6. EVALUATION OF PROJECT ALTERNATIVES

6.1 General

Evaluation of alternatives was accomplished through habitat evaluation and cost analysis. The evaluation is a three-step procedure: (1) calculate the environmental outputs of each alternative; (2) estimate costs for each alternative; and (3) compare the alternatives to evaluate the best overall project alternative based on habitat benefits and cost. While cost and environmental outputs must be considered, other factors such as the ability to construct, schedule, likelihood to achieve projected results, incalculable environmental benefits, local support, and ancillary benefits are very important in deciding the preferred alternative.

6.2 Environmental Outputs

This project would produce environmental benefits in two main areas: site-specific benefits and systemic benefits.

6.2.1 Site-Specific Benefits. The project would improve aquatic and wetland habitats at the project site. Increasing lake depths and improving water quality would promote and improve the warm-water lake environment and resulting warm-water fisheries communities. The project also would improve wetland characteristics within targeted areas. The type of wetlands created would vary, but could include shallow water marsh and/or fresh meadows.

Habitat Evaluation Procedures (HEP) were utilized to evaluate potential site-specific benefits of alternatives at Lake Belle View. Participants for this analysis included biologists from the Corps and the WDNR. HEP helps to evaluate the quality and quantity of particular habitats for certain species. The qualitative component is known as the Habitat Suitability Index (HSI) for key indicator species and is rated on a scale of 0.0 to 1.0. The quantitative component is the measure of acres of habitat that is available for the selected species. From the qualitative and quantitative determinations, the standard unit of measure, the Habitat Unit (HU), is calculated using the formula: HSI x Acres = HUs.

The proposed project alternatives would affect the form and value of different habitats within the project area. Changes in quantity and/or quality of HUs would occur as habitat matures naturally or is influenced by development. These changes influence the cumulative HU derived over the life of the project. Cumulative HUs are annualized and averaged. This determines what is known as the Average Annual Habitat Units (AAHUs). AAHUs are used as an output measurement to compare all the alternatives as a whole.

The quantities of different habitats created for the project alternatives were estimated by projecting the alternative onto aerial photographs of the project area. This allowed for quantification, in terms of surface acres, for different types of resulting habitat. General habitat types identified for each alternative are lake, river, wetland, and riparian.

To evaluate and quantify changes to these habitat types, HSI models were utilized for key indicator species shown in Table 6.1. These species were selected for two reasons. First, HSI models were available for these species. Secondly, each species is associated with a guild or association of other similar species that utilize a similar type of habitat. Habitat benefits were calculated for each habitat type using these models and methodologies.

Table 6.1. Indicator species utilized for habitat analysis using appropriate Habitat Suitability Index models.

Species	Scientific Name	Habitat Type Evaluated
Largemouth bass	*Micropterus salmoides*	Lake
Bluegill	*Lepomis macrochirus*	Lake
Smallmouth bass	*Micropterus dolomieu*	River
Marsh wren	*Cistotnorus palustris*	Restored wetland
Wood duck	*Aix sponsa*	Existing wetland
Eastern meadowlark	*Sturnella magna*	River riparian

6.2.2 Systemic Benefits. The project would implement fish passage at the Belle View Dam, allowing downstream aquatic organisms access to historic upstream habitats that have generally become isolated since initial dam construction in 1845. Implementation of fish passage at Lake Belle View would provide fish access to approximately 218 miles of main stem and tributary stream habitat.

