Hickory Cove Marsh Restoration And Living Shoreline

Bridge City, TX

WRDA 2016 Section 1122

Beneficial Use of Dredged Material

Appendix E: Cost Effectiveness and Incremental Cost Analysis

U.S. Army Corps of Engineers

Southwest Division

Galveston District

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List of Acronyms

AAHU	Average Annual Habitat Unit
CE/ICA	Cost Effectiveness / Incremental Cost Analysis
EGM	Economic Guidance Memorandum
ICA	Incremental Cost Analysis
IDC	Interest During Construction
NER	National Ecosystem Restoration
OMRR&R	Operations, Maintenance, Repair, Replacement, and Rehabilitation

1 Introduction

Comparing benefits and costs for ecosystem restoration provides a challenge to planners and decision makers because benefits and costs are not measured in the same units. Environmental restoration benefits can be measured in habitat units or some other physical unit, while costs are measured in dollars. Therefore, benefits and costs cannot be directly compared. Two analyses are conducted to help planners and decision makers identify plans for implementation, though the analyses themselves do not identify a single ideal plan. These two techniques are cost effectiveness and incremental cost analysis. Use of these techniques are described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies (U.S. Water Resources Council 1983).

Cost effectiveness compares the annual costs and benefits of plans under consideration to identify the least cost plan alternative for each possible level of environmental output, and for any level of investment, the maximum level of output is identified.

Incremental cost analysis of the cost-effective plans is conducted to reveal changes in costs as output levels are increased. Results from both analyses are presented graphically to help planners and decision makers select plans. For each of the best buy plans identified through incremental cost analysis, an “is it worth it?” analysis is then conducted for each incremental measure or plan to justify the incremental cost per unit of output to arrive at a recommended plan.

As this appendix will document, the National Ecosystem Restoration Plan identified as the Tentatively Selected Plan, is Alternative 3 which comprises marsh creation, a breakwater structure, and a restored living shoreline feature. For this study, the environmental outputs are average annual habitat unit (AAHU), which are the product of a Habitat Suitability Index and an alternatives acreage analysis. The development of the AAHUs is discussed in detail in Appendix B-6—Ecological Modeling.

2 Measures and Alternatives

2.1 Measures

A measure is defined as a means to an end; an act, step, or procedure designed for the accomplishment of an objective. In other words, a measure is a feature (structure), or an activity, that can be implemented at a specific geographic site to address one or more planning objectives. Measures are the building blocks of alternatives and are categorized as structural and non-structural. Equal consideration was given to measures during the planning process while conducting this feasibility study. A detailed description of each of these can be read in the Main Report Chapter 3.9.

- **Dredge Material Placement/Marsh Creation**
- **Breakwaters**
- **Living Shorelines**

2.2 Alternatives

The array of management measures was combined into alternatives that would address ecosystem restoration of the coastal habitats, as well as restore structure and function of the study area. Each of the alternatives listed below could be a standalone plan or be combined with other alternatives to form a suite of plans.

In the subsequent sections, only the 1.3 million cubic yard scale of Alternate 1 is carried forward for comparison of Alternatives 2 and 3. The team identified the sediment volume as a source of uncertainty in the analysis, due to either variable coastal conditions, budget allocation decisions at the District, and corresponding cost share capabilities of the Non-Federal Sponsor. The scales of sediment placement were assessed to confirm that, should smaller placements be necessary based on the conditions noted above, the varied scales of sediment placement were justified. Based upon Vatical Team guidance at an In Progress Review, it concurred with the PDT explanation that the largest sediment volume should be considered in combination with other measures to assess Alternatives 2 and 3.

3 Average Annual Habitat Units and Costs

In order to determine benefits of an environmental restoration plan, future with-project environmental outputs are compared to future without-project outputs. The difference between the two represents the benefits from project implementation. The Average Annual Habitat Units (AAHUs) were calculated using the Annualizer Tool in the Institute for Water Resources Planning Suite II. Appendix B-6 – Ecological Modeling provides further documentation on how AAHUs were calculated for each Future-Without Project (FWOP) and Future-With Project (FWP) condition benefits.

3.1 Existing and Future-Without Project Average Annual Habitat Units

For this study, FWOP baseline conditions are assumed to be the same as existing conditions, given the existing habitat quality. Future-Without Project conditions were estimated by a team of biologists, including representatives from USACE, Bridge City TX, and State of Texas resource agency representatives.

