UPPER MISSISSIPPI RIVER RESTORATION FEASIBILITY REPORT WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

GREEN ISLAND
HABITAT REHABILITATION AND ENHANCEMENT PROJECT

POOL 13, UPPER MISSISSIPPI RIVER
RIVER MILES 545.9 THROUGH 548.7
JACKSON COUNTY, IOWA

APPENDIX H
HABITAT EVALUATION AND QUANTIFICATION

UPPER MISSISSIPPI RIVER RESTORATION FEASIBILITY REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

GREEN ISLAND
HABITAT REHABILITATION AND ENHANCEMENT PROJECT

APPENDIX H
HABITAT EVALUATION AND QUANTIFICATION

TABLE OF CONTENTS

Editor will doublecheck page numbers after all reviews are complete.

TABLES

GREEN ISLAND
HABITAT REHABILITATION AND ENHANCEMENT PROJECT

APPENDIX H
HABITAT EVALUATION AND QUANTIFICATION

1. INTRODUCTION TO HABITAT EVALUATION

This appendix presents the Green Island Habitat Restoration and Enhancement Project (Project) habitat analysis, cost effectiveness, and incremental cost procedures the Project's planning team used to evaluate all the possible alternatives and ultimately determine the team's preferred alternative. These planning procedures are based upon the planning framework established in, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies [P&G (U.S. Water Resources Council, 1983)].

The P&G provide the instructions and rules for Federal water resource planning. The P&G requires Federal planners to include only increments providing net National Economic Development (NED) benefits for flood damage reduction, navigation, and other traditional benefit-cost analysis. Increments not providing net NED benefits may be included provided they are cost effective.

For U.S. Army Corps of Engineers (Corps), Rock Island District (District), environmental planning, where traditional benefit-cost analysis is not possible because costs and benefits are expressed in different units, cost effectiveness and incremental cost analyses offer plan evaluation approaches consistent with the Corps' P&G Program paradigm. The planning paradigm in the P&G provides a rational and deliberate approach to solving problems and making decisions. Such decision-making requires information, for example, information about future environmental conditions with, and without, the implementations of each alternative plan under consideration.

District planners will conduct a cost effectiveness analysis to ensure the least cost plan alternative is identified a) for each possible level of environmental output and b) for any level of investment, the maximum level of output is identified. The Project's planning team conducts the subsequent incremental cost analysis of the cost-effective plans to reveal changes in costs as environmental output levels increase.

Benefit-cost analysis is generally considered the best-case scenario for Federal water resources decision- making. In benefit-cost analysis, the monetary cost of a plan is subtracted from the monetary value of the benefits to be provided by that plan to compute net dollar benefits. When there is a range of alternative plans, the plan providing the most net benefits is considered optimal and is typically the Recommended Plan.

When project benefits are not measured in dollars, e.g., environmental restoration projects, cost effectiveness and incremental cost analyses offer next-best approaches. While the cost effectiveness and incremental cost analyses of alternative plans may not identify a unique or optimal solution, they can lead to more-informed choices from among alternatives by elevating the decision-making process above cost oblivious decision making (Yoe, 1993).

This appendix emphasizes how the Habitat Evaluation Team (HET) studied, analyzed, and arrived at its habitat benefit outputs conclusions. The cost analysis is contained in Appendix F, *Cost Estimate*. The Project's incremental cost analysis is detailed in Section V *Evaluation and Comparison of Alternatives,* of the Main Report.

Biologists from the Corps' Regional Planning and Environmental Division North, the U.S. Fish and Wildlife Service, and Iowa Department of Natural Resources (Iowa DNR) comprised the HET that evaluated the Project's potential benefits of habitat rehabilitation features. Section IV, *Plan Formulation*, of the Main Report describes the Project's features in detail.

2. HABITAT EVALUATION METHODOLOGY

Per Engineering Circular1105-2-412, *Assuring Quality of Planning Models*, the HET used four Corps-approved habitat evaluation models in their analysis:

- Bluegill model for overwintering fish habitat benefits (Palesh and Anderson, 1990)
- Muskrat model for aquatic habitat benefits (Allen and Hoffman, 1984)
- Dabbling Duck model for migratory birds (Devendorf, 2021)
- Floodplain Forest model to evaluate the expected benefits of forestry-related measures (USACE, 2020)

The HET selected indicator species based on each model's applicability to Midwestern habitats and wildlife species. The HET felt these models were the best fit given the Project goals and the models' team approach ownership/consensus on the results. Table H-1 shows species, habitat, and feature information.