In general, riverine fishery resources have evolved to utilize a variety of habitats throughout their life cycle. Various life stages of fish utilize different habitats for spawning, feeding, resting, overwintering, and as refuge during floods and droughts. Moreover, some fish species frequently move long distances to meet certain desired habitat conditions, thus maximizing their fitness and ability to reproduce and pass on genetic material. Within the upper Midwest, studies have documented long-distance migration for species such as smallmouth bass, catfish, and walleye. For example, Langhurst and Schoenike (1990)[7] identified movements of 40 to 60 miles for smallmouth bass between summering and wintering habitat found in the Embarrass River and downstream Wolf River of eastern Wisconsin. Studies by the WDNR have observed channel catfish migrations of over 70 miles in the lower Wisconsin River. Further, radio telemetry studies by the Iowa DNR on walleyes observed several long distance migrations on the Mississippi River. Although no studies have been performed on the Sugar River system, anecdotal observations suggest that smallmouth bass make seasonal migrations between tributaries such as Allen Creek and the Sugar River (located approximately 20 miles downstream of Lake Belle View). Other observations on the nearby Pecatonica River suggest that walleye may make upstream spawning runs into tributaries often considered to be habitat for brown trout. Table 6.2 presents a list of species that show migratory behaviors that may be observed in the Sugar River above or below Lake Belle View.

Table 6.2. Possible migratory fishes of the Sugar River observed at or below the project site.

• Walleye	• Shorthead redhorse
• Smallmouth bass	• Golden redhorse
• Channel catfish	• Silver redhorse
• Northern pike	• River redhorse*
• Brown trout	• Northern hog sucker
• Bigmouth buffalo	• Northern hog sucker
• Quillback	• White sucker

* The river redhorse (*Moxostorna carinaturn)* is a rare species listed as threatened by the State of Wisconsin. It was collected in the Sugar River prior to 1977, but its current status in the river is unknown. Although not well documented, this species may make upstream spawning migrations.

[7] Langhurst, R. W., D. L. Schoenike. 1990. Seasonal Migration of Smallmouth Bass in the Embarrass and Wolf Rivers, Wisconsin. North American Journal of Fisheries Management: Vol. 10, No. 2, pp. 224-227.

In addition to benefits to fish, providing fish passage also may benefit organisms such as freshwater mussels. Mussels utilize fish as a parasitic host for their larvae. Allowing upstream fish passage would allow for mussel resources to colonize upstream habitats that have become isolated since the dam was put in place. Systemic fish passage benefits are quantified by the amount of upstream habitat made available through feature implementation.

Fish passage benefits are most easily quantified in stream miles. It is assumed that among the alternatives, the quality and quantity of fish passage is consistent. The exceptions to this are alternatives using rock ramp structures and bypass channels. These alternatives would not pass 100% of all river flows and may not provide access as efficiently as alternatives that would pass all river flows. For these alternatives, the amount of stream miles is prorated by the percentage of river flow passable times the percent of time.

6.2.3 Combined Benefits. For comparison of project alternatives, the site-specific benefits were added to systemic benefits from fish passage. Site-specific benefits were normalized to a scale with a maximum score of 50. Systemic benefits were normalized to a scale with a maximum score of 50. Site-specific benefits and systemic benefits were added together for a total possible score of 100. This can be represented by the following equation:

Relative Annualized Habitat Benefits =
(0.5*[AAHUs]/[maximum AAHUs]*100) + (0.5* [relative fish passage benefits]*100)

This approach allows for the combination of two different types of habitat units. By counting both site-specific and systemic benefits as 50% of the total, it provides equal weighting of benefits between site-specific benefits and systemic benefits.

6.3 Cost Estimates

Cost estimates have been calculated for each project alternative and are discussed in more detail in Section 8 and Appendix E. These cost estimates include costs for project planning, construction, LERRDS, and future project operation and maintenance of the project life. These total costs were then averaged to compute an annualized cost for each project alternative. The annualized costs were calculated by applying a 6-3/8% annual interest rate to the construction costs over the 50-year life of the project. Table 6.3 shows the costs compared to the outputs for each alternative.

Table 6.3. Costs and environmental outputs of each project alternative.

