Appendix C

Habitat Evaluation & Quantification

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1. Introduction

This appendix provides the documentation of the habitat evaluation and quantification process that was conducted to evaluate the benefits of various habitat features for the Lake Lou Yeager Section 206, Continuing Authorities Program, Aquatic Ecosystem Restoration Project (LLY). Active participants included an aquatic ecologist, a wildlife biologist, and a hydraulic engineer from the St. Louis District Corps of Engineers. The U.S. Fish and Wildlife Service (USFWS; Marion Illinois Ecological Services Office) and the Illinois Department of Natural Resources were consulted regarding the habitat evaluation, but passed on the opportunity to participate due to resource issues (Table 1). The USFWS stated that they would review the habitat evaluation spreadsheets during their review of the project documents.

Table 1. The team that participated in the Habitat Benefits Analysis for Lake Lou Yeager Section 206, Continuing Authorities Program, Aquatic Ecosystem Restoration Project.

Team Member	Specialty	Affiliation
Teri Allen, Ph.D.	Aquatic Ecologist	USACE
Ben McGuire	Wildlife and Wetland Biologist	USACE
John Vest	Hydraulic Engineer	USACE

Quantification is needed in the project planning process to evaluate benefits of project features because traditional benefit/cost evaluation is not applicable. To determine environmental restoration project benefits, models have been developed to quantify habitat benefits of project features for selected species.

We used both wildlife and fisheries based models to evaluate the effects of project feature on species at LLY. This was done because wildlife and aquatic habitats would be affected by the proposed feature. For non-forested wetland wildlife, we used the Slider Turtle (Morreale and Gibbons 1986) and Mink (Allen 1986) Habitat Suitability Index Models, developed by the U.S. Fish and Wildlife Service. For aquatic habitat, we used the White Crappie (Edwards et al. 1982) and the Bluegill (Stuber et al. 1982) Habitat Suitability Index Models, developed by the U.S. Fish and Wildlife Service. HSI models are widely accepted by local agencies, and have become the primary habitat evaluation method used in the St. Louis District Army Corps of Engineers.

Each of the HSI planning models used are presently approved for regional or nationwide use in accordance with documented geographic range, best practices and its designed limitations (see PCX and/or model review history for details). The PCX is comfortable with application of the planning models and/or the models have been reviewed and issues concerning the models and their documentation have been resolved to the satisfaction of the PCX.

Consistent with guidance from the USACE Ecosystem Planning Center of Expertise, the Agency Technical Review Team for the LLY Project will conduct an assessment of the models used for the project. This process will not result in certification, but will evaluate the technical quality and appropriateness of the models utilized.

2. Habitat Evaluation Methodology

The HSIs are numerical models that evaluate the quality and quantity of particular habitat for species selected by team members (Table 1). The qualitative component of the analysis is known as the habitat suitability index (HSI) and is rated on a 0.0 to 1.0 scale, with higher values indicating better habitat for that species. The HSI for a particular habitat type is determined by selecting values that reflect present and future project area conditions from a series of abiotic and biotic metrics. Each value corresponds to a suitability index for each species. Future values are determined using management plans, historical conditions, and best professional judgment. The quantitative component is the number of acres of the habitat being evaluated. From the calculated qualitative and quantitative values, the standard unit of measure, the habitat unit (HU) is calculated using the formula (HSI × Acres = HUs). Habitat units are calculated for specific target years to forecast changes in habitat values over the life of the project with- and without-project conditions. When HSI scores are not available for each year of analysis, a formula that requires only target year HSI and area estimates is used (USFWS 1980). This formula is:

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

Where:

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

T_1= first target year of time interval

T_2 = last target year of time interval

A_1 = area of available habitat at beginning of time interval

A_2 = area of available habitat at end of time interval

H_1 = habitat suitability index at the beginning of time interval

H_2 = habitat suitability index at end of the time interval

3 and 6 = constants derived from integration of HSI × Area for the interval between any two target years

This formula was developed to precisely calculate cumulative HUs when either HSI or area or both change over a time interval, which is common when dealing with the unevenness found in nature. Habitat Unit gains or losses are annualized by summing the cumulative HUs calculated using the above equation across all target years in the period of analysis and dividing the total (cumulative HU) by the number of years in the life of the project (i.e., 50 years). This calculation results in the Average Annual Habitat Units (AAHUs) (USFWS 1980).

The benefits of each proposed project feature (net AAHUs) are then determined by subtracting with-project benefits from without-project benefits. The effects of various habitat improvement feature combinations (alternatives) can then be evaluated by comparing the net AAHUs and costs for each alternative considered.

