Appendix H

Cost Effectiveness &

Incremental Cost Analysis

1. Purpose

Corps of Engineers guidance requires a cost effectiveness analysis and an incremental cost analysis for recommended environmental restoration and mitigation plans. A cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of environmental output. An incremental cost analysis of the solutions is conducted to reveal changes in costs for increasing levels of environmental outputs. In the absence of a common measurement unit for comparing the nonmonetary benefits with the monetary costs of environmental plans, cost effectiveness and incremental cost analysis (CE/ICA) are valuable tools to assist in decision making. This appendix presents the results of the CE/ICA of the Piasa and Eagle's Nest Islands Habitat Rehabilitation and Enhancement Project (HREP), Madison and Jersey counties, Illinois.

2. Method

The study area was evaluated using guidance documents and software prepared by the Corps of Engineers' Institute for Water Resources (IWR). IWR - Planning Suite Software (Version 2.0), a USACE-certified model, was used to automate steps in the cost effectiveness and incremental cost analysis. Much of the text of this appendix was borrowed from IWR Report (IWR 94-PS-2), *Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps*[1]. The cost effectiveness and incremental cost analysis procedures are presented in nine steps, which are grouped into four tasks listed below.

A. Formulation of Combinations
Step 1 Display outputs and costs
Step 2 Identify combinable management measures
Step 3 Calculate outputs and costs of combinations

B. Cost Effectiveness Analysis
Step 4 Eliminate economically inefficient solutions
Step 5 Eliminate economically ineffective solutions

C. Development of Incremental Cost Curve
Step 6 Calculate average costs
Step 7 Recalculate average costs for additional outputs

D. Incremental Cost Analysis
Step 8 Calculate incremental costs
Step 9 Compare successive outputs and incremental costs

The results of these analyses are displayed as graphs and tables at the end of this appendix. They allow the decision makers to progressively compare alternative levels of environmental outputs and ask if the next level is "worth it" – that is, is the additional environmental output in the next level worth its additional monetary costs? It is important to note that these analyses will not usually lead, and are not intended to lead, to a single best solution as in economic cost-benefit analyses. They will improve the quality of decision making by ensuring that a rational, supportable, focused, and

[1] Orth, K. D. 1994. Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps. No. IWR-94-PS-2. Army Engineers Institute for Water Resources. Ft. Belvoir, VA.

traceable approach is used for considering and selecting alternative methods to produce environmental outputs.

A. Formulation of Combinations

Step 1. Display outputs and costs. Outputs were determined using Habitat Evaluation Procedures and are presented as net Average Annual Habitat Units (for further detail see Appendix G, *Habitat Evaluation and Quantification*). Costs estimates were based on unit price estimates. Costs were annualized over a 50-year period of analysis at an interest rate of 2.875 % for Fiscal Year 2017. These costs include initial construction with mobilization and demobilization, contingency (30%), planning, engineering, and design (15%), and construction management (10%) above the actual estimated cost for construction. Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs for the 50-year period of analysis, and Adaptive Management and Monitoring costs were also calculated for each alternative and included in the total annualized costs used in the CE/ICA. The period of analysis was limited to 50-years accordance based on with Corps Regulations (ER 1105-2-100, p. 2-11), even though project measures are anticipated to continue having beneficial effects beyond 50 years. The base year of 2025 and period of analysis continued until 2075.

Step 2. Identify combinable management measures. The management measures were reviewed to determine which were dependent on other measures. Using the hydraulic model results, the planning team combined measures into feasible alternatives. Alternatives that did not perform in the hydraulic model were not evaluated further. Table 1 describes the measures that were included in each alternative moved forward for detailed evaluation.