ALTERNATIVE	CONSTRUCTION COST[1]	LANDS	REAL ESTATE COSTS	TOTAL[2]	ANNUAL O&M	ANNUALIZED COST [3]	SITE-SPECIFIC OUTPUTS	SYSTEMIC OUTPUTS	COMBINED
ALTERNATIVE 1 Eastern Diversion Northern Riffles									
1A - 5 Acres Dredging	$5,567,996	$465,000	$42,000	$6,075,000	$16,268	$395,000	35.6	218	90.2
1B - 10 Acres Dredging	$6,217,334	$465,000	$42,000	$6,724,000	$16,268	$435,500	41.1	218	96.4
1C - 15 Acres Dredging	$6,832,285	$465,000	$42,000	$7,339,000	$16,268	$473,800	44.3	218	100.0
ALTERNATIVE 2 Eastern Diversion Southern Riffles									
2A - 5 Acres Dredging	$4,754,596	$403,000	$34,000	$5,192,000	$16,268	$339,900	34.6	218	89.1
2B - 10 Acres Dredging	$5,366,818	$403,000	$34,000	$5,804,000	$16,268	$378,100	40.1	218	95.3
2C - 15 Acres Dredging	$5,906,237	$403,000	$34,000	$6,343,000	$16,268	$411,700	43.3	218	98.9
ALTERNATIVE 3 Eastern Diversion with Complete Separation									
3A - 5 Acres Dredging	$6,096,238	$438,000	$25,000	$6,559,000	$20,000	$443,400	24.5	218	77.7
3B - 10 Acres Dredging	$5,805,706	$438,000	$25,000	$6,269,000	$20,000	$424,700	30.0	218	83.9
3C - 15 Acres Dredging	$7,566,519	$438,000	$25,000	$8,030,000	$20,000	$538,300	33.5	218	87.8
ALTERNATIVE 4 Western Diversion with Separation									
4A - 5 Acres Dredging – Riffle Structure	$2,689,921	$306,000	$15,000	$3,011,000	$12,000	$206,400	24.5	218	77.7
4B - 10 Acres Dredging – Riffle Structure	$3,354,467	$306,000	$15,000	$3,675,000	$12,000	$249,300	30.0	218	83.9
4C - 15 Acres Dredging – Riffle Structure	$3,977,990	$306,000	$15,000	$4,299,000	$12,000	$289,500	33.5	218	87.8
4D - 5 Acres Dredging – Rock Ramp	$2,427,852	$306,000	$15,000	$2,749,000	$12,000	$189,400	24.5	109	52.7
4E - 10 Acres Dredging – Rock Ramp	$3,092,397	$306,000	$15,000	$3,413,000	$12,000	$232,300	30.0	109	58.9
4F - 15 Acres Dredging – Rock Ramp	$3,715,921	$306,000	$15,000	$4,037,000	$12,000	$272,600	33.5	109	62.8
4G - 5 Acres Dredging – Bypass Channel	$2,422,806	$306,000	$15,000	$2,744,000	$12,000	$189,100	24.5	109	52.7
4H - 10 Acres Dredging – Bypass Channel	$3,087,351	$306,000	$15,000	$3,408,000	$12,000	$232,000	30.0	109	58.9
4I - 15 Acres Dredging – Bypass Channel	$3,710,875	$306,000	$15,000	$4,032,000	$12,000	$272,300	33.5	109	62.8

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Table 6.3 (Continued)