Table H-1. Habitat Types and Associated Models

Model	Habitat	Feature
Dabbling Duck	Moist Soil Unit	Berms, gates, and pumps
Bluegill Overwintering	Lentic Aquatic Habitat	Dredge cuts
Muskrat	Emergent Freshwater Marsh	Berms, gates, and pumps
Floodplain Forest	Floodplain Forest	TSI and WLM

The qualitative component, or habitat suitability index (HSI), of each model is rated on a 0.0 (unsuitable) to 1.0 (optimal) scale. The qualitative characteristics of a given habitat type determine HSI for a set of evaluation species. The model procedures include the use of limiting factors, which is a habitat requirement for an individual species during a critical time of year.

Absence of that habitat requirement makes the habitat unsuitable and results in the lowest HSI value of 0.0 for that species. Habitat quality values can be improved by:

- increasing the quantity of habitat types that may be limited or lacking in the study area;
- altering a limiting factor, such as raising excessively low dissolved oxygen for a fish species;

- altering a management strategy, such as cropping practices or water level manipulation; or

- a combination of the preceding measures, depending on management goals, target species requirements, or available funds.

The quantitative component of model analyses is the measure of acres of habitat 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 HET annualized the Project feature's HUs to determine habitat changes over the Project's 50-year life because once construction begins and as a project matures, habitat changes occur, and therefore habitat benefits may change. Many features, such as tree planting, would not begin to show benefits until well into the Project life. The particular dynamics of a project ecosystem determines the target years (TY) chosen for analysis (Table XX-2). With or without a project, habitat conditions change over time; therefore, the overall value of a proposed project depends upon the comparison of expected with-project benefits to expected without-project benefits. Annualized HUs are referred to as average annual habitat units (AAHUs). The annualization calculation (USFWS, 1980) is similar to a loan amortization formula used to calculate a loan payment over the life of a loan. Since habitat benefits go up and down over the project life, the formula is a little different to capture this unevenness found in nature. The formula is:

$$\int_0^T HU\,dt = (T_2 - T_1)\left[\left(\frac{A_1H_1 + A_2H_2}{3}\right) + \left(\frac{A_2H_1 + A_1H_2}{6}\right)\right]$$

Where:

$\int_0^T HU\,dt = CumulativeHUs$

$T_n =$ target year
$A_1 =$ the area at the beginning of the time interval
$H_1 =$ the habitat suitability index at the beginning of the time interval
$A_2 =$ the area at the beginning of the time interval
$H_2 =$ habitat suitability index at the beginning of the time interval

The Main Report, Section IV. A, *Model Performance,* discusses the Cumulative HU calculation used specifically for this Project. To facilitate comparison of Project alternatives, the HET established without-project conditions TY.

See the Main Report, Section IV. B, *Changes in Habitat Conditions Over Time*, for a full explanation of how the HET derived TYs. This appendix has model summary tables and other data derived from elaborate Excel files not contained in this appendix.

Electronic copies of these spreadsheets are available [redacted]

Table H-2. HET Model Target Years

TY	Muskrat	TY	Dabbling Duck	TY	Bluegill	TY	Floodplain Forest
0		0		0		0	
1	Dependable water levels	1	Dependable water levels	1	Dependable water levels	1	Dependable water levels
10	2 cycles of management	10	Plant community established	10	2 cycles of management	10	N/A
25	Habitat stability	25	Pin oak maturation	25	Habitat Stability	25	Regeneration of forest occurs
50	Project maturity	50	Project maturity	50	Project maturity	50	Project maturity

3. EVALUATION SPECIES SELECTION

The HET used four models for the habitat analysis (Table H-1). Although a set list of species has been used, each individual represents a guild of other similar species utilizing the habitat in similar ways. In essence, each species reflects an array of habitat variables for the species being evaluated. The evaluated species also reflect the goals and objectives, as listed in the Main Report, Section II, *Need For and Objectives of Action*.

