

Aquatic Ecosystem Restoration for Gulf Intracoastal Waterway

**Cost Effectiveness / Incremental Cost Analysis
Appendix E FINAL**

Beneficial Use of Dredged Material

Section 204

**Goose Island State Park
Aransas County, Texas**

March 2024



**US Army Corps
of Engineers®**
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.

For this study, the environmental output is the average annual habitat unit (AAHU), which is derived from the product of a Habitat Suitability Index and an alternatives acreage. The development of the AAHU is discussed in detail in the Appendix C – Habitat Modeling.

2. Measures and Alternatives

2.1.1 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.

2.1.2 Alternatives

The array of management measures was combined into alternatives that would address ecosystem restoration of the riverine 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.

- **Alternative 3A – Saline marsh in existing cells**
- **Alternative 3B – Saline marsh in existing cells and living shoreline**
- **Alternative 3C – Saline marsh in existing cells, addition of new low and high elevation marsh cells***
- **Alternative 3D – Saline marsh in existing cells, addition of new low and high elevation marsh cells***
- **Alternative 3E – Saline marsh in existing cells, addition of new low and high elevation marsh cells and living shoreline**

* The difference between alternative 3C and 3D is the location of the higher elevation marsh; scale and acreage are identical; alternative 3E added a living shoreline. Alternatives cannot be combined because the environmental team started with a base alternative (3a) and added features to evaluate resulting scales in the other alternatives.

3. Average Annual Habitat Units and Costs

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 C – Habitat Modeling provides further documentation on how AAHUs were calculated for each Future-Without Project (FWOP) and Future-With Project (FWP) condition benefits.

3.1.1 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 as well as the Texas Parks & Wildlife Department and local representatives.

3.1.2 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 2023 Federal Discount Rate of 2.5% (per EGM 23-01 dated 17 October 2022).

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 Table 1.

Table 1 Average Annual Habitat Units

Reach	Alternatives	AAHU Benefits	Acres
GIWW along Goose Island State Park	3A	7.87	23
	3B	11.87	29.5
	3C	16.52	39
	3D	17.27	39

3.1.3 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%. Costs are expressed in October 2022 (FY 23) price levels.

Table 2 provides a summary of total and annual costs, including an initial estimate of annualized Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) for each alternative. Project first cost includes construction costs; planning, engineering, and design (PED); construction management; and contingency estimates. Real estate cost was estimated on a per-acre basis for each alternative and includes a contingency factor. Construction durations were estimated to be 9 to 11 months for all alternatives, used to calculate interest during construction (IDC). Construction and related first costs, real estate cost and IDC are summed to calculate the annual investment costs. The annual with-project OMRR&R is added to the annual investment cost to obtain the total annual costs.

Table 2 Annual Costs

Reach	Project First Cost (PFC)	Real Estate	IDC	Economic Cost	Annual Investment Cost	Annual M&AM	Annual OMRRR*	Total Annual Cost
1. GIWW along Goose Island State Park								
ALT 3A	\$3,597,200	\$1,915,700	\$51,400	\$5,564,300	\$196,200	Included PFC	\$0	\$196,200
ALT 3B	\$4,271,700	\$4,383,300	\$80,600	\$8,735,700	\$308,000	Included PFC	\$0	\$308,000
ALT 3C	\$5,400,700	\$1,509,200	\$78,800	\$6,988,700	\$246,400	Included PFC	\$7,400	\$253,800
ALT 3D	\$5,447,600	\$1,508,100	\$79,300	\$7,035,100	\$248,000	Included PFC	\$7,400	\$255,400

*ER projects do not have OMRR&R costs since the restoration features are designed to be self-sustaining. Only engineered features are assigned O&M costs such as the new containment levees constructed for sediment placement

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. 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. Table 3 displays the annual benefits and annual costs for the cost-effective alternatives.