3.2 Future-With Project Average Annual Habitat Units

Environmental restoration benefits are calculated by subtracting the FWOP AAHU from the FWP AAHU. For the comparison of measures, both environmental outputs and costs were annualized over a 50-year planning horizon using the FY 2021 Federal Discount Rate of 2.5% (per EGM 20-01 dated 31 October 2020). The 50-year planning horizon is used primarily for analytical purposes pertaining to the benefit-cost calculations; actual benefits may well indeed be realized longer than 50 years and any discussion of such longer-term benefitting would be found in Appendix B-6 – Ecological Modeling.

The resulting benefits are then used, along with annual costs, to identify cost effective plans and perform incremental cost analysis. The calculation of benefits (outputs/AAHUs) are shown in

.

	Alternatives	AAHU Benefits
Hickory Cove Marsh	ALT 1A—500K CY of Marsh Creation	70.5
	ALT 1B—900K CY of Marsh Creation	78.5
	ALT 1C—1.3M CY of Marsh Creation	87.3
	ALT 2—1.3M CY of Marsh Creation + Breakwater	256.4
	ALT 3—1.3M CY of Marsh Creation + Breakwater + Living Shoreline	291.5

3.3 Costs

Total project economic costs were annualized using the Annualizer Tool in Institute for Water Resources (IWR) Planning Suite II. A period of analysis of 50 years was used, along with a Federal Discount rate of 2.5% (per EGM 20-01 dated 31 October 2020). Cost estimates are expressed in October 2020 dollars/price-level.

Cost estimates provided throughout the remainder of this appendix exclude the costs related to dredging activities that would occur independently of these ecosystem restoration features. Finally, no type of monitoring nor operation & maintenance is attached to this project; details to explain such to be found in the main report and/or the Appendix B-6 – Ecological Modeling.

provides a summary of total and annualized plan costs. Construction durations were estimated to be 12 months or fewer for all alternatives, thus negating the need for calculating interest during construction (IDC). Only construction first costs are used to calculate annual costs. No OMRR&R have been included with this analysis. Cost estimates provided throughout the remainder of this appendix exclude the costs related to dredging activities that would occur independently of these ecosystem restoration features. Finally, no type of monitoring nor operation & maintenance is attached to this project; details to explain such to be found in the main report and/or the Appendix B-6 – Ecological Modeling.

	Project First Cost	Real Estate	IDC	Economic Cost	Annual Investment Cost	Annual M&AM	Annual OMRRR	Total Annual Cost
HICKORY COVE MARSH								
ALT 1A—500K CY of Marsh Creation	$1,813,000	$71,700	N/A	$1,884,700	$66,450	N/A	N/A	$66,450
ALT 1B—900K CY of Marsh Creation	$2,527,400	$93,100	N/A	$2,620,500	$92,400	N/A	N/A	$92,400
ALT 1C—1.3M CY of Marsh Creation	$2,567,000	$106,200	N/A	$2,673,200	$94,250	N/A	N/A	$94,250

ALT 2—1.3M CY of Marsh Creation + Breakwater	$25,617,100	$106,200	N/A	$25,723,300	$906,950	N/A	N/A	$906,950
ALT 3—1.3M CY of Marsh Creation + Breakwater + Living Shoreline	$28,523,000	$162,000	N/A	$28,685,000	$1,011,400	N/A	N/A	$1,011,400

3.4 Cost Effectiveness and Incremental Cost Analysis

To conduct the CE/ICA analysis, environmental restoration benefits (increase in with-project AAHUs) and annual costs were entered into IWR Planning Suite II. This resulted in 5 cost effective plans for each reach, shown in Table 3-3.

Cost effective plans are defined as the least expensive plan for a given set of benefits, or environmental output. In other words, no other plan would provide the same or more benefits for a lower cost. All combinability and dependency relationships were determined outside of the tools available within the IWR Planning Suite II software program by the environmental team members before providing the AAHUs for the CE-ICA analysis. As such, the “No plans can be combined” option was checked within IWR Planning Suite in running the analysis. Moreover, initially all five of the proposed plans qualified as Cost Effective Plans; subsequently three of the alternatives (plus by definition the No Action plan scenario) qualified as Best Buy Plans.

Table 3-1. Annual Benefits and Annual Cost for Cost Effective Alternatives

	Alternatives	AAHU	Annual Cost ($1s) October 2020 Prices
Hickory Cove Marsh	ALT 1A—500K CY of Marsh Creation	70.5	$66,450
	ALT 1B—900K CY of Marsh Creation	78.5	$92,400
	ALT 1C—1.3M CY of Marsh Creation	87.3	$94,250
	ALT 2—1.3M CY of Marsh Creation + Breakwater	256.4	$906,950
	ALT 3—1.3M CY of Marsh Creation + Breakwater + Living Shoreline	291.5	$1,011,400

3.4.1 Cost Effective Plans

Note that cost effective plans (red triangles) include those identified as “Best Buy” plans (green squares), which will be discussed in the next section.