ALTERNATIVE	CONSTRUCTION COST[1]	LANDS	REAL ESTATE COSTS	TOTAL[2]	ANNUAL O&M	ANNUALIZED COST [3]	SITE-SPECIFIC OUTPUTS	SYSTEMIC OUTPUTS	COMBINED
ALTERNATIVE 5 - Western Diversion without Separation									
5A - 5 Acres Dredging - Riffle Structure	$2,352,375	$341,000	$15,000	$2,708,000	$10,000	$184,800	6.0	218	56.8
5B - 10 Acres Dredging - Riffle Structure	$2,970,537	$341,000	$15,000	$3,327,000	$10,000	$224,700	12.9	218	64.6
5C - 15 Acres Dredging - Riffle Structure	$3,587,648	$341,000	$15,000	$3,944,000	$10,000	$264,600	20.5	218	73.1
5D - 5 Acres Dredging - Rock Ramp	$2,090,305	$341,000	$15,000	$2,446,000	$10,000	$167,900	6.0	109	31.8
5E - 10 Acres Dredging - Rock Ramp	$2,708,467	$341,000	$15,000	$3,064,000	$10,000	$207,800	12.9	109	39.6
5F - 15 Acres Dredging - Rock Ramp	$3,325,587	$341,000	$15,000	$3,682,000	$10,000	$247,700	20.5	109	48.1
5G - 5 Acres Dredging - Bypass Channel	$2,085,259	$341,000	$15,000	$2,441,000	$10,000	$167,600	6.0	109	31.8
5H - 10 Acres Dredging - Bypass Channel	$2,703,421	$341,000	$15,000	$3,059,000	$10,000	$207,500	12.9	109	39.6
5I - 15 Acres Dredging - Bypass Channel	$3,320,532	$341,000	$15,000	$3,677,000	$10,000	$247,300	20.56	109	48.2

[1] Construction costs include preliminary estimated construction costs, design costs and construction management costs. This is a preliminary estimate.
[2] Total cost is total project cost. It does not include operation and maintenance costs.
[3] Annualized Cost includes O&M costs for incremental analysis purposes.

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6.4 Alternative Comparison

Traditional benefit-cost analysis is not possible for planning ecosystem restoration projects because the costs and benefits are expressed in different units. However, cost effectiveness and incremental cost analyses can provide decision makers with relative benefit-cost relationships of the various alternatives. While these analyses are not intended to lead to a single best solution, they do improve the quality of decision making by ensuring that a rational, supportable, focused, and traceable approach is used for considering and selecting alternatives to produce ecosystem outputs.

The Corps of Engineers guidance requires cost effectiveness and incremental cost analyses for recommended ecosystem restoration plans. A cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of ecosystem output. For the purpose of this analysis, only construction, LERRDs, and operation and maintenance costs were compared among the alternatives. The study costs are assumed to be constant among the alternatives. Cost effectiveness means that no plan can provide the same benefits for less cost or more benefits for the same cost. Then, incremental analysis of the least cost solutions is conducted to reveal changes in cost for increasing level of outputs. Plans that provide the greatest increase in benefits for the least increase in costs are identified as "Best Buy" plans.

The results of the cost effectiveness and incremental cost analyses are presented below. Figure 6.1 shows the cost effectiveness results all alternatives. Each point represents an alternative. Cost effective (circle) and "Best Buy" (triangle) plans are labeled with alternative name. Besides the No Action alternative, nine of the alternatives were cost effective. Of the nine, six alternatives were identified as "Best Buy" plans, including No Action.

