# APPENDIX I

# POPLAR ISLAND EXPANSION STUDY COST EFFECTIVENESS / INCREMENTAL COST ESTIMATE

GENERAL REEVALUATION REPORT (GRR) AND

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (SEIS)
FOR THE

POPLAR ISLAND ENVIRONMENTAL RESTORATION PROJECT

CHESAPEAKE BAY, TALBOT COUNTY, MARYLAND

## I.1 INTRODUCTION

The Poplar Island Expansion ecosystem restoration project delivery team formulated a set of alternatives designed to restore island habitat by expanding the area of the existing Poplar Island construction footprint. Initial and secondary screening used non-economic criteria and objectives to eliminate alternative alignments to the south and to the west of the existing island footprint. The six northern lateral expansion options remaining after screening are located to the north and east of the existing island footprint. The footprints of the six options are essentially identical, and will produce an approximately 575-acre northern lateral expansion continuous with the existing Poplar Island project.

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 options. 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, they contribute to informed decision making for ecosystem restoration projects.

## I.2 PROJECT OUTPUT ANALYSIS

The project delivery team defined and measured the expansion project outputs in terms of habitat units or Island Community Units (ICUs). The expected ICUs were evaluated for each expansion alternative from the outset of dike construction (Appendix H). Outputs include interim ICUs expected to accrue during early stages of cell development and wetland and upland cell ICUs expected to result from planned habitat development activities. The ICUs were evaluated on an annual basis over time based on the expected island expansion alternative construction and development pattern. Project outputs are expected to begin to accrue as the perimeter dikes are constructed and continue to grow and accrue during the development of island upland and wetland cells.

### I.2.1 No-Action (Without Project) 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 by the existing Poplar Island project without expansion of its construction footprint. The environmental outputs or ICUs were evaluated for the currently authorized Poplar Island project under construction. The period of analysis used was 50 years with a project base year of 2010, the first year of expected outputs with construction of an expansion alternative. The existing Poplar Island project without expansion is expected to produce a total of 18,077 ICUs during the 2010-2059 analysis period, an average of 362 ICUs per year. Table I-1 displays the ICU evaluation for the existing Poplar Island project without expansion for the period of analysis.

The total estimated project construction cost for the existing Poplar Island project without expansion is $396 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 island site. The cost estimate includes the cost to construct the dikes, to develop and operate the project, to dredge, transport and place dredged material at the site and to develop the island habitat. Table I-2 displays the analysis of costs for the existing Poplar Island project without expansion.

**Table I-1. Poplar Island Existing Project Benefit Analysis**

| Base Year of Analysis: 2010 | | | ICU= Island Community Units | 50 yr. Period of Analysis |
|---|---|---|---|---|
| Project Year | Year | Wetland ICUs | Other ICUs | Total ICUs |
| 0 | 2010 | 100.50 | 154.50 | 255.00 |
| 1 | 2011 | 109.00 | 154.00 | 263.00 |
| 2 | 2012 | 114.90 | 154.10 | 269.00 |
| 3 | 2013 | 109.40 | 154.60 | 264.00 |
| 4 | 2014 | 128.90 | 154.10 | 283.00 |
| 5 | 2015 | 155.80 | 154.20 | 310.00 |
| 6 | 2016 | 183.20 | 153.80 | 337.00 |
| 7 | 2017 | 211.40 | 2.60 | 214.00 |
| 8 | 2018 | 240.90 | 0.10 | 241.00 |
| 9 | 2019 | 263.90 | 0.10 | 264.00 |
| 10 | 2020 | 285.80 | 0.20 | 286.00 |
| 11 | 2021 | 305.40 | 9.60 | 315.00 |
| 12 | 2022 | 315.00 | 15.00 | 330.00 |
| 13 | 2023 | 323.10 | 12.90 | 336.00 |
| 14 | 2024 | 328.10 | 10.90 | 339.00 |
| 15 | 2025 | 331.60 | 9.40 | 341.00 |
| 16 | 2026 | 334.40 | 12.60 | 347.00 |
| 17 | 2027 | 335.70 | 20.30 | 356.00 |
| 18 | 2028 | 337.00 | 47.00 | 384.00 |
| 19 | 2029 | 337.00 | 36.00 | 373.00 |