Figure 3-1. Cost Effective Results

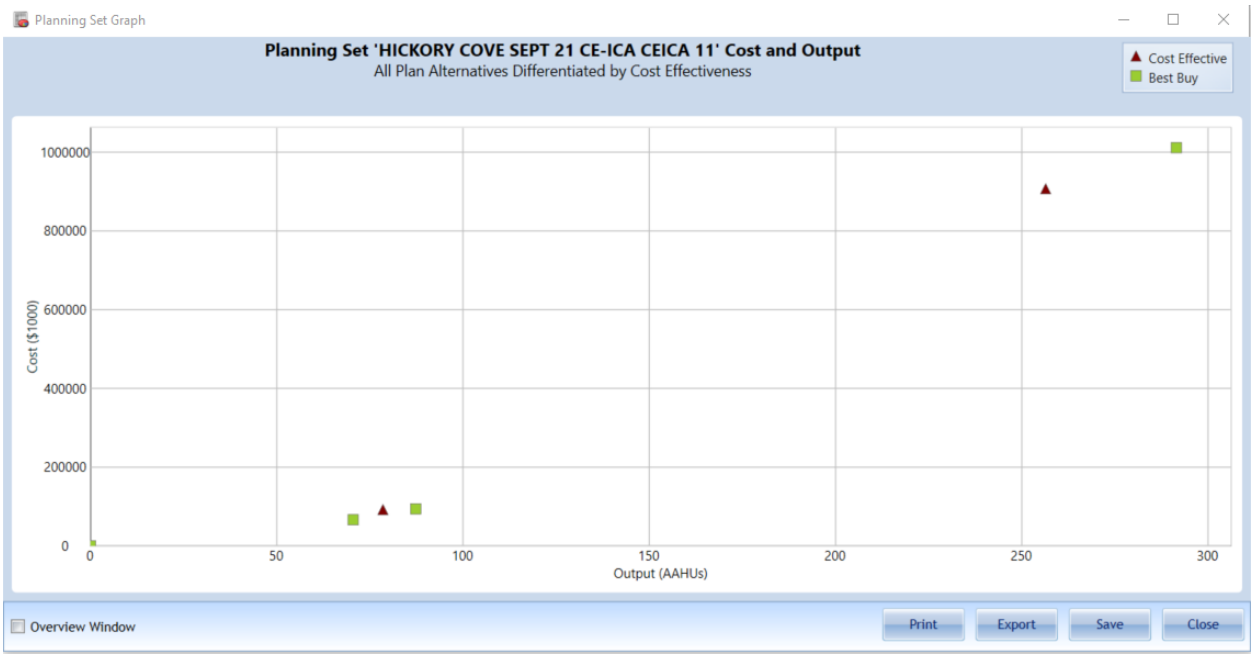

Table 3-2. Cost Effective Plans

Cost Effective Plans	Plan Description	AAHUs	Annualized Cost ($1s)	Annualized Cost/AAHUs ($1)
No Action Plan	No Action Plan	0	$0	0
ALT 1A—500K Marsh Creation		70.5	$66,450	$943
ALT 1B—900K Marsh Creation		78.5	$92,400	$1,177
ALT 1C—1.3M Marsh Creation		87.3	$94,250	$1,080
ALT 2—1.3M MC + Breakwater		256.4	$906,950	$3,537
ALT 3—1.3M MC + BW + Live Shoreline		291.5	$1,011,400	$3,470

3.4.2 Incremental Analysis and Best Buy Plans

The next step in the CE/ICA analysis is to perform an incremental cost analysis (ICA) on the cost-effective plans. ICA compares the incremental cost per incremental benefit (output or lift in environmental output) among the plans to identify plans that maximize the last dollar spent. Starting with the no action plan, the incremental cost per incremental benefit is calculated from the no action for each cost-effective plan. The plan with the least incremental cost per incremental output is identified as the first of the “with-project” best buy plans. Then starting with that plan, the incremental cost per incremental benefit is calculated between that plan and each remaining cost-effective plan, and the one with the least incremental cost per incremental benefit is identified as the next plan in the array of best buy plans. This process continues until there are there are no remaining plans. The last plan in the best buy array, is typically the “kitchen sink” plan, or the plan that contains all of the management measures being analyzed.

From the cost-effective alternatives, four were identified as “Best Buy” plans (including the No Action plan). The results of the analysis are shown graphically in

.

