DEFINITE PROJECT REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

SECTION 206
LAKE BELLE VIEW
AQUATIC ECOSYSTEM RESTORATION PROJECT

APPENDIX C
HABITAT EVALUATION, BENEFITS QUANTIFICATION,
AND INCREMENTAL ANALYSIS

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OVERVIEW

This appendix provides an ecological assessment of the project area and quantifies, to the extent possible, ecological benefits resulting from the proposed project alternatives. This assessment includes identification of existing conditions, as well as a forecast for future conditions resulting from potential project alternatives and a no action alternative. It also compares resulting environmental improvements to the associated costs of each alternative.

1. EXISTING CONDITIONS

1.1 Project Location and History

Lake Belle View is a shallow, 93-acre millpond located on the Sugar River at Belleville, Wisconsin, approximately 20 miles southwest of Madison. The millpond is located in the upper reaches of the Sugar River and its accompanying watershed which occurs in south-central Wisconsin.

The Sugar River watershed above Lake Belle View is approximately 172 square miles, with two major river channels joining immediately upstream of the lake. The majority of this watershed occurs within the driftless area which predominates southwestern Wisconsin, an area unaffected by glaciation. The soil in this area is characterized as loess, which is easily eroded, forming deep cut valleys and narrow river channels (UW 1995). When the area was settled in the 1800's, land was cleared for agriculture and homes. Since then, much of the watershed has been heavily farmed, resulting in increased erosion and nutrient runoff within the watershed. In additional to heavy agricultural land use within the watershed, areas of the eastern watershed are experiencing rapid urban growth.

The Sugar River was first dammed at Belleville in 1845 for the purpose of powering a sawmill. The present Lake Belle View was created in 1920 when an additional dam was constructed a short distance from the original dam. The construction of Lake Belle View resulted in an abundance of deep, lentic habitat. These types of areas provided habitat that favored lentic fish species, including centrarchid species such as bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*).

Since its completion in 1920, river sediments have been accumulating throughout Lake Belle View. River flows from the Sugar River enter Lake Belle View, at which point water velocities decrease and suspended sediments fall from the water column. Over time, sedimentation has reduced lake depths and overall habitat quality. Lake Belle View currently suffers from ecological problems typically associated with artificial impoundments on river systems. These include shallow depths, elevated turbidity and nutrient levels, abundant rough fish, and little aquatic vegetation. In addition to problems within Lake Belle View, the dam creating the impoundment presents an impassable barrier to upstream migration of fisheries resources.

The discussion below provides additional information on existing conditions within Lake Belle View and the adjacent Sugar River. Information for this summary originates from UW 1995; data provided by the Wisconsin Department of Natural Resources (WDNR); and additional field data collected by the Rock Island District, Corps of Engineers (Corps).

1.2 Existing Conditions for Lake Belle View

1.2.1 Bathymetry and Substrate

Currently, Lake Belle View has an average depth of less than 2 feet and a maximum depth of less than 10 feet immediately behind the dam. Lake bathymetry is highly uniform, with depths throughout most of the lake only varying between 1 and 2 feet. Lake substrates are almost entirely fine silts, with gravel and cobble at a few locations.

1.2.2 Water Quality

Because Lake Belle View is a shallow, flow-through lake, water temperature and dissolved oxygen (DO) conditions are often similar throughout the lake. Although limited, existing data suggest that summer lake water temperatures may average between 22 and 26°C (72 to 79°F), with maximum daily temperatures as high as 30°C (86°F). During the summer, Lake Belle View has a warming effect on Sugar River temperatures. Continuous temperature data collected during the month of August 2000 demonstrated an average river inflow temperature of 20°C (68°F) and an average outflow temperature of 22°C (72°F).

Existing, limited data suggest that DO levels generally remain above 5 mg/L. During the summer, DO levels can exceed saturation levels during daylight levels due to the photosynthetic action of cyanobacteria. Although the existing data have not shown anoxic conditions during the summer in Lake Belle View, such conditions often occur on eutrophic lakes as a result of respiration. However, due to its shallow depth, wind and wave action, and river inflow (and subsequent short retention time), such conditions may not be expected to occur frequently within the lake.

UW (1995) also collected point measurements for total phosphorous within Lake Belle View during June and July of 1995. Total phosphorous within the lake averaged 0.31 mg/L, with a range of 0.138 to 1.04 mg/L (N = 16). Total phosphorous also was measured upstream within the Sugar River. Total phosphorous concentrations averaged 0.41 mg/L, with a range of 0.146 to 0.636 mg/L (N = 6). These observations would identify Lake Belle View as a highly eutrophic system, relative to other lakes (Wetzel 1983).

Virtually no data exist for total suspended solids within Lake Belle View. However, the lake can certainly be considered a turbid system. UW (1995) did collect some Secchi Depth measurements (a measure of water transparency), with depth observations of less than 2 feet. Other observations by UW

(1995) include conductivity measurements ranging between 437 and 682 :S/cm, and pH measurements that fell between 7.5 and 8.7.

1.2.3 Vegetation and Physical Cover

Previous observations by UW (1995) suggest that aquatic vegetation is extremely limited within the lake. Species observed include curly-leaved pondweed (*Potamogeton crispus*), Sago pondweed (*Potamogeton pectinatus*), leafy pondweed (*Potamogeton foliosus*), coontail (*Ceratophyllum demersum*), and *Elodea*. However, UW (1995) estimated only 6% to 7% of the lake bottom was covered with vegetation. During the summer of 2001, Lake Belle View was drawn down for dam repairs. This drawdown allowed for physical observation of the exposed the lakebed. However, during the drawdown, almost no submergent or emergent aquatic vegetation was apparent. In addition to a lack of vegetation, only 1% to 2% of the lakebed included submerged trees, brush, or other physical habitat.

1.2.4 Fishery Resources

Lake Belle View's fishery resource can be characterized based on anecdotal observations, as well as a fishery survey performed by the WDNR in 1969. Lake Belle View's fishery resource is dominated by common carp (*Cyprinus carpio*), as well as various species of catostomids (suckers and redhorse) and ictalurids (catfish and bullheads). The lake contains a low abundance of desirable fish species such as largemouth bass, bluegill, and black crappie. The lack of desirable fish is a direct result of the shallow lake depths, high turbidity levels, and low aquatic vegetation.

Lake Belle View currently represents ideal common carp habitat, including shallow depths, turbid waters, and fluctuating water quality conditions. Common carp are an exotic species originally introduced to the United States in the 1800's. They are undesirable and often have an adverse effect on aquatic resources. Common carp feed on aquatic vegetation and resuspend fine sediments, both of which works to further exacerbate poor water quality and suppress desirable fish species. Lake Belle View likely serves as a nursery for common carp fry and juveniles that end up populating the Sugar River both above and below Lake Belle View.

1.2.5 Adjacent Terrestrial Resources

Areas adjacent to Lake Belle View include existing terrestrial wetland areas, as well as developed areas. Existing wetlands include riparian zones of the project area that largely include floodplain forest habitat, with the area of the peninsula along the west side of the lake existing as sedge meadow/wet prairie (UW 1995). Species observed within the floodplain forest include common species such as species of ash (*Fraxinus* spcs.), willow (*Salix* spcs.), and maples (*Aceracea*). Species observed within the sedge meadow/wet prairie include species such as sedges (*Carex* spcs), asters (*Aster* spcs), and reed canary grass (*Phalaris arundinacea*). Areas along the north shore of the lake include several private homes. The eastern shore abuts immediately against State Highway 69, with the southern shore and peninsula consisting of a village park.