The HET chose forestry, fish, bird, and mammal species to evaluate the effect of the proposed Project's dredge work, pump, gates, timber stand improvement (TSI), and vegetation management. These models allowed the HET to analyze changes in habitat quality for a wide range of bird and mammal species for a variety of animal and ecosystem conditions including:

- migratory and resident use;
- game and nongame species;
- common and rare status; and
- non-forested wetlands, river, and backwater aquatic habitats.

4. HABITAT EVALUATION ASSUMPTIONS

Prior to field evaluation, the HET reviewed aerial photography, topographic maps, and preliminary design drawings. During field evaluation, assumptions were developed regarding existing conditions and projected post-Project conditions relative to limiting factors and management practices.

The HET made several assumptions regarding model performance, changes in habitat conditions over time, future management use, habitat use, management reliability, and berm design.

4.1. Model Performance. For the models, the HET calculated habitat values for each species by multiplying acres by HSI and then amortizing the habitat units over the life of the Project to get AAHUs.

$$HSI_i \times acres = HU_i \quad \text{(Initial HU).}$$

The AAHUs for all the species are then added together for each Project feature's total AAHU score. Additionally, AAHUs were decreased by an efficiency value (w), which was determined using H&H modeling. The efficiency percent was calculated by modeling different berm and gate, and berm, pump, and gate scenarios. (See Appendix E, Attachment A for additional information).

$$AAHU \times w = HUf \text{ (Final HU).}$$

In this analysis, the HET took a more ecosystem approach, by adding the AAHU scores for all the species, which were calculated using the acres they utilize most often. The HET felt this assumption indicated ecosystem trends better than individual species either dominating or undervaluing the final AAHU sum. The HET used the IWR Planning Suite 2.0 (USACE Certified) to calculate final AAHU scores.

4.2. Changes in Habitat Conditions Over Time. Habitat conditions are not static. Either through natural processes or human activity, habitat evolves and may change in quality and/or quantity. Imbedded in the model evaluations, the HET added habitat benefit fluctuation (change) over the life of the Project. To assess the change over the period of analysis, The HET identified TYs where a change in the habitat variables may be noticed. Noticeable changes are characterized by a change in habitat benefit output.

To facilitate comparison of Project alternatives, the HET used the same with-Project TY for the without-Project (existing conditions). Since there would be limited ability for water level management (WLM) and habitat improvements under this scenario, the TYs indicate more of a trend point rather than a point of noticeable change. The HET assumed this scenario would see a gradual decline in habitat value based on water inundation and wind fetch resulting in aquatic vegetation decline, limited tree survivability, and decrease in water quality.

4.3. Future Water Level Management. The Iowa DNR would develop a new management plan to best meet Green Island management goals. The new management plan would include the ability to pump water out of the Project. This would be a new capability and would mimic the historic river flood pulse.

The WLM would be designed to meet annual waterfowl migration peaks and provide maximum acres of habitat. Water Level Management would be designed to provide a longer growing season at a lower water level for bottomland hardwood species and buttonbush. A longer growing season and lower water levels are essential to encourage growth and natural reproduction of these species.

The HET recognized as water levels are manipulated up and down, floodplain forest habitat may be in direct competition with aquatic habitat for the fixed number of acres in the Project area. The HET assumed while there may be trade-offs between the two habitat types, the WLM cycle is a balanced approach to ensure benefits to both habitat types over the life of the Project. The HET concluded the proposed management would mimic the historic river flood pulse and resulting benefits to and from the floodplain.

4.4. Ridge and Swale. Ridge and swale include changes in terrestrial elevation alternating from higher and lower in short linear distances. The change in elevation is typically less than 6 feet and more than 1 foot that would promote distinct changes in vegetation communities occurring across the alternating sequence of variability of ridges and swales. Depending on the geomorphology of the localized area and/or capacity to drain surface water would change the suitability of supporting a limited number of tree species. Collectively, the elevational height of the ridge, ability to remove high water event surface water, and ability to return subsoil water conditions to or below field capacity moisture retention is critical to what tree species are suited to be sustainable. Swales vary from being suitable to high flood tolerant tree species, wetland shrub species, or emergent wetland plants by ability to reduce subsoil moisture post higher water events. Ridge and swale features would be constructed by scraping out terrestrial soil (to create the swale) and pushing out the excavated soil to various elevations (to create the ridge). A bottomland ridge is a natural landform that promotes vegetation communities preferring better drained subsoil conditions post high-water events. A natural ridge is higher in elevation near the edge of the open water than the elevation of land further inland from that edge. A natural ridge feature would be constructed by pushing up swale material adjacent to open water areas to gain increased elevation that would support diverse forest communities.