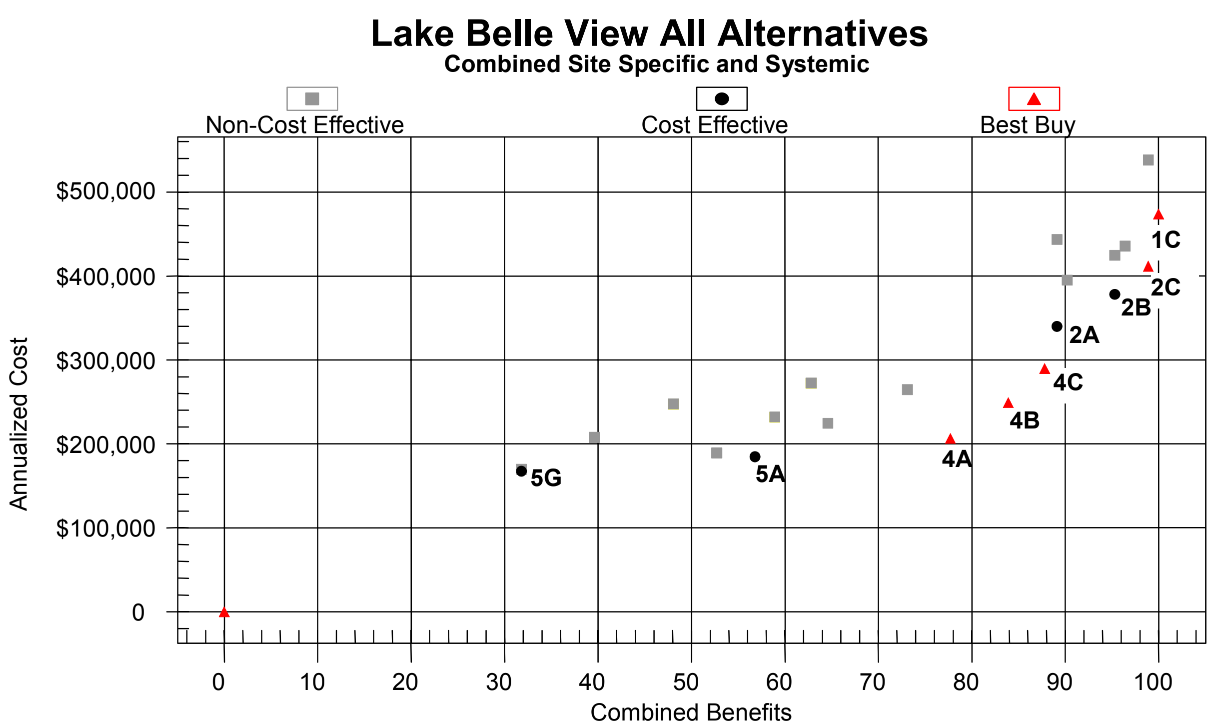

Figure 6.1. All alternatives.

Figure 6.2 and Table 6.4 show the five "with-project" alternatives that were identified as "Best Buy" plans. These alternatives are considered to be the most cost effective and incrementally justified plans to accomplish restoration at the project site. These plans were presented to the Lake Committee.

Alternatives 4A and 4B were considered to be worth the incremental investment. Alternative 4C was considered to be worth the additional cost of $10,308 because it provides the maximum level of sediment removal, which interests the Sponsor. Alternative 2C was considered to be worth the additional cost of $11,009 because it maximizes sediment removal and restores the river to a free-flowing condition, which interests the WDNR. However, Alternative 1C was not considered to be worth the incremental cost of $56,456 for 1.1 benefit unit. Alternatives 4C and 2C were presented, along with the No Action alternative, at public meetings. The community consensus was for Alternative 2C.