1.3 Existing Conditions for Sugar River

1.3.1 River Above Lake Belle View

The dam at Lake Belle View currently serves as an impassable barrier to upstream movement for fisheries and aquatic resources. As such, it divides the upper watershed from the river below Lake Belle View. Watershed characteristics of the Sugar River near Lake Belle View have briefly been described above. Above Lake Belle View, the Sugar River first branches into two main forks (West Branch Sugar River and Sugar River) and eventually branches out into numerous tributaries that form the upper watershed. Above Lake Belle View is approximately 218 miles of mainstem and tributary stream habitat. Lotic habitat types are variable, ranging from cold-water headwater streams, to warm-water forage fishery tributaries, to the mainstem Sugar River, which supports warm-, cool-, and cold-water fishery resources. The current WDNR stream classification for the Sugar River's fish and aquatic life community is "cold" from its headwaters downstream to French Town Road, which is a 5 miles above Lake Belle View. Overall habitat quality for the upper watershed varies between high-quality streams to low-quality areas that serve as little more than drainage ditches. However, recent improvements in land-use practices have resulted in better overall water quality and instream habitat conditions within the Sugar River. Within the last 20 years, various streambank restoration projects have helped to improve stream habitat conditions. Currently, water quality in the upper Sugar River is generally considered to be good (Sugar-Pecatonica Rivers Water Quality Management Plan, March 1995, WDNR). The entire stretch of the Sugar River within this upper watershed is classified as Exceptional Resource under the State of Wisconsin's antidegradation rules, NR 102 and NR 207.

Fishery surveys of the upper Sugar River performed in 1974 and 1992 resulted in the collection of 31 and 28 species of fish, respectively (UW 1995; Wisconsin DNR unpublished data and personal communications). This includes collection of the mottled sculpin (*Cottus bairdi*), a fish that is generally an indicator of good water quality. Surveys also collected include both smallmouth bass (*Micropterus dolomieu*; a cool-water species) and brown trout (*Salmo trutta*; a cold-water species). Other common species included white sucker (*Catostomus commersoni*), northern hog sucker (*Hypentelium nigricans*), creek chub (*Semotilus atromaculatus*), hornyhead chub (*Nocomis biguttatus*), shorthead redhorse (*Moxostoma macrolepidotum*), silver redhorse (*Moxostoma anisurum*), common shiner (*Notropis cornutus*), spotfin shiner (*Notropis spilopterus*), bluntnose minnow (*Etheostoma chlorosomum*), Johnny darter (*Etheostoma nigrum*), and stonecat (*Noturus flavus*). The 1992 survey also collected high numbers of yearling carp at several stations. These undesirable fish most likely originated from Lake Belle View.

In addition to these common fishes, the Sugar River also may contain rare or unique species. Species that have been listed as threatened or endangered by the State of Wisconsin and have been found in the Sugar River include the river redhorse (*Moxostorna carinaturn*); redfin shiner (*Lythrurus umbratilis*), pallid shiner (*Notropis amnis*), starhead topminnow (*Fundulus dispar*), and gravel chub (*Erimystax x-punctatus*). Many of these species may have been collected in low numbers over 25 years ago. They also may have been collected in river reaches well downstream below other impediments such as dams at Albany and/or Brodhead. In most, if not all, cases, current status of these species within the Sugar River is unknown.

In addition to a diversity of fish species, the Sugar River also contains mussel resources, as well as other invertebrates. Mussels recently found include plain pocketbook (*Lampsilis cardium*); fat mucket (*L. siliquoidea*) Elk toe (*Alasmidonta marginata*); and fluted-shell (*Lasmigona costata*); as well as other species. Recent Sugar River surveys also identified buckhorn (*Tritogonia verrucosa*) and ellipse (*Venustaconcha ellipsiformis*); two mussel species which are State listed.

1.3.2 River Below Lake Belle View

Below Lake Belle View, the Sugar River flows freely downstream before encountering the next impassable dam at Albany, approximately 22 miles downstream. Although available fishery data are limited, the Sugar River mainstem in this stretch supports both cool- and warm-water fishery resources. In addition to those species discussed above, additional fish species found downstream include, but are not limited to, walleye (*Stizostedion vitreum vitreum*), channel catfish (*Ictalurus punctatus*), northern pike (*Esox lucius*), and quillback (*Carpiodes cyprinus*). The dam creating Lake Belle View affects downstream water quality and fishery resource communities. As mentioned above, the lake increases average daily water temperatures during summer months. Downstream flows also may be more turbid as a result of resuspended sediments within the lake. Moreover, common carp populations in the lower river are likely augmented by young of year carp originating from the lake.

1.4 Ecosystem Restoration Opportunities

As outlined above, aquatic habitat conditions at Lake Belle View are poor. Moreover, the existing dam forms a permanent barrier, limiting movement of fishery resources between river reaches above and below Lake Belle View. The Lake Belle View ecosystem restoration project targets improvement of the immediate project site at Lake Belle View, as well as fishery resources within the adjacent river.

1.4.1 Project Area

The project area has been identified to include Lake Belle View and affected adjacent island and riparian areas. This includes an area of about 133 surface acres which, under baseline conditions, includes 93 acres identified as lake habitat, with the remaining 40 acres consisting of floodplain islands and adjacent riparian areas.

1.4.2 Project Objectives

Project objectives for this project have been discussed elsewhere and include: (1) improve water quality in Lake Belle View and the Sugar River, (2) increase lake depths, (3) increase diversity of aquatic habitat, and (4) improve diversity and quality of wetland habitat.

1.4.3 Project Features

Project features are those that address some/all of the identified project objectives. These project features are combined into specific project alternatives that are evaluated to identify quantifiable project costs and resulting environmental benefits. The various project features for this project have been discussed elsewhere and include: (1) lake sediment dredging, (2) lake/river separation (river diversion), (3) wetland enhancement, (4) fish passage implementation; and (5) carp control measures.

1.4.4 Project Alternatives

The project alternatives for this project are discussed in Chapter 5 of the Definite Project Report and include 27 combinations of various project features. The general types of project alternatives include iterations of:

- Eastern river diversion with river/lake separation (Alternatives 1, 2 and 3);
- Western river diversion with river/lake separation (Alternative 4);
- Western diversion without river separation(Alternatives 5); and
- No Action Alternative.

Each project alternative includes three possible options for dredging:

- Option A - 5 acres of dredging
- Option B - 10 acres of dredging
- Option C - 15 acres of dredging

Project alternatives are then labeled as 1A, 1B, and so forth, to indicate the general alternative type and the associated dredging option.

1.4.5 Potential Environmental Benefits

Site-Specific Benefits. This ecosystem restoration project will result in two main areas of environmental benefit. First, the project will improve aquatic and wetland habitats at the project site. Increasing lake depths and improving water quality should promote and improve warm-water lentic environment and resulting warm-water fisheries communities. The project also would improve wetland characteristics within targeted areas. Proper sloping and seeding of lake substrates should promote a diverse vegetative community. The type of wetlands created may vary, but could include shallow water marsh and/or fresh meadows. Moreover, the project would promote aquatic vegetation throughout the lake. Although the desire by the project sponsor is to create and manage much of the project area as a lake environment, improved aquatic vegetation would likely allow much of the project site to also be classified as deep marsh. Thus, the project would have additional wetland benefits beyond areas immediately targeted for wetland improvement.

Systemic Benefits through Fish Passage. The project will 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 and completion of the existing dam facility in the 1920's. Implementation of fish passage at Lake Belle View would provide fish access to approximately 218 miles of mainstem 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, fish 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) 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 C.1. 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	• White sucker
• Quillback	

* 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.

