Final
Supplemental Environmental Assessment
Appendix F: Mitigation Plan

Arkansas River Navigation Study
Arkansas and Oklahoma

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1.0 INTRODUCTION

Federal agencies are required to mitigate activities that have unavoidable adverse impacts to natural resources such as fish and wildlife, wetlands, and other special aquatic sites. The requirements stem from laws such as the Clean Water Act, the Fish and Wildlife Coordination Act, the Migratory Bird Treaty Act, the Endangered Species Act, and the Magnuson-Stevens Act. The U.S. Army Corps of Engineers (USACE) has additional responsibility under section 906 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2283), to mitigate for damages to ecological resources, including terrestrial and aquatic resources, and fish and wildlife losses that result from a water resources development project. Section 906(d) of WRDA 1986 introduced comprehensive requirements such that any proposal submitted to Congress for authorization of a water resources project must contain a specific mitigation plan unless it is determined that the project will have negligible adverse impacts on ecological resources and fish and wildlife without implementation of mitigation measures.

Mitigation planning is an integral part of the overall planning process. In order to evaluate appropriate mitigation needs and options, the type, location, and level of potential adverse ecological impacts are identified and documented in the Supplemental Environmental Assessment (SEA) to the Final Feasibility Report and Environmental Impact Statement for the Arkansas River Navigation Study, Arkansas and Oklahoma (ARNS), McClellan-Kerr Arkansas River Navigation System (MKARNS) dated August 2005 (2005 FR/EIS). Practicable avoidance and minimization measures were considered, followed by an assessment of potential compensatory mitigation measures and a rough order of magnitude cost for those measures.

This document presents the compensatory mitigation plan for unavoidable habitat impacts associated with the MKARNS 12-foot Deepening project and Supplemental Environmental Assessment (SEA). This plan addresses both compensatory mitigation work and other activities performed during project planning to avoid, minimize, rectify, or reduce habitat impacts from each project alternative (see Engineer Regulation (ER) 1105-2-100, Appendix C, and ER 1105-2-103. Additional details of those avoidance and minimization efforts are included in the plan formulation and environmental consequences sections of the project's environmental compliance document, and those actions are incorporated into the mitigation objectives of this plan. The planning work performed to document those sequencing actions is complete and led the team to the need to develop a compensatory habitat mitigation plan for unavoidable impacts to fish and wildlife resources. This document details the work performed, including coordination, plan formulation, and environmental compliance, to develop the compensatory habitat mitigation plan.

The authority and requirements for compensatory mitigation are founded in Federal laws and regulations. The legal foundation for mitigation for ecological resources includes the Clean Water Act, various Water Resources Development Acts, and other environmental laws. These laws are implemented and administered through rules, guidance, regulations, and policies issued by Executive Branch agencies.

The relevant laws and regulations specific to compensatory mitigation planning for Corps of Engineers civil works projects are listed in the References section of this document. The specific procedures followed to develop this compensatory habitat mitigation plan are found in ER 1105-2-100, Appendix C. Other forms of mitigation, such as plans for cultural resources conservation or induced flood damages, may also be required for a project. Those types of mitigation requirements are not directly related to fish and wildlife habitat impacts and are not covered in this plan.

Compensatory mitigation is the "restoration (re-establishment or rehabilitation), establishment, enhancement, and/or in certain circumstances preservation of aquatic resources for the purposes of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved" (see 40 CFR 230.92). It is the policy of the Corps of Engineers civil works program, and in accordance with Section 906 of WRDA 1986, as amended, to demonstrate that impacts to all significant ecological resources, both terrestrial and aquatic, have been avoided and minimized to the greatest extent practicable, and that any remaining unavoidable impacts have been compensated to the greatest extent possible. Section 906(d) of WRDA 1986, as amended, requires functional assessments to be performed to define ecological impacts and to set mitigation requirements for impacted habitats. Corps of Engineers policy in ER 1105-2-100, paragraph C-3(d), requires the use of a habitat-based methodology, supplemented with other appropriate information, to describe and evaluate the impacts of the alternative plans, and to identify the mitigation needs.

USACE planning regulations requires that impacts to significant resources resulting from project activities be forecasted and compared and contrasted with the condition of these resources without the project over the project period of analysis. The period of analysis is the time required for the implementation of the project plus 50 years in accordance with ER 1105-2-103.