| Base Year of Analysis: 2010 | | | ICU= Island Community Units<br>50 yr. Period of Analysis | |
|---|---|---|---|---|
| **Project Year** | **Year** | **Wetland ICUs** | **Other ICUs** | **Total ICUs** |
| 20 | 2030 | 337.00 | 44.00 | 381.00 |
| 21 | 2031 | 337.00 | 47.00 | 384.00 |
| 22 | 2032 | 337.00 | 47.00 | 384.00 |
| 23 | 2033 | 337.00 | 47.00 | 384.00 |
| 24 | 2034 | 337.00 | 47.00 | 384.00 |
| 25 | 2035 | 337.00 | 47.00 | 384.00 |
| 26 | 2036 | 337.00 | 47.00 | 384.00 |
| 27 | 2037 | 337.00 | 47.00 | 384.00 |
| 28 | 2038 | 337.00 | 47.00 | 384.00 |
| 29 | 2039 | 337.00 | 47.00 | 384.00 |
| 30 | 2040 | 337.00 | 47.00 | 384.00 |
| 31 | 2041 | 337.00 | 47.00 | 384.00 |
| 32 | 2042 | 337.00 | 47.00 | 384.00 |
| 33 | 2043 | 337.00 | 47.00 | 384.00 |
| 34 | 2044 | 337.00 | 47.00 | 384.00 |
| 35 | 2045 | 337.00 | 47.00 | 384.00 |
| 36 | 2046 | 337.00 | 47.00 | 384.00 |
| 37 | 2047 | 337.00 | 68.00 | 405.00 |
| 38 | 2048 | 337.00 | 83.00 | 420.00 |
| 39 | 2049 | 337.00 | 83.00 | 420.00 |
| 40 | 2050 | 337.00 | 83.00 | 420.00 |
| 41 | 2051 | 337.00 | 83.00 | 420.00 |
| 42 | 2052 | 337.00 | 83.00 | 420.00 |
| 43 | 2053 | 337.00 | 83.00 | 420.00 |
| 44 | 2054 | 337.00 | 83.00 | 420.00 |
| 45 | 2055 | 337.00 | 83.00 | 420.00 |
| 46 | 2056 | 337.00 | 83.00 | 420.00 |
| 47 | 2057 | 337.00 | 83.00 | 420.00 |
| 48 | 2058 | 337.00 | 83.00 | 420.00 |
| 49 | 2059 | 337.00 | 83.00 | 420.00 |
| | | | **Total ICUs** | **18,077** |
| | | | **Annual ICUs** | **361.54** |

## Table I-2. Poplar Island Existing Project Cost Analysis

**Project Costs by Type and Year**

| Project Year | Year of Outlay | Construction | Site Development | Habitat Development | Dredging, Transport, Placement | Total Costs | Discounted Costs |
|---|---|---|---|---|---|---|---|
| -2 | 1998 | $12,380,600 | $0 | $0 | $0 | $12,380,600 | $13,747,283 |
| -1 | 1999 | $35,488,982 | $0 | $0 | $0 | $35,488,982 | $37,396,515 |
| 0 | 2000 | $17,804,392 | $1,999,989 | $0 | $538,000 | $20,342,381 | $20,342,381 |
| 1 | 2001 | $32,701,719 | $6,801,431 | $0 | $10,566,110 | $50,069,260 | $47,515,312 |
| 2 | 2002 | $6,936,603 | $13,389,097 | $36,059 | $12,573,536 | $32,935,295 | $29,661,041 |
| 3 | 2003 | $0 | $8,133,141 | $764,437 | $4,453,642 | $13,351,220 | $11,410,592 |
| 4 | 2004 | $0 | $13,349,000 | $825,325 | $2,666,229 | $16,840,554 | $13,658,595 |
| 5 | 2005 | $0 | $10,480,000 | $1,200,000 | $10,576,521 | $22,256,521 | $17,130,472 |
| 6 | 2006 | $0 | $10,784,000 | $918,883 | $12,895,210 | $24,598,093 | $17,967,014 |
| 7 | 2007 | $0 | $4,625,000 | $949,279 | $13,756,448 | $19,330,727 | $13,399,391 |
| 8 | 2008 | $0 | $6,031,890 | $2,305,898 | $16,276,858 | $24,614,646 | $16,191,717 |
| 9 | 2009 | $0 | $4,585,000 | $2,380,990 | $15,304,157 | $22,270,147 | $13,902,240 |
| 10 | 2010 | $0 | $3,680,000 | $2,457,914 | $15,396,072 | $21,533,986 | $12,757,000 |
| 11 | 2011 | $0 | $2,900,000 | $2,500,000 | $15,396,072 | $20,796,072 | $11,691,436 |
| 12 | 2012 | $0 | $2,450,000 | $2,500,000 | $15,396,072 | $20,346,072 | $10,854,992 |
| 13 | 2013 | $0 | $2,100,000 | $2,500,000 | $15,396,072 | $19,996,072 | $10,124,091 |
| 14 | 2014 | $0 | $2,900,000 | $2,500,000 | $0 | $5,400,000 | $2,594,583 |
| 15 | 2015 | $0 | $2,450,000 | $2,500,000 | $0 | $4,950,000 | $2,257,051 |
| 16 | 2016 | $0 | $2,100,000 | $2,500,000 | $0 | $4,600,000 | $1,990,474 |
| 17 | 2017 | $0 | $1,800,000 | $2,500,000 | $0 | $4,300,000 | $1,765,751 |
| **Totals** | | **$105,312,296** | **$100,558,548** | **$29,338,785** | **$161,190,999** | **$396,400,628** | **$306,357,931** |
| | | | | | **Average Annual Cost** | **50 yrs. @ 5.375%** | **$17,762,817** |