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.

2. HABITAT ASSESSMENT METHODOLOGY

The purpose of this analysis is to quantify, to the extent possible, environmental benefits resulting from various project alternatives. Participants for this analysis included biologists from the Corps and the WDNR. A habitat analysis was conducted to evaluate potential site-specific benefits of alternative habitat improvement features at Lake Belle View. Quantification of site-specific project benefits is expressed in terms of Habitat Units (HUs), which are a measure of both habitat quantity and habitat quality. Habitat quantity is measured in acres, while habitat quality is measured with Habitat Suitability Indices (HSIs) for key indicator species. Conversely, systemic fish passage benefits are quantified by the amount of upstream habitat made available through feature implementation.

Comparison of alternative designs and combinations of features is accomplished through cost-effectiveness evaluation and incremental cost analysis. Cost-effectiveness evaluation is used to identify the least costly solution to achieve a range of project benefits. Incremental cost analysis is a tool that can be used to scale the size of the project or of individual features by determining changes in costs associated with increasing levels of benefits.

2.1 Habitat Evaluation Methodology for Site-Specific Benefits

The methodology utilized for evaluating site-specific benefits was the Habitat Evaluation Procedures (HEP), which was developed by the U.S. Fish and Wildlife Service. The HEP is a numerical system for evaluating the quality and quantity of particular habitats for an individual species. The qualitative component of the analysis is measured by one or more Habitat Suitability Index (HSI) models. A separate HSI model is required for each individual indicator species. Each HSI model considers a number of environmental variables that are important for determining habitat conditions for the given species. Field data are collected or estimated for each of these variables, and each variable correlates the field data to a resulting habitat suitability value between 0 and 1.0. The mathematical model then calculates a single overall value for habitat suitability for a given species. This value identifies habitat quality for the identified area for the identified species.

The quantitative component of the HEP analysis is the measure of surface area 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.

Habitat improvements of any project, as measured with HUs, can be estimated for any point in time. However, habitat conditions can change over the life of a project. Following construction, habitat conditions will have changed over existing conditions. Habitat benefits from project features also will change as the project ages over time. Thus, habitat benefits should be estimated for a series of points in time to evaluate the benefits and life expectancy of a proposed action. The particular dynamics of the ecosystem under study will determine the target years chosen for analysis. HUs can then be “annualized” to estimate average changes brought about by project features/alternatives over time. The annualization calculates Average Annual Habitat Unit (AAHUs) for the project over a defined project life.

For project planning and impact analysis, the project life was established as 50 years. To facilitate comparison, target years were established at 0 (existing conditions), 1, 5, 10, 25, and 50 years. HUs were calculated for each of the target years, with weighted averages used to calculate AAHUs for each indicator species. This AAHU represents the average change in habitat conditions expected over the life of the project. The overall value of a proposed project is evaluated by comparison of With-Project conditions to Without-Project conditions.

For this analysis, EXHEP software (Corps 2001) was utilized to perform the HEP analysis. This software requires input for the HSI variables, as well as habitat acreages for the identified target years. This software then computes various model outputs, including AAHUs. Output is calculated for each individual indicator species, as well as a combined total that represents total AAHUs for all indicator species (and thus all habitat types). This allows for comparison of alternatives for individual species, as well as overall combined benefits.

2.1.1 Application of Modeling Output

The HSI models utilized for this analysis were developed by the U.S. Fish and Wildlife, Biological Services Program. These models are suggested as an aid for impact assessment and habitat management activities. However, caution should be exercised when interpreting modeling output for this effort. Documentation for the models state that "*The HSI models… are complex hypotheses of species-habitat relationships, not statements of proven cause and effect relationships*." Although these models are mathematically precise, their output should not be interpreted as definitive absolutes. Rather, output for the Future With-Project condition can be compared to the Future Without-Project condition to identify and project a relative index of magnitude in the possible change of habitat types and overall habitat quality.

2.1.2 Habitat Identification and Indicator Species Selection

The proposed project alternatives will affect the form and value of different habitats within the project area. Thus, the quantities of different habitats created for various project alternatives were estimated. To perform this, different habitat types resulting under With-Project conditions, as well as a No Project alternative, were projected onto orthorectified aerial photographs of the project area. This allowed for a quantification, in terms of surface acres, for different types of resulting habitat. Habitat types identified for each alternative are included below.

Table C.2. Surface acreage of general habitat types observed under baseline conditions, and potentially observed under future without-project and various future with-project features at Lake Belle View.

Habitat Class	Baseline	Future w/o	Alt 1	Alt 2	Alt 4	Alt 5
Lake	98.3	98.3	45.6	45.6	50.2	98.2
River	--	--	16.7	16.7	27.2	--
Existing wetlands[1]	34.3	34.3	32.3	32.3	32.8	33.9
Restored wetlands[2]	--	--	22.4	22.4	20.3	--
River riparian[3]	--	--	9.1	9.1	--	--
Berm[4]	--	--	6.8	6.8	2.1	--
Rock dyke[5]	--	--	--	--	--	0.5
Millrace	0.3	0.3	--	--	0.3	0.3
Total	132.9	132.9	132.9	132.9	132.9	132.9

[1]Existing wetlands: This represents existing riparian zones of the project area that exist as wetland. The majority of this exists as bottomland forest, with the area of the peninsula along the west side of the lake existing as a sedge meadow/wet prairie.
[2]Restored wetlands: These are areas that currently exist as lake habitat that will be sloped and vegetated to create shallow marsh and inland meadow areas under given project alternatives.
[3]River riparian: These are areas that will form the riparian zone under alternatives that include rerouting of the river channel (i.e., Alternatives 1 and 2).
[4]Berm: In given alternatives, this represents surface acreage of the berm that separates the river and lake.
[5]Rock levee: For Alternative 5, this represents surface acreage of the rock levee that will direct river flows along the west end of the lake.

To evaluate and quantify changes to these habitat types, Habitat Suitability Index (HSI) models were utilized for key indicator species. The indicator species for this analysis were included in Table C.1. These species were selected for two reasons. First, HSI models were available for these species. Secondly, each species is associated with a guild of other similar species that utilize a similar type of habitat.

Table C.3. Indicator species utilized for habitat analysis using appropriate Habitat Suitability Index models.

Species	Scientific Name	Habitat Type Evaluated
Largemouth Bass (lake model)[1]	*Micropterus salmoides*	Lake
Bluegill (lake model)[2]	*Lepomis macrochirus*	Lake
Smallmouth Bass (river model)[3]	*Micropterus dolomieu*	River
Marsh Wren[4]	*Cistotnorus palustris*	Restored Wetland
Wood Duck[5]	*Aix sponsa*	Existing Wetland
Eastern Meadowlark[6]	*Sturnella magna*	River Riparian

[1] Stuber et al. 1982a
[2] Stuber et al. 1982b
[3] Edwards et al. 1983
[4] Gutzwiller and Anderson 1987
[5] Sousa and Farmer 1983

[6] Schroeder and Sousa 1982

Indicator Species for Lake Habitat. Lake restoration of this project is targeting a warm-water lentic environment. Bluegill and largemouth bass are two species commonly associated with warm-water lentic habitats of southern Wisconsin. Becker (1983) states that "In Wisconsin, almost all species of fish are associated with largemouth bass, except for coldwater fishes." Both species also would depend on lake restoration in order to improve habitat conditions. Harsh overwintering conditions are likely one of the limiting factors for centrarchid communities in Lake Belle View. Becker (1983) reports that bluegills and largemouth bass are among the first fish to die-off in winterkill lakes. Both species are also popular species for sport anglers.