This draft plan identifies avoidance steps and minimization measures that either have or would be employed to lessen impacts to natural resources from implementation of the proposed action. These are described in Section 1.2 below.

Among the natural resources, the unavoidable adverse impacts expected are direct and indirect impacts to bottomland forest and aquatic resources. Aquatic resources impacted are riverine, wetland/marsh, shallow backwater, and gravel bars. Although dredging and placement of material in the Arkansas River is part of the proposed activities, there would be no net less of riverine habitat output as a result. Dredging and placement of material would cause temporary impacts as described in the SEA.

1.1 Study Background

The MKARNS system (Figure 1) is approximately 445 miles in length and consists of a series of 18 locks and dams. The authorized project area includes the MKARNS from the Port of Catoosa near Tulsa, Oklahoma, downstream to the confluence with the Mississippi River in southeastern Arkansas.

The 2005 FR/EIS and the Report of the Director of Civil Works (Director's Report), dated 27 September 2005, recommended modifications and improvements for navigation and channel maintenance. The Recommended Plan consisted of three broad components:

- Component 1 would change the existing MKARNS dredge material disposal plan for the existing 9-foot channel with new dredge material disposal sites;

- Component 2 would replace the existing flow management plan for the MKARNS with an Operations Only component to improve navigation and hydropower; and
- Component 3 would deepen the navigation channel throughout the MKARNS from 9 feet to 12 feet.

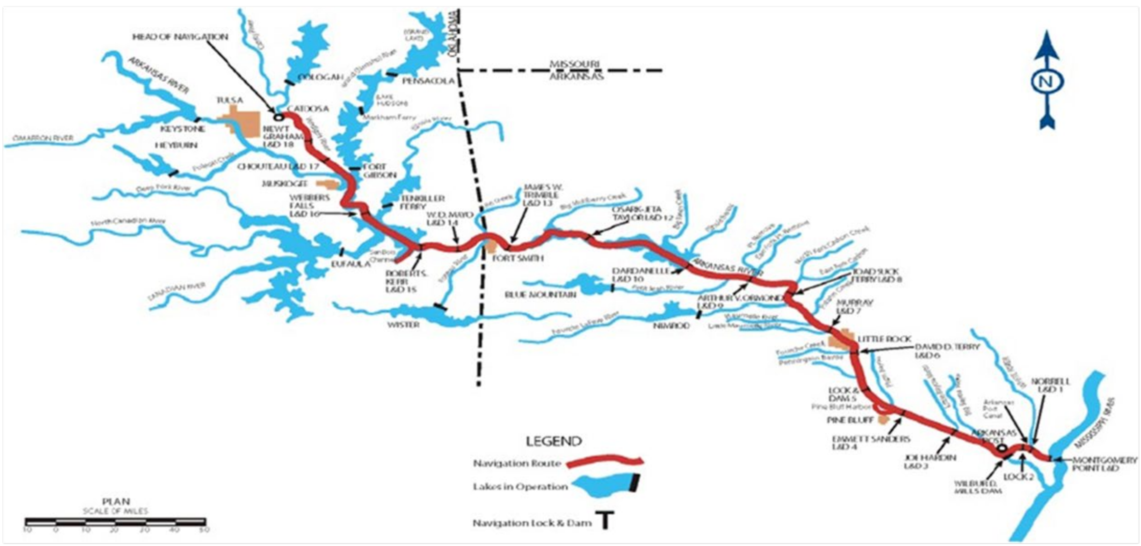

Figure 1. McClellan-Kerr Arkansas River Navigation Study Area

The recommended plan was authorized by Congress in the Energy and Water Development Appropriations Act of 2004 (Sec 136, Public Law 108-137). Implementation of the first two components began subsequent to authorization.

1.2 Proposed Action

The Proposed Action for this monitoring and adaptive management plan is deepening the MKARNS navigation channel from its current 9-foot navigation depth to the congressionally authorized 12-foot depth.

The USACE received Operations and Maintenance funds in the mid 2000sto begin work on the third component (deepening the navigation channel). These funds were used to construct some rock revetments and dike notching identified for the 12-foot channel component, thus marking the start of construction.