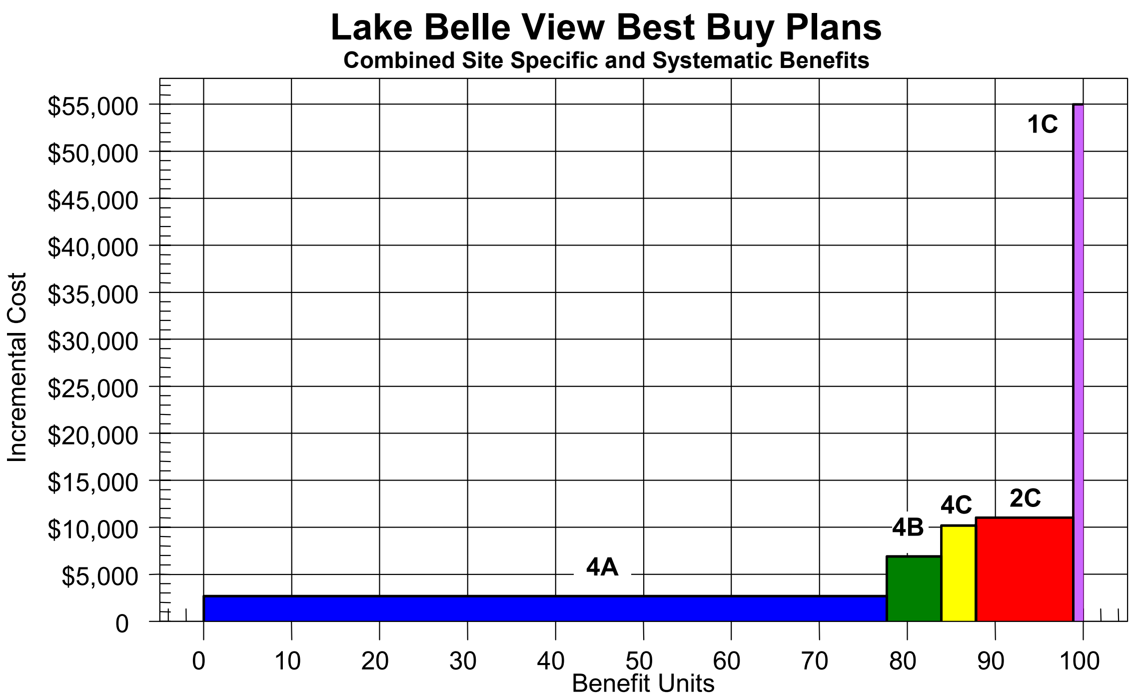

Figure 6.2. Best Buy plans.

Table 6.4. Incremental cost of Best Buy plans.

Plan	Total Project Cost - Includes O&M, Real Estate, and Study Costs	Annualized Cost	Incremental Cost	Output	Incremental Output	Incremental Cost/Output
4A	$3,011,000	$206,400	$206,400	77.7	77.7	$ 2,656
4B	$3,675,000	$249,300	$ 42,900	83.9	6.2	$ 6,919
4C	$4,299,000	$289,500	$ 40,200	87.8	3.9	$10,308
2C	$6,343,000	$411,700	$122,200	98.9	11.1	$11,009
1C	$7,339,000	$473,800	$ 62,100	100	1.1	$56,456

The Recommended Plan is Alternative 2C: Eastern Diversion with Southern Riffles. This plan consists of building a diversion berm to reroute the river along the eastern diversion route, excavating the eastern diversion channel, adding three riffle structures at the southern end of the new channel, enhancing existing wetlands with dredged material, and dredging 15 acres to an 8-foot depth. The plan provides 98.9 benefit units out of a possible 100 units at a total cost of $6,343,000.

6.5 Recommended Plan

The Recommended Plan consists of routing the river along the current channel alignment. Diversion berms would be constructed to elevation 862. A spillway would be constructed at the upper end at elevation 861 to minimize overtopping damage to the berm. Inflow control structures would be included to assist in water level management within the lake and allow large flood events to use the flood storage of the lake. A carp gate with boat passage would be constructed at the inflow structure to restrict carp from entering the lake but allowing boats to pass. A river channel would be excavated parallel to Highway 69. The channel would reconnect with the river at the existing millrace just upstream of the Highway 69 Bridge. Three riffle structures would be placed for fish passage and grade control. The crest elevation of the most upstream control point or riffle structure must be the same elevation as the crest of the existing dam (857.4 ft NGVD). Sediment removal would be accomplished over 15 acres of lake through hydraulic dredging. Wetland areas adjacent to the existing islands and the western shore would be enhanced by placement of dredged material. Any material not used in construction of the wetland enhancement would be placed in an adjacent placement site on the western shore. Periodic drawdown would be implemented as an operation and maintenance function. Frequent rough fish removal also would be implemented to support this alternative.

The Recommended Plan meets all objectives of the project shown in Table 6.5.

Table 6.5. Project goals and objectives.