Table 1. Alternative Plans

Alternative #	Measures Included	Alternative Description
1	D0B0R0I0	No Action
2	D1B1R0I1	Braided 200 ft Piasa Chute + Minimum Backwater Dredging + Island Diversity
3	D1B2R0I1	Braided 200 ft Piasa Chute + Maximum Backwater Dredging + Island Diversity
4	D1B1R1I1	Braided 200 Ft Piasa Chute+ Minimum Backwater Dredging + Notched Rock Structure + Island Diversity
5	D1B2R1I1	Braided 200 ft Piasa Chute + Maximum Backwater Dredging + Notched Rock Structure + Island Diversity
6	D2B1R0I1	Braided 300 ft Piasa Chute + Minimum Backwater Dredging + Island Diversity
7	D2B2R0I1	Braided 300 ft Piasa Chute + Maximum Backwater Dredging + Island Diversity
8	D2B1R1I1	Braided 300 ft Piasa Chute + Minimum Backwater Dredging + Notched Rock Structure + Island Diversity
9	D2B2R1I1	Braided 300 ft Piasa Chute + Maximum Backwater Dredging + Notched Rock Structure + Island Diversity

Step 3. Calculate output and costs of combinations. Table 2 at the end of this appendix displays the outputs and costs of alternatives.

Table 2. Results of CE/ICA for Alternative Plans.

Alt #	Alternative Code	Output (AAHU)	Construction Cost ($)*	Annualized Construction Cost ($)	Annualized OMRR&R ($)	Annualized AM & Monitoring ($)	Total Annualized Cost ($)	Average Cost Per Unit ($/AAHU)
1	D0B0R (No Action)	0	0	0				-
2	D1B1R0I1	366.5	22,130,000	839,791	5,850	12,000	857,641	2,340
3	D1B2R0I1	376.3	24,500,000	929,728	5,850	12,000	947,578	2,518
4	D1B1R1I1	430.1	23,750,000	901,267	5,850	12,000	919,117	2,137
5	D1B2R1I1	431.2	26,250,000	996,137	5,850	12,000	1,013,987	2,352
6	D2B1R0I1	417.4	27,130,000	1,029,532	5,850	12,000	1,047,382	2,509
7	D2B2R0I1	417.8	29,630,000	1,124,402	5,850	12,000	1,142,252	2,734
8	D2B1R1I1	447.6	28,880,000	1,095,941	5,850	12,000	1,113,791	2,488
9	D2B2R1I1	447.4	31,250,000	1,185,878	5,850	12,000	1,203,728	2,690

**Based on unit price estimates October 2016; 2.875% interest rate for FY2017*

B. Cost Effectiveness Analysis

Steps 4 and 5. Eliminate economically inefficient solutions and economically ineffective solutions. Steps 4 and 5 were carried out using the IWR-Planning Suite software. Step 4 eliminates economically inefficient solutions and identifies the least cost solution for each level of output. *Inefficient in Production* is defined as any alternative where the same output level can be generated at a lesser cost by another alternative. The alternatives are evaluated and wherever there are two or more alternatives providing the same output level, aside from any other considerations (*i.e.,* uncertainty about the reliability of cost or output estimates), the more costly alternative(s) generating that same output level is eliminated. For example, if two plans produce two AAHUs and one costs $3,000 while the other costs $4,000, the more expensive plan is eliminated.

Step 5 eliminates the economically ineffective solutions by identifying and deleting those solutions that will produce less output at equal or greater cost than subsequently ranked solutions. *Ineffective in Production* is defined as any alternative where a greater output level can be generated at a lesser or equal cost by another alternative. For example, if one plan produces 2 AAHUs for $8,000 and the next plan produces 4 AAHUs for $6,000, the first plan would be eliminated because it is not economically effective.

Of the 9 alternatives evaluated, 5 plans were considered cost effective (Table 3; Figure 1).