Changes in river conditions and new hydrologic survey data and information has warranted changes in the design of the 2005 approved 12-Foot MKARNS Channel Deepening Project. Additional appropriations received in the FY22 Infrastructure Investment and Jobs Act (IIJA), known as the Bipartisan Infrastructure Law (BIL), are being used to update hydrologic modeling and project designs, as well as updating National Environmental Policy Act (NEPA) compliance, economics, costs, and continue construction of the 12-ft navigation channel. Specific features of the proposed action consist of the following:

Navigation Channel Improvements:

- Dredging 5,7911,099 million cubic yards (M cy) of material in AR and OK (137 sites; 3,715 acres) to facilitate a 12-foot navigation channel.
- Construction of 37 new upland dredge material disposal sites in Oklahoma and 2 in Arkansas to supplement current disposal site capacity.
- Construction of 41 new and use of 170 permitted in-water disposal sites in Arkansas to supplement current disposal site capacity.
- Construction of 23 new river training structures (AR-18; OK-5), or rock dikes, to concentrate flows to scour specific areas of the riverbed to avoid or reduce maintenance dredging.
- Modification of 89 existing rock training structures (AR-84; OK-5) by raising and/or extending to concentrate flows to scour specific areas of the riverbed to avoid or reduce maintenance dredging.
- All compensatory mitigation efforts in addition to requirements found in other compliance documents for resources such as those protected by Endangered Species Act and National Historic Preservation Act

Navigation Channel Maintenance:

Dredging and disposal to maintain the new 12-foot navigation channel would continue. An updated Dredge Disposal Management Plan (DMMP) for the MKARNS 12-foot Channel has been developed and will be implemented concurrent with project construction. Dredge material will be disposed of in existing and new upland and in-water disposal sites in close proximity to dredge locations. For new disposal sites, areas with high quality habitat such as bottomland forest or wetlands would be avoided wherever practical.

1.3 Summary of Impacts

Direct and indirect impacts from the proposed action on environmental resources are described in detail in the Supplemental Environmental Assessment (SEA). NEPA defines direct impacts as those which are caused by the action and occur at the same time and place. Indirect impacts are defined as those which are caused by the action and are later in time or farther removed, but still reasonably foreseeable.

For the proposed action, the impacts to significant natural resources needing associated mitigation are summarized in Table 1.

Table 1. Summary of Natural Resource Impacts

Resource	Impact Intensity and Description
Terrestrial Habitat Loss - Disposal	Major Adverse - Potential impacts to terrestrial resources from maintenance and deepening dredging include a conversion of approximately 860 acres of various habitat types to dredged material disposal sites along the MKARNS. These sites are generally areas of degraded habitat and agricultural fields. Approximately 74 acres bottomland forest would be lost, although this number is expected to decrease as designs are refined. Thus, 74 acres represents an expected worst-case scenario for bottomland hardwood forest loss.
Aquatic Habitat Loss - Dredging	Major Adverse - Approximately 3,715 acres of navigation channel substrate would be dredged for deepening (1,377 acres in AR; 2,338 acres in OK). The same area would be dredged for maintenance, as needed. There is also a potential loss of 165 acres of gravel beds due to dredging activities.
Aquatic Habitat Loss - Structures	Major Adverse - The potential loss of 2,484 acres of shallow water dike field habitat in Arkansas and Oklahoma (existing preapproved maintenance dredged material disposal sites).
Aquatic Resources – Mussels	Major Adverse - Deepening the channel may impact mussel communities. Prior dredging and deepening have degraded the existing substrate. Opportunities may exist to further reduce and avoid impacts to mussels through design refinements, and mussel relocations.
Threatened and Endangered Species	Minor Adverse - Conversion of terrestrial habitat for dredge disposal sites may result in take of Federally Threatened or Endangered Species during dredged material disposal pit construction, dredged material disposal, or other ground disturbance activities, but most of the effects are expected to be infrequent and of short duration. Implementation of the BMPs and RMPs, and dredge disposal activities would avoid and minimize take to the extent practicable. Specific impact avoidance and minimization efforts, and any Take under the Endangered Species Act (ESA) is further discussed in the SEA and Final ESA documentation.