4.5. Pump Station and Water Control Structures. The pump station would include 2K to 20K GPM pumps operated independently and capable of pumping in both directions. Design capacity as discussed in the main report, Section II, *Need For and Objectives of Action*, assumes all pump station features would have adequate pumping capacity to provide a 90-120 day growing season for wetland and aquatic plants for each year in the management cycle.

4.6. Bottomland Hardwood Timber Stand Improvement. The TSI includes a variety of techniques such as tree thinning, invasive species management, mowing and herbicide treatment. The District's Forest Management Plan's (Guyon et al., 2012) planting methods (direct seeding, bare root seedlings, RPM trees, etc.) maximize the longevity of the forest and are cost-effective. The TSI requires an understanding of individual site quality (e.g., soils, water regime, and elevation) and species requirements. Hard-mast species planted may include Bur Oak, Swamp White Oak, Pin Oak, Northern Pecan, Shellbark Hickory, and Black Walnut. Other species found in the floodplain include Kentucky Coffeetree and Hackberry. Other trees with "winged fruit or light-seeded" (Green Ash, Cottonwood, Silver Maple and/or Sycamore) could begin to occupy the area creating a diverse forest community.

5. RESULTS OF HABITAT EVALUATION

The Project planning team screened out several measures before this habitat quantification exercise. See Section IV, Plan Formulation the Main Report for a full list of screened measures and descriptions of potential Project measures.

The HET considered the No Action Alternative as the without-project condition. The difference between the feature's AAHU total and the without-project AAHU totals yields the net benefits of each proposed feature.

6. DISCUSSION

Tables XX-3 through XX-6 show the annualized habitat output for each Project alternative including the No Action Alternative. Rounding errors are present but they were consistent and did not change the alternative rankings.

The results of the habitat analysis support the premise that the functions and values of the Project area can be restored with the features proposed. The model analysis indicates improvement in water level control and water management capability through a water control structure and pump station, TSI, and provide a high level of quantified Project outputs (net benefits), with no unacceptable trade-offs in habitat values for any evaluated species. This combination of features would allow the Iowa DNR site manager optimal management flexibility which would add to habitat diversity and quality and would best meet the overall management objectives for the site.

Table H-3. Habitat/Model: Emergent Freshwater Marsh/Muskrat (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
No Action Alternative 1	Blake's Lake	0	0.24	193.5	46.44	36.25		36.25
		1	0.24	193.5	46.44			
		10	0.21	193.5	40.64			
		25	0.17	193.5	32.90			
		50	0.17	193.5	32.90			
	Middle Pool	0	0.29	278.16	80.67	52.21		52.21
		1	0.29	278.16	80.67			
		10	0.22	278.16	61.2			
		25	0.17	278.16	47.29			
		50	0.14	278.16	38.94			
	Pool A	0	0.73	385.9	281.69	209.57		209.57
		1	0.73	385.9	281.69			
		10	0.52	385.9	200.65			
		25	0.52	385.9	200.65			
		50	0.52	385.9	200.65			
No Pump/No Browns Alternative 5	Blake's Lake	0	0.24	193.5	46.44	39.22	0.076	2.98
		1	0.24	193.5	46.44			
		10	0.22	193.5	40.64			
		25	0.19	193.5	32.9			
		50	0.19	193.5	32.9			
	Middle Pool	0	0.29	278.16	80.67	70.71	0.26	18.5
		1	0.29	278.16	80.67			
		10	0.27	278.16	75.1			
		25	0.25	278.16	69.54			
		50	0.23	278.16	63.98			
	Pool A	0	0.73	385.87	281.69	209.57	0	0.00
		1	0.73	385.87	281.69			
		10	0.52	385.87	200.65			
		25	0.52	385.87	200.65			
		50	0.52	385.87	200.65			