Goals	Objectives
Improve aquatic habitat Enhance wetland habitat	1. Improve water quality in Lake Belle View and the Sugar River 2. Increase lake depths 3. Increase diversity of aquatic habitat 4. Improve diversity and quality of wetland habitat

The Recommended Plan would improve water quality in Lake Belle View and the Sugar River by separating the lake and the river. The river would maintain velocity and would not drop sediments and nutrients in the lake. The water temperature of the lake also would be reduced. The warming effect that the lake has on the river would be reduced. Lake depths would be increased through 15 acres of dredging. Aquatic diversity would increase by routing the river around the lake. River connectivity would be restored, allowing fish to move freely to upstream habitat. Sediment removal and rough fish control also would increase the aquatic diversity of the project area by allowing more species to reestablish communities in the area. Wetland habitat diversity and quality would be improved by creating depth diversity. The wetlands also would improve water quality in the lake by acting as a natural filter for runoff and binding nutrients in the water.

The Recommended Plan meets the four evaluation criteria of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The four criteria are acceptability, completeness, effectiveness, and efficiency.

- **Acceptability.** The plan is acceptable to Federal, state, tribal, local entities, and the public. It is compatible with existing laws, regulations, and policies. It is fully supported by the WDNR, Dane County, and the Village of Belleville. In addition to community support for the plan, the WDNR believes that the Eastern Diversion alternatives best meet the Department's primary objective of restoring the river to a more natural condition and providing uninterrupted movement of aquatic life. Dane County is interested in contributing financially to any alternative that fully separates the river and the lake. The Township of Montrose would like assurance that the frequency of minor floods will not increase before they commit to a financial contribution to the project.

- **Completeness.** The plan is complete. Realization of the plan does not depend on implementation of actions outside the plan.

- **Effectiveness.** The plan is effective. It addresses all the project objectives. It improves the water quality in Lake Belle View and the Sugar River through river diversion. The depths of the lake are increased through sediment removal. The diversity of aquatic habitat is increased through river diversion, providing fish passage, rough fish control, and sediment removal. The diversity and quality of wetland habitat is increased through wetland enhancement.

- **Efficiency.** The plan is efficient. It is a cost-effective solution to the stated problems and objectives. No other plan produces the same level of output more cost effectively. The plan is cost effective and provides the greatest increase in benefits for the least increase in costs. It provides 11.1 additional benefit units at an increased cost of $11,009 per unit.

6.6 Resource Significance

Due to the significance of the resource, the project stakeholders felt that a "with-project" plan was worth the cost and preferable to No Action. Settlement and development have caused the ecosystem in the project area to degrade. However, according to the WDNR, high quality resources still exist throughout the Upper Sugar River watershed. The Sugar River is considered to be an exceptional cold-water resource. The Upper Sugar River watershed is the focus of many environmental improvement, educational, and recreational projects. The lake is considered to be a unique resource, providing many recreational opportunities for the public. The lake is the hallmark of the Village. The view looking west from Highway 69 is considered to be a valuable asset, drawing residents and those interested in recreation. In addition, the citizens of Belleville take great pride in the dam as it symbolizes the Village's heritage.

6.7 Reasonableness of Costs

It is recognized that justification of a project does not rest solely on the tests of cost effectiveness and incremental cost analysis. The significance of the resource, the significance and effectiveness of the outputs, risk and uncertainty, and the success and cost of comparable projects also weigh in the decision. The Recommended Plan restores a significant resource while preserving another. It is acceptable to the major stakeholders. The plan is effective, efficient, and complete. Comparison to other projects is difficult due to its uniqueness. Past environmental restoration projects have compared average annual cost to AAHUs to identify whether projects are justified. For this project, a straight comparison is misleading because the benefits were normalized to a maximum score of 100.

When upstream HUs are combined with the site-specific benefits, it would suggest that the Recommended Plan might provide between 176 and 308 AAHUs. More details can be found in Appendix C. Based on an average annual cost of $411,700, this would provide an average cost per AAHU ranging between $1,337 and $2,339 per AAHU.