### I.2.2 Poplar Island Expansion Alternatives

The size and basic configuration of the northern lateral expansion options were defined during initial and secondary screening based on physical constraints, engineering considerations and project delivery team objectives and criteria. The basic alignment and location of the six options that were carried forward after the screening did not vary significantly. Each option is expected to provide a 575-acre expansion to the footprint of the existing Poplar Island project.

The six options are distinguished primarily by variance in either their wetland to upland design ratio or in the upland dike height of the existing Poplar Island project, as follows:

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

**I.2.2.a Alternatives Cost Analysis** Conceptual level cost estimates were developed for each of the northern lateral alignment options. These 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 done for the 50 percent wetland, 50 percent upland alignment and for the 60 percent wetland, 40 percent upland with 5-ft dike raising of the existing upland cells alignment. The construction costs for the other four alternatives were based on those 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 Poplar Island restoration project.

Table I-3 displays the cost estimates for each northern lateral expansion alignment. These cost estimates were used in the CE/ICA analysis.

**Table I-3. Poplar Island Expansion Alignments, Project Cost Estimates**

| Alignment | Dike Construction Cost | Non-Dike Project Costs | Total Project Cost |
|---|---|---|---|
| 50% Wetland & 50% Upland | $104,080,000 | $179,940,000 | $284,020,000 |
| 50% Wetland & 50% Upland + 5' Raising | $104,450,000 | $195,050,000 | $299,500,000 |
| 55% Wetland & 45% Upland | $104,400,000 | $177,990,000 | $282,390,000 |
| 55% Wetland & 45% Upland + 5' Raising | $104,780,000 | $191,310,000 | $296,090,000 |
| 60% Wetland & 40% Upland | $105,080,000 | $182,080,000 | $287,160,000 |
| 60% Wetland & 40% Upland + 5' Raising | $105,460,000 | $193,470,000 | $298,930,000 |

**I.2.2.b Environmental Benefits (ICU) Evaluation** Each of the six northern lateral expansion alignments was evaluated for a 50 year period of analysis to evaluate the expected output in ICUs associated with construction and development of the alignment. The ICUs were evaluated based on the unique site development plan and cell development plan for each alignment. For each alignment, an average yearly ICU amount was computed. Table I-4 displays the results of the evaluation of expected ICUs for each alignment. The outputs displayed in the table define the expected increase by alignment in ICUs from the expected output for the existing Poplar Island project.

**Table I-4. Expansion Alignments Expected Yearly Average ICU Output by Alignment for 50-year Period of Analysis**

| Alignment | Total ICUs (50 yr period) | Yearly Average ICUs |
|---|---|---|
| 50% Wetland & 50% Upland | 7,693 | 154 |
| 50% Wetland & 50% Upland + 5' Raising | 8,088 | 162 |
| 55% Wetland & 45% Upland | 8,274 | 165 |
| 55% Wetland & 45% Upland + 5' Raising | 8,669 | 173 |
| 60% Wetland & 40% Upland | 8,599 | 172 |
| 60% Wetland & 40% Upland + 5' Raising | 9,015 | 180 |

## I.3 COST EFFECTIVENESS ANALYSIS

Table I-5 displays the cost effectiveness analysis for the six northern lateral expansion alignments and the No-Action alternative. 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.

The table is arranged in ascending order from least to greatest output in ICUs. The no-action alternative, listed first in the table, produces 362 expected yearly ICUs. The 50 percent wetland, 50 percent upland alignment and the 50 percent wetland, 50 percent upland plus a 5-ft raising of the existing upland cells alignment (shaded in gray), were eliminated on the basis of cost effective principles because the 55 percent wetland, 45 percent upland alignment produces more output for less cost than each of those two alternatives. There were four cost effective alignments remaining after the cost effectiveness analysis. From a cost effectiveness perspective, selection of any of these alignments would be acceptable. The last column in Table I-5 shows the average cost per ICU for each alternative. The alternative with the least average cost per ICU is the 60 percent wetland, 40 percent upland plus a 5-ft raising of the existing upland cells alignment, with a cost of $55,934 per ICU on an annual basis.

