MLLW. Currently, barges access the PIERP through the Cell 6 opening and transit the length of the cell to the dredged material offloading area along the northern cross-dike (Figure 4-4). The offloading facilities and fuel farm will be relocated to the southern Cell 6 perimeter, and a new pier will be constructed. Additional cell activities required to complete the project include the restoration of internal borrow sites within wetland Cell 4 and construction of temporary cross dikes within wetland Cell 5.

4.4.3.c Recreational/Educational Opportunities The Talbot County Commissioners have expressed interest in the development of additional recreational and educational opportunities in keeping with the PIERP's environmental restoration focus. From 2003-2004, there were 175 educational tours of PIERP, given to interested groups and individuals from around the world. A total of approximately 1,800 people visited the PIERP in 2004, and interest in the project is expected to continue. Examples of recreational and educational opportunities to be considered include: recreational fisheries enhancements, interpretive nature trails, and other passive recreational/education opportunities. The addition of recreational/educational opportunities is also under consideration in the expansion study, and the resulting recommendation will be a plan that would be incorporated into both the existing PIERP and the expansion. The plan formulation process for analyzing recreational and educational components is discussed in Section 4.11.3.

4.5 SCREENING PROCESS FOR EXPANSION OPTIONS

The purpose of the screening process is to eliminate options that do not meet the goals (Section 4.2.1) and objectives (Section 4.2.2) of the study or cannot be built within the socioeconomic, engineering, environmental, legal/policy, and agency constraints (Section 4.2.3).

4.5.1 Vertical Expansion

Vertical expansion of the existing upland cells at the PIERP was evaluated at 5-foot incremental increases in height, to a maximum final design height of +35 ft MLLW. Each additional 5-ft increment would increase the capacity of the upland cells by approximately 6 mcy. The maximum final design height was limited by the results of slope stability analysis that had shown that temporary dike heights above +40 MLLW might not be stable. A total of three vertical expansion options were evaluated: a 5-ft height increase to +25 ft MLLW, a 10-ft height increase to +30 ft MLLW, and a 15-ft height increase to +35 ft MLLW. The results of a raising-alone option are presented on in Table 4-1 below.

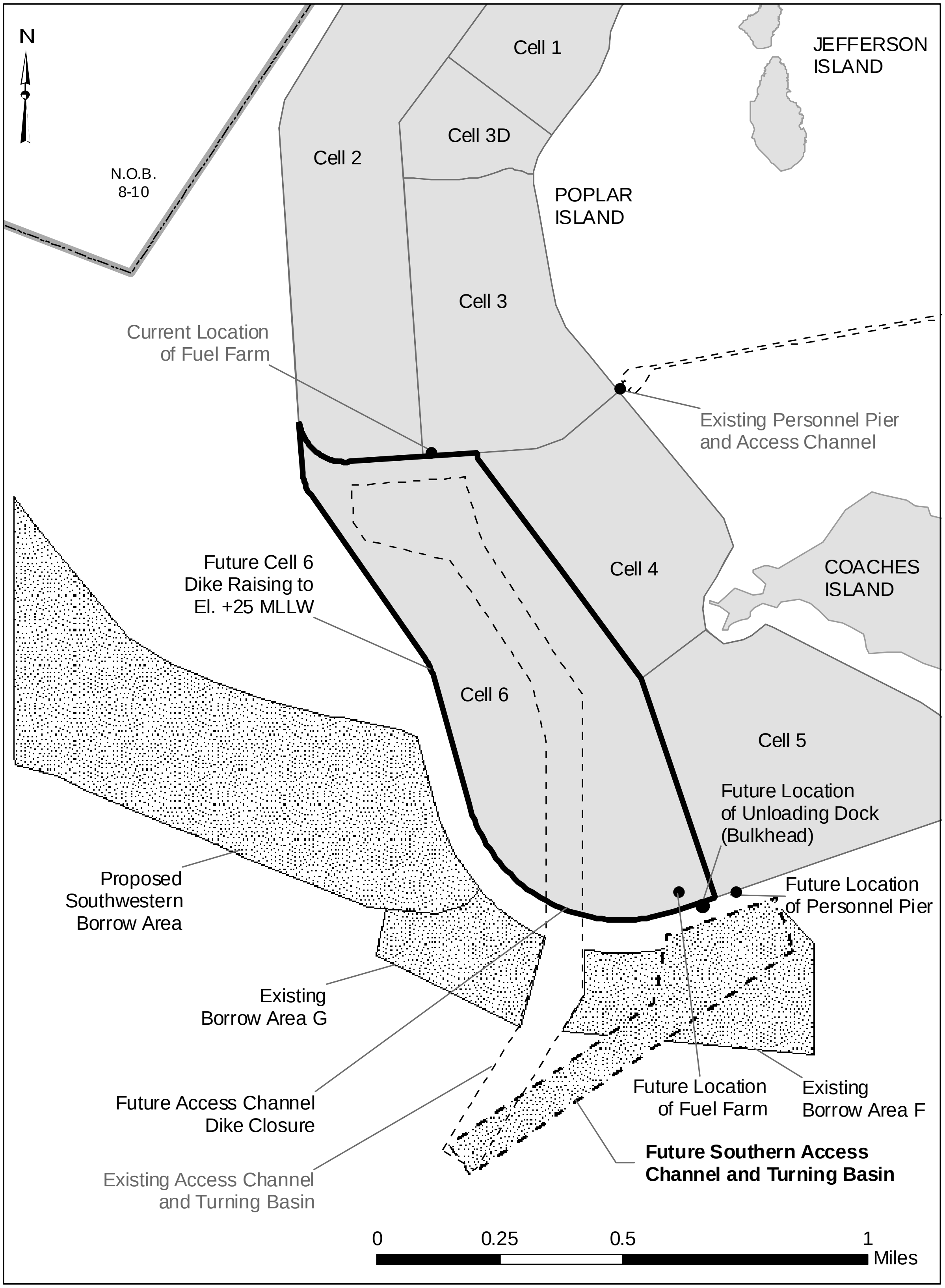


Figure 4-4. Cell 6 Closure Activities Required for Poplar Island

Table 4-1. Placement Summary For Vertical Expansion of Existing Upland Cells 2 & 6

Expansion and/or Raising Option*	Total Capacity (mcy)	Last Year at 3.2 mcy**	Years of Cell 6 Overload	Last Wetland Placement	Last Upland Placement	Placement Contingency (years)
Existing 1140-acre Project	**40.4**	2014	**7**	2014	2015	1
Existing Uplands Raised to +25 MLLW	**46.4**	2016	**9**	2014	2017	3
Existing Uplands Raised to +30 MLLW	**52.4**	2018	**11**	2014	2019	5
Existing Uplands Raised to +35 MLLW	**58.4**	2019	**13**	2014	2020	6

**Total acres (1,126), upland area (569 acres), and wetland area (557 acres) available for placement are for the existing project, and are the same for each of the vertical expansion alternatives. The acreage does not include the area taken up by the interior cross dikes.*
***Annual placement volume of 3.2 mcy will begin in 2009.*

The vertical raising provides from 6 to 18 mcy of additional dredged material placement capacity extending the project life from 2 to 5 years, and it does so without taking up any additional Bay bottom. The expansion of upland placement capacity without any expansion of wetland habitat results in a significant increase in contingency to deal with the many uncertainties of wetland development. Based on the experience in the existing PIERP, a contingency of approximately two years is necessary to ensure proper wetland cell development (Appendix A, Attachment C). Therefore, the potential for successfully completing the wetland development while employing efficient (cost effective) dredged material placement methods, would be enhanced.

It should be noted that most, if not all, of the materials required for vertical expansion of the existing upland cells would be obtained from borrow sources outside of the limits of the existing project – most likely the borrow area to the southwest of Cell 6. As shown in Table 4-1, vertical expansion alone provides no relief to the cell overloading that will occur during the latter years of the existing project. Furthermore, every year of additional capacity results in an additional year of inefficient placement as the upland cells would have to be overloaded with placement lifts ranging from 5 to 9 ft under the vertical expansion alone option in contrast to the optimal 3-foot lift thickness.

The option of vertical raising only was eliminated as a viable alternative for the project early in the plan formulation process because of several factors. The Federal DMMP projected an annual volume of 3.2 mcy of dredged material from the upper Chesapeake Bay approach channels to the Port of Baltimore and the southern approach channels to the C&D Canal will need to be accommodated starting in 2010 (USACE, 2005). Vertical expansion (dike raising alone) could not accommodate the entire 3.2 mcy of dredged material that will need a placement site, and it cannot be assumed that any other placement options (i.e., Mid-Bay Island restoration or Dorchester County wetland restoration) will be constructed or move forward prior to or during the operational lifetime of the PIERP.

In addition, early discussions among the design team identified that a vertical raising of the existing uplands alone as an alternative failed to provide any substantial additional environmental benefits in comparison to the existing project. Placement of large quantities of dredged material in a cell during a given placement year (overloading the cells) would reduce consolidation rates and ultimately reduce the overall capacity of the upland cells. Raising the dikes has only a minor additional environmental benefit compared to the existing project because the dike raising would not create additional habitat, only delay the development and realization of habitat goals already associated with the uplands, as currently planned. It does, however, reduce the amount of Bay bottom that would be required for development of a new placement site.

Lastly, the public repeatedly voiced concerns about the impact that raising the dikes would have on the overall aesthetics (Appendix G, 12 Jan 2004 and 6 Oct 2004 public meetings) of the project area. Therefore, the vertical expansion alternative alone was not considered a viable option worthy of additional evaluation by itself. However, because vertical expansion would increase the potential for successful wetland development and increase overall capacity of the site, vertical expansion was pursued in combination with a lateral expansion alternative.

4.5.2 Lateral Expansion

4.5.2.a Alignment Alternatives In the Reconnaissance Study (GBA, 2003), six lateral expansion alignments (Alignments 1 through 6) for the PIERP were developed, ranging in size from 313 to 1,129 acres (Figures 4-3a through 4-3c) (Table 4-2). Evaluation of the alignments during the plan formulation process included consideration of environmental resources, cultural resources, real estate, engineering factors, agency comments, and public input. Early in the process, general indications were that the public concern opposed alignments located to the south and southwest of the existing project. Although the engineering analyses were still in progress, general engineering knowledge about site conditions at each of the six reconnaissance alignment locations indicated that the southern and southwestern locations were also less favorable than the northern location. It was at this point that the seventh alignment (Alignment 7), a 630-acre northern alignment was added to the original six alignments already being evaluated (Figure 4-3d). One additional alignment, Alignment 8 (Figure 4-3d), a breakwater off the northeastern corner of Cell 1, was also added during the early stages of the plan formulation process to provide protection to Poplar Harbor and Jefferson Island and minimize sand migration along the western side of the existing PIERP.

In the initial screening, Alignment 8 was eliminated from further consideration because it did not include any expansion of the island and, therefore, did not meet the study's goals of providing additional capacity or providing additional habitat (through wetland restoration). If no plan for expansion of PIERP is ultimately approved or implemented, then the construction of this breakwater could be re-evaluated as an option for the protection of Poplar Harbor.

The seven remaining alignments were initially assumed to be consistent with the existing PIERP, and therefore included a habitat split of 50 percent uplands, 50 percent wetlands and final design dike heights of +20 ft MLLW for uplands and +8 ft MLLW for wetlands.

Dredged material placement capacities for the seven alignments ranged from 11 to 48 mcy (Table 4-2). See Appendix A, Section 4 for a more detailed descriptions of each of the seven alignments.

Table 4-2. The Seven Alignments Evaluated in the Reconnaissance Study

Alignment	Area (acres)	Additional Site Capacity (mcy)	Additional Site Life (years)
1	753	32	13
2	754	30	13
3	754	29	13
4	1129	48	20
5	749	30	13
6	313	11	5
7	631	24	10

The alignments were developed within the study constraints listed in Section 4.2.3. In particular, the following four environmental/engineering/legal constraints defined the boundaries within which the alignments could be sited: (1) avoid Poplar Harbor, (2) avoid deep water, (3) avoid NOBs, and (4) minimize loss of shallow water habitat.

Potential sand borrow sources for both the lateral and vertical expansion were identified at four separate locations (Figure 4-5) (GBA, 2003). The four areas were designated as the southeast, southwest, northeast, and northwest borrow areas. Each area was delineated to distinguish between those areas containing thicker deposits of sand up to 20 ft thick, and those deposits of sand approximately 10 ft thick. Table 4-3 presents a summary of the total area and total quantity of sand available at each site based on the reconnaissance subsurface investigations.

Table 4-3. Borrow Summary

Borrow Area	Area (acres)	Quantity (mcy)
Southeast	473	9.1
Southwest	211	4.2
Northeast	345	7.2
Northwest	170	4.6

It was desirable to limit borrow excavation to that portion of the borrow area that was located within the footprint of the proposed alignment to avoid disturbance of the Bay bottom outside of the project limits. A detailed analysis of the borrow areas associated with each alignment is presented Attachment A - *Borrow Analysis*.

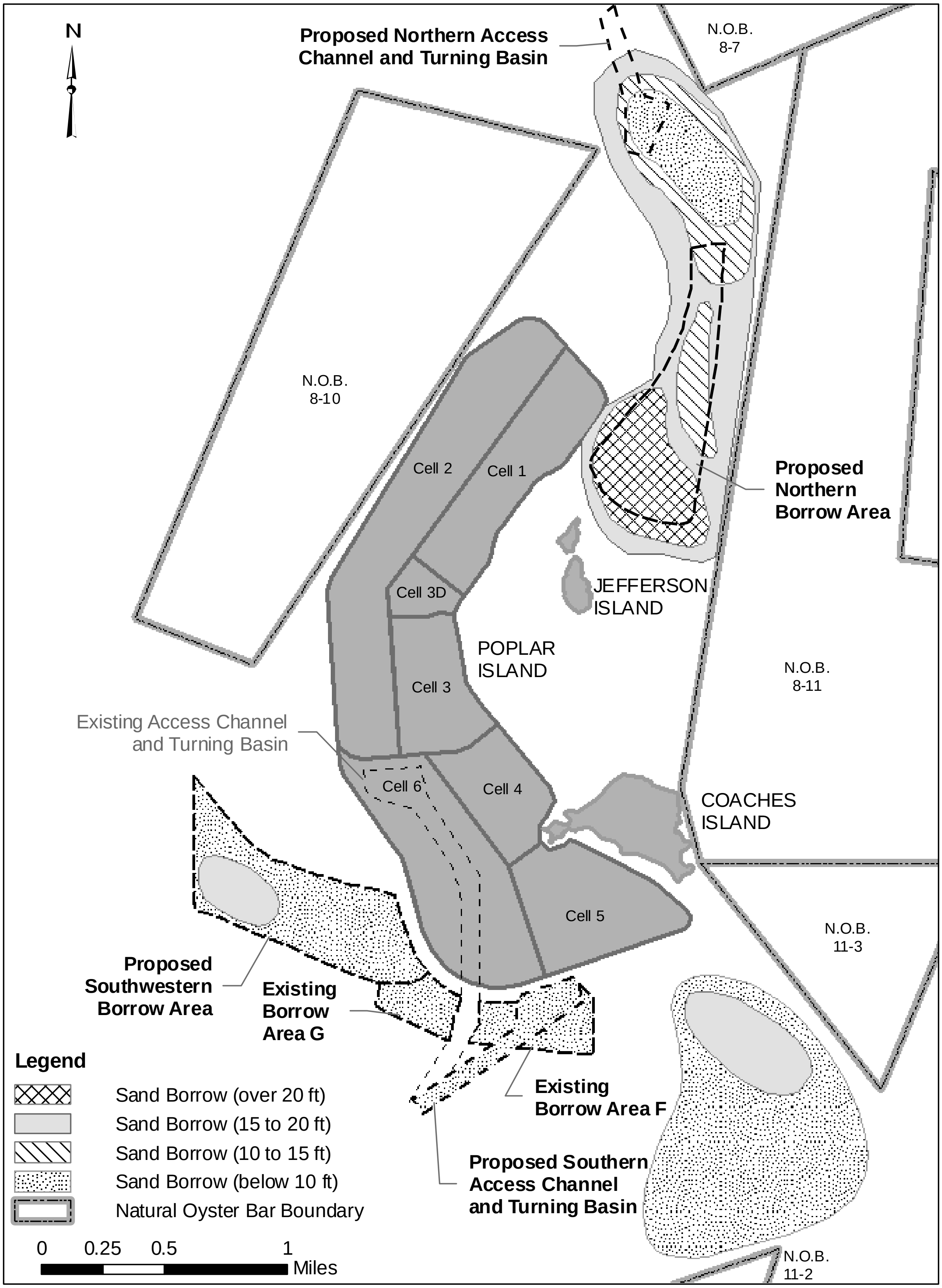


Figure 4-5. Potential Sand Borrow Areas and Depths at Poplar Island

4.5.2.b Screening of Proposed Alignments To evaluate the seven remaining alignments (Table 4-4), the following screening categories were used:

- Cost
- Site Capacity and Life
- Engineering Suitability
- Agency and Public Concerns

The engineering evaluation consisted of an engineering screening process for the seven specific alignments (Figures 4-3a through 4-3d), supplemented by a series of generic placement analyses and analysis of the potential source of dike construction materials. These evaluation elements were the basis for defining the minimum expansion area and capacity that would be required to efficiently accommodate average annual dredged material placement needs, and to identify the optimum location for the expansion. The screening process for each category is described in the following sections, and results of the screening are summarized in Table 4-4.

Table 4-4. Summary of Alignment Screening Process

Alignment	First Cost[(a)] ($M)	Dredged Material Placement Capacity[(b)] (mcy)	Site Life[(c)] (yr)	Engineering Suitability Score[(b)]	Agency Concerns/ Public Comments
Alignment 1 - 753 ac South & West expansion	$424	32	13	44.5	• Island height/Viewshed impacts • Noise during construction • Crabbing and clamming usage in area of southern expansion • Prime benthic habitat to the south • Potential avoidance of cultural resource to the southwest
Alignment 2 - 754 ac South, West, & North expansion	$427	30	13	40	• Island height/Viewshed impacts • Noise during construction • Crabbing and clamming usage in the southern area and crabbing/pound netting to the north • Oyster bar avoidance to north, east and west • Prime benthic habitat to the south • Potential avoidance of cultural resource to the north and southwest
Alignment 3 - 754 ac South, West, & North expansion	$415	29	13	43	• Island height/Viewshed impacts • Noise during construction • Crabbing and clamming usage in the southern area and crabbing/pound netting to the north • Oyster bar avoidance to north, east and west • Prime benthic habitat to the south • Potential avoidance of cultural resource to the north and southwest

Alignment	First Cost[a] ($M)	Dredged Material Placement Capacity[b] (mcy)	Site Life[c] (yr)	Engineering Suitability Score[b]	Agency Concerns/ Public Comments
Alignment 4 - 1,129 ac South, West, & North expansion	$665	48	20	46	• Island height/Viewshed impacts • Noise during construction • Crabbing and clamming usage in the southern area and crabbing/pound netting to the north • Oyster bar avoidance to north, east and west • Prime benthic habitat to the south • Potential avoidance of cultural resource to the north and southwest
Alignment 5 - 749 ac South & North expansion	$410	30	13	47.5	• Island height/Viewshed impacts • Noise during construction • Crabbing and clamming usage in the southern area and crabbing/pound netting to the north • Oyster bar avoidance to north, east and west • Prime benthic habitat to the south • Potential avoidance of cultural resource to the north and southwest
Alignment 6 - 313 ac North expansion	$160	11	5	56	• Island height/Viewshed impacts • Noise during construction • Crabbing and pound netting to the north and northeast • Oyster bar avoidance to north, east and west • Potential avoidance of cultural resource to the north
Alignment 7 - 631 ac North expansion	$296[d]	24	10	63.5	• Island height/Viewshed impacts • Noise during construction • Crabbing and pound netting to the north and northeast • Oyster bar avoidance to north • Potential avoidance of cultural resource to the north

(a) *Source: Reconnaissance Plan (GBA, 2003)*
(b) *Source: Appendix A*
(c) *No. of years after completion of existing project at full placement rate of 3.2 mcy/yr. Source: Appendix A*
(d) *Source: USACE-Baltimore, based on criteria developed by GBA (2003)*

Cost

The estimated cost for each alignment is shown in Table 4-4. Costs for the first six alignments were developed in the *Poplar Island Modification Reconnaissance Study* (GBA, 2003). The cost for the seventh alignment was developed by the USACE-Baltimore District using the same basis as the other alignments.

