Draft
Appendix H-2
Habitat and Mitigation Analysis

March 2024

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1 Introduction

The Keystone Dam Safety Modification Study (DSMS) is located in the Arkansas River Basin in Tulsa County, Oklahoma.

This appendix will describe the habitat classifications, model selections, data collection, and future without-project (FWOP) and future with-project (FWP) habitat conditions. In addition to habitat quantification, this appendix will also describe the mitigation plan and the monitoring and adaptive management plan associated with mitigation efforts. Additional information regarding the study can be found in the Draft Environmental Assessment (EA).

2 Habitat Classification

2.1 Ecology of the Project Area

Three basic vegetation zones can be found around Keystone Dam: upland forest, wetlands, and non-native grasslands. Non-native grasses are abundant around the dam and are expected to yield very low habitat quality due to regular disturbance. Wetlands around Keystone Dam are similar and mostly caused by rutting due to the extensive recreation use at White Water Off-road Vehicle (ORV) Park.

The upland forest, Post Oak-Blackjack (Cross Timbers regions) types, represents a mixture of forest and grassland ecosystems characteristic of most of the lake shoreline and recreation areas. The Cross Timbers region is a transition area between the once-prairie, now winter-wheat growing regions to the west, and the forested low mountains of eastern Oklahoma. The region does not possess the arability and suitability for crops such as corn and soybeans that are common in the Central Irregular Plains to the northeast. The Cross Timbers stretch across Oklahoma from north to south, with portions extending into Kansas to the north and Texas to the south and are sometimes described as containing some of the most extensive tracts of ancient forests in the eastern United States. Included in this ecoregion for Keystone Lake is the Keystone Ancient Forest, with 300-year-old post oaks and 500-year-old cedars. This forest type exists because of its limited commercial value for timber production and is protected through its designation as an Environmentally Sensitive Area by USACE. Transitional "cross-timbers" (little bluestem grassland with scattered blackjack oak [*Quercus merilandica*] and post oak trees [*Quercus stellata*]) is the native vegetation, and rangeland and pastureland comprise the predominant land cover.

2.2 Model Selection and Data Collection

Three habitat types were assessed for the Keystone DSMS: upland forest, wetland, and grassland. This assessment was based on the existing conditions of the area surrounding Keystone Dam. The Barred Owl Habitat Suitability Index (HSI) and Downy Woodpecker HSI were utilized to assess upland forest habitat (U.S. Fish and Wildlife Service [USFWS], 1987). The American Coot HSI and Red-eared Slider HSI were used to assess the ecological integrity and conditions of wetlands within the potential project areas. The Eastern Meadowlark HSI was used to evaluate grassland habitat around Keystone Dam. The models were chosen based on similar habitat surveys in Tulsa, OK and best professional judgment.

Table 1. Models and Corresponding Habitat Type

	Upland Forest	Wetland	Grassland
Barred Owl	X		
Downy Woodpecker	X		
Slider Turtle		X	
American Coot		X	
Eastern Meadowlark			X

The habitat assessments for the Keystone DSMS were conducted on August 10-11, 2021. The data collection sites were selected based on aerial imagery from existing Geographic Information System (GIS) data and were in accordance with the final array of alternatives as described in the Draft EA (Figure 1). See Attachment A for photos of the existing site conditions.