Table H-3. Habitat/Model: Emergent Freshwater Marsh/Muskrat (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
Small Critical Alternative 3	Blake's Lake	0	0.24	193.5	46.44	86.63	0.58	50.39
		1	0.24	193.5	46.44			
		10	0.32	193.5	61.92			
		25	0.53	193.5	102.56			
		50	0.53	193.5	102.56			
	Middle Pool	0	0.29	278.16	80.67	111.96	0.53	59.75
		1	0.29	278.16	80.67			
		10	0.29	278.16	61.20			
		25	0.44	278.16	47.29			
		50	0.50	278.16	38.94			
	Pool A	0	0.73	385.87	281.69	292.64	0.28	83.08
		1	0.73	385.87	281.69			
		10	0.74	385.87	285.54			
		25	0.77	385.87	297.12			
		50	0.77	385.87	297.12			
Balanced Water Level Management Alternative 6	Blake's Lake	0	0.24	193.5	46.44	86.63	0.58	50.39
		1	0.24	193.5	46.44			
		10	0.32	193.5	61.92			
		25	0.53	193.5	102.56			
		50	0.53	193.5	102.56			
	Middle Pool	0	0.29	278.16	80.67	111.24	0.53	59.03
		1	0.29	278.16	80.67			
		10	0.30	278.16	83.45			
		25	0.39	278.16	108.48			
		50	0.56	278.16	155.77			
	Pool A	0	0.73	385.87	281.69	301.13	0.30	91.57
		1	0.73	385.87	281.69			
		10	0.74	385.87	285.54			
		25	0.80	385.87	308.70			
		50	0.81	385.87	312.55			

Table H-3. Habitat/Model: Emergent Freshwater Marsh/Muskrat (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
Cadillac Alternative 2	Blake's Lake	0	0.24	193.5	46.44	99.89	0.64	63.64
		1	0.24	193.5	46.44			
		10	0.47	193.5	90.95			
		25	0.58	193.5	112.23			
		50	0.58	193.5	112.23			
	Middle Pool	0	0.29	278.16	80.67	120.89	0.57	68.67
		1	0.29	278.16	80.67			
		10	0.33	278.16	91.79			
		25	0.44	278.16	122.39			
		50	0.59	278.16	164.11			
	Pool A	0	0.73	385.87	281.69	299.21	0.30	89.64
		1	0.73	385.87	281.69			
		10	0.74	385.87	285.54			
		25	0.80	385.87	308.70			
		50	0.79	385.87	304.84			

Table H-4. Habitat/Model: Moist Soil/Dabbling Duck (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
No Action Alternative 1	Cell 2.5	0	0.24	31.23	7.34	8.3		8.3
		1	0.24	31.23	7.34			
		10	0.24	31.23	7.34			
		25	0.28	31.23	8.81			
		50	0.28	31.23	8.81			
	Cell A	0	0.51	76.61	38.76	38.09		38.09
		1	0.51	76.61	38.76			
		10	0.51	76.61	38.76			
		25	0.51	76.61	38.76			
		50	0.47	76.61	36.08			
	Fish Lake	0	0.47	187.9	88.50	88.56		88.56
		1	0.46	187.9	86.25			
		10	0.46	187.9	86.25			
		25	0.48	187.9	90.57			
		50	0.47	187.9	88.50			
	Moist Soil Unit	0	0.26	70.55	18.27	16.67		16.67
		1	0.26	70.55	18.27			
		10	0.26	70.55	18.27			
		25	0.22	70.55	15.80			
		50	0.22	70.55	15.80			
No Pump/No Browns Alternative 5	Cell 2.5	0	0.24	31.23	7.34	8.89	0.066	0.59
		1	0.24	31.23	7.34			
		10	0.28	31.23	8.81			
		25	0.29	31.23	9.18			
		50	0.29	31.23	9.18			
	Cell A	0	0.51	76.61	38.76	41.89	0.09	3.80
		1	0.51	76.61	38.76			
		10	0.54	76.61	41.45			
		25	0.57	76.61	43.28			
		50	0.54	76.61	41.45			