3.1.1. Cost Effective Plans

Table 3 Annual Benefits and Annual Cost for Cost Effective Alternatives by Reach

Reach	Alternatives	AAHU	Annual Cost (\$1s) October 2022 Prices
GIWW along Goose Island State Park	3A	7.87	\$196,200
	3C	16.52	\$253,800
	3D	17.27	\$255,400

In Figure 1, the No Action Plan is by definition the point (0,0). Moving right along the AAHUs axis, the first red triangle represents Alternative 3A. Continuing right along the output axis, the blueish gray circle represents Alternative 3B (and it's apparent here that the costs are higher than for two plans that are cheaper with more AAHUs). Next is a red triangle representing Alternative 3C. Finally, the green square denotes Alternate 3D which is both a Cost Effective and a Best Buy Plan; "Best Buy" plans are discussed in further detail in the section. Table 4 displays the cost details for the cost-effective plans.

Figure 1 Cost Effective Results

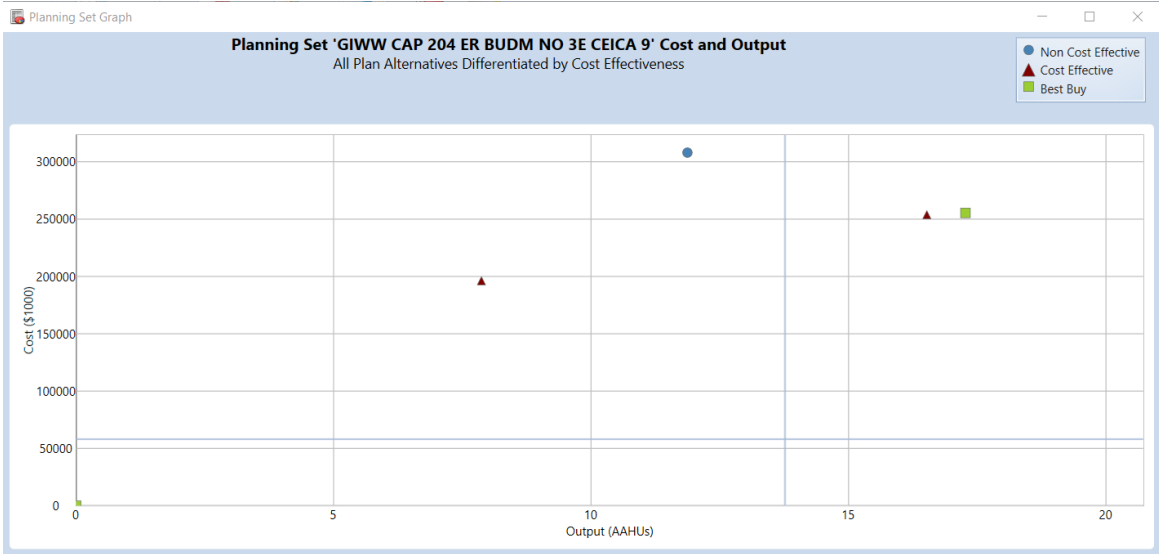


Table 4 Cost Effective Plans

Plan	Output (AAHU)	Total Annual Cost (\$1s)	Avg Cost (\$1s/AAHU)	Incremental Cost (\$1s)	Incremental Output (AAHU)	Incremental Cost per Output	Plan First + Real Estate Inc. Costs
No Action Plan	0	\$0	\$0	\$0	0	\$0	\$0
Alternative 3A	7.87	\$196,200	\$24,900	\$196,200	7.87	\$24,900	\$5,600,000
Alternative 3C	16.52	\$253,800	\$15,400	\$57,600	8.65	\$6,700	\$7,000,000
Alternative 3D (also Best Buy)	17.27	\$255,400	\$14,800	\$1,600	0.75	\$2,100	\$7,000,000

3.1.2 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 increase 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 no remaining plans. The last plan in the best buy array, is typically the “kitchen sink” plan, or the plan that contains all the management measures being analyzed.