Indicator Species for River Habitat. On-site river restoration for this project is targeting a cool-water river environment. Smallmouth bass are common in medium to large streams and rivers throughout Wisconsin. Historically, the Sugar River was noted for its strong smallmouth bass population. However, limited observations suggest that smallmouth populations above Lake Belle View may be reduced compared to historic levels. Smallmouth also are often associated with other fish in stream and river systems. Becker (1983) gives an example where smallmouth bass were found in conjunction with 16 other species within a Wisconsin river community. Lyons et al. (1988) state that smallmouth bass are found with other species including stonecats, rosyface shiner, sand shiners, hornyhead chub, and golden redhorse. Smallmouth bass also are a popular sport species.

Indicator Species for Wetland Habitat. Wetland habitat concerns for this project include existing wetland areas, as well as areas of Lake Belle View targeted for wetland enhancement. Existing wetlands include riparian zones of the project area that largely include bottomland forest habitat, with the area of the peninsula along the west side of the lake existing as sedge meadow/wet prairie. Areas of Lake Belle View targeted for wetland enhancement would be sloped and vegetated to create shallow marsh and inland meadow areas under given project alternatives.

To assess changes in existing wetland areas that would result from project alternatives, wood duck was selected as an indicator species for these types of habitats. Existing wetlands exist largely as bottomland forests, habitat frequented by wood ducks. Wood ducks are commonly observed within the project area and are a favorite of sportsmen and nature observers.

In addition to existing wetland areas, other wetland types targeted for enhancement with this project could include forms that would likely be classified as shallow marshes and different forms of inland fresh meadows. The frequency of inundation, and accordingly, vegetation, will be variable as different portions of the wetland will be made at different elevations and seeded with different plant species. This should benefit a variety of vegetation and resulting terrestrial and amphibian life that will utilize different portions of the wetland.

For the purpose of this analysis, the marsh wren was selected as an indicator species to quantify benefits from wetland restoration. Marsh wrens frequent shallow marshes dominated by plants such as cattails (*Typha* species) and bulrush (*Scirpus* species). Portions of Lake Belle View may likely be seeded to grow such plant communities. It is likely that other plant types will be used in other areas targeted for wetland restoration, such as plants typical of fresh meadows. Such areas may not be ideal habitat for marsh wren, but are valuable for other species. The analysis could attempt to fragment all areas projected for wetland enhancement and utilize several indicator species for each type of wetland habitat. However, such an effort would be difficult and speculative as the exact composition of wetland areas has not been finalized.

Therefore, for the purpose of this analysis, it was assumed that all areas targeted for wetland enhancement would include shallow marshes consisting of cattail and/or bulrush plant types. Although the habitat and species ultimately benefiting may likely be different than that indicative of marsh wren habitat, the overall benefits would likely be similar to those observed for marsh wren.

Indicator Species for River Riparian Habitat. Under project alternatives that include re-creation of a river channel (i.e., Alternatives 1 and 2), portions of the Lake Belle View project area will be converted to riparian areas. Under existing conditions and future without-project conditions, riparian areas to Lake Belle View largely exist as bottomland forest. However, with the given project alternatives in place, some of this riparian habitat will be different compared to existing or future without-project conditions. Much of this new riparian area will be comprised of grassy areas with limited shrub or tree cover. Such habitat would prove to be more representative of a species such as meadow lark habitat. For this reason, eastern meadowlark was selected to represent this riparian habitat that would exist under the given alternatives.

Habitats Not Evaluated for Improvement. In addition to the habitats identified as being components of the project, some areas would not serve as valuable habitat. For example, portions of the project area have been or would be identified as either berms, rock dyke, or millrace. These features would exist to different extents under future alternatives. Such features occupy space within the project area that would not serve as valuable habitat by themselves. However, these areas must be accounted for within the evaluation. Because these areas would not serve as valuable habitat, they are assumed to have no habitat value within the overall analysis. It should be noted that some of these habitat features may augment other habitats. For example, although the rock dyke may not provide great habitat itself, it would provide structure for fish within lake and/or river habitat. These types of benefits were included as appropriate.

2.1.3 Data Collection, Input, and Modeling Assumptions

Baseline Conditions. Existing data on the physical and biological characteristics of Lake Belle View and the adjacent Sugar River are limited. However, this information is important in characterizing habitat conditions and serving as input into the HSI models, which in turn provide estimates on habitat quality and quantity. Much of the available data obtained from this analysis are from UW (1995), as well as WDNR unpublished survey data. Additional data were collected by the analysis team during the summer and fall of 2000. However, in some instances, assumptions needed to be made regarding baseline conditions. For example, some of the physical data (e.g., water temperatures and turbidity) for Lake Belle View were represented by surrogate water bodies within the region. Surrogate water bodies were selected that reasonably represented conditions at the project site for the variable of concern. Other key habitat variables were estimated based on best professional judgment of the project team. Best professional judgment was used only when existing data or surrogate data were not available.

Future Conditions With- and Without-Project Alternatives. Habitat conditions may not remain static over time. Either through natural processes or human activity, habitat can evolve or change in form, quality, and/or quantity over time. Substantial changes in habitat conditions would occur at the project site following construction of any of the project alternatives. In addition, habitat conditions also would change at the project site as the project ages over time. The HEP analysis attempted to quantify these changes in habitat conditions. To this end, a number of assumptions had to be made about physical conditions, and thus input data for the HSI models for the project site under future with- and without-project conditions.

For this analysis, the assumption was made that habitat conditions at Lake Belle View would remain the same under all future without-project conditions as they are under existing conditions. After careful consideration, the project team decided that conditions at the project site are likely to be in a general state of equilibrium. Sediment storage capacity for the lake has likely been reached, and little additional storage of sediment would occur in the future. In other words, the amount of sediment entering the lake is generally close to the amount leaving through the Belle View Dam. Thus, the lake would likely remain shallow and be dominated by silt substrate in the future. Because rough fish would continue to be present, no change would be anticipated for water clarity and aquatic vegetation. Likewise, no evidence suggests that temperature regimes, DO levels, or other physical or chemical conditions would change greatly in the immediate future. Moreover, any changes that would occur would likely be so minor as to be difficult to detect by the HSI models.

Conversely, future conditions at the project site would change to varying degrees under the identified project alternatives. For all project alternatives, resulting future with-project conditions were modeled over a 50-year planning horizon. Physical habitat conditions for each alternative were estimated at identified points in time to model and quantify corresponding habitat conditions.

Projections of resulting physical habitat conditions were based on a number of considerations, including alternative design characteristics, and how these designs would change habitats from projected future without-project conditions. Physical characteristics of each project alternative were quantified and input into the HSI models discussed above. In many cases, assumptions were made within the analysis, based on best professional judgment, on how the project would affect habitat conditions following project construction. For example, assumptions were made with lake restoration regarding water quality, cover, lake depths and bathymetry over the life of the project. This includes how sedimentation and eutrophication would affect lake depths and subsequent aquatic vegetative cover within the lake. To the extent possible, future with-project input data were based on given design characteristics, existing habitat conditions, and how habitat conditions may change over time. It is acknowledged that much of the future with-project input data for these models are extremely difficult to predict and are thus based largely on best professional judgment. For example, it is extremely difficult to quantitatively predict how eutrophication may affect lake depths and bathymetry over time. Changes in bathymetry in turn would greatly affect vegetative growth. These two variables can affect model output estimates of suitability. Although based on professional judgment, efforts were made to be consistent on these assumptions among project alternatives, thus providing the ability to compare the relative differences among project alternatives.