The costs include:

• Initial construction	Dikes, dike stabilization, spillways/outlets, and infrastructure, plus study costs—conceptual, pre-feasibility, feasibility
• Habitat development	Planning, design, and construction of channels, planting and seeding, operation and maintenance, and site monitoring
• Site development	Dredged material management, site management, site monitoring and reporting
• Dredged material transport and placement	Mobilization and demobilization, transport of dredged material to PIERP, and unloading

Site Capacity and Life

A placement analysis methodology was developed to address the need to balance placement between upland and wetland cells to prevent upland placement capacity from being exhausted before placement of dredged material into wetland cells could be completed. The detailed placement analysis, including wetland and upland cell construction and development criteria, is presented in Appendix A, Attachment C. The placement analysis was developed so that it could be applied to the existing project over its remaining life, and the potential expansion alternatives under consideration. The purposes of the analyses were to determine:

- The remaining placement life of the existing, built-out, Poplar Island project up to the maximum authorized upland elevation of +20 ft MLLW.
- A reasonable sequence of dredged material placement and cell development for the existing Poplar Island project employing efficient placement and site development methods.
- The minimum expansion project size that would support future dredged material placement requirements.
- The maximum percentage of wetlands that could be efficiently supported in the various expansion alignments.
- The maximum potential vertical expansion of existing upland cells that could be achieved based on technical limitations such as containment dike stability.
- The maximum desirable vertical expansion of the existing upland cells that would expand the percentage of the expansion area devoted to wetlands.

Also incorporated into the placement analysis was the understanding that development of habitat, particularly wetland habitat, required the carefully controlled placement of dredged material in a sequence that assured that the wetland cells would not be overfilled. This is accomplished by placing material into wetland cells in gradually diminishing increments over a period of years. It was also recognized that efficient use of upland capacity required dredged material to be placed in relatively thin lifts (less than 3 ft) so that the dredged material could be consolidated to a significant extent during the year or two before the surface was inundated by subsequent dredged material placement.

The placement analysis consisted of a mathematical model of the incremental placement of dredged material, beginning with empty cells and ending when the entire upland and wetland placement capacity was exhausted (Appendix A, Attachment C). The estimated placement capacity and lifetime for each alignment are shown in Table 4-4. The factors used to design the model were based on dredged material placement needs and habitat development constraints developed during the initial three years of placement and site development at the existing PIERP. Key assumptions used to develop the placement model included (Appendix A, Attachment C):

- The average annual placement rate is 3.2 mcy/year (starting in 2010).
- Cost effective placement requires that upland dredged material placement capacity extend beyond the time required to complete all wetland dredged material placement.
- The final upland surface elevation would average +20 ft MLLW.
- Placement in wetland cells must be strictly controlled to prevent overloading and to facilitate cell development.
- Wetland grading and planting is limited to two subcells per year.

Based on the placement experience at Poplar Island, it has become apparent that an efficient dredged material placement operation requires upland placement capacity to extend beyond the placement capacity in the wetlands. Each wetland cell must be filled with gradually diminishing quantities of dredged material so that the target low marsh surface elevation of 1.5 MLLW ± 0.3 ft can be achieved. As the last wetland cells are being completed, it is estimated that total dredged material placement quantities during the final wetland placement years will range from less than one hundred thousand cubic yards to, at most, several hundred thousand cubic yards - far less than the 3.2 mcy on average that must be accommodated each year. Therefore, the bulk of the annual placement volume during latter years of wetland development must be directed to upland cells within the existing placement site, or to other placement sites.

Engineering Suitability

The screening process for engineering suitability and cost effectiveness considered eight engineering criteria:

- Expansion Size. Increased project size allows greater operational efficiency because dredged material can be spread out over a larger area in thinner lifts. Expansion areas under about 400 acres marginally satisfy this requirement, areas between 400 and 1000 acres should fully satisfy the requirements, and areas over 1000 acres exceed the requirements.

- Additional Capacity. Capacity added by the expanded site, either lateral or vertical, needs to satisfy minimum annual placement needs and provide a project life that will alleviate cell overloading and extend the life of the existing PIERP to a point that will exceed the anticipated availability of other placement sites. The average annual inflow for PIERP will increase from 2.0 to 3.2 mcy when the Pooles Island open-water placement site closes. It is anticipated that additional capacity in the range of 20 to 30 mcy will satisfy capacity requirements.

- Dike Foundation Material. The cost of the containment dikes for the potential lateral expansion alignments will be affected by the foundation material. The most favorable material consists of sand with minor silt or clay content. Good materials include silty or clayey sand, or stiff clay materials with high shear strength and low compressibility characteristics. Poor foundations include very soft clay and silt materials where both shear strength and compressibility are unacceptable.

- Borrow Material Quantity and Quality. In addition to the location of borrow materials, the project cost is affected by the quantity and quality of materials available for dike construction. Minimum cost is associated with borrow sources that consist of clean sand (less than 30 percent silt and clay fines) and provide at least twice the quantity required for the project dikes. Where sand sources are located beneath a layer of silt or clay materials, cost for recovery of those materials increases and the rating is adjusted downward accordingly.

- Borrow Material Location. The project containment dikes will be constructed using sand obtained from borrow sources on the Bay bottom within or near the project site to minimize costs associated with transport. It is desirable to obtain all materials required for construction of the containment dikes from borrow sites within the footprint of the project or from the access channel required to deliver dredged material to the completed project to minimize the amount of the Bay bottom that is disturbed as a result of the borrow material dredging.

- Depth of Water Beneath Site. The depth of water affects the construction cost for the containment dikes and the available placement capacity. Depths between 8 and 10 ft below MLLW are considered ideal. Depths greater than 10 ft increase the cost of dike construction and armor stone placement (because of the trapezoidal shape of the dikes) even though the site capacity increases. Depths less than 5-ft could also increase the cost of stone placement if there is a need to dredge an access channel along the exterior toe of the dike to accommodate the draft of the loaded stone barges. Decreasing the quantity of stone per barge (light loading) to accommodate depths less than 5-ft would also increase the cost of stone placement because it would increase the overall number of barge trips.

- Length of Access Channel. Placement of dredged material within the site requires an access channel between deeper water (elevation –25 ft MLLW) and the project. The cost of the initial construction and the maintenance of the channel is directly proportional to the channel length.

- Armor Stone Size. The largest component of the initial construction cost is associated with the armor stone used to protect the submerged portion of the sand perimeter dike from erosion and wave activity. Larger stone size results in greater stone quantities associated with greater armor thickness. The required stone size is associated with the exposure to greater wave energy, which is governed by the depth of water, fetch, and orientation of the dike alignment relative to dominant wind directions. The alignments with proportionally less western, southwestern, and northwestern exposure would generally require smaller armor stone size.

The engineering criteria do not all carry the same level of importance. Those factors associated with the source and quality of borrow materials for dike construction are critical with respect to initial construction cost and potential environmental impacts. Therefore, each criterion was ranked on a scale of 1 (least important) to 3 (most important) in the following order: borrow material quantity & quality (3); borrow material location (3); capacity (2); foundation material (2); depth of water (2); access channel length (2); size (1); and armor stone size (1).

Table 4-5 summarizes the scoring, weighting, and ranking of the alignments for engineering suitability. (See Appendix A for more detailed explanations of the criteria, the scoring of the alignments, and the weighting of the criteria). Alignments 6 and 7 received the highest score and were ranked 2 and 1, respectively. Both of these sites are located to the north of the existing project where foundation conditions and borrow sources are the most favorable.

Agency Concerns and Public Comments

Public comments on the expansion study alignments were solicited at the following public meetings in 2004:

• Kent Island	January 12
• Tilghman Island	January 15
• Regional Watermen	March 3
• Coastal Conservation Association	April 26
• Maryland Saltwater Sportsmen	June 1
• Carroll County Maryland Saltwater Sportsmen	June 15
• Maryland Charter Boat Captains Association	July and August
• Tilghman Island	October 6
• Maryland Watermen's Association	November 16
• DMMP Citizens' Advisory Committee	Bi-monthly

The concerns raised by the public included:

- Impacts to local aesthetics from the island expanding further north, south, or east toward the mainland or expanding vertically.

Table 4-5. Engineering Suitability Scores

		ALIGNMENT 1			ALIGNMENT 2			ALIGNMENT 3			ALIGNMENT 4			ALIGNMENT 5			ALIGNMENT 6			ALIGNMENT 7		
Criterion	**WF***	**Data**	**RS***	**WS***	**Data**	**RS**	**WS**	**Data**	**RS**	**WS**	**Data**	**RS**	**WS**	**Data**	**RS**	**WS**	**Data**	**RS**	**WS**	**Data**	**RS**	**WS**
Expansion Size (ac)	1	750	3	3	750	3	3	750	3	3	1120	4	4	750	3	3	313	2	2	630	3	3
Expansion Capacity (mcy)	2	26.8	3	6	26.8	3	6	26.8	3	6	41.6	4	8	26.8	3	6	11.6	1	2	23.2	3	6
Dike Foundation Material	2	Sandy silt & clay—fair to poor	2	4	Sandy silt & clay—fair	2.5	5	Sandy silt & clay—fair	2.5	5	Sandy silt & clay—fair	2.5	5	Sandy silt & clay—fair	2.5	5	Silty sand & clay—fair to good	3.5	7	Silty sand—good	4	8
Borrow Material Quantity & Quality	3	Fair/ mixed	2.5	7.5	Fair/ mixed	2	6	Fair/ mixed	3	9	Fair/ mixed	3	9	Fair/ mixed	2.5	7.5	Good	4	12	Very good	4.5	13.5
Borrow Material Location (percent inside footprint)	3	100	5	15	< 20	1	3	70	2	6	70	2	6	100	5	15	100	5	15	100	5	15
Depth of Water Beneath Site (ft)	2	0-10	3	6	0-10	3	6	0-10	3	6	0-10	3	6	0-10	3	6	0-10	3	6	0-10	3	6
Length of Access Channel (mi)	2	0.5-1.0	3	6	0.5-1.0	3	6	0.5-1.0	3	6	0.5-1.0	3	6	0.5-1.0	3	6	< 0.5	5	10	< 0.5	5	10
Armor Stone Size (lb)	1	1500-3000	3	3	1500-4000	2	2	1500-4000	2	2	1500-4000	2	2	1500-4000	2	2	1500-4000	2	2	1500-4000	2	2
Total Weighted Score				**44.5**			**40**			**43**			**46**			**47.5**			**56**			**63.5**
Ranking				**5**			**7**			**6**			**4**			**3**			**2**			**1**

******WF** *= weighting factor*
RS *= raw score; scores range from 1 to 5, with 5 indicating the optimal conditions for a given criterion*
WS *= weighted score*

- Noise and light impacts from extended construction.
- Loss of crabbing areas to the south and crabbing, clamming, and pound netting areas to the north and east of the existing island.
- Loss of clamming bottom to the south of the existing island.
- Navigation to the north and south of the island.

State and Federal resource agencies participated in the PDT meetings and the BEWG meetings and have been consulted, both formally and informally, throughout the study. In addition, the expansion project was presented at Poplar Island Working Group Meetings (May 25 and November 5, 2004) and at numerous Federal and State DMMP, CAC, and BEWG meetings (Appendix F). The USACE held a meeting with NMFS and USEPA on December 15, 2004 and with the USFWS on January 21, 2005. Issues of concern to the agencies were discussed and included:

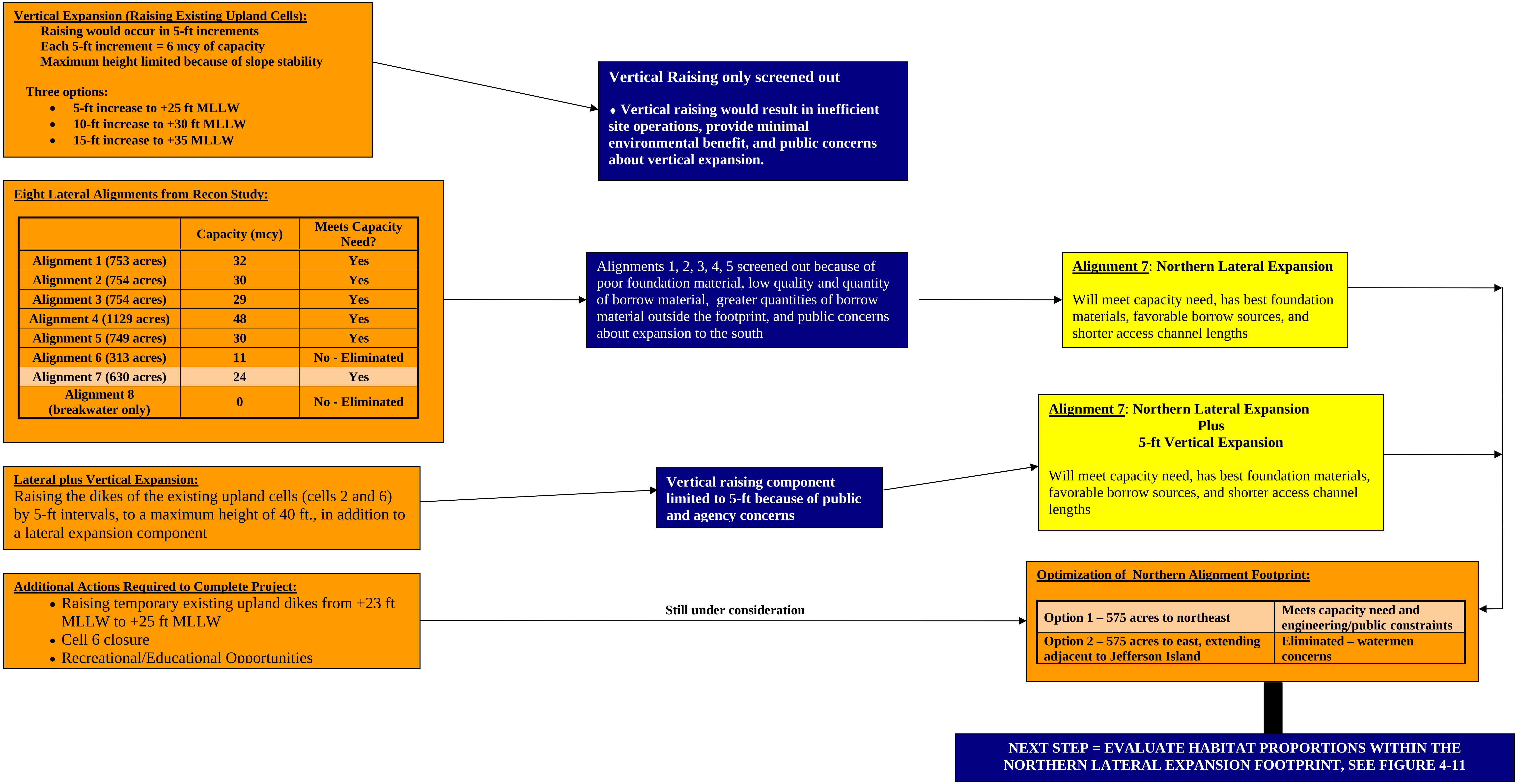
• National Marine Fisheries Service	-Loss of benthic habitat south of the existing island -Loss of open water, shallow water habitat, and EFH -Loss of commercial shellfish harvesting areas
• Maryland Department of Natural Resources	-Loss of open water and shallow water habitat -Protection of oyster beds from sedimentation during channel dredging, sand mining, and dike construction
• USEPA – Region III	-Loss of open water and shallow water habitat
• USFWS	-Loss of habitat quality associated with dike raising

<u>4.5.2.c Selection of Alignment for Detailed Analysis</u> After consideration of each screening criterion, it was determined that the engineering criteria and the public/agency concerns were the most important criteria for the restoration project. The screening process for the lateral and vertical alignments is shown in Figure 4-6.

Alignments 1, 2, 3, 4, 5 were screened out as a result of a combination of factors, including comparatively poor foundation materials, low quality and quantity of borrow material, greater quantities of the borrow material were located outside the project footprint, and public concerns that expansion to the south would encroach upon regions heavily utilized by the watermen.

The two northern alignments, Alignments 6 and 7, rated highest after screening for the following reasons:

- Initial input indicated that the northern alignments avoid areas of heavy regional watermen's usage to the south of PIERP.
- The northern alignments have the most favorable foundation material for construction of containment dikes (Appendix A, Attachment E).



Vertical Expansion (Raising Existing Upland Cells):

Raising would occur in 5-ft increments
Each 5-ft increment = 6 mcy of capacity
Maximum height limited because of slope stability

Three options:

- **5-ft increase to +25 ft MLLW**
- **10-ft increase to +30 ft MLLW**
- **15-ft increase to +35 MLLW**

Vertical Raising only screened out

♦ Vertical raising would result in inefficient site operations, provide minimal environmental benefit, and public concerns about vertical expansion.

Eight Lateral Alignments from Recon Study:

	Capacity (mcy)	Meets Capacity Need?
Alignment 1 (753 acres)	32	Yes
Alignment 2 (754 acres)	30	Yes
Alignment 3 (754 acres)	29	Yes
Alignment 4 (1129 acres)	48	Yes
Alignment 5 (749 acres)	30	Yes
Alignment 6 (313 acres)	11	No - Eliminated
Alignment 7 (630 acres)	24	Yes
Alignment 8 (breakwater only)	0	No - Eliminated

Alignments 1, 2, 3, 4, 5 screened out because of poor foundation material, low quality and quantity of borrow material, greater quantities of borrow material outside the footprint, and public concerns about expansion to the south

Alignment 7: Northern Lateral Expansion

Will meet capacity need, has best foundation materials, favorable borrow sources, and shorter access channel lengths

Lateral plus Vertical Expansion:
Raising the dikes of the existing upland cells (cells 2 and 6) by 5-ft intervals, to a maximum height of 40 ft., in addition to a lateral expansion component

Vertical raising component limited to 5-ft because of public and agency concerns

Alignment 7: Northern Lateral Expansion
Plus
5-ft Vertical Expansion

Will meet capacity need, has best foundation materials, favorable borrow sources, and shorter access channel lengths

Additional Actions Required to Complete Project:

- Raising temporary existing upland dikes from +23 ft MLLW to +25 ft MLLW
- Cell 6 closure
- Recreational/Educational Opportunities

Still under consideration

Optimization of Northern Alignment Footprint:

Option 1 – 575 acres to northeast	Meets capacity need and engineering/public constraints
Option 2 – 575 acres to east, extending adjacent to Jefferson Island	Eliminated – watermen concerns

NEXT STEP = EVALUATE HABITAT PROPORTIONS WITHIN THE NORTHERN LATERAL EXPANSION FOOTPRINT, SEE FIGURE 4-11

Figure 4-6. Screening Process for the Poplar Island Expansion Study – Vertical and Lateral Expansion Components

- The northern alignments have sufficient sand borrow within their footprints and access channels (Appendix A, Attachment A).
- The access channel for the northern alignments would be shorter than those required for southern areas and would generate a relatively high proportion of excavation material that could be used in dike construction.
- The northern alignment provides additional protection for Poplar Harbor and Jefferson Island.

Next, Alignment 6 was screened out because it did not efficiently meet the capacity needs (approximately 20-30 mcy) of the expansion project (Table 4-5). Therefore, Alignment 7, with a capacity of 24 mcy, good foundation material, a favorable borrow location within the footprint of the project, sufficient quantity and quality of available borrow material, and a shorter access channel length was selected as the most favorable option for the lateral expansion.