From the cost-effective alternatives, two were identified as “Best Buy” plans (including the No Action plan). The result of the analysis is shown graphically in Figure 2. Incremental Cost Analysis Result. The alternative Best Buy plans are:

- **Alternative No Action Plan (by definition)**
- Alternative 3D (represented by the green rectangle in Figure 2 , as the sole Best Buy Plan other than No Action—represented as the point (0,0))

Figure 2 Incremental Cost Analysis Result

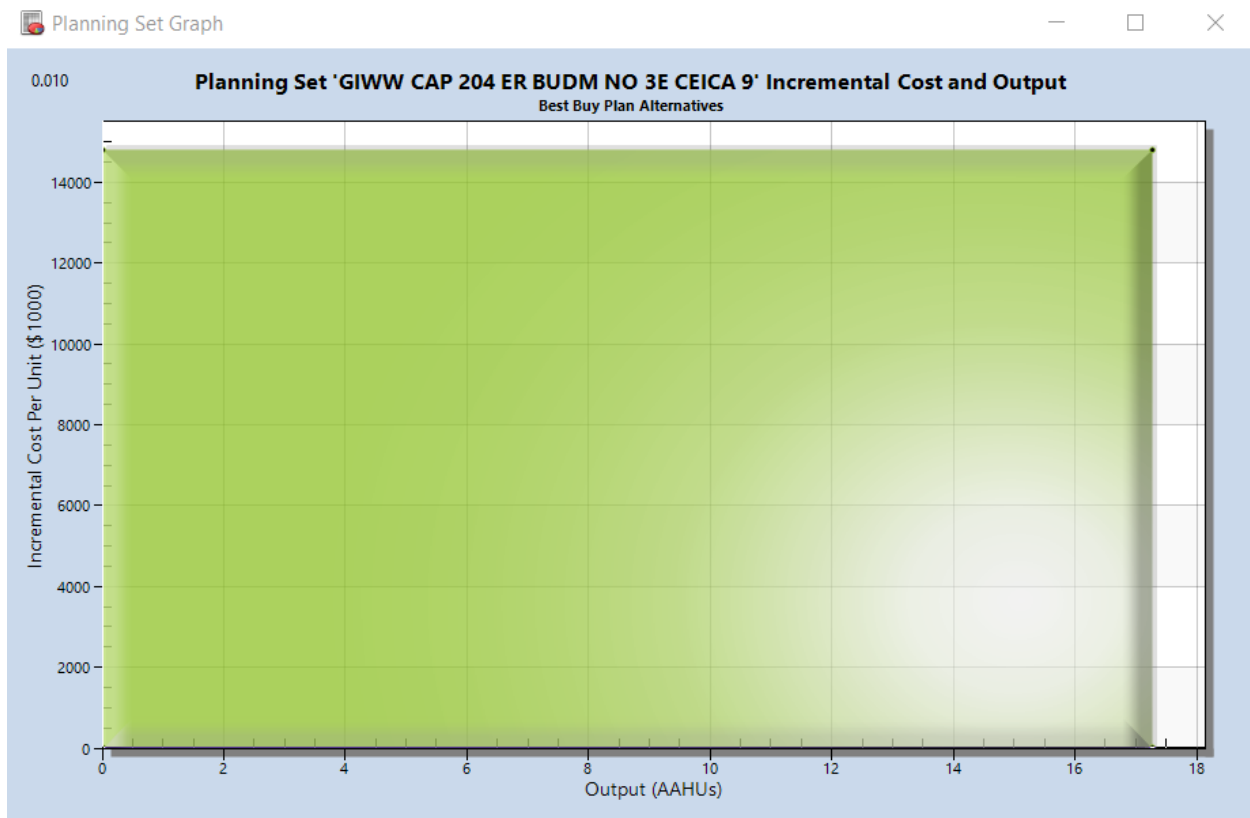


Table 5 Best Buy Plans

Plan	Output (AAHU)	Total Annual Cost (\$1s)	Avg Cost (\$1s/AAHU)	Incremental Cost (\$1s)	Incremental Output (AAHU)	Incremental Cost per Output	Plan First + Real Estate Costs
No Action Plan	0	\$0	0	0	0	0	\$0
Alternative 3D	17.27	\$255,400	\$14,800	\$255,400	17.27	\$14,800	\$7,000,000

4. “Is It Worth It” Analysis

The Cost Effective—Incremental Cost Analysis presented in the previous section does not lead to a definitive plan for choosing the recommended plan, but rather serves to inform the selection process. Using the results of the CEICA analysis, the benefits associated with the environmental incremental outputs must be evaluated against the incremental increase in costs. This analysis, called the “Is It Worth It?” analysis evaluates each plan, its incremental outputs and costs, and the benefits provided by the plan to make a case that the plan is worth the Federal investment to achieve those benefits.