**Table I-5. Poplar Island Restoration Alignment, Cost Effectiveness Analysis, FY 2005 Interest Rate 5.375%**

| Alignment | Total Cost ($000s) | Present Value Cost ($000s) | Total ICUs | Ave. Annual Cost ($000s) | Ave Annual ICUs | Ave Cost $/ICU |
|---|---|---|---|---|---|---|
| Existing Poplar (No-Action) | $396,401 | $306,358 | 18,077 | $17,763 | 362 | $49,069 |
| 50% Wetland & 50% Upland | $680,421 | $516,868 | 25,770 | $29,968 | 516 | $58,078 |
| 50% Wetland & 50% Upland + 5' Raising | $695,901 | $524,358 | 26,165 | $30,403 | 524 | $58,020 |
| 55% Wetland & 45% Upland | $678,791 | $515,828 | 26,351 | $29,908 | 527 | $56,751 |
| 55% Wetland & 45% Upland + 5' Raising | $683,561 | $519,608 | 26,676 | $30,127 | 534 | $56,418 |
| 60% Wetland & 40% Upland | $692,491 | $522,758 | 26,746 | $30,310 | 535 | $56,654 |
| 60% Wetland & 40% Upland + 5' Raising | $695,331 | $522,868 | 27,092 | $30,316 | 542 | $55,934 |

## I.4 INCREMENTAL ANALYSIS OF COST EFFECTIVE ALIGNMENTS

Table I-6 displays the incremental analysis of the four cost effective alignments. The table is arranged by output in ascending order starting with the No-Action alternative. Table I-6 displays the incremental ICUs gained with each alignment compared to the No-Action alternative, and the incremental cost on an annual basis of each plan compared to the No-Action alternative. Table I-6 also displays the cost per incremental ICU gained by construction of the alignment compared to the No-Action alternative.

The incremental analysis indicates that 60 percent wetland, 40 percent upland plus a 5-ft raising of the existing upland cells alignment provides the best return on investment in terms of cost per ecosystem restoration output gained among the alternatives. The incremental cost per ICU of implementing the 60 percent wetland, 40 percent upland plus a 5-ft raising of the existing upland cells alignment instead of the No-Action alternative is $69,739.

**Table I-6. Poplar Island Restoration Alignments, Incremental Analysis of Cost Effective Alignments, Cost per ICU of Implementing Each Remaining Plan Instead of the No-Action Plan, FY 2005 Interest Rate 5.375%**

| Alignment | Ave. Annual Cost ($000s) | Ave Annual ICUs | Incremental ICUs | Incr. Cost ($000s) | $/Incr. ICUs |
|---|---|---|---|---|---|
| Existing Poplar (No-Action) | $17,763 | 362 | N/A | N/A | N/A |
| 55% Wetland & 45% Upland | $29,908 | 527 | 165 | $12,145 | $73,606 |
| 60% Wetland & 40% Upland | $30,127 | 534 | 172 | $12,364 | $71,884 |
| 55% Wetland & 45% Upland + 5' Raising | $30,310 | 535 | 173 | $12,547 | $72,526 |
| 60% Wetland & 40% Upland + 5' Raising | $30,316 | 542 | 180 | $12,553 | $69,739 |

## I.5 COMPARISON OF ALTERNATIVES TO THE EXISITING PROJECT

An additional level of incremental analysis was done to compare the expected annual incremental ICU outputs and the annualized incremental costs of each of the six northern lateral expansion alignments with the existing Poplar Island project. Table I-7 display the incremental ICUs and the incremental cost for each alignment expressed in annual terms, and shows the cost per incremental ICU associated with construction of the alignment when compared to the existing Poplar Island project. The alignments are arranged in order from the alignment with the least cost per ICU compared to the existing project to the alignment with the most cost per ICU compared to the existing project.

From a cost perspective the 60 percent wetland, 40 percent upland plus a 5-ft raising of the existing upland cells, with a cost of $69,739 per incremental ICU, is the preferred alignment when compared to the existing Poplar project. The difference in cost per incremental ICU between the most costly and least costly expansion alternative is approximately $9,500 on an annual basis.