4.5.3 Lateral Expansion plus Vertical Expansion

In combination with lateral expansion, vertical expansion could allow for an increase in total environmental benefits by increasing the percentage of the lateral expansion that could be allocated as wetlands and would increase the potential of realizing maximum wetland benefit. Based on geotechnical analyses (Appendix A, Attachment C), the maximum raising is approximately 15 ft, which would provide 17 to 18 mcy, and about five to six additional years of placement life for the existing project. In theory, the additional upland capacity might allow an expansion area to be devoted to a higher percentage of wetland habitat while still satisfying efficient placement criteria. However, since it not desirable to obtain extensive borrow materials from wetland cells, there is a minimum percentage of each lateral expansion alignment that should be designated as upland since borrow materials can be obtained from under proposed upland cells. In addition, the upland cells provide greater dredged material capacity per acre than wetland cells.

Because of the public concerns about the vertical expansion, and because the vertical expansion alone would provide only minimal environmental benefits to the overall expansion project, USACE decided to limit any vertical expansion component to a 5-ft raising of the existing upland cells (to final design height of +25 ft MLLW, temporary dike height of +30 ft MLLW). Raising the existing upland dikes by 5 ft would provide an additional six mcy of placement capacity. At an average annual placement rate of 3.2 mcy per annum, the additional capacity from the vertical expansion would add approximately two additional years to the upland placement capacity. This increase in placement duration is a function of the height of the dike raising and is independent of the size of the lateral expansion alignment. The additional two years would provide a significant additional contingency that might be needed to recover from extreme weather conditions that prevent cell grading, or a slower rate of consolidation of thicker dredged material layers within some of the proposed wetland cells within either the existing PIERP or the lateral expansion.

4.5.4 Results of the Screening Process for Expansion Options

Based on the screening process, and with consideration of the environmental and engineering constraints identified at the initiation of the study (avoid NOBs, SWH, deep water, provide protection to Poplar Harbor, provide capacity, borrow as much as possible within footprint, remain consistent with existing project), two preliminary options remained for the expansion (Figure 4-6):

1. A northern lateral expansion only (alignment 7), and
2. A northern lateral expansion (alignment 7) plus a vertical expansion (consisting of a 5-ft raising of the existing upland cells).

The engineering analysis (Appendix A) recommended that the entire area north of the project, consisting of approximately 1,000 acres bounded by the existing oyster bars to the west, north, and east, be included for consideration of any expansion alignment. Additional engineering, environmental (EA, 2005a), and cultural investigations (RCG&A, 2005 and 2004) of the entire area were conducted so that the optimal location and size for the expansion alignment could be determined (see chapter 3).

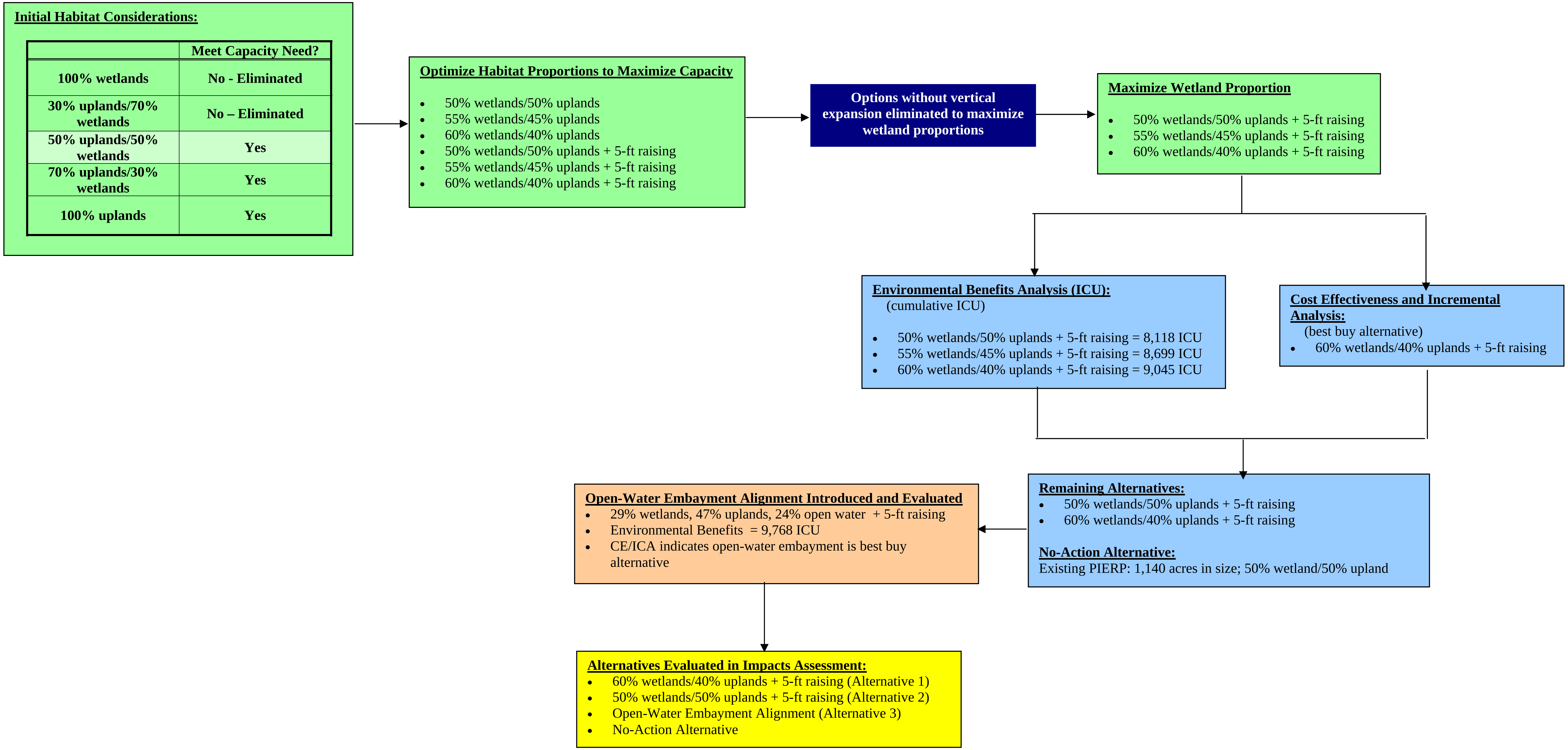
4.6 OPTIMIZATION OF THE HABITAT PROPORTIONS FOR EXPANSION

Through the development of the lateral expansion alignment footprint, a 50 percent wetland, 50 percent upland ratio was assumed, so that the lateral expansion would be consistent with the existing project. Once the essential size features of the lateral expansion alignment were determined, multiple variations of the wetland to upland habitat proportion within the footprint were evaluated to determine the most suitable proportion that would most adequately achieve the project goals (Figure 4-7).

The 630-acre northern alignment (Alignment 7) was analyzed for the full range of theoretically possible upland and wetland habitat proportions. The 630-acre alignment was considered the maximum footprint practical for the northern area based on the known environmental constraints, namely avoiding the NOBs to the north, northwest, and east of the existing project.

4.6.1 Initial Habitat Screening

The initial screening involved evaluating habitat diversity within the lateral expansion to optimize the balance between maximum placement volume (100 percent uplands) and maximum habitat value (100 percent wetlands). Based on the observation from the existing PIERP that maintaining a wetland development pace of two cells per year would be extremely optimistic, the analysis was performed assuming wetland cell development at the rate of one cell per year. A range of wetland components that theoretically could be developed, ranging



Initial Habitat Considerations:

	Meet Capacity Need?
100% wetlands	No - Eliminated
30% uplands/70% wetlands	No – Eliminated
50% uplands/50% wetlands	Yes
70% uplands/30% wetlands	Yes
100% uplands	Yes

Optimize Habitat Proportions to Maximize Capacity

- 50% wetlands/50% uplands
- 55% wetlands/45% uplands
- 60% wetlands/40% uplands
- 50% wetlands/50% uplands + 5-ft raising
- 55% wetlands/45% uplands + 5-ft raising
- 60% wetlands/40% uplands + 5-ft raising

Options without vertical expansion eliminated to maximize wetland proportions

Maximize Wetland Proportion

- 50% wetlands/50% uplands + 5-ft raising
- 55% wetlands/45% uplands + 5-ft raising
- 60% wetlands/40% uplands + 5-ft raising

Environmental Benefits Analysis (ICU):
(cumulative ICU)

- 50% wetlands/50% uplands + 5-ft raising = 8,118 ICU
- 55% wetlands/45% uplands + 5-ft raising = 8,699 ICU
- 60% wetlands/40% uplands + 5-ft raising = 9,045 ICU

Cost Effectiveness and Incremental Analysis:
(best buy alternative)

- 60% wetlands/40% uplands + 5-ft raising

Remaining Alternatives:

- 50% wetlands/50% uplands + 5-ft raising
- 60% wetlands/40% uplands + 5-ft raising

No-Action Alternative:
Existing PIERP: 1,140 acres in size; 50% wetland/50% upland

Open-Water Embayment Alignment Introduced and Evaluated

- 29% wetlands, 47% uplands, 24% open water + 5-ft raising
- Environmental Benefits = 9,768 ICU
- CE/ICA indicates open-water embayment is best buy alternative

Alternatives Evaluated in Impacts Assessment:

- 60% wetlands/40% uplands + 5-ft raising (Alternative 1)
- 50% wetlands/50% uplands + 5-ft raising (Alternative 2)
- Open-Water Embayment Alignment (Alternative 3)
- No-Action Alternative

Figure 4-7. Plan Formulation Process for the Poplar Island Expansion Study – Optimizing Wetland/Upland Habitat Proportions within the Lateral Northern Alignment (Prior to Open-Water Embayment)

from 0 to 100 percent wetlands, was evaluated. An initial sequence of five habitat proportions were evaluated (Appendix A, Attachment C):

- 100 percent uplands
- 70 percent uplands, 30 percent wetlands
- 50 percent uplands, 50 percent wetlands
- 30 percent uplands, 70 percent wetlands
- 100 percent wetlands

A northern lateral alignment that consisted of 100 percent or 70 percent uplands would meet the capacity needs, but would not add significant environmental benefit to the ecosystem restoration project since the majority of environmental benefits are associated with the wetland cells (Figure 4-8). In addition, informal consultation with resource agencies indicated that a minimum of 50 percent wetland habitat would need to be incorporated into the lateral expansion. Therefore, a 50 percent wetland habitat proportion was used as the lower limit of wetland habitat in the design of the northern lateral expansion.

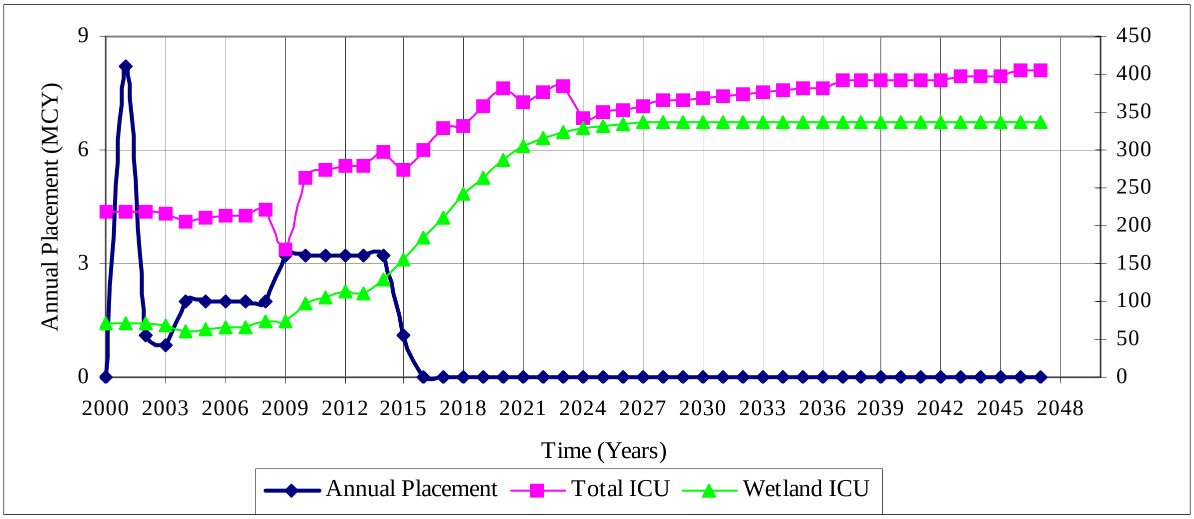


Figure 4-8. PIERP Annual Dredged Material Placement

The conclusion of the initial placement evaluation was that any expansion site consisting entirely of wetland habitat was not feasible because of the quantity limitations. For a 630-acre lateral expansion consisting of 100 percent wetland habitat where wetland cells are developed at a rate of one cell per year, wetland placement would extend 17 years beyond the date when upland capacity would be exhausted. This would result in an exceptionally inefficient and costly dredged material placement operation, and the 100 percent wetland option was screened out of the evaluation.

However, to determine the upper limit of wetland habitat that would be consistent with efficient dredged material placement additional evaluation was needed.

The 630-acre northern alignment (Alignment 7) was next evaluated for a lateral expansion consisting of 30 percent upland and 70 percent wetland habitat, where wetland cells are developed at the rate of one cell per year. The results of that analysis indicated that wetland placement would extend seven years beyond the date when upland capacity would be exhausted. Therefore, an expansion site consisting of 70 percent wetlands was also considered unfeasible, and screened out of the evaluation.

The 630-acre northern alignment (Alignment 7) was evaluated for a lateral expansion consisting of 40 percent upland and 60 percent wetland habitat, where wetland cells are developed at the rate of one cell per year. The results of that analysis indicated that wetland placement would extend four years beyond the date when upland capacity would be exhausted. Therefore, an expansion site consisting of 60 percent wetlands was considered to represent the *upper limit* of wetland proportions that might be achieved. Achieving this upper limit of 60 percent wetland would be dependent on the realization of additional upland placement capacity by raising the existing upland cells or by efficient placement of borrow sites within upland cell limits.

Based on the placement analysis and after the initial screening process for the habitat proportions, two wetland to upland ratios remained:

1. 50 percent wetland, 50 percent upland, and
2. 60 percent wetland, 40 percent upland.

To fully characterize the implications of the variable wetland to upland ratios, USACE added an evaluation of a third option: 55 percent wetland, 45 percent upland.

4.6.2 Maximizing Wetland Proportions

Maximizing the wetland proportion within the lateral expansion alignment is an important component of the habitat restoration project because wetlands provide a greater environmental benefit for remote island habitats, as compared to uplands. Environmental benefits from the proposed expansion increase as the percentage of wetlands for the project increases, since the wetlands provide the majority of the environmental benefits incorporated into the calculation. Figure 4-8 shows the relative contribution of the wetlands for the existing PIERP (50 percent wetlands, 50 percent uplands), based on the calculated Island Community Units (ICU) (see Section 4.8.1 and Appendix H for methodology).

The size of the wetlands areas was constrained by the minimum necessary to achieve environmental goals (50 percent) and the maximum possible for efficient operation of the site (approximately 60 percent). Higher proportions of wetlands result in very inefficient placement of very small quantities of dredged material after the upland portion of the placement site has been filled to capacity. The placement analyses indicated that lateral expansion only could marginally support 50 percent, and possibly 55 percent, wetlands without raising the existing upland cells, but could not support 60 percent wetland habitat (Appendix A, Attachment C).

However, with the 5-ft dike raising, both the 50 percent and 55 percent wetland schemes go from marginally acceptable schemes to well supported schemes, and the 60 percent wetland scheme also well supports the needed operational flexibility. Raising the existing upland cells five feet, from +20 to +25 ft MLLW, increases the upland placement capacity by approximately six mcy for each of the three raising schemes—the equivalent of almost two additional years of placement. That additional two years significantly increase the probability of successfully completing the wetland placement and cell development. Not only can the placement be completed in accordance with efficient placement methods, but the ability to accommodate difficulties during placement and cell development is enhanced.

4.7 OPTIMIZATION OF NORTHERN LATERAL EXPANSION FOOTPRINT

The next step in the plan formulation process was to optimize the 630-acre northern lateral expansion defined in the reconnaissance studies (Alignment 7) to mutually provide the maximum amount of capacity and greatest environmental benefit that could be supported by efficient site operations.

As indicated in the Engineering Suitability portion of Section 4.5.2.b, lateral expansion alignments with areas between 400 and 1,000 acres and additional capacity in the range of 20 to 30 mcy will satisfy minimum capacity requirements. The engineering analyses (Appendix A, Attachment C) concluded that the recommended expansion alternative should be a minimum of 500 acres in size to accommodate average annual dredged material placement needs of approximately 3.2 mcy, and that the expansion site should consist of a minimum 50 percent wetland habitat. At 50 percent wetlands, a 500 to 600 acre expansion site was determined to be *marginally* acceptable with respect to: (1) its capacity to accommodate required annual dredged material placement, and (2) its capacity to provide sufficient dike fill material for dike construction from borrow sources located within the footprint of the upland cells of the expansion. This marginal status can be improved by either reducing the wetland component below 50 percent of the total area – an option that is not consistent with the PIERP authorization and reduces the overall environmental benefits of the project – or by raising the existing upland dikes to increase the upland placement capacity.

Therefore, based on engineering analysis and best engineering judgment, a proposed alignment consisting of approximately 575 acres was developed within a Study Area north of the existing project. To support a potential increase in the wetland proportion of the lateral expansion and to assure optimum development of the wetlands in the existing PIERP, a 5-ft vertical expansion component (of the existing upland cells) was also incorporated into the analysis.