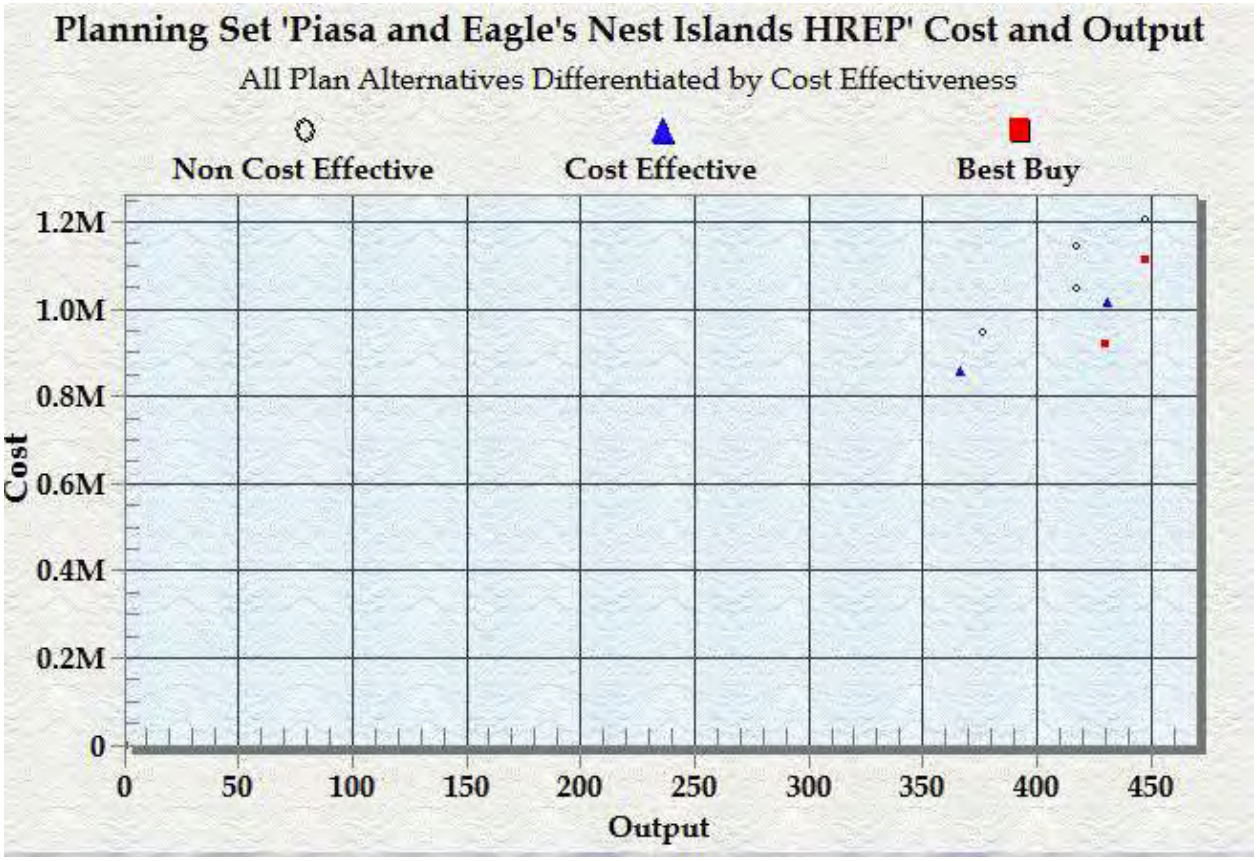

Figure 1. All Alternatives Plans Differentiated by Cost Effectiveness

Table 3. Cost Effective Plans

Alt #	Alternative Code	Output (AAHU)	Cost ($) (Total Annualized Cost)	Average Cost Per Unit ($/AAHU)
1	D0B0R (No Action)	0	0	
2	D1B1R0I1	366.5	857,641	2,340
4	D1B1R1I1	430.1	919,117	2,137
5	D1B2R1I1	431.2	1,013,987	2,352
8	D2B1R1I1	447.6	1,113,791	2,488

C. Development of Incremental Cost Curve

Step 6. Calculate average costs. Average costs for each least-cost, cost-effective plan are determined by dividing the cost of the plan by the output (AAHUs). Average costs are expressed in cost per AAHU ($/AAHU). The plan with the lowest average cost is identified. Plans with less output at a higher average cost are eliminated.

Step 7. Recalculate average costs for additional outputs. This step asks the question: "of the remaining levels of output, which has the lowest additional cost for additional output?" Using levels of output from Step 6, the average annual costs for additional output are calculated. The previous step's lowest average cost level of output is used as the "zero level." Levels of output less than the lowest average cost level are dropped from further analysis, while levels of output greater than the lowest average cost level advance to the next recalculation. Recalculations are then made using the new lowest average cost level as the "zero level" until the highest level of output is reached. Steps 6 and 7 were carried out using the IWR-Planning Suite software. The outcome of this evaluation is displayed in Table 4.

Table 4. Incremental Costs of Best Buy Plans.