Model Performance. Assumptions were required for the two HSI models utilized in the analysis of benefits from lake restoration. First, it was assumed that the lacustrine model for the largemouth bass and bluegill HSI models would be utilized for this analysis, as opposed to the riverine model. The lake models were selected because the project site currently has characteristics of a lake environment, and because the improvements would result in an environment almost entirely lacustrine.

Secondly, assumptions were made regarding key HSI curves within selected HEP models. For largemouth bass, a modification was made to variable V2, which addresses percent lacustrine area ≤ 6 m in depth. Discussion with the project team identified that, given the unique characteristics of our project site under the proposed alternatives, a lake depth of about 2 m (6 ft) was necessary for successful overwintering by warm-water lentic fish. Thus, the curve was modified in that it represents percent area ≤ 2 m, as opposed to 6 m.

For largemouth bass, a modification also was made to variable V2, which addresses percent lacustrine area ≤ 2 m in depth (formerly 6 m in depth, as discussed above). The HSI curve was assigned a value of 0.0, as opposed to 0.3, for when 100% of the lacustrine area is less than or equal to 2 m in depth for northern latitudes. The existing HSI model for largemouth bass does not contain any specific variable(s) to address overwintering habitat conditions. Becker (1983) reports that largemouth bass are among the first fish to die-off in winterkill lakes. Harsh overwintering conditions are likely one of the limiting factors for centrarchid communities in Lake Belle View. The modification of variable V2 helps to account for overwintering conditions.

The smallmouth bass HSI models also required modification of two HSI curves to address site-specific conditions. For smallmouth bass, a modification was made to variable V1, which addresses dominant substrate within the river channel. An additional HSI curve category for substrate was included that contained a suitability of 0.5. This value better represents what would be expected at the project site, as opposed to accompanying categories within the model that assigned values of 0.3 (which would be too low) and a value of 0.7 (likely too high).

The smallmouth bass HSI model also included modification to variable V14, which addresses water fluctuation rates. An additional HSI curve category for water fluctuation was included that contained a suitability of 0.7. This value better represents what would be expected at the project site, as opposed to accompanying categories within the model that assigned values of 0.3 (which would be too low) and a value of 1.0 (likely too high).

2.2 Habitat Evaluation Methodology for Systemic Benefits from Fish Passage

Evaluating systemic benefits resulting from fish passage is in many ways more difficult than evaluating site-specific benefits discussed above. Fish passage can benefit a wide range of fish species, as well as freshwater mussels and possibly other aquatic organisms. Moreover, different fish species may use specific areas and types of upstream habitat during certain time periods. However, while fish passage does provide beneficial access to additional habitat, it is not creating or restoring the habitat itself, because such habitat already exists under base conditions. Furthermore, quantitatively predicting population or community response from fish passage would be virtually impossible.

It was decided that the resulting benefits from fish passage would be quantified in terms of habitat made accessible. Ideally, the quality of upstream habitat would be identified to further evaluate the benefits of fish passage. However, the HEP discussed for site-specific benefits include specific indicator species. Because fish passage can benefit a broad range of species, and because individual fish species may only use small habitat areas seasonally to meet specific life history requirements, the utilization of species-specific HSI models was not chosen to quantify these systemic benefits.

Alternative methods were considered to assess habitat quality and benefits of upstream fish passage. Utilization of various indices that assess quality of physical habitat could be valuable. Similarly, review of Index of Biological Integrity (IBI) data also may provide insight into upstream habitat quality. However, use of physical habitat or biological indices was not feasible for this analysis. Upstream fish passage provides access to 218 miles habitat, which occurs within the mainstem as well as numerous tributaries. Unfortunately, existing quantitative data are limited or nonexistent on the habitat quality for much of this upstream habitat. Moreover, large quantities of additional data would need to be collected to reasonably assess upstream habitat quality. Because of the miles of habitat and the distribution of habitat between a number of tributary systems, such data collection was not feasible.

Although detailed identification of upstream habitat quality would prove difficult, discussions within the project team identified that fish passage would be a valuable component of the project. Anecdotal observations and professional judgment suggest that upstream habitat is generally of good quality. It is believed that habitat quality is good enough to provide habitat for many life stages of various fish species during different seasons. Fish passage would provide unique upstream mainstem and tributary habitats. It also would benefit upstream resources by providing access to downstream habitats that may be especially valuable for overwintering.

Therefore, to evaluate the benefits of fish passage, the team assumed that passage would be beneficial, and to rank the benefits on an equal level with site-specific benefits observed at the project site. To evaluate benefits resulting from fish passage, the total miles of available upstream habitat was quantified in terms of stream miles. This value was then prorated in terms of the percentage of flow that would be provided through any fish passage structure. For example, alternatives that include re-creation of the river channel would pass 100% of river flows and would receive 100% of the fish passage benefits. Conversely, a bypass channel may only pass 50% of river flows and thus only would receive 50% of the upstream passage benefits.

It is recognized that actual fish passage benefits may exceed the relative benefits based on prorated river flows. For example, alternatives that provide for a bypass channel with diversion of 50% of spring and summer flows may likely observe more than 50% of the total benefits observed through an alternative that includes a restored river channel that diverts 100% of flow. However, it is impossible to predict this incremental difference in observed benefit. Prorating the benefits, based on river flows, provides a logical way to "award" greater benefits to alternatives that would likely result in better environmental conditions.

2.3 Cost Effectiveness and Incremental Cost Analysis Methodology

Environmental benefits observed both at the project site and through fish passage were combined and compared to overall costs through the Cost Effective and Incremental Cost Analysis. First, the environmental costs and benefits are calculated for each project alternative, as well as for the future without-project condition. For this project, costs and benefits are calculated for site-specific benefits (measured in HUs); as well as for benefits from fish passage (measured in pro-rated miles of upstream habitat). The methodology for calculating environmental costs and benefits is given above. Next, the economic costs associated with each project alternative are calculated. This includes costs for planning, construction, and operation and maintenance of the project. Then, the environmental costs and benefits are compared to overall costs through the Cost Effective and Incremental Cost Analysis.

The Cost Effective and Incremental Cost Analysis was performed using IWR-Plan software. This plan formulation decision support software (IWR-PLAN Version 3.30, July 2001) has been developed by the U.S. Army Corps of Engineers Institute for Water Resources for the specific purpose of comparing environmental costs and benefits to total project costs. The software is essentially a way of calculating and accounting costs and benefits for a range of project alternatives.

2.3.1 Calculation of Total Annualized Habitat Benefits

Habitat benefits were calculated for each habitat type using the models and methodologies discussed above. For analysis of site-specific benefits with HEP, total AAHUs were summed for all habitat types for all target years, with weighted averages used to calculate AAHUS. In the case of lake habitat, two indicator species were used. Thus, an average was taken for model output between the largemouth bass and bluegill models. This provided a single AAHU value for lake habitat, which in turn was added to those outputs for river, river riparian, existing, and created wetland habitat types. This allowed for the calculation of total AAHUs for all habitat types while preventing bias for lake habitat by not "double counting" habitat units for the two lake species models, compared to the other habitats which used a single species.

For comparison of project alternatives, the site-specific benefits were added with systemic benefits from fish passage. To do this, the total relative site-specific benefits counted as half of the total benefits observed, while the total relative systemic benefits counted as the other half. For example, the total AAHUs were calculated for site-specific benefits associated with each alternative. The total maximum AAHUs for site-specific benefits for any alternative was recorded and served as the denominator to compute the relative site-specific benefits for all project alternatives. This relative value was then multiplied by 0.5 to count as 50% of the total benefits. Then, the total relative fish passage benefits for each alternative was multiplied by 0.5 to count as the remaining 50% of total benefits. The two relative values (relative AAHUs and relative fish passage values) were added together to arrive at a single relative Annualized Habitat Benefit value for overall benefits. 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; one which is measured in AAHUs and refers to the amount of habitat created or improved, the other measured as the amount of habitat to which access has been provided through fish passage. Also, 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.