Preliminary subsurface information suggested that very soft deep deposits of silt and clay located along the western limits of the northern Study Area should be avoided, if possible (Figure 4-9). Subsurface information also indicated that the primary source of borrow sand for dike construction was located along the eastern side of the Study Area (Figure 4-10). Therefore, the upland portion of the expansion area was located on the eastern half of the alignment. Because of the lateral expansion's exposure to high wave energy to the west, north, and northeast, it was considered unlikely that wetland cells would be opened directly to

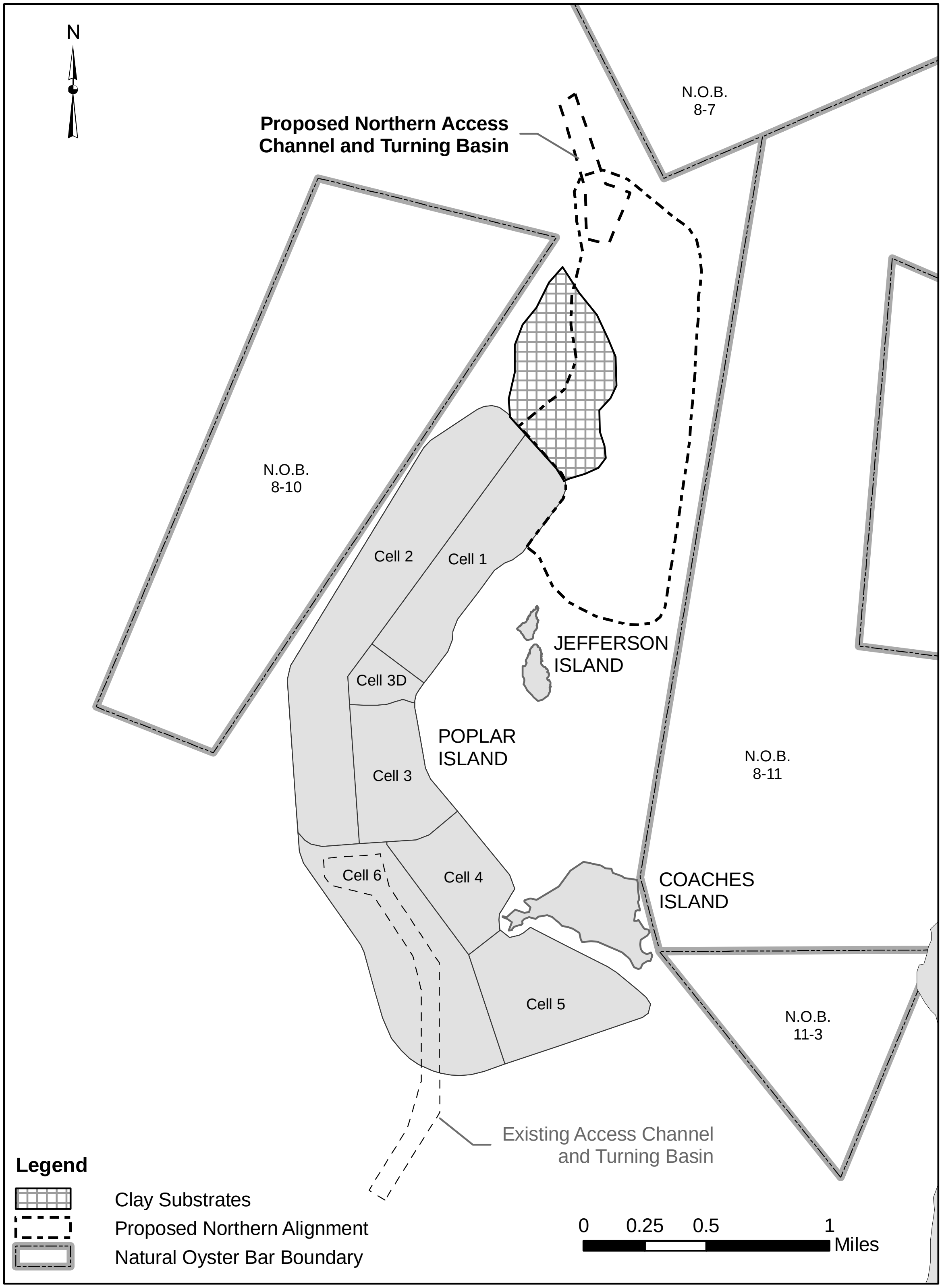


Figure 4-9. Location of Clay Substrates at Poplar Island

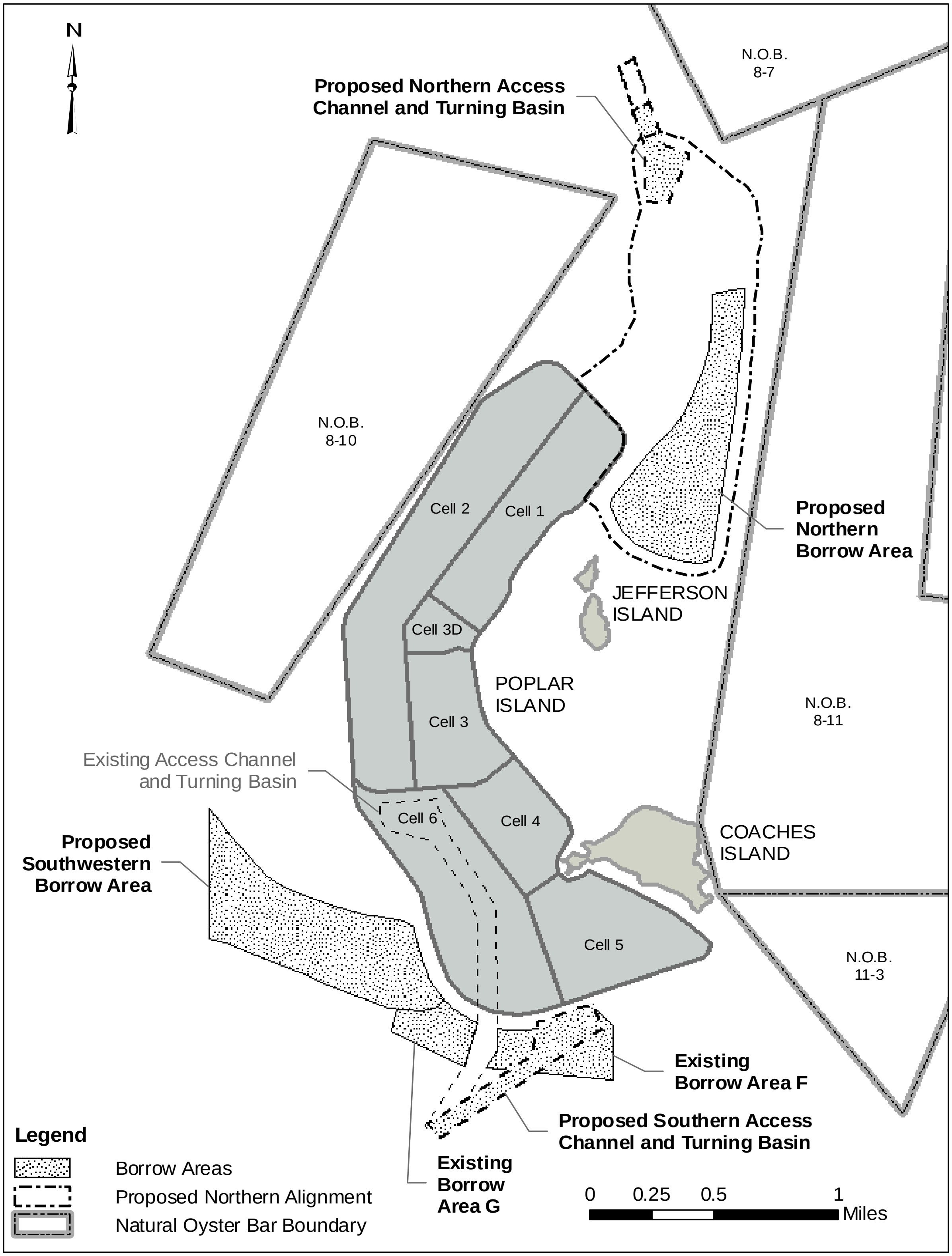


Figure 4-10. Location of Existing and Proposed Borrow Areas and Proposed Access Channels

the Bay as they will be in the existing PIERP (as planned, the perimeter dikes of the wetland cells for the existing PIERP will eventually be breached, allowing free tidal flow and exchange with the Bay to support wetland function). Therefore, the lateral expansion configuration included a 25-acre tidal gut to supply the water needed for tidal flushing of wetland cells. Excluding this tidal gut, the lateral expansion area available for dredged material filling is approximately 550 acres.

4.7.1 Northern Alignment Option 1

A 575-acre northern alignment (Option 1) of 550-acres with a 50 percent wetlands, 50 percent upland ratio and a 25-acre tidal gut to facilitate water exchange within the wetland cells (Figure 4-11) was developed. This alignment was presented at the public meeting at Tilghman Island on October 6, 2004 (Appendix G). Local watermen present at the public meeting requested that the alignment be shifted more to the south to reduce transit time around the PIERP and to avoid areas utilized for crab harvesting.

4.7.2 Northern Alignment Option 2

A second option for a northern alignment (Option 2) was developed to address the watermen's concern. For this option, two of the wetland cells were moved to the southern portion of the lateral expansion alignment, adjacent to Jefferson Island (Figure 4-11). A second tidal gut was incorporated into this lower portion of wetland cells. The upland cells remained in approximately the same location, on top of the sand borrow locations. Moving the wetlands cells to the south also increased the length of the northern access channel. Both this option and the first option were presented at a meeting with the watermen at Tilghman Island on November 16, 2004 (Appendix G). The watermen requested that the second option be removed from consideration because it encroached on harvesting areas to the east of Jefferson Island that are used for a longer duration during the crabbing season compared to some of the areas in the deeper waters to the north.

4.7.3 Placement Analysis for the Northern Lateral Alignment

Based on previous analysis and engineering judgment, dredged material placement analyses were performed for six variations related to the 575-acre northern alignment (550 placement acres plus the 25-acre tidal gut). The six schemes included:

1. 50 percent wetlands without raising of existing uplands
2. 55 percent wetlands without raising of existing uplands
3. 60 percent wetland without raising of existing uplands
4. 50 percent wetlands with 5-foot raising of existing uplands
5. 55 percent wetlands with 5-foot raising of existing uplands
6. 60 percent wetland with 5-foot raising of existing uplands

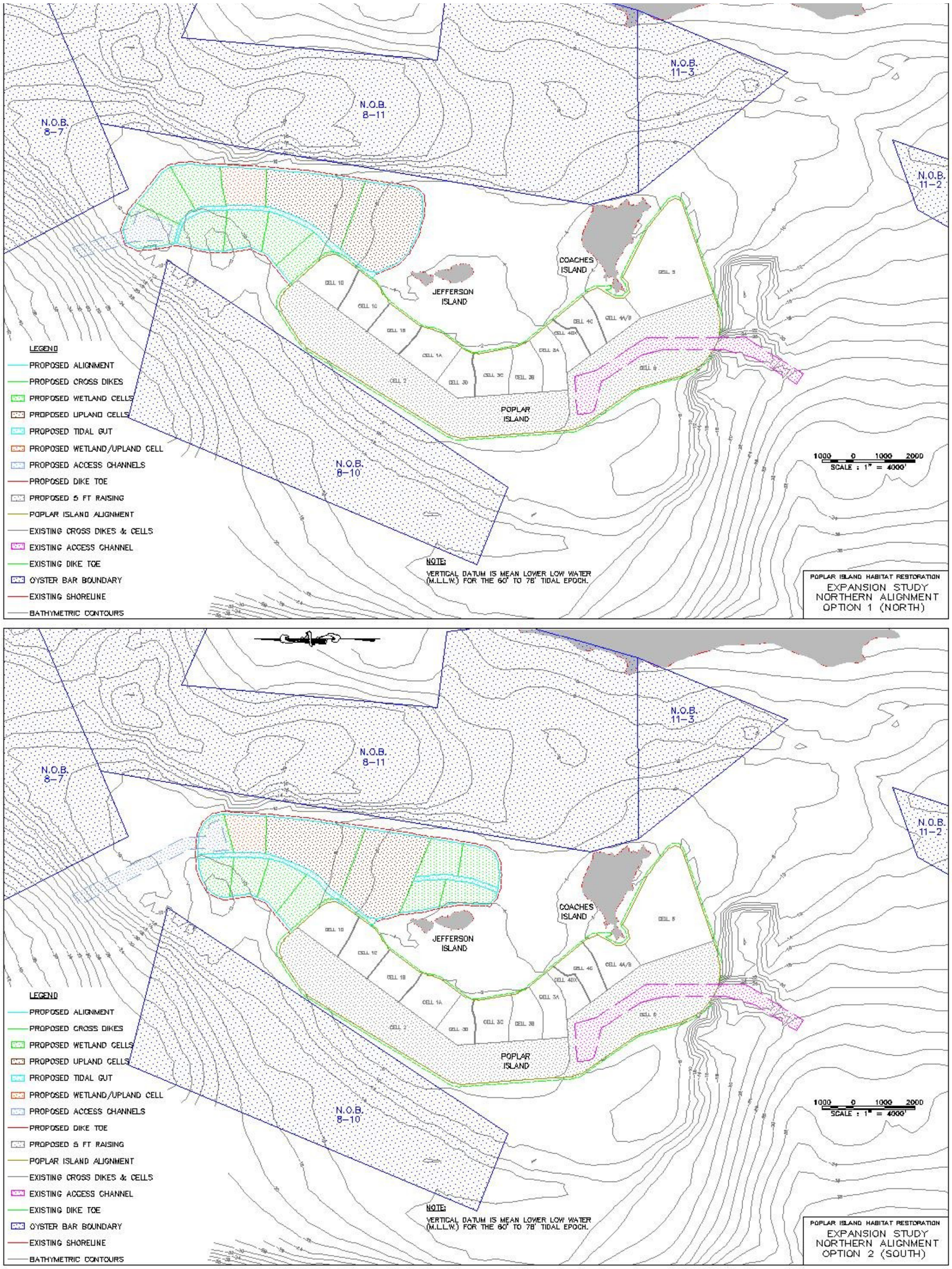


Figure 4-11. Northern Alignment Options Considered During Screening Process

In all cases, the final average elevation of the uplands associated with the lateral expansion was +20 ft MLLW, and the average final elevation of the raised uplands of the existing project was +25 ft MLLW. Total capacity of the entire project (existing plus expansion) for each of these six options is provided in Table 4-6.

Table 4-6. Capacity and Lifetime Evaluation of Northern Alignment Schemes

Alternative	Total Upland Area (ac)*	Total Upland Capacity (mcy)	Total Wetland Area (ac)	Total Wetland Capacity (mcy)	Total Site Capacity (mcy)	Last Year 3.2 mcy Placed	Last Year Wetland Inflow	Last Year of Inflow into Site**
Existing 1140-ac project	570.0	32.6	570.0	7.8	40.4	2014	2014	2015
Northern expansion with 50 percent wetlands (no raising)	844.0	49.0	832.0	15.5	64.5	2021	2021	2022/2027
Northern expansion with 55 percent wetlands (no raising)	816.5	47.3	859.5	16.3	63.6	2020	2021	2022/2027
Northern expansion with 60 percent wetlands (no raising)	804.0	46.5	872.0	16.9	63.4	2020	2021	2021/2026
Northern expansion with 50 percent wetlands + 5-ft raising	844.0	55.0	832.0	15.5	70.5	2021	2021	2022/2027
Northern expansion with 55 percent wetlands + 5-ft raising	816.5	53.3	859.5	16.3	69.6	2021	2021	2022/2027
Northern expansion with 60 percent wetlands + 5-ft raising	804.0	52.5	872.0	16.9	69.4	2022	2021	2023/2027

**Note: The totals for schemes 1 through 6 are the sum of existing project and proposed expansion.*

***Note: The second year reflects the potential development of the sheltered dredged material offloading facilities that may be recovered as a wetland cell, or may be left as an open cell.*

At 50 percent wetlands, placement of dredged material within the expansion wetland cells requires approximately 11 years. The upland cells are filled to capacity in 12 years, with the final year accommodating less than 0.60 mcy. At 55 percent wetlands, the upland capacity in the twelfth year decreases to only about 0.32 mcy. At 60 percent wetlands, upland capacity is reached in the eleventh year, concurrent with the final year of wetland placement, and there is no contingency to deal with difficult placement or development of wetland cells.

4.7.4 Borrow Quantity Needed to Support Northern Alignment Options

The volume of borrow material available within the alignment footprint and the access channel for each option was compared to the volume of material required for dike construction (Table 4-7). The volume required was estimated at 1.75 times the dike volume to account for loss of fines during dredging and unsuitable material found in the borrow area. Although the USACE typically prefers to identify borrow areas with 2.0 times the quantity of material required, the extremely high quality sand deposits in the northern Study Area should result in a decreased loss of fines during dredging, and they should provide superior engineering properties for dike construction. Therefore, a borrow factor of 1.75 was considered acceptable for the expansion site provided that dike construction is accomplished by stockpiling and mechanical placement, as has been used to construct the dikes for the existing PIERP.

Table 4-7. Analysis of Borrow Quantities for Northern Alignment Options

Option	Dike Volume (mcy)	Gross Borrow Volume Available within Footprint & Access Channel (mcy)	Net Borrow Volume Available within Footprint & Access Channel[a] (mcy)	Net Borrow Volume Required from Outside (mcy)	Gross Borrow Volume Required from Outside[b] (mcy)
1. Northern expansion with 50 percent wetlands (no raising)	3.3	5.7	3.3	0	0
2. Northern expansion with 55 percent wetlands (no raising)	3.3	5.4	3.1	0.2	0.4
3. Northern expansion with 60 percent wetlands (no raising)	3.3	5.2	3.0	0.3	0.6
4. Northern expansion with 50 percent wetlands + 5-ft raising	3.7	5.7	3.3	0.4	0.8
5. Northern expansion with 55 percent wetlands + 5-ft raising	3.7	5.4	3.1	0.6	1.2
6. Northern expansion with 60 percent wetlands + 5-ft raising	3.7	5.2	3.0	0.7	1.4

[a] *After losses during dredging and unsuitable material; calculated by dividing gross volume by borrow factor of 1.75*

[b] *To account for losses during dredging and unsuitable material; calculated by multiplying net volume by borrow factor of 2.0 (higher borrow factor to allow for less suitable material expected in borrow areas outside of the northern Study Area).*

This analysis shows that borrow material may have to be obtained from outside the footprint or the access channel for each option except option 1. The two most likely sources are the borrow area to the southwest of existing Cell 6 (Figure 4-10) and sand obtained from required dredging of the shipping channels. The southwest borrow area is estimated to contain approximately 4.2 mcy of sand suitable for dike construction (GBA, 2003). The area would also be used as a source of materials for activities required to complete the existing project: closure of the opening at the south end of Cell 6 of the existing PIERP and raising of the Cell 6 temporary dikes to +25 ft MLLW. However, based on the subsurface investigations (Appendix A, Attachment E) the southwest borrow area can accommodate the borrow requirements for both the completion of the existing project and the raising of the upland cells associated with the expansion project (Table 4-8).

Table 4-8. Borrow Requirements for Completion of Existing Project

Project Feature	Borrow Source	Borrow Yield (mcy)	Borrow Area Disturbed (acres)
Cell 6 Closure	South Access Channel & Basin	0.6	28
Cell 6 Dike Raising to +23	Southwest Borrow Area	0.9	54
Cell 4 Restoration	Southwest Borrow Area	0.6	38
Misc. Cell Development	Southwest Borrow Area	0.4	27
TOTALS		**2.5**	**147**

Following the evaluation of options for raising the existing upland elevation, increasing the size of the wetlands, and an analysis of dredged material placement for the six options for the 575-acre northern alignment, an environmental benefits analysis and incremental cost analysis was performed for the six options as discussed in the following sections.

4.8 SCREENING OF EXPANSION HABITAT PROPORTIONS

To optimize the wetland/upland proportion relative to environmental benefits, cost, and site operations, an environmental benefits analysis and a cost effectiveness/incremental cost analysis (CE/ICA) were used to evaluate each of the six options (Figure 4-7).

4.8.1 Environmental Benefits

The PIERP is a habitat restoration project unique within the Chesapeake Bay. To adequately evaluate the outputs of the proposed expansion project, it was necessary to re-evaluate and re-design the method used to quantify the environmental benefits (outputs) of both the existing project and the proposed expansion options. At the start of the project it was decided that individual species would not be used to quantify environmental benefits, but rather the fish and wildlife communities that would inhabit the island ecosystems. (For purposes of this analysis, ‘community’ and ‘guild’ are used interchangeably to describe a group of interacting animals that utilize the resources of a given habitat in a similar way.) The method, developed by USACE-Baltimore with input from a working group involving resource agency representatives, calculates Island Community Units (ICUs) to quantify environmental benefits (with a focus on animal communities) over the life of the restoration project. This restoration measurement was reviewed and approved by the BEWG, and was also employed in the Mid-Chesapeake Bay Island Ecosystem Restoration Feasibility Study. Environmental benefits of fully developed (graded and planted) cells, in addition to interim environmental benefits realized during dredged material placement, were included in the analysis for the six schemes for the lateral expansion options:

1. 50 percent wetland, 50 percent upland without raising of existing uplands
2. 55 percent wetland, 45 percent upland without raising of existing uplands
3. 60 percent wetland, 40 percent upland without raising of existing uplands
4. 50 percent wetland, 50 percent upland with 5-foot raising of existing uplands,
5. 55 percent wetland, 45 percent upland with 5-foot raising of existing uplands
6. 60 percent wetland, 40 percent upland with 5-foot raising of existing uplands

Environmental benefits for each of six expansion options were calculated and used in the cost effectiveness (CE) and incremental cost analysis (ICA) analysis (see Section 4.8.2).