Table H-4. Habitat/Model: Moist Soil/Dabbling Duck (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
No Pump/No Browns Alternative 5	Fish Lake	0	0.47	187.9	88.50	92.01	0.037	3.45
		1	0.46	187.9	86.25			
		10	0.46	187.9	86.25			
		25	0.51	187.9	95.08			
		50	0.51	187.9	95.08			
	Moist Soil Unit [1]	0	N/A	N/A	N/A	N/A	N/A	N/A
		1	N/A	N/A	N/A			
		10	N/A	N/A	N/A			
		25	N/A	N/A	N/A			
		50	N/A	N/A	N/A			
Small Critical Alternative 3	Cell 2.5	0	0.24	31.23	7.34	14.63	0.43	6.34
		1	0.29	31.23	9.18			
		10	0.48	31.23	15.05			
		25	0.49	31.23	15.43			
		50	0.49	31.23	15.43			
	Cell A	0	0.51	76.61	38.76	60.63	0.37	22.54
		1	0.60	76.61	45.97			
		10	0.77	76.61	58.61			
		25	0.84	76.61	63.97			
		50	0.84	76.61	63.97			
	Fish Lake	0	0.47	187.9	88.50	157.06	0.44	68.50
		1	0.69	187.9	130.40			
		10	0.84	187.9	156.90			
		25	0.86	187.9	161.41			
		50	0.87	187.9	163.66			
	Moist Soil Unit [1]	0	N/A	N/A	N/A	N/A	N/A	N/A
		1	N/A	N/A	N/A			
		10	N/A	N/A	N/A			
		25	N/A	N/A	N/A			
		50	N/A	N/A	N/A			

[1] Not a feature of this Alternative

Table H-4. Habitat/Model: Moist Soil/Dabbling Duck (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
Balanced Water Level Management Alternative 6	Cell 2.5	0	0.24	31.23	7.34	14.72	0.44	6.45
		1	0.33	31.23	10.27			
		10	0.48	31.23	15.05			
		25	0.49	31.23	15.43			
		50	0.49	31.23	15.43			
	Cell A	0	0.51	76.61	38.76	64.12	0.41	26.02
		1	0.62	76.61	47.80			
		10	0.84	76.61	63.97			
		25	0.87	76.61	66.73			
		50	0.88	76.61	67.57			
	Fish Lake	0	0.47	187.9	88.50	163.45	0.46	74.89
		1	0.69	187.9	130.40			
		10	0.88	187.9	165.73			
		25	0.89	187.9	167.98			
		50	0.91	187.9	170.24			
	Moist Soil Unit	0	0.26	70.55	18.27	54.76	0.70	38.10
		1	0.73	70.55	51.43			
		10	0.75	70.55	53.12			
		25	0.80	70.55	56.44			
		50	0.80	70.55	56.44			
Cadillac Alternative 2	Cell 2.5	0	0.24	31.23	7.34	14.72	0.44	6.45
		1	0.33	31.23	10.27			
		10	0.48	31.23	15.05			
		25	0.49	31.23	15.43			
		50	0.49	31.23	15.43			
	Cell A	0	0.51	76.61	38.76	62.88	0.39	24.79
		1	0.62	76.61	47.80			
		10	0.81	76.61	62.21			
		25	0.86	76.61	65.81			
		50	0.86	76.61	65.81			

Table H-4. Habitat/Model: Moist Soil/Dabbling Duck (Berm, Gates, and Pumps) HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
Cadillac Alternative 2	Fish Lake	0	0.47	187.9	88.50	164.36	0.46	75.79
		1	0.69	187.9	130.40			
		10	0.88	187.9	165.73			
		25	0.91	187.9	170.24			
		50	0.91	187.9	170.24			
	Moist Soil Unit	0	0.26	70.55	18.27	54.76	0.70	38.10
		1	0.73	70.55	51.43			
		10	0.75	70.55	53.12			
		25	0.80	70.55	56.44			
		50	0.80	70.55	56.44			

Table H-5. Habitat/Model: Lentic Aquatic Habitat/Bluegill Overwintering (Dredge cuts) HSI and AAHU Values