2.3.2 Calculation of Total Annualized Costs

Cost estimates have been calculated for each project alternative and are discussed in Appendix E. These cost estimates include costs for project planning, construction, 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.

2.3.3 Cost-Effective and Incremental Cost Analysis

Once annualized habitat benefits and annualized costs are calculated, the two can be compared to identify the most cost-effective project alternatives. For the cost-effective analysis, the analysis compares which alternatives provide the greatest relative combined average annual benefits (both site-specific and systemic) for given project costs. The incremental cost analysis then compares project alternatives to identify how much additional cost is required to achieve additional subsequent environmental benefits.

3. RESULTS OF ENVIRONMENTAL AND COST EFFECTIVENESS/INCREMENTAL COST ANALYSES

3.1 Results of Site-Specific Habitat Benefits

Analysis of site-specific benefits suggests that all project alternatives generally would result in some improvement at Lake Belle View, relative to future without-project conditions (Table C.4). However, the level of improvement and habitats affected are dependent upon project alternative. As discussed above in Table C.2, the quantities of different habitat types are different under each project alternative. In terms of total habitat, Alternatives 1 and 3 generally provide the greatest total AAHUs, relative to Alternatives 4 and 5. Alternative 5 would provide substantially less habitat than Alternatives 1 and 2.

Total AAHUs is greatly affected by the amount of dredging for each alternative. For Alternative 1, increased dredging results in an increase from 35.6 AAHUs with 5 acres of dredged area, to 44.3 acres with 15 acres of dredging; an increase of over 20%. Effects of dredging are similar for Alternatives 2 through 4, and even more dramatic for Alternative 5, which relies entirely on dredging for site-specific benefits.

Further review suggests that different restoration actions would have varying degrees of success to improve habitat conditions. Review of modeling results (Table C.4) shows that total AAHUs for lake habitat actually decrease with 5 acres of dredging under Alternatives 1 and 2. The reason for this is because the habitat area of the lake decreases under the alternatives, relative to the base condition (Table C.2). However, the overall suitability for lake habitat does increase. For Alternatives 1 and 2, 5 acres of dredging would increase the lake habitat suitability from 0.15 under future without-project, to 0.27 (increase of 0.11; Table C.5). For Alternatives 1 and 2, 15 acres of dredging would increase the lake habitat suitability from 0.15 under future without-project, to 0.46 (increase of 0.31; Table C.5). Changes would be highly similar for different dredging options under Alternative 4. Dredging options under Alternative 5 also would improve habitat conditions; however, habitat suitabilities would be noticeably lower than Alternatives 1 through 4. The reason for this is that under Alternative 5, the entire area would be classified as lake habitat, resulting in an overall lower percentage of habitat that would be improved.

Alternatives 1 through 4 would provide for additional habitats generally not present under baseline or future without-project conditions. For example, both Alternatives 1 and 2 would provide flowing, riverine habitat conditions (Table C.4). Alternative 1 (placement of riffles along the northern shore) would provide slightly more riverine habitat than Alternative 2 (placement of riffles along the eastern shore), with a difference of about 1 AAHU. Conversely, Alternative 2 would provide slightly less riverine-like habitat, with a difference of about 2 AAHUs from Alternative 2 and 3 AAHUs from Alternative 1. Changes in habitat suitability show a similar trend, with Alternative 1 providing slightly better suitability than Alternative 2, while both Alternatives 1 and 2 are noticeably improved over Alternative 4. Alternative 5 would not provide additional riverine benefits over future without-project benefits.

Table C.4. HEP model output for selected indicator species representing projected improvements in habitat, as measured in Average Annual Habitat Units, for various habitats associated with Lake Belle View, Belleville, Wisconsin. Under each alternative(s), Option A is for 5 acres of dredging, Option B is for 10 acres of dredging, and Option C is for 15 acres of dredging.

Alternative(s) and Corresponding Change in AAHUs from Future Without-Project Condition												
HEP Model	**1A**	**1B**	**1C**	**2A**	**2B**	**2C**	**4A, D, G**	**4B, E, H**	**4C, F, I**	**5A, D, G**	**5B, E, H**	**5C, F, I**
Bluegill/Largemouth* (lake habitat)	-2.7	2.9	6.1	-2.7	2.9	6.1	-0.8	4.7	8.2	6.1	13.0	20.6
Eastern Meadowlark (river riparian)	5.9	5.9	5.9	5.9	5.9	5.9	--	--	--	--	--	--
Smallmouth Bass (river habitat)	11.2	11.2	11.2	10.2	10.2	10.2	7.9	7.9	7.9	--	--	--
Wood Duck (existing wetland)	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1
Marsh Wren (wetland enhanced)	21.5	21.5	21.5	21.5	21.5	21.5	17.7	17.7	17.7	--	--	--
Total AAHUs	**35.6**	**41.1**	**44.3**	**34.6**	**40.1**	**43.3**	**24.5**	**30.0**	**33.5**	**6.0**	**12.9**	**20.5**

*Represents an average of HEP model output for Bluegill and Largemouth HEP models.

Table C.5. HEP model output for selected indicator species representing projected improvements in habitat, as measured in Habitat Suitability, for various habitats associated with Lake Belle View, Belleville, Wisconsin. A value of zero represents zero habitat quality, while a value of 1.0 represents perfect habitat quality. Values in bold are the average difference in HSI value between the future with- and future without-project. Values beneath represent the actual change in HSI.

Alternative(s) and Corresponding Change in Habitat Suitability from Future Without-Project												
HEP Model	**1A**	**1B**	**1C**	**2A**	**2B**	**2C**	**4A, D, G**	**4B, E, H**	**4C, F, I**	**5A, D, G**	**5B, E, H**	**5C, F, I**
Lake Habitat* Bluegill and Largemouth Bass	**0.11** 0.15 to 0.27	**0.24** 0.15 to 0.39	**0.31** 0.15 to 0.46	**0.11** 0.15 to 0.27	**0.24** 0.15 to 0.39	**0.31** 0.15 to 0.46	**0.13** 0.15 to 0.28	**0.24** 0.15 to 0.39	**0.31** 0.15 to 0.46	**0.06** 0.15 to 0.21	**0.13** 0.15 to 0.28	**0.21** 0.15 to 0.36
River Habitat Smallmouth Bass	**0.67** 0.00 to 0.67	**0.67** 0.00 to 0.67	**0.67** 0.00 to 0.67	**0.61** 0.00 to 0.61	**0.61** 0.00 to 0.61	**0.61** 0.00 to 0.61	**0.30** 0.00 to 0.30	**0.30** 0.00 to 0.30	**0.30** 0.00 to 0.30	**--**	**--**	**--**
Wetland Enhanced Habitat Marsh Wren	**0.96** 0.00 to 0.96	**0.96** 0.00 to 0.96	**0.96** 0.00 to 0.96	**0.96** 0.00 to 0.96	**0.96** 0.00 to 0.96	**0.96** 0.00 to 0.96	**0.88** 0.00 to 0.88	**0.88** 0.00 to 0.88	**0.88** 0.00 to 0.88	**--**	**-**	**--**
Existing Wetland Habitat Wood Duck	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21	**0.00** 0.21 to 0.21
River Riparian Habitat Eastern Meadow Lark	**0.65** 0.00 to 0.65	**0.65** 0.00 to 0.65	**0.65** 0.00 to 0.65	**0.65** 0.00 to 0.65	**0.65** 0.00 to 0.65	**0.65** 0.00 to 0.65	**--**	**--**	**--**	**--**	**--**	**--**

*Represents an average of HSI model output for Bluegill and Largemouth HEP models.