4.1.1 No Action

Details: (0 AAHUs, \$0 Ann Cost)

The No Action plan does not address any of the study objectives and would not restore coastal marsh habitats that would benefit migratory, breeding, and wintering waterfowl, waterbirds, and aquatic organisms. The No Action would also not demonstrate that BU can be effectively used to restore habitat, nor would it address existing or future problems related to degrade/degrading ecosystems or the dredging and placement challenges on the GIWW.

Pros:

- No surface disturbance or impacts to any natural resources or the human environment.

Cons:

- 0 acres of improved habitat leaving Goose Island in its existing condition.
- Would contribute to the significant national loss of wetland habitats occurring for fish and wildlife species and no efforts to offset this loss would be achieved for the study area.
- Ineffective to improve habitat for nationally significant migratory bird, threatened and endangered species, and aquatic wildlife populations within the study area.
- Material dredged from the GIWW would be placed in another location.

4.1.2 *Alternative 3D*

Details: 39-acre variable elevation marsh creation (17.27 AAHUs, \$255,400 Ann Cost; \$14,800 Incremental Cost per AAHU)

The additional federal investment of spending at least \$14,800 (incremental cost/incremental output) to realize the last added habitat unit is worth pursuing over the No Action Plan because it addresses the study objectives and increases the availability of limited and degrading habitat in the study area. It creates 39 acres of salt marsh and creates a more diverse habitat by incorporating low elevation and high elevation marsh cells but places the high elevation marsh cells in a better location, offering greater protection and extending sustainability. This plan is supported by the PDT, NFS, and resource agencies, and is the Tentatively Selected Plan (TSP) for this project.

Pros:

- Demonstrates BU material can be used for ecosystem restoration and utilizes dredge material that would otherwise be placed offshore or in an upland placement area.
- Creates and sustains 39 acres of emergent salt marsh for 50 years after construction with negligible degradation. No interior marsh, low or high elevation, would be anticipated to degrade; however, some degradation may occur to low elevation marsh in new cells north of the high elevation marsh area from RSLC and erosion due to wave action.
 - The higher elevation marsh and interior low elevation marsh is expected to withstand erosion and/or degradation. No loss is expected to occur to the interior marsh due to the added protection from the higher elevation marsh and extent of new marsh cells.
- Creates a critical habitat for nationally significant migratory birds, threatened and endangered species, and aquatic wildlife populations within the study area.
- Contributes to offsetting the national loss of wetland habitats.
- Creates habitat diversity that has greater long-term sustainability for fish and wildlife organisms.
- Best buy plan

Cons:

- The newly created low elevation marsh north of the existing containment levee is likely to undergo some interspersion after 50 years, shifting the marsh to have a greater coverage of open water to emergent marsh.

5. Post TSP Cost Refinements

5.1.1 *Post TSP - CE/ICA Results*

Alternatives Cost were updated post TSP due to review comments. To conduct the CE/ICA analysis, environmental restoration benefits (increase in with-project AAHUs) and annual costs were entered into IWR Planning Suite II. Table 6 displays the Post TSP total and annual Cost Summary. Table 7 displays the cost-effective alternatives post TSP cost refinements.

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.

Table 6 Post TSP Total and Annual Cost Summary

Reach	Project First Cost (PFC)	Real Estate	IDC	Economic Cost	Annual Investment Cost	Annual M&AM	Annual OMRRR	Total Annual Cost
1. GIWW STA 1160 to STA 1225								
ALT 3A	\$3,419,700	\$858,700	\$39,900	\$4,318,200	\$152,300	Included PFC	\$0	\$152,300
ALT 3B	\$3,827,300	\$1,737,300	\$38,900	\$5,603,500	\$197,600	Included PFC	\$0	\$197,600
ALT 3C	\$5,278,800	\$782,500	\$63,400	\$6,124,600	\$215,900	Included PFC	\$7,400	\$223,300
ALT 3D	\$5,521,600	\$781,400				Included PFC		\$224,900

*ER projects do not have OMRRR costs since the restoration features are designed to be self-sustaining. Only engineered features are assigned O&M costs such as the new containment dikes constructed for sediment placement. Costs are expressed in FY 23.