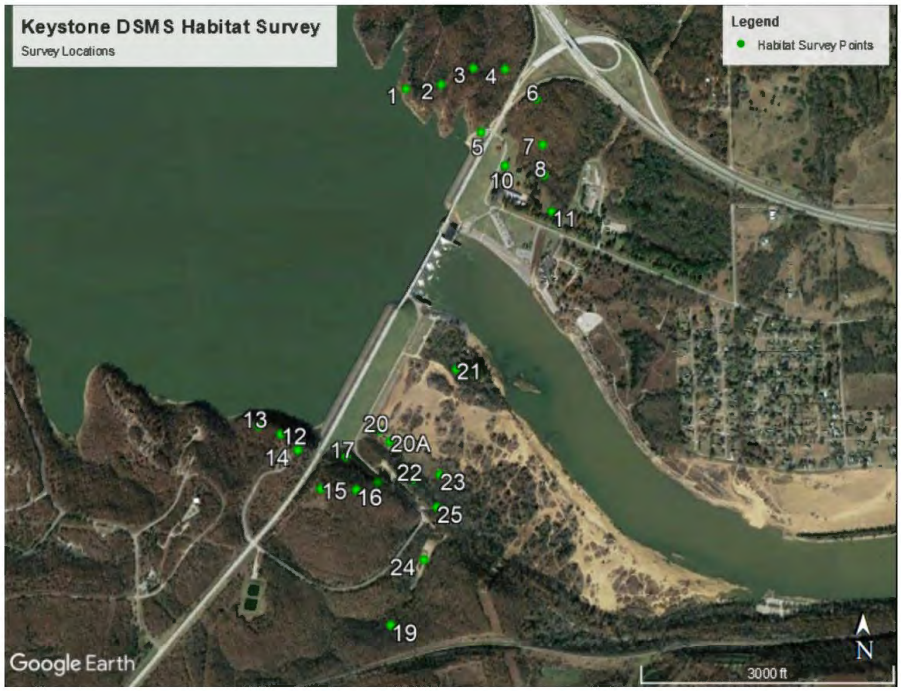

Figure 1. Keystone DSMS Habitat Survey

2.3 Habitat Evaluation Procedure and Habitat Suitability Index

A baseline assessment using the Habitat Evaluation Procedure (HEP) was required before any habitat impacts to the project area could be quantified. See Attachment B for existing conditions as observed through the evaluation. HEP involves defining the study area, delineating habitats

(i.e., cover types) within the study area, selecting HSI models and/or evaluation species, and characterizing the study area based on the results of the HEP. HEP was developed by the U.S. Fish and Wildlife Service (USFWS) in order to quantify the impacts of habitat changes resulting from land or water development projects (USFWS 1980). HEP is based on suitability models that provide a quantitative assessment of the habitat requirements for a species or group of species.

Habitat quality is estimated using the habitat models selected to represent each specific habitat type(s). Each model consists of a list of variables or Suitability Indices (SIs) that are essential to satisfy the life requisites (e.g., reproduction, food, cover, etc.) of a particular species. Each SI can be expressed as a mathematical function with each habitat metric as an independent variable. Each SI ranges from 0.1 to 1.0, with 1.0 representing optimal condition for the variable in question. The SIs for each specific life requisite are then calculated using a mathematical formula to estimate the Life Requisite Suitability Index (LRSI) for each life requisite. The final Habitat Suitability Index (HSI) of the habitat type can then be calculated as a function of the LRSIs.

The HSI methodology and calculations for the slider turtle habitat model is provided in Table 2. Three LRSIs are calculated (food/cover, water, and temperature). The suitability of the food/cover component (SIFC) is assumed to be equal to the suitability level determined for the percent of cover of emergent and submerged vegetation. The suitability of the water component (SIW) is assumed to be the lowest suitability of the three water component variables. The suitability of the temperature component (SIT) is assumed to be equal to the suitability determined for the mean surface water temperature during the critical period (USFWS, 1986).

Table 2. Slider Habitat Suitability Index Metrics

Species	**Life Requisite Suitability Indices (LRSI)**	**HSI Formula**
		$SIFC = SIV1$
Slider	Food/ Cover	$SIW = \min\{SIV2, SIV3, SIV4\}$
	Water	$SIT = SIV5$
	Temperature	$HSI = \min\{SIFC, SIW, SIT\}$

Life Requisite Suitability Index Formulas & Variables	
SIV_1	Percent cover of emergent and submerged vegetation
SIV_2	Velocity
SIV_3	Water depth
SIV_4	Water regime
SIV_5	Water temperature

The American coot HSI information is provided below in Table 3. One LSRI is calculated for reproduction. The percent of the wetland basin dominated by persistent herbaceous vegetation and the interspersion of such vegetation, evaluated by the edge index between emergent vegetation and open water, are assumed to have equal value in determining the reproductive habitat index value (RSI) (USFWS, 1985).

Table 3. American Coot Habitat Suitability Index Metrics

Species	**Life Requisite Suitability Indices (LRSI)**	**HSI Formula**
American Coot	Reproduction	$HSI = SIR = \{SIV1 \times SIV2\}^{1/2} \times SIV3$
	Life Requisite Suitability Index Formulas & Variables	
	SIV_1	Percent of wetland basin dominated by persistent emergent herbaceous vegetation
	SIV_2	Edge index between emergent vegetation and open water
	SIV_3	Water regime

The barred owl HSI information is provided below in Table 4. One LSRI is calculated for reproduction. The calculation of an HSI for the barred owl considers only the life requisite value calculated for reproductive habitat. Therefore, the HSI for the barred owl is equal to the reproduction suitability index (SIR) (USFWS, 1987).