4.8.1.a Methods

Step 1: Habitat Types and Workgroup Development
The Mid-Chesapeake Bay Island Project plan formulation group determined by consensus to focus on four habitat types that would be constructed as part of large island restoration: upland, high marsh, low marsh, and intertidal/mudflats. This approach was then applied to the Poplar Island expansion study. Table 4-9 provides the areal distribution of habitat types for the six options analyzed. Uplands are primarily important to the island ecosystem because of the nesting habitat they provide for colonial waterbirds (unvegetated) and colonial wading birds (vegetated). During PIERP plan formulation, it was recognized that low marsh has greater primary productivity than high marsh, and that low marsh would provide additional habitat for fish and benthic invertebrates. Because of the value of the low marsh habitat and the large amounts of low marsh lost to erosion throughout the Chesapeake Bay region, an approximate distribution of 80 percent low marsh to 20 percent high marsh was agreed upon for the habitat development of PIERP. The 80 percent low marsh to 20 percent high marsh distribution was incorporated into the plan formulation process for the lateral expansion.

Expansive mudflats/intertidal areas no longer exist in the Chesapeake Bay system and are thought to have been historically rare because of the low tidal range of the Chesapeake Bay system. However, mudflats created intermittently during dredged material placement at PIERP are extensively used as foraging habitat by a large variety of bird species. Because of their recognized value, mudflats are an important component of the created habitats of a large island restoration project. The plan formulation group agreed to include mudflats/intertidal acreage as approximately 10 percent of the low marsh acreage for formulation.

Table 4-9. Potential Distribution (in acres) of Habitat Types for Expansion Study Options

Expansion Option	Upland	Wetland	Number of bird islands (3 acres each)	High Marsh*	Low Marsh*	Mudflat/ Intertidal*
550 acre expansion with 50% wetlands	275	275	7	55	220	22
550 acre expansion with 50% wetlands and 5-ft vertical raising	275	275	7	55	220	22
550 acre expansion with 55% wetlands	247.5	302.5	7	60.5	242	2.4
550 acre expansion with 55% wetlands and 5-ft vertical raising	247.5	302.5	7	60.5	242	2.4
550 acre expansion with 60% wetlands	235	315	8	63	252	2.5
550 acre expansion with 60% wetlands and 5-ft vertical raising	235	315	8	63	252	2.5

**Assumed that 80 percent of wetland is low marsh, 20 percent is high marsh, and 10 percent of low marsh acreage is mudflat/intertidal (acres are presented to the nearest acre).*

Additional information on island ecosystem habitat and the fish and wildlife communities utilizing island habitats was needed to quantify the environmental benefits large island restoration projects in the Chesapeake Bay. A workgroup was developed to gather the ecological data needed to determine the environmental benefits for each expansion option. Members of the workgroup included representatives from State and Federal agencies, plus private consulting firms, and were chosen based on their expertise of remote island habitat or a specific ecological community. The goals of the workgroup were:

1) identify species that use the Mid-Chesapeake Bay islands and assign these species to communities, and

2) identify the limiting habitat requirements for guild/communities based on the species that comprise those communities,

The panel of experts was polled using the Delphi Method (Crance, 1987), the results of which were used to define an Island Community Index (Step 4) and calculate Island Community Units (Step 5).

Step 2: Guild/Community Identification

A total of nine fish and wildlife guilds/communities were identified as primary users of remote island habitat in the Chesapeake Bay:

- Colonial nesting wading birds (herons, egrets, and ibises)
- Waterfowl
- Colonial nesting waterbirds (gulls, terns, and skimmers)
- Raptors
- Shorebirds
- Herpetofauna
- Benthic Invertebrates
- Resident/Forage Fish
- Commercial/Predatory/Higher Trophic Level Fish

Step 3: Weighting of Guilds/Communities

It was recognized that not all communities relied on or would use the restored island to the same degree. Therefore, a weighting factor was assigned to each guild/community depending on the extent to which a community would utilize remote island habitat (Table 4-10). Weights were determined by consensus of the Mid-Chesapeake Bay Island Plan Formulation Group. Mammals were not included as a specific community for the ICU analysis because birds and fish were identified as the primary users of remote island habitat. Weights (W, as a proportion) are incorporated into the Island Community Unit calculation that is outlined in Step 5.

Table 4-10. Weighting Factors (W) Assigned to Each Guild/Community/Assemblage to Calculate ICUs

Colonial Nesting Wading Birds (herons, egrets, ibises)	12 %
Waterfowl	10 %
Colonial Nesting Waterbirds (gulls, herons, and skimmers)	12 %
Raptors	2 %
Shorebirds	14 %
Birds (total)	**50 %**
Resident/Forage Fish	23 %
Commercial/Predatory/Higher Trophic Level Fish	5 %
Fish (total)	**28 %**
Reptile/Herpetofauna	**2 %**
Benthic Invertebrate	**20 %**

The heavy weight assigned to colonial wading birds and waterbirds, collectively, reflects the reliance these assemblages have on remote island habitat for nesting. The coastal plain, home to nearly 100 percent of the breeding population, is the most important physiographic region in Maryland for nesting colonial wading birds and waterbirds (MDNR, 1996). MDNR (1996) further identifies that most of the large islands of the Chesapeake Bay, specifically Barren Island, Bloodsworth Island, Coaches Island, Pooles Island, Poplar Island, and the Smith Island archipelago, support large numbers of colonial nesting birds. Although, not necessarily reflective of regional trends, a decline in Maryland colonies of Black Skimmer, Common Tern, Gull-Billed Tern, Laughing Gull, and Herring Gull was recorded between 1985 and 2003 (Brinker MDNR, 2005)

Step 4: Island Community Index (ICI)

An Island Community Index (ICI) for each guild/community for each habitat type was defined. The index is a value between 0 and 1.0. The index is defined as follows:

- 1.0 = optimum/maximum use,
- 0.75 = use probable, but not optimum,
- 0.5 = use possible/some use,
- 0.25 = minimum use,
- 0 = no use/habitat value.

ICIs were then used to classify the probability that a guild/community would utilize a specific habitat type, based on the characteristics and limiting features (i.e., size, vegetation, substrate, maturity) of the habitat. The supporting information for defining ICIs was gathered from the expert workgroup and a literature search. The complete list of ICIs used in the analysis is located in Appendix H.

Step 5: Island Community Unit (ICU) Calculation

The annual placement schedule and cell development plan (formulated by USACE Engineering) determined the size of each cell (in acres) and identified the years in which a cell would be filled, graded, and planted. Once planted, cells start to accrue habitat benefits. The maturity time (the time until a habitat develops full benefits) assumed for each habitat type is located in Table 4-11.

Incorporating the defined ICIs, guild weights, habitat areas determined by USACE-Baltimore District Engineering, and maturity dates, ICUs were calculated using the following formula, derived by the Mid-Chesapeake Bay Island Plan Formulation Group:

$$\sum_{g} [[\sum_{H} (I_{gH} * A_{H})] * w_{g}]_{g}$$

where g = guild/community
H = habitat type
I = Island Community Index (ICI) Value (Appendix H)
A = acreage of habitat type
W = weighting factor for the guild/community (Table 4-9).

Table 4-11. Habitat Maturity Dates used for the Island Community Unit Incremental Calculation

Wooded upland for Colonial Nesting Wading Birds (nesting)-- (herons, egrets, and ibises)	25+ years
Upland nesting habitat for Colonial Nesting Waterbirds (gulls, terns, and skimmers) (This is essentially an expiration date. Use as nesting habitat is only viable until vegetation is established; after that no use for nesting.)	1 year
Upland for waterfowl use (including woody/shrubby cover surrounding pools for nesting)	10 years
High Marsh (no woody vegetation)	5 years*
High Marsh with woody/shrubby vegetation	10 years
Low Marsh	5 years*
Intertidal (mudflats) (maintained as unvegetated)	5 years*
Benthic invertebrate communities	10 years

**will have some additional benefits after 5 years as invertebrate community develops to maturity*

A 3-acre bird island was incorporated into the design as decided by the plan formulation group to provide waterbird (unvegetated) and wading bird (vegetated) nesting habitat with managed predator protection. Additional assumptions made in quantifying environmental benefits are that the wetland subcells become continuous once the interior dikes are removed in year 15, and that only upland habitat was evaluated for year 25.

Appendix H contains detailed information on the ICU calculation, including assumptions for the realization of environmental benefits within wetland and upland cells and a summary of the habitat features that provide value to the proposed habitat types. Tables summarizing the cell development and ICU analysis for each of the six expansion options are also located in Appendix H.

Step 6: Interim Benefits

It was also assumed that cells will have interim environmental benefits while placement is occurring, but prior to planting. During years when a cell is receiving dredged material, the cell will be either impounded water (produced by dewatering placed dredged material), mudflat, or a combination of open water and mudflat. The rules used to calculate ICUs to quantify the interim environmental benefits associated with these interim habitats are located in Appendix H.

Step 7: Total ICU/Year

Once the ICUs and interim ICUs for each subcell were calculated, ICUs for all cells for an individual year were summed to obtain Total ICU/year. The Total ICU/year versus time was plotted to determine how the habitat benefits will develop and come on-line with construction of the lateral expansion (Appendix H).

4.8.1.b Results of Environmental Benefits Quantification To determine the environmental benefits from the lateral expansion, ICU were calculated for three options with differing wetland to upland ratios: 1) 50 percent wetland, 50 percent upland, 2) 55 percent wetland, 45 percent upland, and 3) 60 percent wetland, 40 percent upland. ICU were then calculated for the same three options in combination with the vertical dike raising, for a total environmental benefits analysis of six different expansion options.

Each expansion option is expected to provide a 550-acre expansion plus a 25-acre tidal gut to the footprint of the existing PIERP project. Using the engineering plan for placement and development of each subcell, the ICU were calculated for each subcell over a 50-year period of analysis (2010 – 2060). Results of this analysis are presented for each of the six expansion options above in Appendix H. The ICUs for each cell for an individual year were summed to obtain Total ICU/year, and the total ICU/yr was used to directly compare the environmental benefits produced by each option. The timeframes discussed below for the realization of environmental benefits assume that construction of the lateral expansion and the vertical dike raising would both be completed in 2010, and that expansion cells would be available for dredged material placement in 2011. Once construction is completed, environmental benefits start to accrue.

For the lateral expansion, environmental benefits would start in year 2010 (5.5 ICU per year). Initial environmental benefits are from the perimeter dikes and the open water areas contained within the lateral expansion. The maximum benefits (highest ICU/yr) are achieved in 2053 for each of the three lateral expansion options (and are expected to persist for decades):

1. 50 percent wetlands, 50 percent uplands = 227 ICU
2. 55 percent wetlands, 45 percent uplands = 245 ICU
3. 60 percent wetlands, 40 percent uplands = 264 ICU

For the vertical dike raising, positive ICU start in 2009 for each ‘raised’ option. Negative benefits calculated for ‘raised’ expansion options between 2010 and 2012 represent the loss of PIERP environmental benefits during those three years because of the delay in upland cell development compared to options that do not include the dike raising. Cells will remain in a state of active dredged material placement, accumulating only interim benefits, for each of the three years during the delay, before cell development (grading and planting) could begin.

For a given proportion of wetlands/uplands, expansion options that include the upland dike raising reach the same maximum benefits as expansion options without the dike raising (lateral expansion only), but take two years longer. For example, both the 50 percent wetlands, 50 percent uplands option and the 50 percent wetlands, 50 percent uplands option with 5’ raising provide a maximum of 227 ICU, but the option without the dike raising would achieve this benefit in 2053, as compared to 2055 for the ‘raised’ option.

4.8.1.c Cumulative Environmental Benefits Cumulative ICU benefits were calculated over a 50-year period of analysis, and the results indicated that ‘raised’ expansion options provide more cumulative ICU compared to the respective options without the vertical expansion:

- 50 percent wetlands, 50 percent uplands = 7,693 ICU,
- 50 percent wetland, 50 percent upland with 5 ft raising = 8,088 ICU,

- 55 percent wetlands, 45 percent uplands = 8,274 ICU,
- 55 percent wetland, 45 percent upland with 5 ft raising = 8,669 ICU,

- 60 percent wetlands, 40 percent uplands = 8,599 ICU,
- 60 percent wetland, 40 percent upland with 5 ft raising = 9,015 ICU.

Expansion options with the vertical expansion provide greater interim benefits as a result of the delay in developing the upland cells. Upland cells remain as mudflats for six years longer with the vertical expansion than they do for the 'non-raised' options, and the interim benefits associated with the upland habitats during these years accounts for greater number of ICU associated with the 'raised' options. Additional discussion and analysis of the contribution of interim benefits is provided in Appendix H.

In general, environmental benefits from the proposed expansion increase as the percentage of wetlands for the project increases, since the wetlands provide the majority of the environmental benefits incorporated into the calculation. (Figure 4-12).

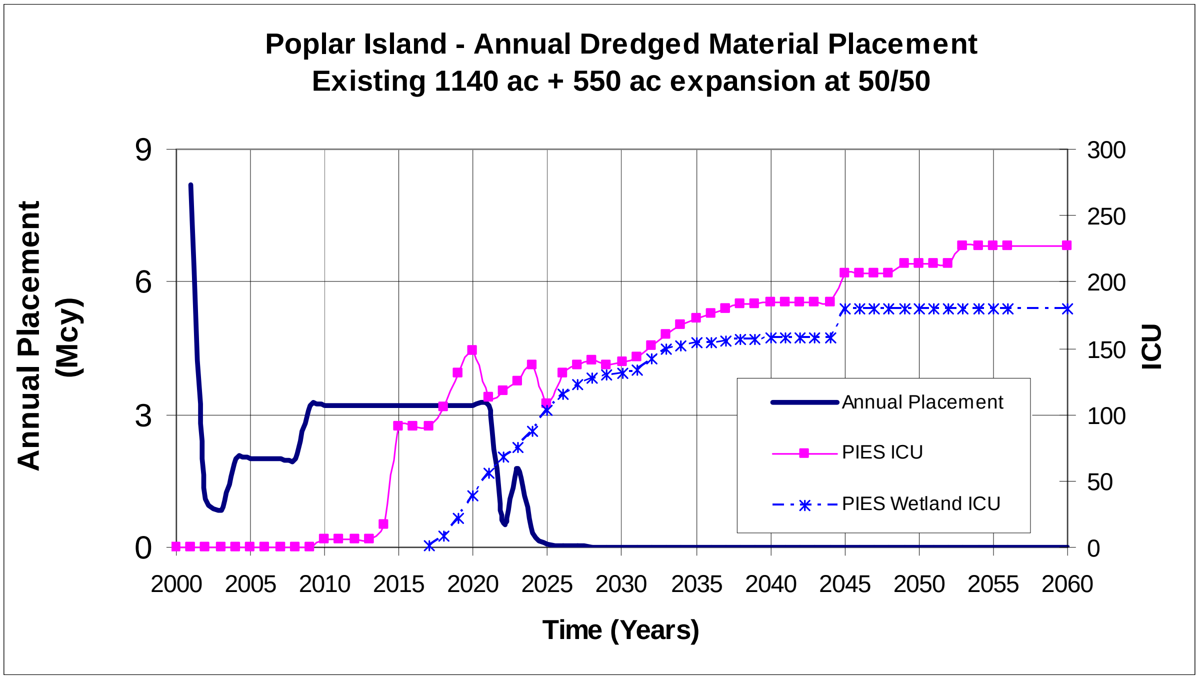


Figure 4-12. Projected Annual Dredged Material Placement with the Lateral Expansion

4.8.2 Cost Effectiveness and Incremental Analysis

USACE projects for flood control, navigation, shoreline protection, and other purposes, including ecosystem restoration projects (like PIERP) rely on a benefit-cost analysis to provide the best plan for project implementation. The difference between the monetary cost of the plan and the value of plan benefits describes the plan's net benefits. USACE performs project-specific analyses to compare the costs and benefits of viable alternatives to identify the most cost-effective solution(s). This information is then used to provide guidance in decision-making.

For ecosystem restoration projects, the value of the ecological resources being protected, restored, or created must be established through legal or institutional recognition, scientific recognition, and public perception of value. A recommended plan is typically identified when the monetary and non-monetary outputs of the restoration project validate its incremental costs above the base plan. However, unlike traditional projects, there is no accepted method for quantifying environmental outputs in monetary terms. Because the benefits of restoration projects usually are not measured in currency, cost-effectiveness (CE) and incremental cost analyses (ICA) are more appropriate benchmarks of a project's value.

Procedures for conducting cost-effectiveness and incremental analyses are based upon the conceptual framework of the U.S. Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. While the *Principles and Guidelines* places emphasis on plans to achieve NED benefits, it also gives reference to allowing cost-effective plans to achieve other benefits, such as environmental benefits. The Corps' planning regulation 1105-2-100, *Guidance for Conducting Civil Works Planning Studies,* directed that incremental cost analyses be performed to discover and display variation in costs and to identify the least-cost plan. The importance of cost effectiveness and incremental analysis is discussed in Engineering Circular 1105-2-210, *Ecosystem Restoration in the Civil Works Program.*

A cost effectiveness/incremental analysis (CE/ICA) was used to evaluate and compare the expected outputs and the expected costs associated with construction and development of the six northern lateral expansion schemes used in the engineering analysis and environmental benefits analysis (Sections 4.5 and 4.8.1, respectively):

1. 50 percent wetland, 50 percent upland without raising of existing uplands
2. 55 percent wetland, 45 percent upland without raising of existing uplands
3. 60 percent wetland, 40 percent upland without raising of existing uplands
4. 50 percent wetland, 50 percent upland with 5-foot raising of existing uplands
5. 55 percent wetland, 45 percent upland with 5-foot raising of existing uplands
6. 60 percent wetland, 40 percent upland with 5-foot raising of existing uplands

CE/ICA is a useful tool to determine whether additional ecosystem outputs gained by increasing levels of restoration are worth the additional monetary cost. Although CE/ICA analyses do not necessarily result in the identification of a single “best” alternative, it contributes to informed decision making for ecosystem restoration projects. The environmental outputs (benefits) for PIERP expansion used for the CE/ICA analysis were the ICU calculated for each expansion option from the start of perimeter dike construction.

4.8.2.a No-Action Alternative The no-action, or without project alternative, was included in the CE/ICA analysis to provide a basis for output and cost comparisons. The no-action alternative is defined as the existing PIERP. The environmental benefits or ICU were evaluated for the currently authorized project (1,140 acres at 50 percent wetland, 50 percent upland and a capacity of 40 mcy) using a 50-year period of analysis, with a project base year of 2010. Year 2010 is the first year of expected environmental benefits after the initiation of construction of a lateral expansion. The existing PIERP without expansion is expected to produce a total of 18,077 ICU during the 2010-2059 analysis period, with an average of 362 ICU per year (Appendix H).

The total estimated project construction cost for the existing PIERP without expansion is approximately $407 million. This cost estimate includes all project outlays starting with dike construction in 1998 and continuing through 2017, the expected year of completion of habitat development at the existing site. The cost estimate includes the cost to construct the dikes, to develop and operate the project, to transport and place dredged material at the site, and to develop the island habitat. The average annual cost of the existing PIERP (50 years at 5.375%) without expansion is approximately $17,760,000.

4.8.2.b Lateral and Vertical Expansion Cost Estimate Conceptual level cost estimates were developed for each of the six options for the northern lateral expansion. The total cost for each of the northern lateral expansion alignments was based on the actual, historical costs of the existing project. These conceptual level costs were then used to estimate projected costs over the lifetime of the project with the expansion. These conceptual level cost estimates include the cost to construct the project, the cost to manage and develop the project site, the cost to transport and place dredged material at the site and the cost to develop the island habitat. Dike construction cost estimates are based on estimates developed for northern lateral alignments with 50 percent wetland, 50 percent uplands and with 60 percent wetland, 40 percent uplands plus a 5-ft vertical expansion. The construction costs for the other four schemes were based on these estimates. Non-dike costs consist of site development, habitat development and dredged material transportation and placement costs. The non-dike component cost estimates are based on the historical costs of the existing PIERP. Based on the cost estimate, costs for the northern lateral expansion would range from approximately $282.4 million (55 percent uplands, 45 percent uplands) to $299.5 million (50 percent wetlands, 50 percent uplands plus 5-ft vertical expansion) (Table 4-12).