Alternative	Incremental Output (Net AAHUs)	Incremental Cost (Annualized Total Cost)	Incremental Output	Incremental Cost	Incremental Cost/Output ($/AAHU)
1 – No Action	0	0	0	0	0
4	430.1	$919,117	430.1	$919,117	$2,137
8	447.6	$1,113,791	17.5	$194,674	$11,124

D. Incremental Cost Analysis

Step 8. Calculate incremental costs. Step 8 was carried out using the IWR-Planning Suite software. Incremental cost is the additional cost incurred by selecting one alternative over another, and is computed by subtracting the cost of one alternative from another. The 3 plans listed in Table 4 are the "best buys," meaning these plans produce the most AAHUs per dollar. The incremental costs shown in Table 4 are calculated by dividing the difference between the different plans output. Figure 2 is a graph of the incremental costs of alternatives as listed in Table 3. As shown in the chart, there are three "best buy" combinations.

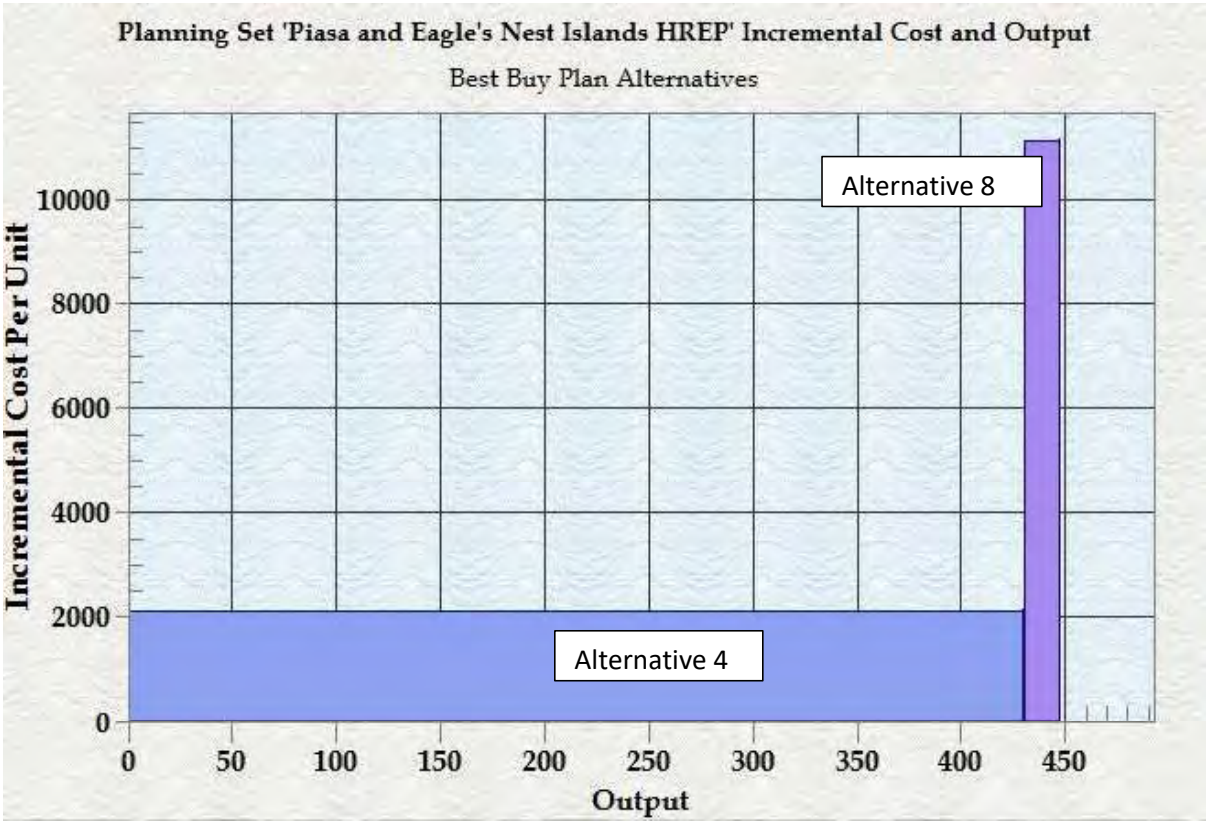

Figure 2. Best Buy Alternatives for Piasa and Eagle's Nest Islands HREP.