In preparation of using the HSI models, the evaluation team conducted several site visits and collected physiochemical data. They also reviewed historical and recent aerial photography, topographic maps, and preliminary hydrological modeling data. During the field evaluations and team meetings, assumptions were developed regarding existing conditions and projected with-project conditions relative to habitat changes over time and management practices.

For the purpose of planning, design, and impact analysis, period of analysis was established as 50 years. To facilitate comparison, target years were established at 0 (existing conditions), 5, 25, and 50 years. HSIs and cumulative HUs for each evaluation species were calculated at each of these target years.

This appendix contains HSI summary tables and other data derived from the 8 spreadsheet files not included in this appendix. These spreadsheets are available upon request. Please contact Dr. Teri Allen, 314-331-8084, email Teri.C.Allen@usace.army.mil if you would like an electronic copy of these files.

3. Habitat Evaluation Species Selection

To begin the habitat evaluation process, the team reviewed the available HSI species models. They selected two fish species and 2 wildlife species (Table 2). Species were selected because they utilize the current or are anticipated to use the future habitat at LLY, and they represented different guilds from different taxonomic families.

Table 2. Aquatic and wildlife evaluation species selected for analysis.

Species	Scientific Name	Family	Primary Habitat Type	Food (Adults)
WETLAND (UPPER LLY)				
Slider Turtle	*Pseudemys scripta*	Emydidae	Aquatic sites with dense surface vegetation	Omnivorous
Mink	*Mustela vison*	Mustelidae	Forested areas near rivers, streams, or lakes	Carnivorous
AQUATIC (LOWER LLY)				
White Crappie	*Pomoxis annularis*	Centrarchidae	Lentic – Open water near submerged cover	Small fish
Bluegill	*Lepomis macrochirus*	Centrarchidae	Lentic - Shoreline	Zooplankton and insects

HSI indicator species included slider turtle and mink for the wetland area of LLY which would be above the proposed berm.

The slider turtle is a semiaquatic, omnivorous reptile that utilizes primarily aquatic areas with dense surface vegetation. Mating occurs in the water, but some suitable terrestrial area is required for egg-laying by nesting females. The mink is a semiaquatic, carnivorous mammal that is most commonly associated with brushy or wooded cover adjacent to aquatic habitats. Mink are most common along streams where there is an abundance of downfall or debris for cover and pools for foraging. Shallow water depth and low flow rates contribute to effective aquatic foraging by mink (Dunstone 1983).

Unlike slider turtles, mink utilize wooded cover adjacent to aquatic habitat for concealment, shelter, and litter rearing. Except for nesting female sliders, movement from an aquatic habitat is not necessary for maintaining a population, since many sliders remain in their natal habitats for years (Gibbons and Semlitsch 1982).

HSI indicator species included White Crappie and Bluegill for the open water area of LLY which would be below the proposed berm. White Crappie are in the family Centrarchidae. They are a predatory warm water sport fish that are most abundant in lakes and reservoirs greater than 5 acres (Trautman 1957; Buck and Thoits 1970). White crappie congregate in loose aggregations around submerged trees, stumps, brush, aquatic vegetation, and boulders (Trautman 1957; Hansen 1965; Pflieger 1997). Crappie over 150 mm feed almost exclusively on small fish (Crawley 1954; Marcy 1954; Burris 1956; Hoopes 1960; Neal 1962), with both adults and juveniles foraging over open water (Grinstead 1979).

Bluegill are also in the family Centrarchidae, but are most abundant along shoreline areas in lentic and lentic-type environments including ponds, lakes, reservoirs, and large low velocity streams (Whitmore et al. 1960). Bluegills are opportunistic feeders. Juveniles and adults feed on zooplankton, aquatic and terrestrial insects, and some plant materials (Scidmore and Woods 1960; Emig 1966; Scott and Crossman 1973).

4. Site Specific Methodology and Assumptions

During the second step of the evaluation process, the team determined what habitats would be affected by the project features and locations in the project area to evaluate these changes. The following HSI spreadsheets were used: Site 1 wetlands, Site 1 open water, Site 1a wetlands, and Site 1a open water. There were a total of 4 evaluation locations; one in the center of each of the proposed lake subunits for each site.

Table 3. Habitat benefit analyses worksheets used for each evaluation site

Habitat	Upper Lake	Lower Lake
Non-forested Wetland	X	
Open Water		X

Final calculations included determining the acreage of non-forested wetland and aquatic habitats using topographical data, management plans, land coverage data files, and aerial photography. Habitat suitability index scores (HSIs) were calculated for each species used in the HSI models. In evaluations that included multiple species, the HSIs were averaged then multiplied by the appropriate acreage to generate HUs and cumulative HUs (see above equation). The cumulative HUs were then annualized to yield AAHUs for with and without project.