Table 4-12. Project Cost Estimates for Expansion Scenarios

Expansion Option	**Dike Construction Cost**	**Non-Dike Project Costs**	**Total Project Cost**
Expansion with 50% wetlands	$104,080,000	$179,940,000	$284,020,000
Expansion with 50% wetlands and 5-ft vertical raising	$104,450,000	$195,050,000	$299,500,000
Expansion with 55% wetlands	$104,400,000	$177,990,000	$282,390,000
Expansion with 55% wetlands and 5-ft vertical raising	$104,780,000	$191,310,000	$296,090,000
Expansion with 60% wetlands	$105,080,000	$182,080,000	$287,160,000
Expansion with 60% wetlands and 5-ft vertical raising	$105,460,000	$193,470,000	$298,930,000

4.8.2.c Cost Effectiveness Analysis The calculated ICUs (Section 4.8.1 and Appendix H) were used to determine the environmental benefits of the both the existing PIERP and the northern lateral expansion. The environmental benefits of the expansion project are defined as the expected increase in ICUs as compared to the expected environmental benefits for the existing PIERP. Each of the six options for the northern lateral expansion was evaluated for a 50-year period of analysis to determine the expected output in ICU associated with construction and habitat development.

The cost effectiveness analysis for the six northern lateral expansion options and the no-action alternative (the existing PIERP) is presented in Table 4-13. The table is arranged in ascending order from least to greatest output in ICUs. The existing PIERP, listed first in the table, produces 362 expected yearly ICUs. The first two options listed after the existing PIERP (shaded in gray) were each eliminated because the 55 percent wetland, 45 percent upland option produces more output for less cost.

Table 4-13. Cost Effectiveness Analysis for PIERP Expansion (FY 2005 Interest Rate 5.375 percent)

Expansion Option	Total Cost ($000s)	Present Value Cost ($000s)	Total ICUs	Average Annual Cost ($000s)	Average Annual ICUs	Ave Cost ($/ICU)
Existing PIERP	$396,401	$306,358	18,077	$17,763	362	$49,069
Expansion with 50% wetlands	$680,421	$516,868	25,770	$29,968	516	$58,078
Expansion with 50% wetlands and 5-ft vertical raising	$695,901	$524,358	26,165	$30,403	524	$58,020
Expansion with 55% wetlands	$678,791	$515,828	26,351	$29,908	527	$56,751
Expansion with 60% wetlands	$683,561	$519,608	26,676	$30,127	534	$56,418
Expansion with 55% wetlands and 5-ft vertical raising	$692,491	$522,758	26,746	$30,310	535	$56,654
Expansion with 60% wetlands and 5-ft vertical raising	$695,331	$522,868	27,092	$30,316	542	$55,934

There were four cost effective expansion options remaining after the cost effectiveness analysis:

1. 55 percent wetland, 45 percent upland without raising of existing uplands
2. 60 percent wetland, 40 percent upland without raising of existing uplands
3. 55 percent wetland, 45 percent upland with 5-foot raising of existing uplands
4. 60 percent wetland, 40 percent upland with 5-foot raising of existing uplands

From a cost effectiveness perspective, selection of any of these options would be acceptable. The option with the least average cost per ICU is the 60 percent wetland, 40 percent upland with a 5-ft dike raising expansion option, with a cost of $55,934 per ICU on an annual basis.

<u>4.8.2.d Incremental Cost Analysis (ICA) of Cost Effective Expansion Options</u>. For the ICA, cost effective options are examined sequentially (by increasing scale and increment of environmental benefit) to determine which options are most efficient in the production of environmental benefits (ICUs). The most efficient options provide the greatest increase in environmental benefits for the least increases in cost. Usually, the incremental analysis by itself will not point to the selection of any single plan. The results of the incremental analysis must be synthesized with other decision-making criteria to select a preferred plan (ER 1105-2-100).

The incremental analysis of the four cost effective expansion options indicated that the 60 percent wetlands, 40 percent uplands plus the 5-ft vertical expansion option provides the best return on investment in terms of cost per ICU (Table 4-14). The incremental cost per ICU of implementing the 60 percent wetlands, 40 percent uplands plus the 5-ft vertical expansion option compared to the existing PIERP is $69,739. From a cost perspective, the 60 percent wetlands, 40 percent uplands plus the 5-ft vertical expansion option is the least-cost option when compared to the existing PIERP.

Table 4-14. Poplar Island Restoration Expansion, Incremental Analysis of Cost Effective Expansion Option, Cost per ICU of Implementing Each Option Instead of the No Action Plan, FY 2005 Interest Rate 5.375%

Expansion Option	Average Annual Cost ($000s)	Average Annual ICUs	Incremental ICUs	Incremental Cost ($000s)*	$/Incremental ICUs**
Existing Poplar	$17,763	362	N/A	N/A	N/A
Expansion with 55% wetlands	$29,908	527	165	$12,145	$73,606
Expansion with 60% wetlands	$30,127	534	172	$12,364	$71,884
Expansion with 55% wetlands and 5-ft vertical raising	$30,310	535	173	$12,547	$72,526
Expansion with 60% wetlands and 5-ft vertical raising	$30,316	542	180	$12,553	$69,739

** Incremental ICUs gained with each expansion option compared to its predecessor.*

*** The cost per incremental ICU gained by construction of the expansion option compared to the preceding option.*

An additional level of incremental analysis was used to compare the expected annual incremental ICU outputs and the annualized incremental costs for each of the six expansion options with the existing Poplar Island project (Table 4-15). The difference in cost per incremental ICU between the most costly and least costly expansion option is only approximately $9,500 on an annual basis.

Table 4-15. Incremental Comparison of Poplar Island Expansion Options with the Existing PIERP

Expansion Option	Average Annual Cost ($000s)	Incremental ICUs	Incremental Cost	Cost/Incremental ICUs
Expansion with 60% wetlands and 5-ft vertical raising	$30,316	180	$12,553,000	$69,739
Expansion with 60% wetlands	$30,127	172	$12,364,000	$71,884
Expansion with 55% wetlands and 5-ft vertical raising	$30,310	173	$12,547,000	$72,526
Expansion with 55% wetlands	$29,908	165	$12,145,000	$73,606
Expansion with 50% wetlands and 5-ft vertical raising	$30,403	162	$12,640,000	$78,025
Expansion with 50% wetlands	$29,968	154	$12,205,000	$79,253

4.8.2.e Summary of the CE/ICA Analysis The results of the CE/ICA are intended to identify the least-cost option (the NER Plan), which for the expansion of PIERP is a northern lateral expansion with 60 percent wetlands, 40 percent uplands plus a 5-ft vertical expansion. However, other options identified as non-cost effective, as well as cost effective plans identified as relatively less efficient in producing environmental benefits in the ICA, may continue to be considered in the plan formulation. Other evaluation criteria, such as environmental significance and effectiveness may impact the decision process. In addition, other factors, such as support by a local sponsor or resource agency or unintended effects on other ecological and economic resources, may lead to the consideration and selection that may not be the most cost effective, or that may incur substantial incremental costs (ER 1105-2-100).

4.9 EVALUATION OF THE OPEN-WATER EMBAYMENT

Following the completion of the plan formulation process, a proposal from NMFS and subsequent discussions with USEPA, USFWS, MDNR, and MDE led to the development and evaluation of an open-water embayment that could potentially be incorporated into a northern lateral alignment.

NMFS initially proposed a variation for the northern lateral alignment that included an open-water embayment at a resource agency meeting on December 15, 2004 (Appendix F, agency coordination dated January 18, 2005). In the NMFS proposal, the footprint of the northern lateral alignment was the same as those proposed by USACE, but approximately 130 acres of wetland located on the western side of the lateral expansion was designated as an open-water embayment protected by segmented breakwaters and bordered by salt marsh and mudflats

(Figure 4-13). The inclusion of an open-water embayment within the footprint of the lateral expansion, ranging from approximately -10 to -12 MLLW feet in depth, would provide semi-protected fisheries habitat adjacent to wetland and upland cells, and would increase the trophic interaction between the wetland cells and the open-water embayment within the lateral expansion. The bottom habitat of the open-water embayment would remain essentially undisturbed, preserving the existing bathymetry and benthic habitat. In addition, the construction of small rock reefs within the open-water embayment would provide cover and enhance fish habitat.

USACE-Baltimore modified the initial open-water embayment proposed by NMFS to enhance the hydraulic characteristics of the proposal and minimize the impact on the dredged material placement capacity of the lateral expansion. At this point, USACE-Baltimore also moved the eastern portion of the lateral alignment back from the NOB 8-11 in response to concerns of the local watermen. Therefore, the open-water embayment alignment consists of a 575-acre (nominal area contained within the project footprint) lateral expansion to the north and northeast of the existing project with a habitat proportion of 29 percent wetland habitat (165 acres), 47 percent upland habitat (270 acres), and 24 percent open-water embayment (130 acres); and a 5-ft vertical raising of the existing upland cells (Cells 2 and 6). No dredged material will be placed within the open-water embayment.

NMFS formally presented this open-water embayment concept to the BEWG for consideration during the March 8, 2005 meeting. The BEWG is the technical team that helped develop the ICU (see Section 4.8.1) to measure the environmental benefits of island restoration. Consequently, the BEWG was asked to evaluate the proposed embayment feature regarding habitat comparability for created wetlands and open-water embayment habitats. At the April 5, 2005 meeting, the BEWG endorsed further study of including an open-water embayment within the lateral expansion of the PIERP. Overall, there was general agreement that diversity of habitat types could be more beneficial than creating more of the same type of habitat currently under construction. The USFWS and NMFS have indicated that the inclusion of an open-water embayment in lieu of wetland habitat within the northern lateral expansion is an environmentally preferred option based on site-specific conditions (Appendix F, agency consultation dated August 5, 2005 and May 19, 2005, respectively). Both agencies have indicated that the open-water embayment design would be applicable only to the lateral expansion of Poplar Island. The general agency agreement of constructing 50 percent (minimum) wetland habitat would continue to be applicable for future island ecosystem restoration projects.

Agency representatives expressed concerns regarding features of the proposed open-water embayment design, including the size of the embayment; location within the expansion (eastern vs. western portion); stability and function of the embayment; protection of wildlife, access for the public, commercial watermen, and recreational fishermen; and long-term maintenance. Specifically, USFWS proposed reducing the size of the open-water embayment to between 80 and 90 acres and incorporation of 1-3 isolated nesting island for colonial

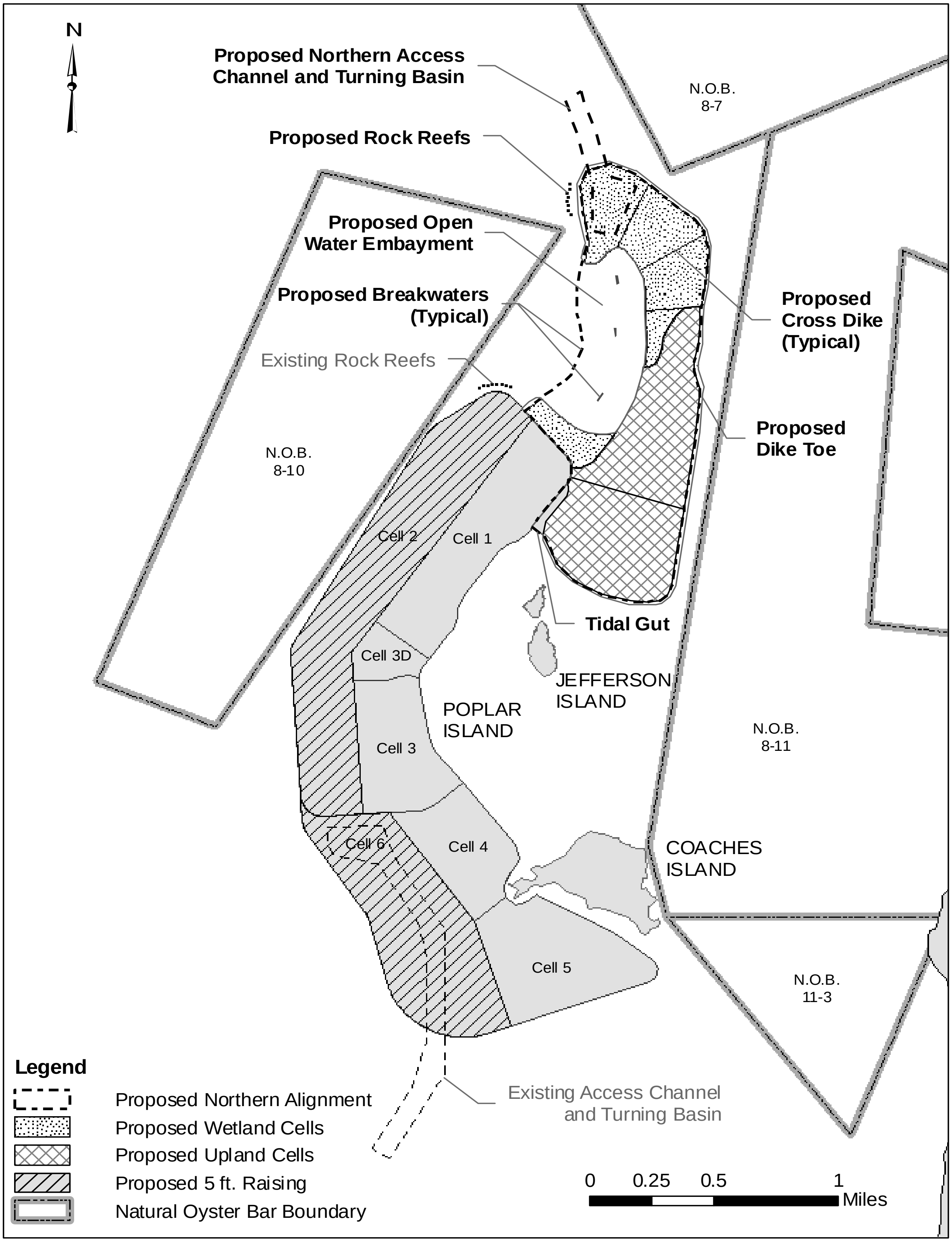


Figure 4-13. Open-Water Embayment Alignment (29% Wetland, 47% Upland, and 24% Open-Water Embayment and 5-ft Raising of PIERP Upland Cells).

waterbird nesting within the embayment (Appendix F, agency consultation dated April 25, 2005). Reducing the size of the open-water embayment to 80-acres, as recommended by USFWS, would result in a habitat proportion of 39 percent wetland (225 acres), 47 percent upland (270 acres), and 14 percent open-water embayment (80 acres) within the lateral expansion (Appendix F, agency consultation dated August 5, 2005). Additional concerns raised by USFWS included the potential for an open-water embayment to become a magnet for recreational fishermen (and the resulting influence of public access on nesting behavior) and the need for additional study of the water circulation, storm protection, and sediment deposition within the embayment. MDNR requested further evaluation of the location of the proposed open-water embayment, the size of the embayment (as it relates to long-term maintenance and stability), the development of additional bird nesting islands, and the fate of material eroded from the adjacent wetlands, and maintenance of the project (Appendix F, agency coordination dated May 12, 2005). MDE raised concerns about sediment transport and water quality issues arising from the location of the open-water embayment on the western side of the lateral expansion (Appendix F, agency coordination). Concerns pertaining to specific components of the open-water embayment (i.e., size and location) will be discussed and evaluated further in the next design phase of the project based on additional consultation with each resource agency (USFWS, NMFS, USEPA, MDNR, and MDE) and MPA (the non-Federal sponsor); results of additional hydrodynamic modeling studies; and additional design considerations. Based on the agency consultation to-date, the open-water embayment could potentially range between 80 to 140 acres in size, and would be determined during the Value Engineering process. However, for the evaluation conducted in this document, the size of the open-water embayment within the northern lateral expansion was estimated to be 130 acres in size.

Based on agency support to include an open-water embayment in the recommended plan, USACE-Baltimore District conducted a preliminary evaluation of the inclusion of an open-water embayment within the footprint of the lateral expansion, including engineering design and feasibility; placement analysis to determine site life and capacity; environmental benefits analysis (using ICUs); general environmental impacts analysis, and cost estimation. At the public meetings for the Draft GRR/SEIS (Appendix G), the inclusion of the open-water embayment received support from the Coastal Conservation Association (CCA). In addition, the incorporation of the open-water embayment into the lateral expansion would help alleviate the concerns expressed by the local watermen regarding loss of productive Bay bottom habitat areas and the need for sand borrow outside the footprint of the project.

Based on the results of the preliminary evaluation (conducted in the Draft GRR/SEIS) and continued agency and public support, USACE-Baltimore District decided to move forward and fully evaluate a northern lateral expansion alignment that included open-water embayment. In response to the Draft GRR/SEIS, letters in support for the open-water embayment were received from USFWS (Appendix F, agency consultation dated August 5, 2005); NMFS (Appendix F, agency consultation dated August 8, 2005); MDNR (Appendix F, agency consultation dated August 4, 2005); and USEPA (Appendix F, agency consultation dated August 8, 2005). When the open-water embayment concept was initially proposed, screening assessments conducted during previous steps of the plan formulation process had already eliminated several expansion options. Therefore, the results of the open-water embayment evaluation were compared only to the viable alternatives remaining after the plan formulation: 1) the no action alternative; 2) 60 percent wetlands, 40 percent uplands plus a 5-ft raising of the existing upland cells; and 3) 50 percent wetlands, 50 percent uplands plus a 5-ft raising of the existing upland cells. Details of the open-water embayment evaluation are provided in the following sections.

4.9.1 Engineering Screening

The proposed alignment with the 130-acre open-water embayment consists of a 575-acre lateral northern expansion of the existing PIERP to the north and northeast, consisting nominally of 29 percent wetland habitat, 47 percent upland habitat, and 24 percent open-water embayment. The northern lateral expansion with the open-water embayment will provide approximately 28 mcy of placement capacity, and approximately 165 acres of wetland habitat; 270 acres of upland habitat; and 130 acres of open-water embayment habitat (Table 4-16). If the open-water embayment had been incorporated into the northern lateral alignment during plan formulation of the original engineering screening process (See Section 4.5.2.b and Appendix A, Attachment B), it would have received the same weighted score as Alignment 7. Alignment 7 consisted of a northern lateral alignment of 630-acres, and had the number one ranking (Table 4-5). Therefore, a northern lateral alignment with an open-water embayment would have been carried forward for a more detailed engineering evaluation.

Table 4-16. Comparison of 60 Percent Wetland and Open-Water Embayment Alternatives

Expansion and/or Raising Option	Total Expansion Area (acres)	Upland Area (acres)	Wetland Area (acres)	Water Area (acres)	Expansion Capacity (mcy)	Last Year at 3.2 mcy	Last Wetland Placement	Last Upland Placement
575-Acre Expansion with 60% Wetland & 40% Upland	575	235	315	25	**23.0**	2020	2021/2026	2021/2021
575-Acre Expansion with 60% Wetland & 40% Upland + 5’ Raising	575	235	315	25	**29.0**	2022	2021/2027	2022/2025
575-Acre Expansion with 29% Wetland, 47% Upland, & 24% Open-Water Embayment	575	270	165	140	**21.8**	2020	2019/2026	2021/2021
575-Acre Expansion with 29% Wetland, 47% Upland, & 24% Open-Water Embayment + 5’ Raising	575	270	165	140	**27.8**	2022	2019/2026	2021/2026

NOTE: The two dates shown in each cell of the last two columns for placement in wetland and upland cells reflect the additional 4 to 5 year period associated with recovery of the wetland cell used as a sheltered dredged material offloading site.