Alternative	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
No Action Alternative 1	0	0.10	299.6	29.96	29.96		29.96
	1	0.10	299.6	29.96			
	10	0.10	299.6	29.96			
	25	0.10	299.6	29.96			
	50	0.10	299.6	29.96			
No Pump/No Browns Alternative 5	0	0.40	299.6	119.84	119.84	0.75	89.88
	1	0.40	299.6	119.84			
	10	0.40	299.6	119.84			
	25	0.40	299.6	119.84			
	50	0.40	299.6	119.84			
Small Critical Alternative 3	0	0.69	299.6	206.72	206.72	0.86	176.76
	1	0.69	299.6	206.72			
	10	0.69	299.6	206.72			
	25	0.69	299.6	206.72			
	50	0.69	299.6	206.72			
Balanced Water Level Management Alternative 6	0	0.69	304.5	210.11	210.11	0.86	180.11
	1	0.69	304.5	210.11			
	10	0.69	304.5	210.11			
	25	0.69	304.5	210.11			
	50	0.69	304.5	210.11			
Cadillac Alternative 2	0	0.69	301.4	207.97	201.06	0.85	171.10
	1	0.69	301.4	207.97			
	10	0.68	301.4	204.95			
	25	0.67	301.4	201.94			
	50	0.64	301.4	192.90			

Table H-6. Habitat/Model: Bottomland Hardwood/Floodplain Forest
HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
No Action Alternative 1	South Central 3rd/4th Ditch	0	0.01	20	0.20	1.04		1.04
		1	0.01	20	0.20			
		25	0.08	20	1.60			
		50	0.04	20	0.80			
	Fish Lake East	0	0.23	4	0.92	0.31		0.31
		1	0.23	4	0.92			
		25	0.14	4	0.56			
		50	0.05	4	0.20			
	McGann's Lake	0	0.35	36	12.6	3.36		3.36
		1	0.35	36	12.6			
		25	0.24	36	8.64			
		50	0.08	36	2.88			
	Sawmill Lake Lower	0	0.37	26	9.62	2.78		2.78
		1	0.37	26	9.62			
		25	0.24	26	6.24			
		50	0.12	26	3.12			
	Sawmill Lake Upper	0	0.32	25	8.00	2.81		2.81
		1	0.32	25	8.00			
		25	0.24	25	6.00			
		50	0.16	25	4.00			
	North Central 3rd Ditch/Fish Lake	0	0.10	20	2.00	2.05		2.05
		1	0.10	20	2.00			
		25	0.11	20	2.20			
		50	0.09	20	1.80			
	North Central 3rd/4th Ditch	0	0.16	40	6.40	5.60		5.60
		1	0.16	40	6.40			
		25	0.15	40	6.00			
		50	0.10	40	4.00			

Table H-6. Habitat/Model: Bottomland Hardwood/Floodplain Forest
HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
No Action Alternative 1	Snider Lake East	0	0.32	27	8.64	6.43		6.43
		1	0.31	27	8.37			
		25	0.25	27	6.75			
		50	0.14	27	3.78			
	Snider Lake West	0	0.30	34	10.20	8.60		8.60
		1	0.30	34	10.20			
		25	0.27	34	9.18			
		50	0.17	34	5.78			
Future with Project but No Pumps Small Critical Alternative 3 and No Pump/No Brown's Lake Alternative 5	South Central 3rd/4th Ditch	0	0.10	20	2.00	2.10	0.51	1.06
		1	0.13	20	2.60			
		25	0.10	20	2.00			
		50	0.09	20	1.80			
	Fish Lake East	0	0.23	4	0.92	1.22	0.75	0.91
		1	0.28	4	1.12			
		25	0.32	4	1.28			
		50	0.30	4	1.20			
	McGann's Lake	0	0.35	36	12.60	9.12	0.63	5.76
		1	0.35	36	12.60			
		25	0.26	36	9.36			
		50	0.14	36	5.04			
	Sawmill Lake Lower	0	0.37	26	9.62	6.92	0.60	4.14
		1	0.37	26	9.62			
		25	0.27	26	7.02			
		50	0.15	26	3.90			
	Sawmill Lake Upper	0	0.32	25	8.00	8.30	0.66	5.49
		1	0.32	25	8.00			
		25	0.38	25	9.50			
		50	0.25	25	6.25			