Table 4. Barred Owl Habitat Suitability Index Metrics

Species	**Life Requisite Suitability Indices (LRSI)**	**HSI Formula**
Barred Owl	Reproduction	$HSI = SIR = \{SIV1 \times SIV2\}^{1/2} \times SIV3$
	Life Requisite Suitability Index Formulas & Variables	
	SIV_1	Number of trees greater than or equal to 51 centimeters diameter at breast height/0.4 hectare
	SIV_2	Mean dbh of overstory trees
	SIV_3	Percent canopy cover of overstory trees

The downy woodpecker HSI information is provided below in Table 5. Two LSRIs are calculated for food and reproduction. The HSI is equal to the lowest life variable (USFWS, 1983).

Table 5. Downy Woodpecker Habitat Suitability Index Metrics

Species	Life Requisite Suitability Indices (LRSI)	HSI Formula
Downy Woodpecker	Food Reproduction	$HSI = V1\ or\ V2$
	Life Requisite Suitability Index Formulas & Variables	
	V_1 Basal area	
	V_2 Number of snags > 15 cm (6 inches) dbh/0.4 ha (1.0 acre)	

The eastern meadowlark HSI information is provided below in Table 6. One LSRI is calculated for food/reproduction. The HSI for the eastern meadowlark is equal to the life requisite value for food/reproduction (USFWS, 1982).

Table 6. Eastern Meadowlark Habitat Suitability Index Metrics

Species	Life Requisite Suitability Indices (LRSI)	HSI Formula
Barred Owl	Food/ Reproduction	$\{V_1 \times V_2 \times V_3 \times V_4\}^{1/4} \times V_5$
	Life Requisite Suitability Index Formulas & Variables	
	V_1 Percent herbaceous canopy cover	
	V_2 Proportion of herbaceous canopy cover that is grass	
	V_3 Average height of herbaceous canopy (average spring conditions)	
	V_4 Distance to perch site	
	V_5 Percent shrub crown cover	

2.4 Habitat Survey Results

After collecting variables in the field, baseline habitat conditions were assessed with HEP using the methodology presented in ESM 102 *Habitat Evaluation Procedures* (USFWS, 1980). The HSI for each sample plot was evaluated by applying field data to applicable variables for each species' model. Baseline HSI for each evaluation species and habitat type are presented in Table 7 (scores are rounded to the nearest decimal).

Table 7. Average Baseline HSI Scores for the Keystone DSMS

	Right Abutment	Left Abutment
Barred Owl	0.8	0.5
Downy Woodpecker	0.5	0.5
American Coot	0.1	--
Slider Turtle	0.7	--
Eastern Meadowlark	0.0	0.0

2.5 Target Years

Target Year (TY) 0 habitat conditions are represented by the existing, or baseline, habitat conditions. The field and desktop collected data were used to quantify the habitat quality of that baseline condition. Target Year 0 conditions serve as a basis of comparison for both Future Without-Project (FWOP) and Future-With Project (FWP) scenarios.

Additional TYs were identified based on when implemented measures would be expected to elicit community responses represented by changes in the projected habitat variables.

TY 1 is used as a standard comparison year to identify and capture changes in habitat conditions that occur within one year after impacts have occurred or restoration/mitigation measures have been constructed. Amount of wetted area, reduction in invasive species, and water regimes are likely variables that may improve within this time period.

TY 5 was selected to capture the possible decrease in habitat quality associated construction that may impact the ecosystem relatively quickly such as natural plant establishment, aquatic vegetative abundance, and plant diversity.

TY 10 is used as a point after the initial growth of vegetation remaining and the likely increase in size they would have sustained for either construction impacts or restoration efforts.

Similarly, TY 25 was selected to capture the growth of upland habitats. Native tree abundance and diversity are also key response variables for this target year.

TY 50 is used as the last projected TY for the study.

2.6 Habitat Units

USACE quantifies the existing, FWOP, and FWP Ecosystem Restoration (ER) benefits using a Habitat Unit (HU) metric. HUs are calculated as the product of the HSI and the number of acres of the habitat of interest. HUs for each FWOP and FWP are then annualized over the 50-year period of analysis utilizing Equation 1 below.