4.9.1.a Capacity Analysis Analysis of dredged material placement was performed using the same mathematical placement model applied to all of the other expansion and dike raising expansion options (Appendix A, Attachment C). An analysis was performed for the inclusion of a 130-acre open-water embayment in the lateral expansion footprint, both with and without an associated 5-ft raising of the existing upland dikes (Appendix A, Attachment G) (Table 4-16). For the same reasons mentioned in Section 4.5.3 (efficient, cost-effective placement of dredged material), the additional six mcy of placement capacity realized by raising the existing upland dikes 5 feet would allow the project to still meet the short-term capacity needs while incorporating the additional habitat diversity provided by the open-water embayment. Therefore, the 5-ft vertical raising of the existing upland cells (Cells 2 and 6) was incorporated into the lateral expansion alignment containing the open-water embayment.

4.9.1.b Sand Borrow Analysis To the maximum extent possible, it is desirable to obtain all sand borrow for the construction of the containment dikes from sand obtained from within the footprint of the project (North Borrow area), and from the excavation required for the new access channel and turning basin. Therefore, sand borrow within the expansion footprint will be limited to the upland cells as shown on Figure 4-14.

The inclusion of an open-water embayment in the lateral expansion footprint has small, but generally favorable, impacts on the sand borrow excavation plan for the expansion construction. A summary of the borrow sources needed for both the 60 percent wetland, 40 percent upland alignment and the open-water embayment alignment both with and without a 5-ft raising of the existing upland dikes is presented in Table 4-17. Because a significant portion of the western perimeter dike for the open-water embayment alignment would be replaced by a stone breakwater structure, and a portion of the interior dikes associated with the tidal gut would be eliminated to accommodate the embayment, the required dike fill quantities decrease by 250,000, to a total of three mcy. Therefore, the inclusion of the open-water embayment would decrease the total required fill quantity from 3.7 mcy to 3.4 mcy (when raising the existing upland dikes is included), as compared to the 60 percent wetland, 40 percent upland alignment.

The proposed open-water embayment alignment has an upland proportion of approximately 47 percent. As compared to the 60 percent wetland, 40 percent upland alignment, this additional seven percent upland capacity replaces a significant percentage of the placement capacity lost as a result of replacing 115 acres of wetland habitat with the open-water embayment. In addition, this increase in upland area also increases the quantity of borrow material available for dike construction from within the project footprint by nearly 15 percent, reducing the quantity of sand borrow required from sources outside the project footprint. The open-water embayment alignment will require approximately 19 acres of sand borrow from the southwestern borrow area, as compared to 91 acres of borrow area for construction of the 60 percent wetland, 40 percent upland alignment.

4.9.2 Environmental Benefits of the Open-Water Embayment Alignment

Constructed and interim environmental benefits of incorporating an 130-acre open-water embayment within the northern lateral alignment were calculated using the same seven-step process and equations presented above (Section 4.8.1.a) to determine total ICUs (annual and cumulative). However, to quantify the contribution of the open-water embayment habitat

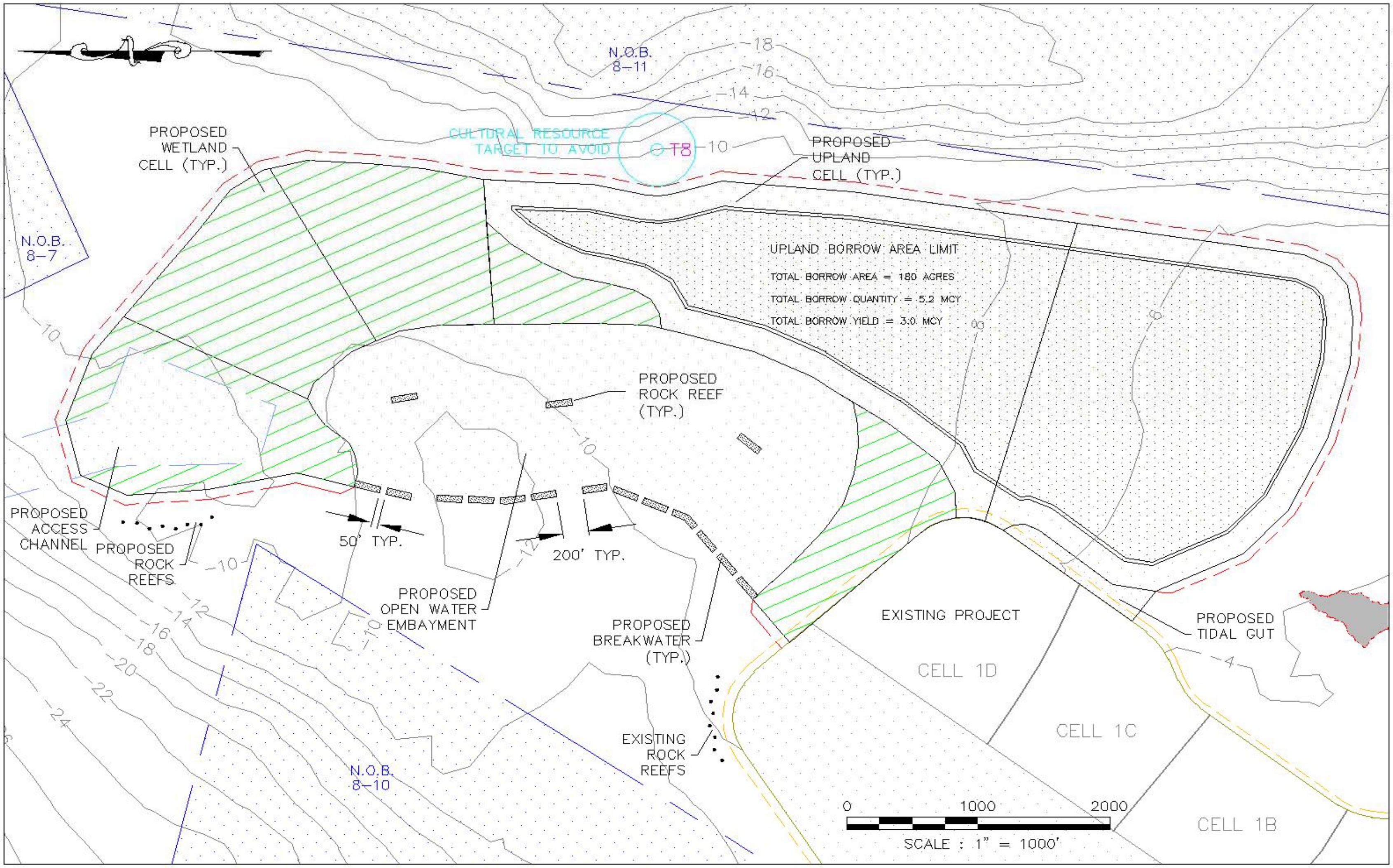


Figure 4-14. Sand Borrow Limits for the Northern Lateral Alignment with an Open-Water Embayment

Table 4-17. Borrow Requirements for the 60 Percent Wetland and Open-Water Embayment Alternatives

Expansion Alternative	Borrow Source	Borrow Volume (mcy)	Borrow Yield (mcy)	Borrow Area Disturbed (acres)
60% Wetland & 40% Upland	North Borrow	4.6	2.6	144
	Channel/Basin	0.5	0.3	30
(3.3 mcy sand required)	SW Borrow	0.7	0.4	42
	Subtotal		**3.3**	
60% Wetland & 40% Upland with 5-ft Raising	North Borrow	4.6	2.6	144
	Channel/Basin	0.5	0.3	30
(3.7 mcy sand required)	SW Borrow	1.5	0.8	91
	Subtotal		**3.7**	
With Open-Water Embayment	North Borrow	5.2	3.0	175
	Channel/Basin	0.5	0.3	30
(3.0 mcy sand required)	SW Borrow	0	0	0
	Subtotal		**3.3**	
With Open-Water Embayment and 5-ft Raising	North Borrow	5.2	3.0	175
	Channel/Basin	0.5	0.3	30
(3.4 mcy sand required)	SW Borrow	0.3	0.2	19
	Subtotal		**3.5**	

provided by the embayment, the methods used to calculate the ICU were modified to reflect use by the fish guilds/communities. Changes to the methods used in the ICU calculation are described in the following sections.

4.9.2.a Guild/Community Identification The fish guilds/communities evaluated in the original ICU model (Appendix H, Table H-2) did not adequately capture open-water habitat use. Coordination with John Nichols (NMFS) and Dave Meyer (NOAA) indicated that to fully evaluate fish use of open-water embayment habitat, the ICU model should be revised to include three fish guilds/communities, rather than the two used in the original ICU model (forage/resident fish and commercial/predatory/higher trophic level fish) (Appendix F, memorandum for record dated 22 April 2005). These three guilds, as well as representative species are:

1. *Bottom feeders (open subtidal and/or reef)* - striped bass (adult and juvenile), white perch (adult and juvenile), spot, croaker, weakfish, summer flounder (adult and older juvenile), and blue crab (adult)

2. *Pelagic zone feeders* - 1) planktivorous species: menhaden, bay anchovy, alewife and blueback herring (juvenile); and 2) piscivorous species: bluefish

3. *Shallow water (<3 feet) and marsh feeders (tidal guts and tributaries)* - striped bass (juvenile), white perch (juvenile), summer flounder (young-of-the-year), blue crab (juvenile), silverside, and killifish. (This group has a preference for bottom habitats compared to pelagic environments)

4.9.2.b Weighting of Guilds/Communities The weighting factor assigned to the fish guilds/communities was also adjusted to account for the additional fish guild/community. Table 4-18 provides the updated weighting factors (W). Note that the overall sum of the weight of the fish communities used to calculate the ICUs was not changed (28 percent) - the fish guilds account for identical proportions in the original model and the updated ICU model.

Table 4-18. Evaluation of the Open-Water Embayment: Weighting Factors (W) Assigned to Each Guild/Community/Assemblage to Calculate ICUs

Colonial Nesting Wading Birds (herons, egrets, ibises)	12%
Waterfowl	10%
Colonial Nesting Waterbirds (gulls, herons, and skimmers)	12%
Raptors	2%
Shorebirds	14%
Birds (total)	**50%**
Bottom Feeders	12%
Pelagic Zone Feeders	8%
Shallow Water (<3 feet) and Marsh Feeders (Tidal Guts and Tributaries)	8%
Fish (total)	**28%**
Reptile/Herpetofauna	**2%**
Benthic Invertebrate	**20%**

4.9.2.c Island Community Index (ICI) Development ICI were defined for the three fish guilds/communities as outlined in Appendix H. Several physical features of the open-water embayment would provide habitat benefits, including water depth; connection to the pelagic zone; subtidal substrate; marsh edge; reef structures; tidal guts; and mudflats. Placement of the open-water embayment on the western side of the proposed alignment would provide fish access to deep pockets (10-12 feet) of water, as well as adjacent deep water outside the alignment. In addition, situating the embayment on the western side of the northern lateral alignment would promote flushing, both from wind driven circulation and water currents. Maximizing marsh edge and the number of tidal channels would provide the greatest connection between the open water and marsh. These features are important for providing input of marsh production to enhance detrital concentrations (which provide a food source) and zooplankton productivity, in addition to providing access to the wetland habitat. As the organic input from the wetland increases, a corresponding increase in benthic diversity would also occur. The incorporation of at least one wide opening (greater than 200 ft) between breakwaters at the mouth of the cove (Figure 4-13) would allow pelagic species, such as adult bluefish and menhaden, access to the embayment. Both species may be limited if such access is not provided.

To quantify the benefits that the embayment would provide to groups other than fish, embayment habitat ICI were defined for each of the non-fish guilds/communities (Appendix H). Total ICUs were calculated as outlined in Appendix H using the adjusted guilds, weighting factors and Island Community Indices.

4.9.2.d Results and Discussion As with the four other habitat types (uplands, low marsh, high marsh, and intertidal/unvegetated mudflats), benefits of the embayment will increase with time as habitats within the project are developed. The open-water embayment provides large benefits much sooner than benefits would be achieved as the wetlands mature. Although there is a time lag before the full benefits of the open-water embayment are fulfilled, it was estimated that greater than 85 percent of the benefits would be achieved by year 5 when three wetland cells and their associated tidal channel are operational. Benefits associated with the open-water embayment were assumed to increase as the wetland cells were developed (Appendix H, Table H-7). That is, as the wetland connection, tidal guts, and shoreline increased, the benefits of the open-water embayment increased. Environmental benefits of the open-water embayment would begin once it was "created" - immediately upon completion of the interior/exterior dikes for the lateral expansion - as opposed to the wetland and upland habitats, in which the start of the environmental benefits is dependent on dredged material placement activities and planting regimes.

Using the updated version of the model, the alignment with the open-water embayment plus a 5-ft vertical raising of the existing upland cells had a cumulative total of 9,768 ICU.

4.9.3 Cost Effectiveness and Incremental Analysis (CE/ICA) for the Open-Water Embayment

4.9.3.a Cost Effectiveness Analysis The cost effectiveness analysis for the 60 percent wetlands, 40 percent uplands plus a 5-ft raising of the existing upland cells, 50 percent wetlands, 50 percent uplands plus a 5-ft raising of the existing upland cells, the open-water embayment plus a 5-ft raising of the existing upland cells, and the no-action alternative (existing Poplar Island) is presented in Table 4-19. The total costs for each of the alternatives evaluated in this analysis were updated based on detailed MCASES cost estimates (Appendix L), using the baseline costs.

The table is arranged in ascending order from least to greatest output in ICUs. The no-action alternative produces 362 expected yearly ICUs (Table 4-19). The 60 percent wetlands, 40 percent uplands plus a 5-ft raising of the existing upland cells alternative and the 50 percent wetlands, 50 percent uplands plus a 5-ft raising of the existing upland cells, shaded in gray, were eliminated on the basis of cost effective principles because the open-water embayment alignment produces more output for less cost compared to either of the other alternatives. From a cost effectiveness perspective, the alignment with the open-water embayment is the preferred alternative (the NER plan).

Table 4-19. Poplar Island Restoration Alternatives Cost Effectiveness Analysis FY 2005 Interest Rate 5.375%

Alternative	Total Cost ($000s)	Present Value Cost ($000s)	Average Annual Cost ($000s)	ICUs	Total ICUs (including PIERP)	Annual ICUs
Existing Poplar (No-Action)	$396,401	$306,358	$17,763	18,077	18,077	362
50% Wetland & 50% Upland + 5' Raising	$634,128	$527,206	$30,568	8,118	26,195	524
60% Wetland & 40% Upland + 5' Raising	$631,023	$526,157	$30,507	9,045	27,122	542
Open-Water Embayment +5' Raising	$624,273	$520,198	$30,161	9,768	27,845	557

4.9.3.b Incremental Analysis of Cost Effective Alternatives An incremental comparison between the cost and outputs of the existing project and the cost and outputs of the alignment with the open-water embayment is presented in Table 4-20. On an incremental basis, the alternative with the open-water embayment provides an increment of 195 ICUs for an incremental cost of $12.4 million on an annual basis. The cost per incremental ICU is $63,579 with implementation of the open-water embayment alternative.

Table 4-20. Poplar Island Restoration Alternatives Incremental Cost per Unit of Implementing Each Remaining Plan Instead of the No-Action Plan FY 2005 Interest Rate 5.375%

Alternative	Average Annual Cost ($000s)	Average Annual ICUs	Incremental ICUs	Incremental Cost ($000s)	$/ Incremental ICUs
Existing Poplar (No-Action)	$17,763	362	N/A	N/A	N/A
Open-Water Embayment +5' Raising	$30,161	557	195	$12,398	$63,579

4.9.3.c Summary of the CE/ICA Analysis for the Open-Water Embayment The results of the CE/ICA are intended to identify the least-cost option (the NER Plan), which for the expansion of PIERP is a northern lateral expansion with an open-water embayment plus a 5-ft vertical expansion. However, other options identified as non-cost effective, as well as cost effective plans identified as relatively less efficient in producing environmental benefits in the ICA, may continue to be considered in the plan formulation. Other evaluation criteria, such as environmental significance and effectiveness may impact the decision process. In addition, other factors, such as support by a local sponsor or resource agency or unintended effects on other ecological and economic resources, may lead to the consideration and selection that may not be the most cost effective, or that may incur substantial incremental costs (ER 1105-2-100).

4.10 SELECTION OF ALTERNATIVES INCLUDED IN THE IMPACTS ANALYSIS

The placement analyses described in the Engineering Appendix (Appendix A, Attachment C) supported the conclusion that a 575-acre placement area would be minimally large enough to accommodate the average annual dredged material placement needs of approximately 3.2 mcy (in conjunction with the existing PIERP) and provide sufficient dike fill material for dike construction from borrow sources located within the footprint of the upland cells of the expansion footprint. Operability of the expansion site would be improved by raising the existing upland cells to increase the upland placement capacity. The additional site capacity and extension of the site lifetime afforded by the proposed expansion would provide a significant additional contingency that might be needed to recover from extreme weather conditions that prevent cell grading or from a slower rate of consolidation of thicker dredged material layers within some of the proposed wetland cells. In theory, the additional upland capacity might allow the expansion area to be devoted to a higher percentage of wetland habitat while still satisfying efficient placement criteria. In addition, the inclusion of an open-water embayment within the proposed northern lateral alignment was supported by the results of the environmental benefits and CE/ICA analyses.

4.10.1 Selection of the Environmentally Preferred Alternative

The environmentally preferred alternative for the expansion of the PIERP includes the open-water embayment, plus a 5-ft vertical raising of the existing upland cells. The 5-ft vertical raising component of the recommended plan provides six mcy of additional dredged material placement capacity without taking up any additional Bay bottom. This vertical expansion of the existing upland placement capacity results in a significant increase in contingency to deal with the many uncertainties of new wetland cell development, increasing the potential for successfully completing the wetland development

Incorporation of an open-water embayment within the northern lateral expansion increases the complexity and diversity of habitat types with the lateral expansion, and would provide a physical connection between the wetlands and deeper waters. The open-water embayment would provide forage access and refugia in the small tributaries and tidal guts in the wetland cells for juvenile fish species, juvenile blue crabs, and diamondback terrapins. The open-water embayment would also provide more diverse habitat types within the northern lateral expansion including deep and shallow subtidal zones, an open water pelagic zone, mudflat habitat, tidal guts throughout the wetland cells, submerged reef habitat, and rock reef habitat. The construction of small rock reefs within the open-water embayment would provide in-water refugia and physical cover to enhance fish habitat.

The incorporation of at least one wide opening (greater than 200-ft) between breakwaters at the mouth of the cove would allow pelagic species, such as adult bluefish and menhaden, access to the cove. Generally, the open-water embayment will increase the potential for commercially important large predator finfish species (such as blue fish, striped bass, and Atlantic croaker) to utilize the habitat because of the access to deep open water. The proximity of the open-water embayment to marsh habitat will provide high order predators with access to marsh dependent lower order species for forage.

The bottom habitat of the open-water embayment would remain essentially undisturbed, preserving the existing bathymetry and benthic habitat. This conservation of bottom habitat, would be beneficial to the benthic community, clams, and blue crabs. The habitat in the created wetland cells will export both detritus and micronutrients via the tributaries and tidal guts into the open-water embayment, thus enhancing the existing benthic community within the open-water embayment and providing more forage opportunities and refugia for EFH species and other finfish.

The alignment with the open-water embayment would impact the least amount of borrow area outside the footprint of the lateral expansion (19 acres, as opposed to 91 and 49 acres), and results of the ICU analysis indicated that the alignment with the open-water embayment will produce the greatest number of environmental benefits (9,768 ICU). Therefore, Alternative 3 – a 575-acre northern lateral expansion with an open water embayment and a 5-ft raising of the existing upland cells – is the environmentally preferred alternative.

4.10.2 Selection of Alternatives Considered in the Impacts Evaluation

Therefore, based on the results of the plan formulation, three alternatives (Table 4-21) that are a combination of lateral and vertical expansion were evaluated in addition to the no-action alternative in the impacts analysis:

1. **Alternative 1** (Figure 4-15)
   - 60 percent wetlands, 40 percent uplands; plus 5-ft vertical expansion
   - Approximately 29 mcy of placement capacity

   Alternative 1 would consist of a 575-acre placement area (including a 25-acre tidal gut) with a 60 percent wetland, 40 percent upland habitat proportion in combination with a 5-foot raising of the existing upland cells. Alternative 1 would provide approximately 29 mcy of additional dredged material placement capacity extending the life of the existing project by approximately seven years. The quantity of sand required from the southwest borrow site would be approximately 1.5 mcy, and sand dredging activities would disturb approximately 91 acres of the borrow area. Implementation of Alterative 1 would result in an additional 9,045 ICU.