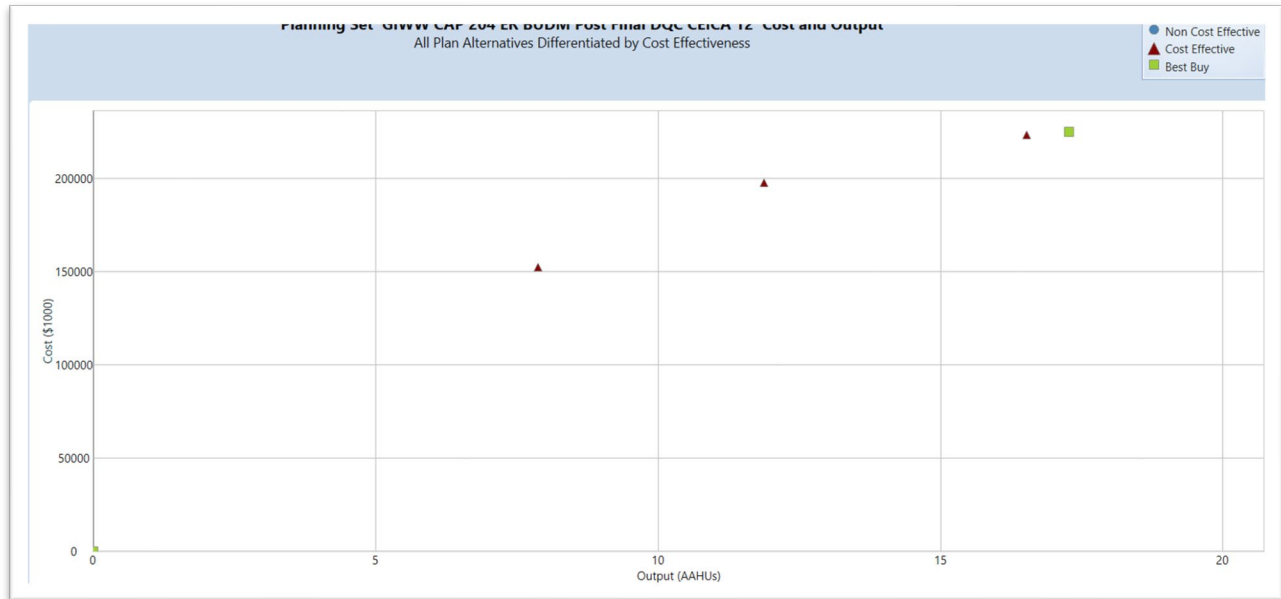
Table 7 Post TSP Annual Benefits and Annual Cost for Cost Effective Alternatives

Reach	Alternatives	AAHU	Annual Cost (\$1s) October 2022 Prices
GIWW STA 1160 TO STA 1225	3A	7.87	\$152,300
	3B	11.87	\$197,600
	3C	16.52	\$223,300
	3D	17.27	\$224,900

In Figure 3 below, the No Action Plan is by definition the point (0,0). Moving right along the AAHUs axis, the first red triangle represents Alternative 3A followed by a second red triangle that represents Alternative 3B. Next is a red triangle representing Alternative 3C. Finally, the green square denotes Alternative 3D which is both a Cost Effective and a Best Buy Plan.

5.1.2 Post TSP Incremental Analysis and Best Buy Plans

Figure 3 Post TSP - Cost Effective Results



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 no remaining plans. The last plan in the best buy array, is typically the “kitchen sink” plan, or the plan that contains all the management measures being analyzed. Table 8 displays the Post TSP Cost Effective Plans.

Table 8 Post – TSP Cost Effective Plans

Plan	Output (AAHU)	Total Annual Cost (\$1s)	Avg Cost (\$1s/AAHU)	Incremental Cost (\$1s)	Incremental Output (AAHU)	Incremental Cost per Output	Plan First + Real Estate Inc. Costs
No Action Plan	0	\$0	\$0	\$0	0	\$0	\$0
Alternative 3A	7.87	\$152,300	\$19,400	\$152,300	7.87	\$19,400	\$4,278,400
Alternative 3B	11.87	\$197,600	\$16,600	\$45,300	4	\$11,300	\$5,564,600
Alternative 3C	16.52	\$223,300	\$13,500	\$25,700	4.65	\$5,500	\$6,061,200
Alternative 3D (also Best Buy)	17.27	\$224,900	\$13,000	\$1,600	0.75	\$2,100	\$6,303,000