Equation 1: Annualization of Habitat Units for the FWOP and FWP Conditions

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

Where:

$$\int_0^T HU\ dt = Cumulative\ HUs$$

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 the end of time interval

H_1 = Index score at the beginning of time interval

H_2 = Index score at the end of time interval

3 and 6 = constants derived from integration of Index score x Area for the interval between any two target years

This formula was developed to estimate cumulative HUs when either the HSI/TXI and/or area is between two time intervals (Tx to Tx+1). The sum of these time intervals over the period of analysis divided by the total number of years of that analysis (50 years for this study) provides an Average Annual Habitat Unit (AAHU). This annualization accounts for the temporal shifts in the logarithmic rate of accumulating ecological benefits that is common when dealing with the unevenness found in nature (USFWS, 1980).

As ecological systems are rarely static, the AAHUs for the FWOP may not be equal to the AAHUs of the existing condition. Therefore, the impact of a project is quantified by calculating the difference between the FWP scenarios and the FWOP. The difference in AAHUs between the FWOP and the FWP represents the net impact attributable to the project in terms of habitat quantity and quality.

Using the habitat models used to establish the existing habitat quality, an interagency team comprised of biologists from USACE, USFWS, Oklahoma Department of Wildlife Conservation (ODWC) and Oklahoma Department of Environmental Quality (ODEQ) projected the future habitat conditions for the FWOP and FWP conditions based on best professional judgment and existing conditions.

2.7 Institute for Water Resources Planning Suite II

The Institute for Water Resources (IWR) Planning Suite II is a water resources investment decision support tool originally built for the formulation and evaluation of ecosystem restoration alternatives; however, it is now more widely used by all USACE business lines for evaluation of actions involving monetary and non-monetary cost and benefits.

The purpose of the IWR Planning Suite II is to assist with the formulation and comparison of plans for Ecosystem Restoration and Mitigation Plans. It has the capability of performing the Cost Effectiveness and Incremental Cost Analysis (CE/ICA). The IWR Planning Suite II has an annualization tool to calculate the AAHUs for the FWOP and each FWP plan.

The IWR Planning Suite II Annualizer Tool was utilized to annualize the HUs of each alternative's FWOP and FWP condition for the Continuing Authorities Program (CAP). In addition to the IWR Planning Suite II, Ecosystem Restoration Planning Center of Expertise (ECO-PCX) annualization spreadsheets were utilized to verify the average annual outputs for each alternative as well. All annualization calculations for AAHUs were confirmed by using two separate methods for verification.

3 Final Array of Alternatives

The final array of management measures, fully described in the Keystone DSMS Draft EA, were combined into alternatives that would address flood risk, as well as provide flood control within the study area.

There were six alternatives considered during the study, including the No Action Alternative. For the purpose of this appendix, only Risk Management Plans (RMPs) 5a, 5c, 6e, 6g, and 7 will be described from a habitat analysis point-of-view. Those alternatives would have physical implications on environmental resources as a result of their implementation. Additional descriptions of each alternative can be found in Section 1.5 of the Draft EA.

- No Action
- RMP 5a and 5c – Dam Raise and Existing Stilling Basin Modification
- RMP 6e – 804 ft Wide Gated Auxiliary Spillway with Stilling Basin Modifications
- RMP 6g - 803 ft Labyrinth Auxiliary Spillway with Stilling Basin Modifications
- RMP 7 – 904 ft Wide Gated Auxiliary Spillway with Dam Raise and Decommissioning of Existing Service Spillway

3.1 Staging, Laydown, and Haul Routes

All alternatives evaluated will require staging, laydown, and haul routes during construction. These temporary construction sites will be placed within pre-disturbed locations to the greatest extent practicable. All impacts from staging, laydown, and haul routes would be temporary in nature and fully restored with native vegetation upon completion of construction features. The areas shown in Figure 2 are approximate and are likely to be updated during the Preconstruction, Engineering, and Design (PED) Phase. Although these areas may be modified at a later date, it is assumed there will be at least 10 acres needed for staging, laydown, and haul routes that may require minimal tree clearing in accordance with the Best Management Practices (BMPs) stated in the Draft EA. It should be noted that there are no expected impacts to habitat resulting from staging, laydown, and haul routes so they will not be discussed in further detail within this Appendix.

Figure 2. Proposed Staging and/or Laydown Area

3.2 RMP 5a and RMP 5c

Risk Management Plan 5a and 5c are the least environmentally damaging alternatives. Adverse impacts to habitat would be limited to potential staging and laydown areas, as well as haul routes. The construction for this alternative would be limited to pre-disturbed locations on the dam embankment (**Error! Reference source not found.**).