The alternative Best Buy plans are:

Plan 1: No Action

Plan 2: ALT 1A—500k-c.y. Marsh Creation

Plan 3: ALT 1C—1.3M-c.y. Marsh Creation

Plan 4: ALT 3—1.3M-c.y. Marsh Creation + Breakwater + Living Shoreline

Figure 3-2. Incremental Cost Analysis Result

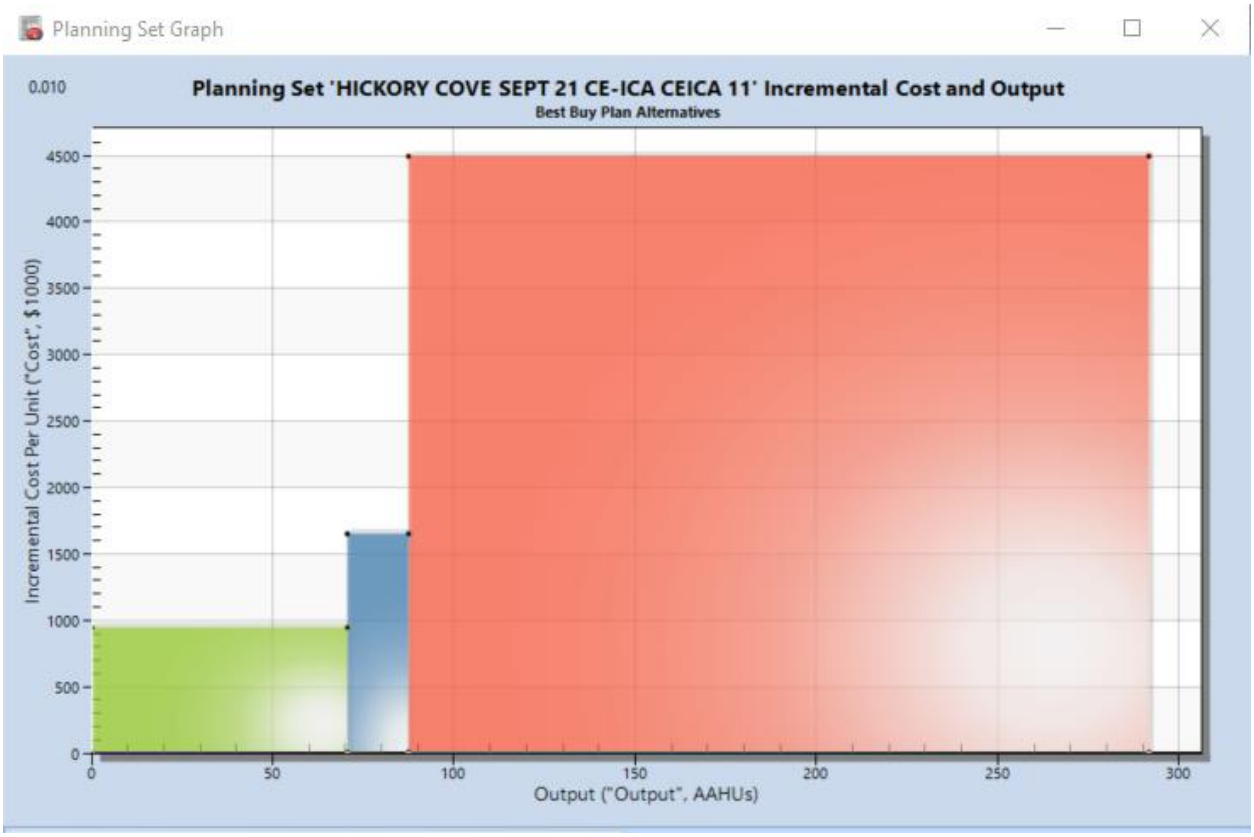

Table 3-3. Best Buy Plans

Plan	Outputs/ AAHUs	Total Annualized Cost ($1s)	Total Annualized Cost/AAHUs ($1s)	Incremental Ann. Cost ($1s)	Incremental AAHUs	Incremental Cost per AAHU	Plan First Costs
PLAN 1: NO ACTION	0	$0	0	0	0	0	$0
PLAN 2: ALT 1A—500k-c.y. Marsh Creation	70.5	$66,450	$943	$66,450	70.5	$943	$1,884,700
PLAN 3: ALT 1C—1.3M-c.y. Marsh Creation	87.3	$94,250	$1,080	$27,800	16.8	$1,655	$2,673,100
PLAN 4: ALT 3—1.3M-c.y. Marsh Creation + Breakwater + Living Shoreline	291.5	$1,011,400	$3,470	$917,150	204.2	$4,491	$28,685,000

3.4.3 "Is It Worth It?" Analysis of Best Buy Plans

No Action Plan: (0 AAHUs; $0 Ann Cost; $0 Incremental Cost; 0 Incremental AAHUs; $0 Increment Cost per AAHU; $0 Average Cost per AAHU).