Table H-6. Habitat/Model: Bottomland Hardwood/Floodplain Forest
HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
Future with Project but No Pumps Small Critical Alternative 3 and No Pump/No Brown's Lake Alternative 5	North Central 3rd Ditch/Fish Lake	0	0.10	20	2.00	2.25	0.09	0.20
		1	0.10	20	2.00			
		25	0.12	20	2.40			
		50	0.11	20	2.20			
	North Central 3rd/4th Ditch	0	0.16	40	6.40	7.69	0.27	2.08
		1	0.16	40	6.40			
		25	0.19	40	7.60			
		50	0.23	40	9.20			
	Snider Lake East	0	0.31	27	8.37	8.90	0.28	2.47
		1	0.31	27	8.37			
		25	0.34	27	9.18			
		50	0.33	27	8.91			
	Snider Lake West	0	0.30	34	10.20	10.61	0.19	2.02
		1	0.30	34	10.20			
		25	0.34	34	11.56			
		50	0.27	34	9.18			
Future with Project with Pumps Cadillac Alternative 2 and Balanced Water Level Management Alternative 6	South Central 3rd/4th Ditch	0	0.10	20	2.00	7.73	0.87	6.70
		1	0.14	20	2.00			
		25	0.44	20	8.80			
		50	0.54	20	10.80			
	Fish Lake East	0	0.23	4	0.92	1.70	0.82	1.39
		1	0.28	4	1.12			
		25	0.46	4	1.84			
		50	0.51	4	2.04			
	McGann's Lake	0	0.35	36	12.60	15.81	0.79	12.45
		1	0.35	36	12.60			
		25	0.43	36	15.48			
		50	0.55	36	19.80			

Table H-6. Habitat/Model: Bottomland Hardwood/Floodplain Forest
HSI and AAHU Values

Alternative	Location	TY	SI	Acres	HUs	AAHU	Efficiency	Final AAHU
Future with Project with Pumps Cadillac Alternative 2 and Balanced Water Level Management Alternative 6	Sawmill Lake Lower	0	0.37	26	9.62	12.44	0.78	9.67
		1	0.37	26	9.62			
		25	0.51	26	13.26			
		50	0.53	26	13.78			
	Sawmill Lake Upper	0	0.32	25	8.00	9.74	0.71	6.93
		1	0.29	25	7.25			
		25	0.38	25	9.50			
		50	0.51	25	12.75			
	North Central 3rd Ditch/Fish Lake	0	0.10	20	2.00	4.93	0.58	2.88
		1	0.14	20	2.80			
		25	0.21	20	4.20			
		50	0.43	20	8.60			
	North Central 3rd/4th Ditch	0	0.16	40	6.40	12.53	0.55	6.93
		1	0.18	40	7.20			
		25	0.33	40	13.20			
		50	0.42	40	16.80			
	Snider Lake East	0	0.31	27	8.37	10.51	0.39	4.08
		1	0.31	27	8.37			
		25	0.39	27	10.53			
		50	0.47	27	12.69			
	Snider Lake West	0	0.30	34	10.20	12.14	0.29	3.54
		1	0.30	34	10.20			
		25	0.35	34	11.90			
		50	0.43	34	14.62			

7. REFERENCES

Allen, A. W., and R. D. Hoffman. 1984. Habitat suitability index models: Muskrat. U. S. Fish Wildl. Serv. FWS/OBS-82/10.46. 27pp.

Devendorf, R. D. 2001. Updated 2021. A Dabbling Duck Migration Model for the Upper Mississippi River. U.S. Army Corps of Engineers, St. Paul District.

Guyon, L., C. Deutsch, J. Lundh, and R. Urich. 2012. Upper Mississippi River Systemic Forest Stewardship Plan. U.S. Army Corps of Engineers. 124 pp.

Institute for Water Resources Planning. 2008. Planning Suite II: Incremental Cost Analysis (CE-ICA) Software (Version 2.0.9.35) website: http://www.pmcl.com/iwrplan/GenInfoOverview.aspPalesh, G. and D. Anderson. 1990. Modification of the habitat suitability index model for the bluegill (*Lepomis macrochirus*) for winter conditions for upper Mississippi River backwater habitats. U.S. Army Corps of Engineers, St. Paul District, January 1990.

Urich, David L., John P. Graham, and Edward A. Gaskins. 1984. Habitat appraisal of private lands in Missouri. Wildlife Society Bulletin 12:350-356.

U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedures, Ecological Services Manual. Washington, DC. 102 pp.

U.S. Water Resources Council. 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Washington, DC.

Yoe, C. 1992. Incremental cost analyses: A tool for Environmental Planning. Review draft discussion paper for Council on Environmental Quality, Washington, DC