Figure 3. Risk Management Plan 5a and 5c

Figure 4. Bridge and Cofferdam Locations

3.3 RMP 6e

Permanent impacts to vegetative communities would result from construction activities associated with the implementation of RMP 6e. Approximately 80 acres of upland forest would be impacted during construction and 5 acres of emergent wetland habitat (Figure 5). It is anticipated that the construction of any staging, laydown, or haul routes would impact vegetative communities. In addition to the general impacts associated with the actual construction site, considerations shall also be made for potential disposal locations for associated excavated material. Although USACE does not intend to use sites that are heavily vegetated for disposal, USACE will assume the highest level of impact to ensure appropriate consideration before the PED Phase. It is assumed RMP 6e would require 155 acres of land to dispose excavated material.

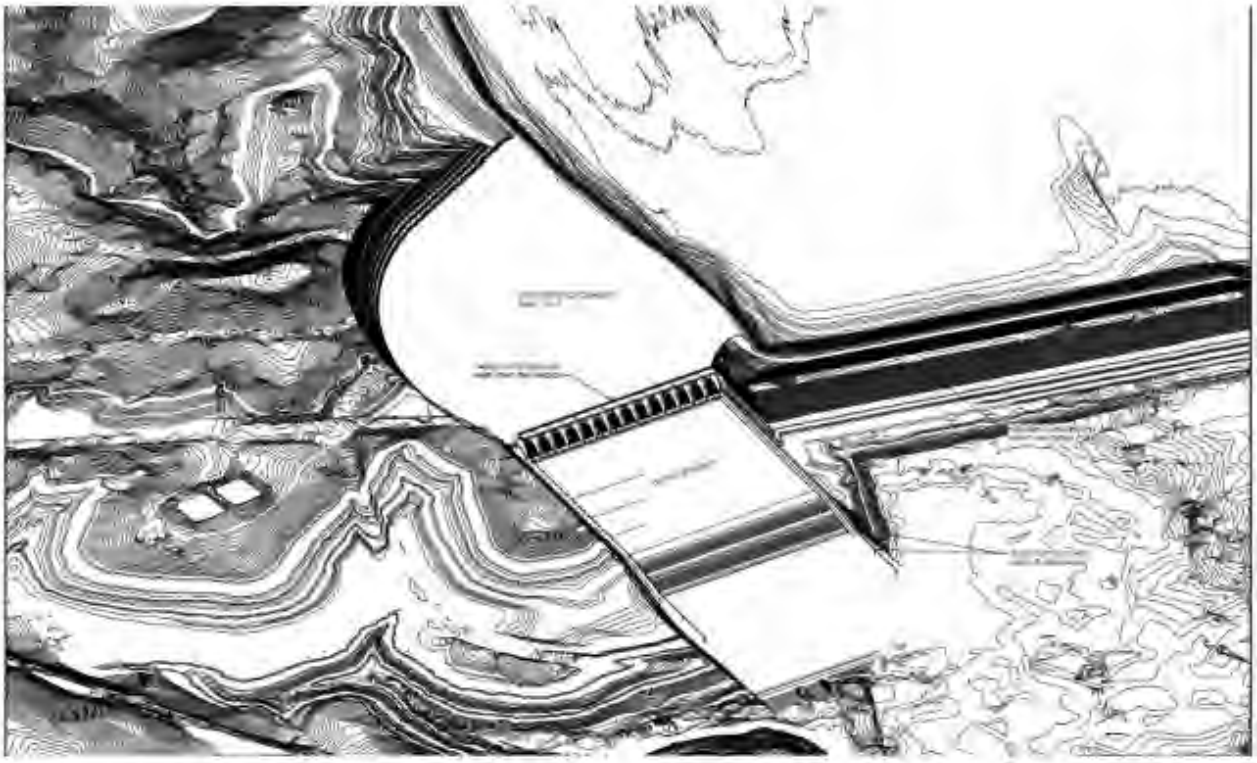

Figure 5. Risk Management Plan 6e

3.4 RMP 6g

Implementation of RMP 6g would result in similar impacts compared to RMP 6e; however, there would be permanent impacts to 40 acres of upland forest habitat and 5 acres of emergent wetland habitat (Figure 6). It is anticipated that the construction of any staging, laydown, or haul routes would impact vegetative communities. In addition to the general impacts associated with the actual construction site, considerations shall also be made for potential disposal locations for associated excavated material. Although USACE does not intend to use sites that are heavily vegetated for disposal, USACE will assume the highest level of impact to ensure appropriate consideration before the PED Phase. It is assumed RMP 6g would require 70 acres of land to dispose excavated material.