1.4 Avoidance and Minimization Measures

The first step in mitigation planning involves efforts to avoid, and then minimize, adverse impacts on environmental resources. Resource agencies have been engaged in discussion about potential impacts through technical meetings and consultations under applicable environmental laws and regulations.

As part of the mitigation process, upland dredge material disposal sites were selected based upon criteria for avoidance and minimization. A total of 39 upland disposal site locations have been identified (OK – 37; AR – 2). Where possible, bottomland hardwood forests and wetlands were avoided. Where sites could not be located outside these habitat types, the design of the pit will be configured to minimize impacts as much as possible. Priority was given to sites on USACE owned land. If suitable USACE land was not available, the team looked for private agricultural lands and possible in-water disposal locations where there was the potential for beneficial use of the dredged material (i.e. sandbar islands). This ultimately reduced the acreage of land needed for mitigation. The construction of upland disposal sites in Oklahoma will be constructed in four phases. The final location of disposal sites will be determined as each phase is funded and detailed designs begin, thus the potential exists to further minimize adverse impacts to significant natural resources (i.e. bottomland forest and aquatic sites). Additionally, as location designs are finalized, the USACE would begin surveying existing upland disposal sites to quantify remaining capacity in an attempt to reduce the number of new upland disposal sites. The two sites identified for upland sites in AR would be constructed on current agricultural land, which will avoid impacts to significant resources.

The USACE would implement all reasonable and prudent measures resulting from Endangered Species Act consultation with the U.S. Fish and Wildlife Service (USFWS) to minimize or avoid impacts to federally listed species. MKARNS 12’ Channel Phase I concurrence is included in Appendix C to the SEA.

2.0 ECOLOGICAL MODELING

Compensatory mitigation is required for unavoidable impacts to the environment that are caused by the recommended plan.

USACE Civil Works policy, including ER 1105-5-412 and in the CECW-CP policy memorandum Policy Guidance on Certification on Ecosystem Output Models, dated August 13, 2008, requires that only habitat models already certified by the USACE Ecosystem Planning Center of Excellence (PCX) be used to determine mitigation, or that models proposed for use undergo the model certification process outlined by the USACE.

2.1 Ecological Model Selection

The 2005 FR/EIS and SEA used Habitat Evaluation Procedures (HEP) to quantify habitat values for the existing conditions and for the future with and without project scenarios. HEP was developed by the USFWS 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 description of the habitat requirements for a species or group of species. HEP models use measurements of appropriate variables to rate the habitat on a scale from 0.0 (unsuitable) to 1.0 (optimal).

Habitat quality is estimated using species models developed specifically for each habitat type(s). Each model consists of a 1) list of variables that are considered important in characterizing fish and wildlife habitats, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality and different variable values, and 3) a mathematical formula that combines the Suitability Index for each variable into a single value for habitat quality. The single value is referred to as the Habitat Suitability Index (HSI).

The Suitability Index graph is a graphic representation of how fish and wildlife habitat quality or "suitability" of a given habitat type is predicted to change as values of the given variable change. It also allows the model user to numerically describe, through the Suitability Index, the habitat quality of an area for any variable value. The Suitability Index ranges from 0.1 to 1.0, with 1.0 representing optimal condition for the variable in question.

After a Suitability Index has been developed, a mathematical formula that combines all Suitability Indices into a single HSI value is constructed. Because the Suitability Indices range from 0.1 to 1.0 the HSI also ranges from 0.1 to 1.0 and is a numerical representation of the overall or "composite" habitat quality of the particular habitat being evaluated. The HSI formula defines the aggregation of Suitability Indices in a manner that is unique to each species depending on how the formula is constructed.

2.2 Habitat Suitability Index Models

2.2.1 Models

The 2005 FR/EIS utilized habitat models that were developed to evaluate the environmental impacts of the proposed dredging and flow changes on the MKARNS. The impacts result from the disposal of dredge material on terrestrial habitats along the MKARNS and ecological benefits resulting from the proposed mitigation. The model methodology is based on the Habitat Evaluation Procedure (HEP). Appendix C-5 of the 2005 EIS – "Terrestrial Habitat Evaluation Procedures" provides a detailed explanation of how habitat suitability index models for bottomland hardwood forests, upland forests, grasslands, and marsh/wetland habitats were developed and used to evaluate habitat impacts from the development of 37 proposed upland dredge disposal sites in Oklahoma.