**Table I-7. Incremental Comparison of Poplar Island Expansion Alignments with Existing Poplar Island Project**

| Alignment | Incremental ICUs | Incremental Cost | $/Incremental ICUs |
|---|---|---|---|
| 60% Wetland & 40% Upland + 5' Raising | 180 | $12,553,000 | $69,739 |
| 60% Wetland & 40% Upland | 172 | $12,364,000 | $71,884 |
| 55% Wetland & 45% Upland + 5' Raising | 173 | $12,547,000 | $72,526 |
| 55% Wetland & 45% Upland | 165 | $12,145,000 | $73,606 |
| 50% Wetland & 50% Upland + 5' Raising | 162 | $12,640,000 | $78,025 |
| 50% Wetland & 50% Upland | 154 | $12,205,000 | $79,253 |

## I.6 FINAL OUTPUT COMPARISON (USING INTERIM ENVIRONMENTAL BENEFITS)

Each of the expansion alternatives was evaluated in terms of its expected output on an annual basis starting in 2010 and extending over a 50-year period of analysis. The alternatives were formulated to produce ICUs in the managed wetland and upland cells. The expected ICUs for cells were evaluated based on cell design parameters. Additional interim ICUs are expected to accrue with the alternatives that include a 5-ft raise of the existing upland cells. These additional interim ICUs were included in the total calculation of ICUs for the raised dike alternatives.

To measure the sensitivity of the CE/ICA to interim outputs, final design expected annual ICUs were compared to average ICUs for the 50-year analysis period used in the CE/ICA analyses. Based on the ICU evaluation each alternative achieves its equilibrium annual output by 2055. Table I-8 shows the total ICUs with interim outputs included and the final expected annual output in ICUs when the alternatives are fully mature. The table shows that the final expected output is identical between the non-raised and the dike raised alternatives for each set of alternatives.

**Table I-8. Average ICUs with Interim Outputs and Expected Final Annual Outputs in 2055 by Expansion Alignment**

| Alignment | Average ICUs With Interim Outputs (2010-2059) | 2055 Annual Output (ICUs) (Final Design) |
|---|---|---|
| 50% Wetland & 50% Upland | 154 | 227 |
| 50% Wetland & 50% Upland + 5' Raising | 162 | 227 |
| 55% Wetland & 45% Upland | 165 | 245 |
| 55% Wetland & 45% Upland + 5' Raising | 173 | 245 |
| 60% Wetland & 40% Upland | 172 | 264 |
| 60% Wetland & 40% Upland + 5' Raising | 180 | 264 |

Similar to Table I-7, Table I-9 compares each alignment to the existing Poplar Island project using the final expected annual output instead of the average for the 50-year analysis period. Table I-9 shows that when final design expected annual ICUs are compared to the incremental cost, the alternatives without the dike raising are less costly than alignments that include a dike raising. This is because the effect of interim ICUs is not factored into the analysis.

The sensitivity analysis shows that the effect of excluding interim benefits from the CE/ICA is to show that the alternatives without a dike raise within each set of expansion alternatives are less costly on an incremental basis than those with a 5-foot dike raise of the existing Poplar Island project.

**Table I-9. Incremental Comparison of Poplar Island Expansion Alternatives with Existing Poplar Island Project Using Expected Final Outputs**

| Alternative | Incremental ICUs | Incremental Cost | $/Incremental ICUs |
|---|---|---|---|
| 60% Wetland & 40% Upland | 264 | $12,364,000 | $46,883 |
| 60% Wetland & 40% Upland + 5' Raising | 264 | $12,553,000 | $47,549 |
| 55% Wetland & 45% Upland | 245 | $12,145,000 | $49,571 |
| 55% Wetland & 45% Upland + 5' Raising | 245 | $12,547,000 | $51,212 |
| 50% Wetland & 50% Upland | 227 | $12,205,000 | $53,767 |
| 50% Wetland & 50% Upland + 5' Raising | 227 | $12,640,000 | $55,683 |

## I.7 INTEGRATION OF THE OPEN-WATER EMBAYMENT ALIGNMENT

Following the completion of the plan formulation process, a proposal from National Marine Fisheries Service (NMFS) and subsequent discussions with the Environmental Protection Agency (USEPA), Fish and Wildlife Service (USFWS), Maryland Department of Natural Resources (MDNR), and Maryland Department of the Environment (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. The inclusion of an open-water embayment within the footprint of the lateral expansion 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 District 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. 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, 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.

Based on the agency consultation to-date, the open-water embayment could potentially range between 80 to 140 acres in size. Concerns pertaining to specific components of the open-water embayment 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. 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.

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 calculation of the environmental benefits of the open-water embayment are provided in the following sections.

### I.7.1 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 I-10. In this stage of the analysis, total costs for each of the alternatives were based on detailed MCASES cost estimates, 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 I-11). 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 I-10. 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 |

### I.7.2 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 I-11. 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 I-11. 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 |