Table 4-21. Summary of Alternatives Carried into Impacts Analysis

	Alternative 1 **60% wetland / 40% upland plus 5 ft raising**	**Alternative 2** **50% wetland / 50% upland plus 5 ft raising**	**Alternative 3** **29% wetland / 47% upland / 24% open-water embayment plus 5 ft raising**
Impact Area - including toe dike (acres)	600	600	470
Placement Area (acres)	550	550	435
Size of Tidal Gut (acres)	25	25	10
Wetland Proportion (%, acres)	60%, 315	50%, 275	29%, 165
Upland Proportion (%, acres)	40%, 235	50%, 275	47%, 270
Open-Water Embayment Proportion (%, acres)	None	None	24%, 130
Southwestern Borrow Area Acres Required (acres)	91	49	19
Additional Placement Capacity (mcy)	29	30	28
Additional Site Life (years)	7	7	7
Incremental Cost per ICU ($)	*	*	$63,579
Additional ICUs**	9,045	8,118	9,768

**no incremental cost per ICU was calculated because Alternatives 1 and 2 was eliminated in the cost-effective analysis, prior to the incremental cost analysis (Appendix I)*
***results based on using fish guilds appropriate to alignment, i.e. resident/forage fish and predatory/higher trophic fish guilds for Alternatives 1 and 2 (alignments with no embayment- Section 4.8.1), and bottom feeding, pelagic zone feeding, and shallow water/marsh feeding fish guilds for* Alternative 3 (open-water embayment alignment, Section 4.9.2)

2. **Alternative 2** (Figure 4-16)
   - 50 percent wetlands, 50 percent uplands; plus 5-ft vertical expansion
   - Approximately 30 mcy of placement capacity

   Alternative 2 would consist of a 575-acre placement area (including a 25-acre tidal gut) with a 50 percent wetland, 50 percent upland habitat proportion in combination with a 5-foot raising of the existing upland cells. Alternative 2 would provide nearly 30 million cubic yards of additional dredged material placement capacity, extending the life of the existing project by approximately seven years, allowing for efficient dredged material placement and high probability of success in wetland development. Upland placement capacity would last at least two full years beyond anticipated wetland placement, and the quantity of fill required from the southwest borrow site would be less than 1.0 million of its estimated 4.2 million cubic yard capacity. Sand borrow excavation from the southwestern borrow area would disturb approximately 49 acres of the borrow area. Implementation of Alternative 2 would result in an additional 8,118 ICU.

3. **Alternative 3 (Environmentally Preferred Alternative)** (Figure 4-14)
   - 29 percent wetlands, 47 percent uplands, 24 percent open-water embayment; plus 5-ft vertical expansion
   - Approximately 28 mcy of placement capacity

   The environmentally preferred alternative, based on the results of the ICU and CE/ICA analysis, would consist of a 575-acre placement area (including a 10-acre tidal gut) of 29 percent wetland habitat, 47 percent upland habitat, and 24 percent open-water embayment; plus a vertical expansion component consisting of a 5-ft raising of the upland cells of the existing project. Alternative 3 would provide approximately 28 mcy of additional dredged material placement capacity, extending the life of the existing project by approximately seven years. The quantity of sand required from the southwest borrow site would be approximately 200,000 cy, and sand dredging activities would disturb approximately 19 acres of the borrow area. The environmentally preferred alternative is the cost-effective plan that maximizes the environmental benefits (the NER Plan), with an incremental cost per ICU of $63,579. Implementation of the environmentally preferred alternative would result in an additional 9,768 ICU.

4. **No-Action Alternative** (existing project at its authorized configuration)
   - 1,140 acres at 50 percent wetlands, 50 percent uplands

Several additional considerations (acceptance of dredged material from other channels and environmental enhancements) evaluated as part of the GRR/SEIS, were not subject to the screening and iterative evaluation of the plan formulation and impacts analysis. Summaries of the study results for these considerations are included in the recommended plan (Chapter 6).

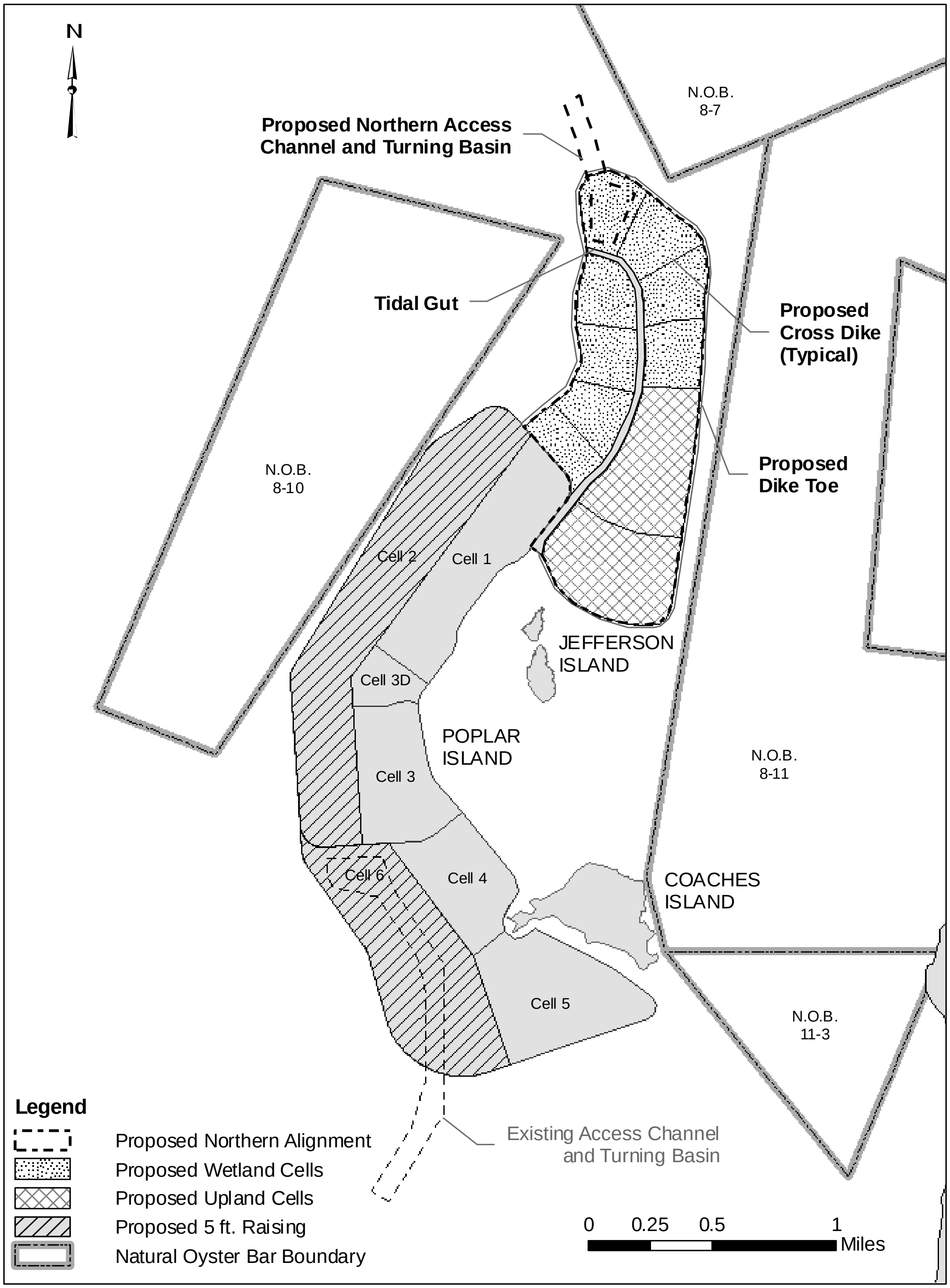


Figure 4-15. Alternative 1 (60% Wetland to 40% Upland Ratio and 5 ft. Raising of PIERP Upland Cells)

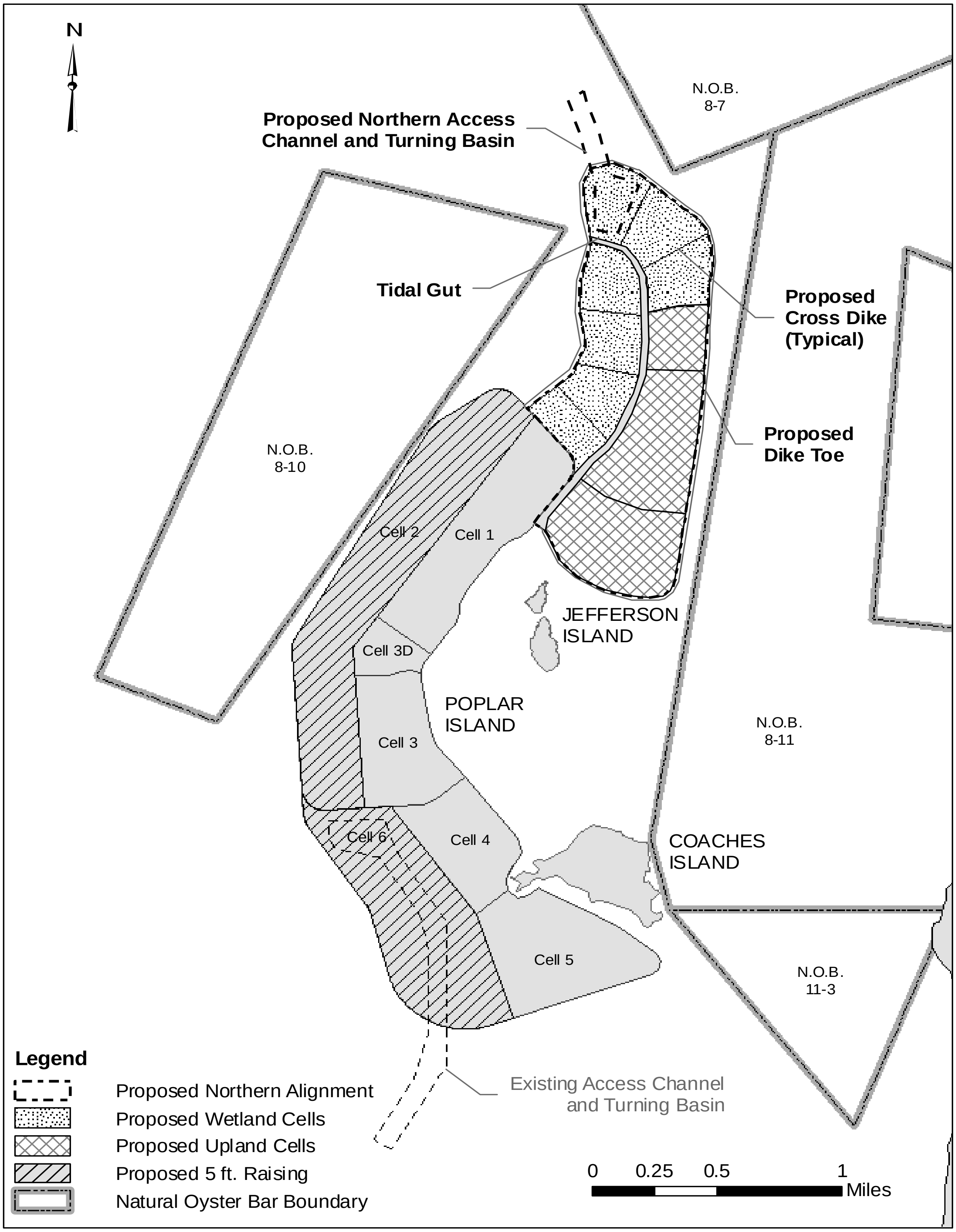


Figure 4-16. Alternative 2 (50% Wetland to 50% Upland Ratio and 5 ft. Raising of PIERP Upland Cells)

4.11 EVALUATION OF ADDITIONAL ACTIONS FOR THE COMPLETION OF THE EXISTING PROJECT

To complete the existing project, additional activities were evaluated as part of the plan formulation process. A more detailed discussion of the project components was included in Section 4.4.3. These actions were not specifically evaluated in the initial EIS for the existing project (USACE/MPA, 1996), and are, therefore, included in the GRR/SEIS (NEPA evaluation). A detailed discussion of the impacts associated with each of the additional actions discussed below is included in Section 5.3

4.11.1 Raising the Existing Upland Dikes from +23 ft MLLW to +25 ft MLLW As discussed in Section 4.4.3, a temporary dike height 5-ft above the targeted final elevation is required to support the water drainage in the upland cells necessary for consolidation (Appendix A, Section 5.9) and, therefore, a design modification to raise existing upland dikes from +23 ft MLLW to +25 ft MLLW is evaluated in the expansion study.

4.11.2 Cell 6 Closure and Additional Cell Activities The actions associated with the Cell 6 closure include: relocation of the existing access channel opening at the southern end of Cell 6, dredging of a turning basin, sand borrow excavation from Borrow Areas F and G, and raising the Cell 6 perimeter dike to elevation +23 ft MLLW (Figure 4-4). Currently, barges access the PIERP through the Cell 6 opening and transit the length of the cell to the dredged material offloading area along the northern cross-dike. The offloading facilities and fuel farm will be relocated to the southern Cell 6 perimeter, and a new pier will be constructed. Additionally, the restoration of internal borrow sites within Cell 4 and miscellaneous cell development, such as the construction of temporary cross dikes within Cell 5 are additional actions that are required for project completion.

4.11.3 Recreational/Educational Opportunities Recreational and educational elements that could be added to the existing PIERP and the proposed lateral expansion were also evaluated. The Talbot County government specifically requested that the PIERP GRR/SEIS include an evaluation of recreational and educational opportunities, and has indicated their support for the development of recreational components (Appendix F, agency consultation dated December 10, 2003 and February 3, 2004). Several considerations for the inclusion of recreational and educational components were studied and screened during the evaluation process as part of the GRR/SEIS. Recreational and educational components of the project will be implemented only to the extent that the components do not adversely impact the created habitats and the goal of the ecosystem restoration process. According to USACE Regulations (Policy Guidance Letter No. 59), the Federal cost for recreational and educational features must be less than 10 percent of the project total cost. Costs for recreational components will be cost shard 50 percent Federal and 50 percent non-Federal. Recreation development at an ecosystem restoration project should be totally ancillary to the primary purpose, appropriate in scope and scale, and shall not diminish the ecosystem restoration benefits used to justify the project (ER 1105-2-100). Additionally, any recreational components incorporated at ecosystem restoration projects, such as the PIERP and proposed lateral expansion, must be compatible with the objectives of the project and enhancement of the public's experience by taking advantage of natural values (ER 1105-2-100).

Initially, a list of recreational and educational components for consideration as part of the GRR/SEIS was drafted based upon projects of similar content in the vicinity of the project area, including Hart-Miller Island (located in the Upper Chesapeake Bay in Baltimore County), Kingman Island (located in the Anacostia River in northeast Washington, D.C.), and Roosevelt Island (located in the Potomac River in Washington, D.C.). The list of components to be considered initially included both active and passive recreational and educational components, however, because of the need to protect the habitat restoration goals of the project, only passive recreation components were considered feasible for implementation at the PIERP. Activities that were considered not feasible for the project, and activities with substantial adverse influences on the existing and created habitats at the PIERP and proposed lateral expansion were screened from further analysis. Components screened out based on these factors included: a camping area for visitors, a playground, an open area for sports activities, food services, a beach area with access for visitors, and reestablishing the pier at Jefferson Island for fishing.

Passive recreational and educational components considered included developing low-impact recreational/educational spaces in a way that benefits the local jurisdictions, the State of Maryland, as well as the objectives of the restoration project. The components included for further consideration in this GRR/SEIS are passive recreational, educational, and habitat-based improvements characterized as low-impacts activities and include the following:

Passive Recreation and Education Components:

- Public tours of the island – the tours of the PIERP offered to the public would be continued.

- Self-guided/interpretive nature trails and boardwalks – A low-impact nature trail could be created along with a series of small boardwalks that overlook the Chesapeake Bay.

- Kiosks with informative signage – Kiosks would be located at set areas along the nature trail and boardwalk in the lateral expansion, and at specified locations at the existing PIERP.

- Avian observation areas – Platforms and/or observation decks would include benches and an overlook.

- Research opportunities for educational institutions – Similar to current conditions, educational institutions would be provided opportunities and permitted to conduct scientific studies at the PIERP and at the proposed lateral expansion during site operations.

- Volunteer opportunities – Similar to current conditions, volunteers would be invited to participate in both wetland and upland plantings, bird census, building platforms to attract avian species (such as butterfly and bluebird boxes), and research opportunities at the PIERP and the proposed lateral expansion during site operations.

- Dock for visiting boats – A dock for visitors to tie-up boats could be located in the turning basin at the northern portion of the lateral expansion with a picnic area and nature trail will be located directly adjacent to and accessible to the docking area.

- Picnic areas – An area for visitors with a set number of tables for picnicking could be included for recreation.

- Demonstration garden – Similar to the demonstration area the PIERP, a garden display area depicting native plants with identification tags could be created in a location to be determined in the proposed northern lateral expansion.

- Stone sculpture/monument/memorial area - Similar to existing conditions at the PIERP, either a stone sculpture area, a monument, or an appropriately designed memorial could be created in a location to be determined in the proposed northern lateral expansion, if appropriate.

- Resting/viewing areas – Locations for resting on benches along the proposed nature trail and the shoreline areas, off of designated paths, could be located in the proposed lateral expansion and the existing PIERP.

Additionally, several proposed project features would provide increased recreational opportunities around the project. The rock reefs, segmented breakwater structures, and armored perimeter dikes constructed for the lateral expansion will provide additional fish cover, increasing their potential as high-functioning fish habitat that could support a more productive recreational fishery in the vicinity of the project. The inclusion of an open-water embayment within the footprint of the lateral expansion, as considered in Alternative 3, would provide semi-protected fisheries habitat adjacent to wetland and upland cells, and would increase the trophic interaction between the wetland cells and the open-water embayment within the lateral expansion and enhance fish habitat. Access to the open-water embayment proposed in Alternative 3 may also provide additional opportunities for recreational fishermen and recreational boaters using non-motorized boats such as canoes and kayaks.

The majority of the passive recreational components can be considered interpretive guidance and media, including: self-guided/interpretive nature trails and boardwalks, kiosks with informative signage, a demonstration garden, a stone sculpture/monument/memorial area, resting/viewing areas, and avian observation areas. Other components such as the public tours of the island, research opportunities for universities, and volunteer opportunities will augment and continue programs already in place at the existing project. A detailed discussion of the impacts associated with each of these components is included in Section 5.3

An Operations Building is currently being considered for construction at the PIERP (Section 3.4.2.a) and is planned to include a conference room and laboratory space, in addition to offices and storage space. The conference room, laboratory space, and restroom facilities planned for the Operations Building may be utilized by visitors to the PIERP. The building may include areas for terrapin and bird processing by students or scientists conducting research; informative displays depicting the history of Poplar Island, the current and future proposals for the PIERP, and the lateral expansion; a TV/AV set-up for viewing educational programs; and exhibits depicting local wildlife (i.e., terrapins, fish, and birds). Although the building have been designed, construction is currently on hold (indefinitely) as a result of budgetary constraints, and were therefore, not included in the recommendations for the recreational and educational components.

Any recreational and educational features implemented at PIERP or the proposed lateral expansion would be consistent with the goals of the restoration project, and implementation would be coordinated extensively with interested agencies and local jurisdictions. In the future, the stakeholders will be encouraged to participate in the planning process to further enhance the vision for recreational and educational components by providing community input on the specific types of recreational/educational uses, and to help shape the plan for the island.