As discussed in Section 1.0, the USACE utilizes the mitigation planning process described in ER 1105-2-100 to determine compensation for non-negligible impacts to significant aquatic, terrestrial, and human resources to the maximum extent practicable and to ensure that the recommended project will not have more than negligible impacts on those resources. Pursuant to that policy, upland forests and grasslands are not considered significant resources, thus mitigation for those resources is not allowable.

To evaluate habitat impacts and required mitigation for the MKARNS 12-foot Channel Project, the USACE used the Bottomland Hardwood Forest and Marsh models employed in the 2005 EIS to evaluate habitat impacts and required mitigation to bottomland hardwood forests and emergent wetlands from the proposed construction of 39 new upland disposal sites (OK – 37; AR – 2).

As discussed previously, USACE Civil Works policy requires that only standard habitat models already certified by the USACE Ecosystem Planning Center of Excellence (PCX) be used to determine mitigation, or that models proposed for use undergo the model certification process outlined by the USACE. As the habitat models developed and utilized for the 2005 EIS were not certified, USACE staff convened a team of biologists from the USFWS, Oklahoma Department of Wildlife Conservation (ODWC), and the Arkansas Game and Fish Commission (AGFC), to review the Bottomland Hardwood Forest and Marsh models used for the 2005 EIS to determine their continued applicability for evaluating newly proposed upland disposal sites in Arkansas and Oklahoma. A meeting was held in Ft. Smith, Arkansas on May 3, 2023, to review the terrestrial model metrics. The team agreed that the existing models were still applicable, with two minor modifications to increase the scores for willows and lotus in the Marsh model. Subsequent to this meeting and minor model revisions, the Bottomland Hardwood Forest and Marsh models were submitted to the USACE Ecosystem Restoration Planning Center of Expertise (Eco-PCX) on July 3, 2023, for model certification.

Single Use Approval for the use of the Bottomland Hardwood Forest and Marsh MKARNS HSI models was received on August 11, 2023, and is effective thru August 10, 2030. To evaluate gravel bed impacts, the Paddlefish Habitat Evaluation Procedures (HEP) model was used as a surrogate due to its reliance on the presence of this habitat to support reproductive life history activities. The Paddlefish model workbook from the PCX library of approved models was used without modification, thus no review/approval of model documentation was required. These models were used to assess and quantify habitat and appropriate mitigation to offset the impacts.

Habitat specific HSI scores were generated for using the habitat- specific spreadsheet calculators. The HSI scores were then multiplied by the acreages to calculate the Habitat Units (HUs).

HUs represent a numerical combination of quality (i.e. Habitat Suitability Index) and quantity (acres) existing at any given point in time. HUs represent a single point in time; however, the impacts of any of the proposed actions would occur over the entire planning horizon (50 years).

To account for the value of change over time, when HSI scores are not available for each year of analysis, the cumulative HUs are calculated using a formula that requires only the target year (TY) and the area estimates (USFWS 1980). The following formula was used:

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

Where:

T1= first target year of time interval

T2 = last target year of time interval 6

A1 = area of available habitat at beginning of time interval

A2= area of available habitat as the end of time interval

H1 = Habitat Suitability Index at the beginning of time interval

H2 = Habitat Suitability Index at the end of time interval

3 and 6 = constants derived from integration of HSI x 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. HU 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 HUs [CHU]) by the number of years in the planning horizon (i.e. 50 years). This calculation results in the Average Annual Habitat Units (AAHUs) (USFWS 1980).

2.2.1.1 Bottomland Hardwood Forest Habitat Suitability Index

The bottomland hardwood forest model utilizes two major components to evaluate the quality of this habitat type:

1. Biota Component of a Forest Community, and
2. Landscape Component of a Forest Community.

Within each component, five variables (V) were measured for evaluation purposes:

<u>Biota Component of Forest Community</u>

V1: CANHMAST – mean proportion of the tree canopy comprised of hard mast species.

V2: CANTREE - mean percentage of the overstory canopy resulting from trees.

V3: DBHTREE - mean diameter of a tree at breast height.

V4: NUMTREESP - count of the number of tree species identified in the sampling area.