General Assumptions and Habitat Characteristics

1. It was assumed that target years of 0 (existing condition), 5, 25, and 50 (future without and future with project conditions) are sufficient to analyze HUs and characterize habitat changes over the estimated period of analysis. The period of analysis was determined to be 50 years

based on the prediction that the accrual of benefits from maximum wetland development and sediment reduction were predicted to level off by 50 years.

2. The annual drawdown of the lake (usually between November and February) was taken into consideration by the team when completing the habitat evaluation.
3. The depths provided by the H&H Section were average depths and did not reflect a constant depth throughout the lake, either above or below the area of the proposed structure.
4. The team projected that without the project, sediment would continue to accumulate at the northern end of the lake, with escalating encroachment farther downstream. Additionally, the team projected that deeper areas of the lake would eventually be lost, thus reducing essential deepwater and overwintering habitat.
5. The team projected that with the project, the majority of the sediment would accumulate upstream of the berm, with reduced sedimentation occurring downstream in the lower lake (see H&H report for values).
6. For planning purposes, the team assumed that motorized aquatic craft would not be present above the proposed berm.
7. For planning purposes, the team assumed that no conversion of non-forest wetland to wetland forest would occur during the life of the project.
8. We assumed that operation of Lake Lou Yaeger would continue under the current management plans and objectives for at least the life of the project.
9. For planning purposes, the team assumed that sufficient overwintering and cover habitat, as well as areas of dissolved oxygen in excess of 5 ppm would be present in the lower lake both with and without the proposed berm for the 50 year evaluation period.
10. The study team determined that the existing seed bank in the study area should be able to allow for natural regeneration and therefore plantings would be unwarranted.
11. The team assumed that no maintenance dredging would occur upstream of the proposed berm during the life of the project.
12. The team projected that "channels" of open water would continue to exist in the each of the two upper tributaries leading into the lake (as is currently seen in the upper most portion of the Raymond Arm), with non-forest wetlands developing in the depositional areas outside of the "channel".
13. The team assumed that the LLY Lake Manager would continue to implement their invasive species management program throughout the life of the project.

Feature Specific Assumptions

1. *Proposed Berm.* It was assumed that the placement of the proposed berm at Site 1 versus Site 1a would not affect habitat evaluation variables, with the exception of depth and water regime.
2. For planning purposes, the team agreed that the lower lake would lose acreage at the rate of 1% per year without the proposed berm and 0.5% per year with the proposed berm.

Non-forest Wetland Evaluation (Upper Lake) – USFWS partners strongly prefer the use of two or more indicator species per habitat type. Thus, we chose to evaluate the upstream impact of this feature using two dissimilar species, the slider turtle and the mink. It was assumed that inducing sedimentation deposition above the berm would result in the development of non-forest wetlands, similar to what currently occurs in shallow areas of the upper lake. No fisheries benefits are expected to be generated upstream of this feature, consequently no fish were used as indicator species for this portion of the lake.

Open water Evaluation (Lower Lake) – USFWS partners strongly prefer the use of two or more indicator species per habitat type. We chose to evaluate the downstream impact of this feature using two popular recreational fish species at LLY, white crappie and bluegill. The HSI models for these species were sensitive enough to respond to changes in sedimentation. White crappie were selected as an indicator species for piscivorous, open water fish; while bluegill were selected as an indicator species for omnivorous, shallow water species. No significant wetland benefits are expected to be generated downstream of this feature, consequently no non-forest wetland organisms were used as indicator species for this portion of the lake.

Wetland Acreage Determination

The wetland acreages used in the HSI evaluation were determined using National Agriculture Imagery Program (NAIP) imagery from 2015 in ArcGIS 10. Land cover types were digitized and areas of each were calculated using ArcGIS for the two different berm options. For future with and without project conditions, the difference between existing and future acres is due to the additional extent of the wetlands which would be expected to develop based on the rate of sedimentation and hydraulic conditions. Additionally, the evaluation team decided that the acreages of non-forested wetland growth would remain constant over time, until the expected end condition was reached. Table 4 lists the acreage of each of the wetland evaluation locations.

Table 4. Acreage of each the wetland evaluation location with and without project.