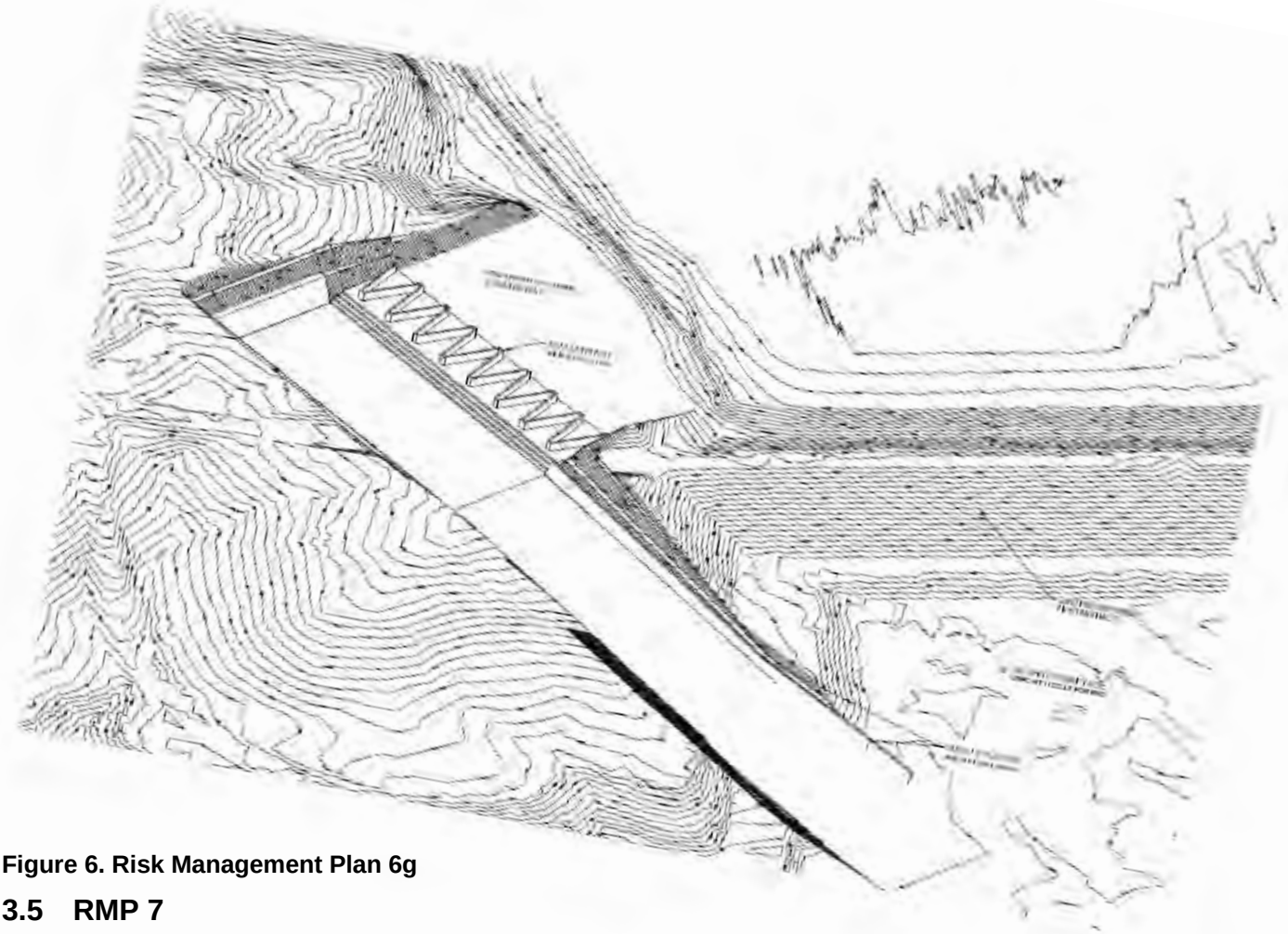

Figure 6. Risk Management Plan 6g

3.5 RMP 7

Risk Management Plan is a combination of a dam raise feature and construction of a new labyrinth spillway. Implementation of RMP 7 would result in similar impacts compared to RMP 6e; however, there would be permanent impacts to 120 acres of upland forest habitat and 5 acres of emergent wetland habitat (Figure 7). It is anticipated that the construction of any staging, laydown, or haul routes would impact vegetative communities. In addition to the general impacts associated with the actual construction site, considerations shall also be made for potential disposal locations for associated excavated material. Although USACE does not intend to use sites that are heavily vegetated for disposal, USACE will assume the highest level of impact to ensure appropriate consideration before the PED Phase. It is assumed RMP 7 would require 295 acres of land to dispose excavated material.