Alternatives 1 through 4 also would provide for additional opportunities for wetland habitat creation and restoration (Table C.4). Alternatives 1 and 2 would provide slightly more AAHUs than Alternative 4, with a difference of about 4 AAHUs. However, the habitat suitability of created wetland areas would be high under Alternatives 1, 2, and 4. Some of the differences in AAHUs for wetland creation are due to the fact that Alternatives 1 and 2 have slightly more acres planned for this habitat type. However, plans for Alternative 4 could also be further refined to include additional acreage for wetland enhancement, increasing the AAHUs for these alternatives. Lastly, Alternative 5 would not include wetland restoration as a project component. As such, no wetland creation benefits would be observed.

Finally, all alternatives would result in a minor loss of some existing wetland habitat (estimated at 0.4 AAHUs or less). Project alternatives could result in some tree clearing and a small loss of bottomland forest and or sedge/wet meadow wetland habitat through creation of new river channel, berm placement, and/or placement of other project features. However, any adverse effects would be offset by the creation of wetland areas associated with project alternatives. In the case of Alternative 5, these alternatives do not include wetland creation. However, these alternatives have not been identified as the selected plan. If for any reason one of these alternatives would be identified as the selected plan, and if it is determined that wetland impacts would occur, then an area would be designated for wetland creation to offset any impacts. This would likely be sedge-meadow or floodplain forest habitat, which could be possible without the rough fish control features associated with other alternatives.

Alternatives 1 and 2 would provide additional riparian habitat, thus providing about 6 AAHUs of habitat not present under Alternatives 4 and 5.

3.2 Results of Systemic Habitat Benefits

Alternatives 1 and 2 would result in a re-created river channel that would essentially pass 100% of river flows. Therefore, this alternative would observe full benefits possible with providing fish passage to upstream habitats. Conversely, Alternative 4 and 5 would include options that would include rock riffle structures and bypass channels. These alternatives would likely either pass 50% or 100% of river flows. Therefore, options for these alternatives were credited to receive either half or full benefits possible with providing fish passage to upstream habitats (Table C.6).

3.3 Combining of Site-specific and Systemic Habitat Benefits

For comparison of project alternatives, the site-specific benefits were added with systemic benefits from fish passage following the methodologies discussed in 2.3.1. Results are depicted in Table C.6.

Table C.6. Combined relative site-specific and systemic habitat benefits for identified project alternatives. Combined benefits were calculated using the formula: Relative Annualized Habitat Benefits = (0.5*[AAHUs]/[maximum AAHUs]*100) + (0.5* [relative fish passage benefits]*100).

Alternative	Difference in AAHUs*	Fish Passage Benefit	Combined Annualized Relative Habitat Benefit
1A	35.6	100%	90.2%
1B	41.1	100%	96.4%
1C	44.3	100%	100.0%
2A	34.6	100%	89.1%
2B	40.1	100%	95.3%
2C	43.3	100%	98.9%
3A	34.6	100%	89.1%
3B	40.1	100%	95.3%
3C	43.3	100%	98.9%
4A	24.5	100%	77.7%
4B	30	100%	83.9%
4C	33.5	100%	87.8%
4D	24.5	50%	52.7%
4E	30	50%	58.9%
4F	33.5	50%	62.8%
4G	24.5	50%	52.7%
4H	30	50%	58.9%
4I	33.5	50%	62.8%
5A	6	100%	56.8%
5B	12.9	100%	64.6%
5C	20.5	100%	73.1%
5D	6	50%	31.8%
5E	12.9	50%	39.6%
5F	20.5	50%	48.1%
5G	6	50%	31.8%
5H	12.9	50%	39.6%
5I	20.5	50%	48.1%
No Action	0	0	0.0%

*Difference in AAHUs between project alternatives and No Action (Future Without-Project).

3.4 Cost Estimation

Cost estimates have been calculated for each project alternative and are discussed in Appendix E. These cost estimates include costs for project planning, construction, and future project operation and maintenance of the project life. For the purpose of this assessment, the total costs were then averaged to compute an annualized cost for each project alternative.

Table C.7. Combined relative site-specific and systemic habitat benefits for identified project alternatives, compared to the annualized project cost.

Project Alternative	Annualized Cost w/ O&M	AAHUs for Site-Specific Benefits	Percent of Systemic Fish Passage Benefits Realized	Combined Annualized Relative Habitat Benefit
1A	$394,983	35.6	100%	90.2%
1B	$435,463	41.1	100%	96.4%
1C	$473,799	44.3	100%	100.0%
2A	$339,912	34.6	100%	89.1%
2B	$378,078	40.1	100%	95.3%
2C	$411,705	43.3	100%	98.9%
3A	$443,425	34.6	100%	89.1%
3B	$424,670	40.1	100%	95.3%
3C	$538,337	43.3	100%	98.9%
4A	$206,367	24.5	100%	77.7%
4B	$249,266	30	100%	83.9%
4C	$289,517	33.5	100%	87.8%
4D	$189,449	24.5	50%	52.7%
4E	$232,348	30	50%	58.9%
4F	$272,599	33.5	50%	62.8%
4G	$189,124	24.5	50%	52.7%
4H	$232,023	30	50%	58.9%
4I	$272,274	33.5	50%	62.8%
5A	$184,836	6	100%	56.8%
5B	$224,741	12.9	100%	64.6%
5C	$264,578	20.5	100%	73.1%
5D	$167,919	6	50%	31.8%
5E	$207,824	12.9	50%	39.6%
5F	$247,661	20.5	50%	48.1%
5G	$167,593	6	50%	31.8%
5H	$207,498	12.9	50%	39.6%
5I	$247,335	20.5	50%	48.1%
No Action	$0	0	0	0.0%

3.5 Cost Effectiveness and Incremental Cost Analysis

Results of the cost effectiveness analysis are provided in Figure C.1. Of all the alternatives evaluated, the following have been determined to be a "best buy," meaning they provide for the most overall environmental benefits for the given average costs: Alternatives 1C, 2C, 4A, 4B, and 4C. In addition, Alternatives 2A, 2B, 5A, and 5G appear to be "cost effective," meaning that while they do not provide the maximum benefits for given cost, they are the next group of alternatives that still provide a high level of benefits for given costs, relative to other alternatives.

It should be reiterated that these results are directly dependent upon the way that site-specific and fish passage benefits were combined. Thus, these comparisons are based on annualized costs vs. annualized relative habitat benefits. As outlined in Section 2.3.1, the analysis gives equal weighting to the benefits observed for fish passage vs. on-site improvements.