Wetland Acreage								
Wetland Acres	**Future Without Project**				**Future With Project**			
Target Year	**Year 0**	**Year 5**	**Year 25**	**Year 50**	**Year 0**	**Year 5**	**Year 25**	**Year 50**
Site 1	44	45	49	54	44	52	69	94
Site 1a	46	47	51	56	46	50	67	88

Open Water Acreage Determination

The open water acreage used in the HSI evaluation were calculated using H&H models for the two different berm sites at target year 0. For future with and without project conditions, the difference between existing and future acreage is due to the additional sediment deposition. In the model, the rate of sedimentation remains constant over time, until the expected end condition was reached at target year 50. For planning purposes, acreage loss was calculated at a rate of 1% per year without the proposed berm and 0.5% per year with the proposed berm. Table 5 lists the acreage of the lower lake at each of the open water evaluation locations.

Table 5. Acreage of each the open water – lower lake evaluation location with and without project.

Open Water Acreage – Lower Lake								
Open Water Acres	**Future Without Project**				**Future With Project**			
Target Year	**Year 0**	**Year 5**	**Year 25**	**Year 50**	**Year 0**	**Year 5**	**Year 25**	**Year 50**
Site 1	1194	1135	929	722	1194	1164	1053	929
Site 1a	1206	1147	938	730	1206	1176	1064	939

5. Results

HSI Evaluation

Individual species HSI scores were averaged prior to calculating cumulative HUs. To see individual species HSI please refer to excel spreadsheets available upon request. Without, with, and net average annualized habitat units were calculated using this averaged HSI score for the non-forested wetland evaluation locations (Table 6) and the open water evaluation locations (Table 7).

The net averaged annualized AAHUs calculated using both the wetland and open water evaluations were summed together for each proposed berm site.

Table 6. Indicator species averaged HSI scores, without, with, and net average annualized habitat units determined using the slider turtle and mink HSI models for the non-forest wetland habitat.

Indicator Species Average HSIs	Target Year	Acres	HUs	Cumulative HU	AAHUs	Net AAHUs
Site 1 - Non-Forest Wetland Habitat						
0.53	0	44	23.3			
Without						
0.53	5	45	23.9			
0.59	25	49	29.0			
0.61	50	54	32.9	1419.19	28	0.00
				Total AAHUs	**28**	
With						
0.71	5	52	36.9			
0.87	25	69	59.8			
0.76	50	94	71.4	2728.04	55	**26**
				Total AAHUs	**55**	
Site 1a - Non-Forest Wetland Habitat						
0.53	0	46	24.4			
Without						
0.53	5	47	25.0			
0.59	25	51	30.1			
0.61	50	56	22.4	1334.34	27	0.00
				Total AAHUs	**27**	
With						
0.71	5	50	35.5			
0.87	25	57	58.1			
0.58	50	88	50.6	2434.05	49	**22**
				Total AAHUs	**49**	

Table 7. Indicator species averaged HSI scores, without, with, and net average annualized habitat units determined using the White Crappie and Bluegill HSI models for the open water habitat.

Indicator Species Average HSIs	Target Year	Acres	HUs	Cumulative HU	AAHUs	Net AAHUs
			Site 1 - Open Water Habitat			
0.84	0	1194	1005			
Without						
0.84	5	1135	953			
0.83	25	929	773			
0.81	50	722	588	39148	783	0.00
				Total AAHUs	**783**	
With						
0.85	5	1164	989			
0.85	25	1053	895			
0.85	50	929	789	44790	893	**113**
				Total AAHUs	**896**	
			Site 1a - Open Water Habitat			
0.84	0	1206	10798			
Without						
0.84	5	1147	10705			
0.83	25	938				
0.81	50	730		39549	791	0.00
				Total AAHUs	**791**	
With						
0.85	5	1176				
0.85	25	1064				
0.81	50	939		44818	896	**105**
				Total AAHUs	**896**	

The net annual impact reflects, in Average Annual Habitat Units (AAHU's), the difference between the future with- and future without- the aquatic ecosystem restoration conditions for Site 1 and Site 1a. For Site 1, approximately 139 more habitat units (HU's) would be available for indicator species every year during the life of the proposed project than would be available if the proposed project was not implemented. For Site 1a, this figure would be 127 more HUs (Table 8).

Table 8. Net annual impact (HUs) for non-forest wetland and open water indicator species based on evaluations for berm placement at sites 1 and 1a.

Habitat	AAHUs With Proposed Action	AAHUs Without Proposed Action	Net Annual Impact
Site 1			
Non-forested wetlands	55	28	26
Open Water – Lower Lake	783	896	113
Total	**838**	**924**	**139**
Site 1a			
Non-forested wetlands	49	27	22
Open Water – Lower Lake	791	896	105
Total	**840**	**923**	**127**

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