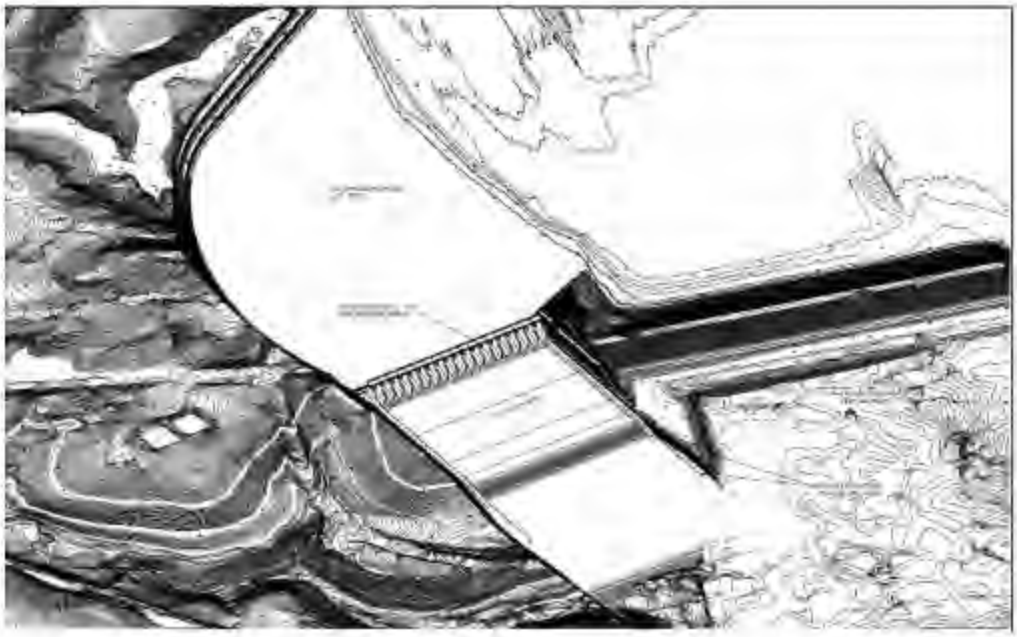

Figure 7. Risk Management Plan 7

4 Summary

This Section provides the inputs and results of the existing, FWOP, and FWP conditions analyses. Section 4.1 is a description of the justifications, calculations and results of the Existing Conditions and FWOP conditions, otherwise known as the No Action Alternative. Section 4.2 will describe the likely future conditions in the study area over the life of each alternative (FWP conditions). See Attachment C for FWOP and FWP assumptions.

The table below depicts the highest level of impact associated with potential disposal sites for excavated material. It should be noted that the FWP for disposal sites is assumed to be 0 beginning in TY 1 to TY 50 due to the permanent disturbance of the sites.

Table 8. Disposal Site AAHUs

				Target Year											
	Area	Model	Acres	0		1		5		10		25		50	
				HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
FWOP	RMP 6e	Not Applicable	155	1.0	155	1.0	155	1.0	155	1.0	155	1.0	155	1.0	155
FWOP	RMP 6g	Not Applicable	70	1.0	70	1.0	70	1.0	70	1.0	70	1.0	70	1.0	70
FWOP	RMP 7	Not Applicable	295	1.0	295	1.0	295	1.0	295	1.0	295	1.0	295	1.0	295

RMP 6e AAHUs = 155
RMP 6g AAHUs = 70
RMP 7 AAHUs = 295

Habitat Units have been rounded to the nearest whole number. Habitat Suitability Index has been rounded to the nearest decimal. Future With-Project Assumes the temporary construction areas would be restored and considers TY 1 as the year after implementing restoration measures.