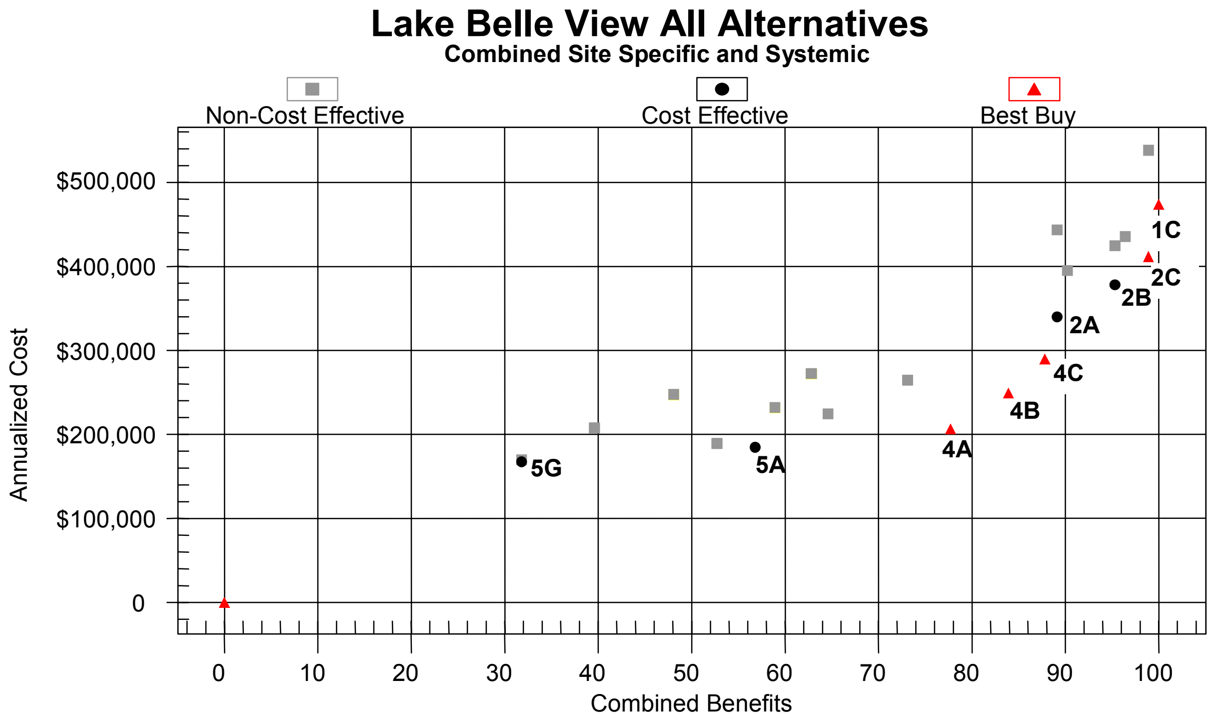

Figure C.1. Cost effectiveness analysis for all project alternatives evaluated for the Lake Belle View Section 206 project.

Results of the incremental cost analysis are provided in Figure C.2. Of all the "best buy" alternatives, Alternative 4A provides the greatest incremental habitat increase. Habitat increases moderately with increasing project cost, as seen in Alternatives 4A, 4B, 4C, and 2C. Alternative 1C recognizes the greatest increase in habitat benefits. However, 1C requires the greatest increase in relative cost, with only minor increases in incremental habitat benefits.

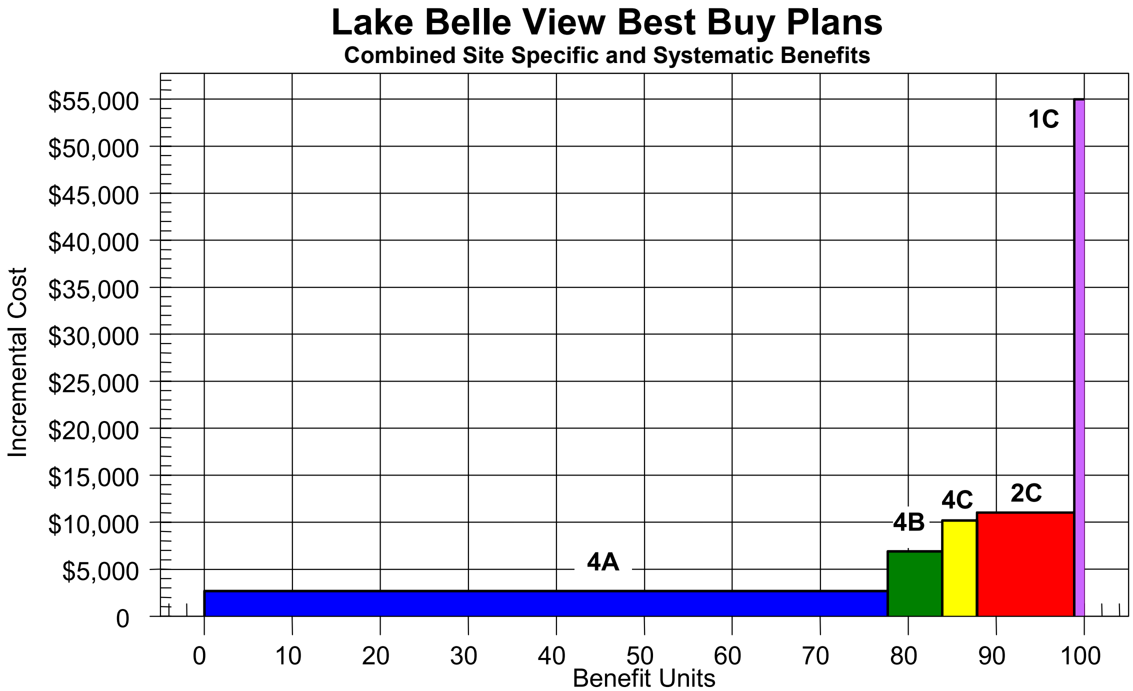

Figure C.2. Incremental cost analysis for all project alternatives evaluated for the Lake Belle View Section 206 project.

Past environmental restoration projects have compared average annual cost to AAHUs to identify whether projects are justified. For this project, a straight comparison becomes difficult because of the systemic fish passage benefits. Fish passage is a valuable part of the project, but does not lend itself easily to quantification by HEP and similar AAHU values. For this analysis, we compared the relative benefit that would be observed by providing fish access to upper watershed, but have only quantified benefits in terms of available upstream habitat. The reasons HEP was not used for this have been discussed above, but include limited data on numerous streams comprising 218 miles of upper watershed, the fact we are not creating or restoring habitat, but rather providing access to this habitat (which is difficult to predict population or community response), as well as the variety of species and life stages that may utilize habitat both upstream and downstream of the project area. Thus, the cost effectiveness and incremental cost analyses discussed above were based on a relative comparison that combined (and weighted equally) site-specific benefits, which were measured in stream miles, and systemic benefits, which were assessed in terms of the relative availability to 218 miles of upstream habitat.

Ultimately, project justification is often accomplished by comparing combined total AAHUs to total cost. While this may not be the best approach for this project, a general summary is shown below that provides an additional estimate of upstream habitat combined with total AAHUs for on-site benefits. This summary provides an idea as to the total benefit-to-cost ratio similar to past Corps analyses of restoration projects. This should not be the only consideration in determining whether or not this restoration project is acceptable at the identified project cost.

Under the selected plan, the re-created river channel would pass 100% of river flows and thus would realize full benefits to providing access to 218 miles of upstream habitat. The width of the various upstream tributaries is variable, but could range from 30 feet just above lake Belle View, to less than 5 feet in the upper headwaters. For gross estimation, an assumed average tributary width of 10 feet was used for 218 miles of upstream habitat. This assumption would provide 264 surface acres of upstream habitat. The overall quality has not been specifically identified, but has been characterized as good by the project team. Using a generic HSI scale, the quality could likely fall within a range between 0.5 (average habitat) and 1.0 (perfect habitat). This scale would provide a range between 132 and 264 "habitat units" resulting from fish passage. The analysis of site-specific benefits identified about 44 AAHUs for the selected plan (Table C.4). When combined with upstream habitat units, it would suggest that the selected plan might provide between 176 and 308 AAHUs. 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.

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