Step 9. Compare successive outputs and incremental costs. Table 4 and Figure 1 were used as decision making tools by progressively proceeding through available levels of output and determining if the next level is worth its additional monetary costs. This step examined the additional habitat value, as featured by increased AAHU output, for an increase in monetary costs. Federal planning for water resources development is conducted in accordance with the requirements of the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G). The P&G provides a decision rule for selecting a tentatively selected plan where both outputs and costs are featured in dollars. This rule states: "The alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (National Economic Development Plan, NED Plan) is to be selected… (Paragraph 1.10.2)". There is no similar rule for plan selection where the outputs are not featured in dollars, as is the case in planning for restoration and mitigation. In the absence of such a decision-making rule, cost-effectiveness and incremental cost analyses helps to better understand the consequences of the preferred plan in relation to other choices.

3. ICA Conclusions and Selection of Tentatively Selected Plan

The best buy alternatives presented provide the information necessary information to make well-informed decisions regarding desired project scale (Table 4, Figure 1). Progressing through the increasing levels of output for the alternatives in Table 4 helps determine whether the increase in Net AAHUs is worth the additional cost. As long as decision makers consider a level of output to be "worth it", subsequent levels of outputs are considered. When a level of output is determined to be "not worth

it", then subsequent levels of output will also likely be "not worth it", and the final decision regarding desired project scale for environmental restoration planning will have been reached.

Typically in the evaluation of Best Buy Alternatives, 'break points' are identified in either the last column in Table 3, or in the stair-step progression from left to right in Figure 1. Break points are defined as significant increases or jumps in incremental cost per output, such that subsequent levels of output may not be considered "worth it". Identification of such break points can be subjective. For Piasa and Eagle's Nest Islands HREP, break points were identified between each of the Best Buy Plans.

The PDT reviewed the Best Buy Plans and determined that the cost to implement the first iteration of Best Buy Plans above the No Action Plan, Alternative 4, was worth the incremental investment above the No Action Plan (Alternative 1) since it provides an acceptable level of restoration for an acceptable cost. It provides 430.1 AAHUs over the No Action Plan at an incremental cost per habitat unit of $2,137.

The next Best Buy Plan, Alternative 8, differs from Alternative 4 by having a 300 foot dredge cut in Piasa Chute versus the 200 foot dredge cut. The PDT determined that although there would be some additional benefits, Alternative 8 would not be considered further since it is similar to Alternative 4 but only provides an additional 17.5 AAHUs at an incremental cost of those AAHUs of $11,124. The PDT and the IL DNR deemed this alternative to "not be worth it" and this alternative was not selected.

4. Summary

The results of the incremental cost analysis and habitat evaluation in this chapter were considered with other factors, including physical features on the site, management objectives of the resources agencies, critical needs of the region, and ecosystem needs of the UMRS. The Piasa and Eagle's Nest Islands HREP team concluded that the alternative plan that best meets the goals and objectives of each agency and the Upper Mississippi River Restoration Programs is alternative 4. This alternative is cost-effective and justified as a "Best Buy" plan. Alternative 4 has an overall output of 430.10 Net AAHUs, and was identified as the Tentatively Selected Plan. While the other "Best Buy" alternatives evaluated for this study would partially address the goals and objectives of the study, the consensus of the interagency team was that Alternative 4 would reasonably maximize ecosystem restoration benefits for the greatest diversity of fish and wildlife, and that other considered alternatives would be less effective in meeting study objectives.

Alternative 4 would restore approximately 76 acres of island habitat, enhance approximately 49 acres of backwater by increasing connectivity and depth, and improve depth and flow for approximately 485 acres of side channel habitat within the study area. This plan includes excavating Piasa Chute with a braided dredge cut 10 foot below minimum pool 200 foot wide, excavating Piasa Island Backwater to 10 feet to improve entrance conditions to restore connectivity and fisheries habitat, a notched rock structure to improve flow and bathymetric diversity within the study area, and constructing islands with the dredge material and stone protection to restore the historic island complex that once existed

For these reasons, Alternative 4 is identified as both the National Ecosystem Restoration Plan (e.g. the plan that reasonably maximizes ecosystem restoration benefits) as well as the study sponsor's preferred plan.