As noted above for the potential disposal locations, the FWP for RMP 6e, 6g, and 7 assume total loss due to permanent impacts. The tables below depict FWOP AAHUs only in order to understand the loss of habitat quality. In addition, because RMP 5a and 5c do not require full-scale tree clearing and excavation, those alternatives will not be included in Table 9.

Table 9. RMP 6e, 6g, and 7 AAHUs for Upland Forest Habitat

	Area	Model	Acres	Target Year 0		1		5		10		25		50	
				HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
FWOP	RMP 6e	Barred Owl	80	0.4	30	0.4	34	0.5	38	0.6	44	0.7	56	0.8	65
FWOP	RMP 6e	Downy Woodpecker	80	0.5	40	0.5	40	0.5	40	0.5	40	0.5	40	0.5	40

Barred Owl AAHU = 53
Downy Woodpecker AAHU = 40

Average AAHU Between Barred Owl and Downy Woodpecker =46

	Area	Model	Acres	Target Year 0		1		5		10		25		50	
				HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
FWOP	RMP 6g	Barred Owl	40	0.4	15	0..4	17	0.5	19	0.6	22	0.7	28	0.8	33
FWOP	RMP 6g	Downy Woodpecker	40	0.5	20	0.5	20	0.5	20	0.5	20	0.5	20	0.5	20

Barred Owl AAHU = 26
Downy Woodpecker AAHU = 20

Average AAHU Between Barred Owl and Downy Woodpecker = 23

	Area	Model	Acres	Target Year 0		1		5		10		25		50	
				HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
FWOP	RMP 7	Barred Owl	120	0.4	44	0.4	51	0.5	57	0.6	66	0.7	83	0.8	98
FWOP	RMP 7	Downy Woodpecker	120	0.5	60	0.5	60	0.5	60	0.5	60	0.5	60	0.5	60

Barred Owl AAHU = 79
Downy Woodpecker AAHU = 60

Average AAHU Between Barred Owl and Downy Woodpecker = 70

Habitat Units have been rounded to the nearest whole number. Habitat Suitability Index has been rounded to the nearest decimal. Future With-Project Assumes the temporary construction areas would be restored and considers TY 1 as the year after implementing restoration measures.

Table 10. RMP 6e, 6g, and 7 AAHUs for Emergent Wetland Habitat

	Area	Model	Acres	Target Year 0		1		5		10		25		50	
				HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU	HSI	HU
FWOP	RMP 6e, 6g, and 7	Slider	5	0.1	1.0	0.1	1.0	0.1	1.0	0.2	1.0	0.1	1.0	0.1	1.0
FWOP	RMP 6e, 6g, and 7	American Coot	5	0.1	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	1.0

Slider AAHU = 1
American Coot AAHU = 1

Average AAHU Between Slider and American Coot = 1

Habitat Units have been rounded to the nearest whole number. Habitat Suitability Index has been rounded to the nearest decimal. Future With-Project Assumes the temporary construction areas would be restored and considers TY 1 as the year after implementing restoration measures.

The summary of AAHUs for each alternative is shown below in Table 11. Risk Management Plan 7 is expected to have the most significant effect to upland forest, followed by RMP 6e, and then RMP 6g. The outcome of this analysis was an important factor when determining the Tentatively Selected Plan (TSP). Risk Management Plan 5a is the TSP and does not require mitigation because the impacts associated with the project would be temporary and occur on pre-disturbed and regularly maintained areas.

A summary of the AAHUs associated with disposal location are not included because they have not been surveyed or refined. If another alternative is selected after the EA is completed, a supplement to evaluate environmental effects of disposal locations must be prepared.

Table 11. The AAHU Difference between FWOP and FWP for Each Alternative for Terrestrial Habitat

Alternative	Habitat Type	FWOP AAHUs	FWP AAHUs	Loss of AAHUs
RMP 6e	Upland	46	0	46
RMP 6g	Upland	23	0	23
RMP 7	Upland	70	0	70
RMP 6e, 6g, and 7	Emergent Wetland	1	0	1

5 References

U.S. Fish and Wildlife Service. 1980. Ecological Services Manual – Habitat as a Basis for Environmental Assessment. 15 September 1980.

--- 1982. Habitat Suitability Index Models: Eastern Meadowlark

--- 1983. Habitat Suitability Index Models: Downy Woodpecker

--- 1985. Habitat Suitability Index Models: American Coot

--- 1986. Habitat Suitability Index Models: Slider Turtle

--- 1987. Habitat Suitability Index Models: Barred Owl

6 List of Preparers

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