From the cost-effective alternatives, two were identified as “Best Buy” plans (including the No Action plan). The result of the analysis is shown graphically in Figure 4. Note, these are the same best buys alternatives as before. Table 9 displays the Post TSP Best Buy Plans

The alternative Best Buy plans are:

- **Alternative No Action Plan (by definition)**
- **Alternative 3D (Represented by the green rectangle in Figure 4, as the sole Best Buy Plan other than No Action, which is represented as the point (0,0)).**

Figure 4 Post TSP - Incremental Cost Analysis Result

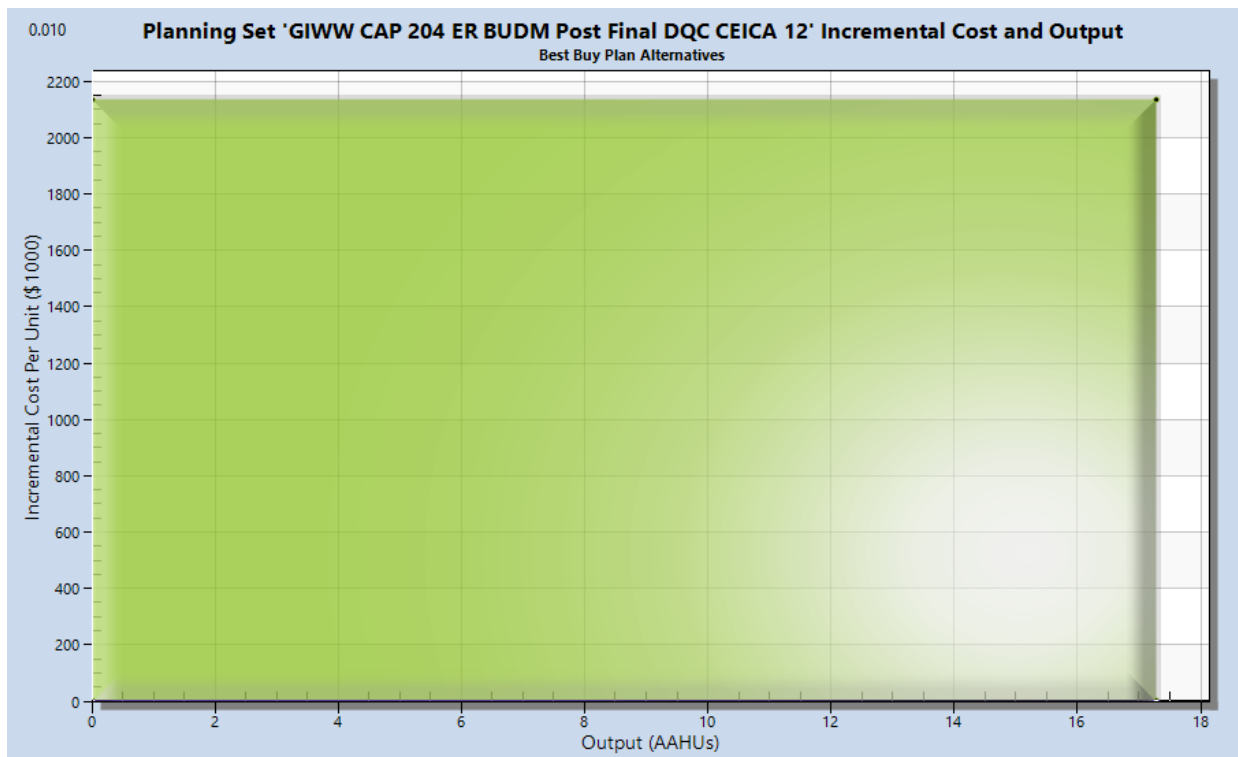


Table 9 Post TSP - Best Buy Plans

Plan	Output (AAHU)	Total Annual Cost (\$1s)	Avg Cost (\$1s/AAHU)	Incremental Cost (\$1s)	Incremental Output (AAHU)	Incremental Cost per Output	Plan First + Real Estate Costs
No Action Plan	0	\$0	0	0	0	0	\$0
Alternative 3D	17.27	\$224,900	\$13,000	\$224,900	17.27	\$13,000	\$6,303,000

6. Comprehensive Benefit Description

In accordance with the Assistant Secretary of the Army for Civil Works (ASA[CW]) policy directive dated 5 January 2021, each study must include, at a minimum, the following plans in the final array of alternatives for evaluation:

- The “No Action” alternative
- A plan that maximizes net total benefits across all benefit categories, and
- A plan that maximizes net benefits consistent with the study purpose.