The no action plan represents no federal action to address the degraded aquatic/riparian ecosystem, and the degradation would continue and increase over the 50-year period of analysis. Nor does this plan does not address the identified resources needed to achieve the planning objectives identified in the main report and the environmental analysis. While there is no cost associated with this plan, the PDT does not believe the action is worth the lack of investment, as it does not address any of the planning objectives and leaves the study area in its degraded state.

Alternative 1a—500k-c.y. Marsh Creation: (70.5 AAHUs; $66.4k Ann Cost; $66.4k Incremental Cost; 70.5 Incremental AAHUs; $943 Increment Cost per AAHU; $943 Average Cost per AAHU).

Yes. This alternative increases habitat over the No Action Plan by creating a rather unique wetlands area. Additionally, this alternative provides navigational benefits by serving as a placement area for future O&M dredging; the area currently lacks adequate placement areas for dredge material.

Alternative 1c—1.3M-c.y. Marsh Creation: (87.3 AAHUs; $94.3k Ann Cost; $27.8k Incremental Cost; 16.8 Incremental AAHUs; $1,655 Increment Cost per AAHU; $1,080 Average Cost per AAHU).

Yes. This alternative provides all of the benefits of the previously described plan. Moreover, the additional amount of dredge material (approximately 800k-c.y. will sustain the created marsh for a longer time period by reducing erosion and subsequent sediment loss.

Alternative 3—1.3M-c.y. Marsh Creation + Breakwater + Living Shoreline: (291.5 AAHUs; $1.0M Ann Cost; $917.2k Incremental Cost; 204.2 Incremental AAHUs; $4,491 Increment Cost per AAHU; $3,470 Average Cost per AAHU).

Yes. This plan would carry forward the benefits described for Alternative 1c, as well as provide other beneficial aspects. The breakwater measure is expected to provide for smaller nooks for nesting habitats for regional bird species. The breakwater is also expected to help reduce shoaling into the navigation waterway, which could then lessen future O&M dredging requirements, costs, and negative ecological impacts related to such. The combination of measures in this alternative also will allow for a wider variety of habitats to develop ecologically. Such marsh growth over a time period is expected to develop an outer ring that will aid in capturing sediment trying to escape the area. And finally, larger volumes of dredge material can be placed under this plan.

4 National Ecosystem Restoration and Recommended Plan

As outlined in ER-1105-2-100, an ecosystem restoration study must identify the National Ecosystem Restoration (NER) Plan. The NER plan is the justified alternative and scale having the maximum excess of monetary and non-monetary beneficial effects over monetary and non-monetary costs. It is the plan where the incremental beneficial effects just equal the incremental, or alternatively stated, where the extra environmental value is just worth the extra costs.

Upon comparing and evaluating the nine best-buy plans, performing an incremental cost analysis on those plans, and evaluating those incremental costs against the against the incremental benefits through the “Is It Worth It Analysis?”, Alternative 3 (1.3M c.y. Marsh Creation + Breakwater + Living Shoreline) has been identified as the NER Plan, and as such, is the recommend plan.

4.1 Cost Estimate of the Recommended Plan

Upon the determination of the recommended plan, an abbreviated risk assessment was made on the risk to cost and scope, which result in a more risk informed estimate of the project first costs. The estimated first cost for the recommended plan is $28,685,000, as shown in Figure 4-1. This includes $24,060,000 for features construction, $198,000 for land and damages, $2,646,600 for pre-engineering design, and $1,780,400 construction management.

Figure 4.1—Project First Costs (September 2021 Prices)

Feature	First Cost
Lands and Damages	$198,000
Marsh Creation	$2,150,000
Living Shoreline	$2,442,000
Breakwater	$19,468,000
PED	$2,646,600
Construction Mgmt	$1,780,400
Total	$28,685,000

Figure 4-2 shows the derivation of average annual costs, based on a 2.5% Federal interest rate and a 50-year period of analysis. The average annual cost of the recommended pan is $62,000, which provides a total lift of 156 average annual habitat units.

Figure 4-2. Derivation of Average Annual Costs (September 2021 Prices, 2.5% Federal Interest Rate, 50 Year Period of Analysis)

Cost Element	Cost
Project First Cost	$28,685,000
Interest During Construction	0
Investment Cost	$28,685,000
Amortization	1,011,400
Interest During Const.	0
Annual OMRRR	0
Average Annual Cost	**$1,011,400**
Average Annual Habitat Units	**291.5**

5 References

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