6.1.1 *No Action Plan*

This alternative has been explained in the previous “Is It Worth It”, Section 4.1.1.

6.1.2 *Maximum Net Benefits Plan – All Categories*

Alternative 3D was identified as the plan that would maximize net total benefits across all four accounts. This plan was selected as the Recommended Plan, as the CEICA analysis indicated that the environmental outputs (17.27 AAHUs) were sufficient to justify an incremental cost per unit of \$14,800 for implementation.

6.1.3 *Maximum Net Benefits Plan Consistent with Study Purpose*

The Economic and Environmental Principles, Requirements and Guidelines for Water and Related Land Resources Implementation Studies (PR&G) and ER 1105-2-100, Planning Guidance Notebook (PGN) states that for ecosystem restoration projects, an aquatic 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 are just equal to the incremental cost, or alternatively stated, where the extra environmental value is just worth the extra costs.

In addition, the PR&G identifies four accounts that must be considered in development of alternatives: National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ) and Other Social Effects (OSE). The following provides a description of these accounts and the potential effects of the Recommended Plan (Alternative 3D).

NED Account

While the GIWW BUDM only quantified ecosystem restoration benefits, the National Economic Development (NED) benefits are discussed qualitatively. The project does not generate any reduction in flood damages or provide any navigation or hydropower benefits; however, there are potential recreation benefits—considered NED benefits—that could count. Primarily, the Texas Gulf of Mexico coast is well known by birdwatchers for being on the migration paths of a variety of birds and other waterfowl. The features included in the Recommended Plan could be reasonably expected to draw birds to the area for foraging and nesting. This would provide and increase benefits for birdwatchers and photographers, all adding to a net increase in NED benefits.

RED Account

Most of the Regional Economic Development (RED) benefits for this project would be short term and related to the construction dollars spent in the local economy. Construction activities will contribute RED economic impact mostly directed to the local economy. Typically, around 67% of construction expenditures and related activities (such as workers temporarily living near the construction site staying at local motels and eating/shopping at local restaurants and shops). Through the multiplier effect, the local/regional economy should see modest increased economic outputs (incomes, tax receipts, etc.), as well as moderate increased levels of (albeit temporary) employment and labor income. In addition to these short-term construction related benefits, other RED benefits that could potentially be captured would be from dollars spent locally by any increased number of recreators brought to the area for fishing, boating/canoeing, or birdwatching. While recreation benefits tied to the recreation experience are captured as NED, the dollars they spend on items such as lodging, food, equipment rentals would be RED benefits. And though the project would not draw many new recreators to the area, any increase would attribute, even if marginally, to the overall RED benefits created by the project.

EQ Account

This account considers effects of significant natural and cultural resources. EQ is extensively covered both in the Main Report and the Environmental Appendix. The description in the "Is It Worth It" Section of this Appendix also summarized the anticipated natural and cultural resources impacts of the Recommended Best Buy Plan Alternative 3D.

OSE Account

This account displays plan effects from perspectives that are relevant to the planning process but are not reflected in the other three accounts (e.g., community impacts, health and safety, displacement, etc.). The Recommended Plan provides habitat restoration to support additional /better recreational opportunities in a way that minimizes the risk to the restored environment. Recreators could be expected to have both better physical as well as emotional health due to the restored environment and related physical activities. In addition to health benefits, the proposed project provides an improved aesthetic value of the project and surrounding areas.

7. 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. Based upon the CE-ICA Analysis, three plans were identified as Cost Effective while Alternative 3D is also a Best Buy Plan. That analysis plus the non-monetary benefits considered in the "Is It Worth It" section lead to Alternative 3D being identified and selected as the Recommended Plan.

8. References

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