V5: VEGSTRATA - count of the number of vegetation strata encountered using the following categories: herbaceous, shrub, midstory tree canopy, overstory tree canopy, vines, duff/twigs/leaf litter, coarse woody debris, snags, and microrelief.

Landscape Component of Forest Community

V6: ADJLANDUSE - land use type for the area adjacent to the sampling points.

V7: CORE - proportion of the sampling area that is represented by the core cover type.

V8: DISTOPW - average distance to open water measured in meters.

V9: NEIGHBOR - distance to the nearest neighbor of similar cover type measured in meters.

V10: PATCHSIZE - size of the sampling area polygon for each cover type measured in acres.

Model Assumptions

Biota of Forest Community

For the Biota of the Forest Community (FBIOTA) life requisite, the Tree Canopy (CANTREE) is an important indication of cover type. The Hard Mast Canopy Cover (CANHMAST) metric was added to capture the diversity and food source conditions. The dbh metric (DBHTREE) was included to capture the age of the stand which also affects the mast production (i.e., succession/sustainability and food availability). The number of tree species (NUMTREESP) metric captures the diversity of the stand. The vegetation strata (VEGSTRATA) metric was included to capture the architecture of the community – herbaceous layer up through the multi-tiered canopies. Both diversity and structure must be present and optimal to achieve a score of 1.0. Shortcomings of one element can be offset (compensated for) by the other. One element can be entirely absent, but suitability can still be achieved with regards to the remaining element. The resulting FBIOTA equation is:

$$FBIOTA = \frac{\frac{\sqrt{V_{CANTREE} \times V_{CANHMAST}} + V_{NUMTREESP}}{2} + \frac{V_{DBHTREE} + V_{VEGSTRATA}}{2}}{2}$$

Landscape component of the Forest Community

The Landscape of the Forest Community (FLANDSCAPE) life requisite evaluates the size of the forest community patch (PATCHSIZE). In addition, the edge (EDGE) and core size (CORE) are weighted against the patch size. Other weighting factors include adjacent land use (ADJLANDUSE), and where the nearest “like” neighbor is (NEIGHBOR), and how far away the nearest open water habitat is located (DISTOPW). Both patch characteristics and outside influences to the system must be optimal to achieve a score of 1.0. Shortcomings of one element cannot be offset (compensated for) by the other element. Rather, each element can weigh down the overall score. If one element is absent (or significantly detrimental), suitability is entirely lost. The resulting FLANDSCAPE equation is:

$$FLANDSCAPE = \sqrt{V_{PATCH} \times \sqrt{V_{CORE} \times V_{EDGE}}} \times \left(\frac{V_{ADJLANDUSE} + V_{DISTOPW} + V_{NEIGHBOR}}{3}\right)$$

The MKARNS 12ft Deepening project continues to be refined in both specific dredging location and quantities, and corresponding upland placement location and sizes. Several assumptions were made to account for unknowns in the final location and size of anticipated impacts that conservatively overestimate existing or future without project (FWOP) habitat value, as well as overall impacts. The actual impacts anticipated are to be less than those presented in the modeling efforts. The impacts and associated mitigation plan likely represent a worst-case scenario with final mitigation plans subject to refinement as more detailed designs are completed.

Impact acreage was determined by assuming the project will have adverse effects to all habitat located within the upland disposal site permanent impact footprint. Habitats impacted from temporary construction areas (i.e. laydown areas, temporary roads, etc.) would be allowed to reestablish itself after completion of upland disposal sites, thus mitigation for these temporary impacts was not necessary as long as those impacts are to insignificant habitats (i.e. disturbed pastures) and short-term (i.e. less than 1 year to recovery).

The following list depicts habitat modeling metric assumption for the 3 separate habitat condition scenarios. The FWOP, future with project (FWP), and FWP on mitigation lands habitat conditions. Assumptions made for each metric, and conditions that were expected to persist in the future are listed below:

Biota Component of Forest Community

V1: CANHMAST – For FWOP, assumed best case scenario for all forested areas. For FWP, assumed total loss of forested areas. For FWP on mitigation lands, assumed no mast production until 25 years after plantings to allow for trees to mature.

V2; CANTREE - For FWOP, assumed best case scenario for all forested areas. For FWP, assumed total loss of forested areas. For FWP on mitigation lands, assumed no minimum canopy cover until 25 years after plantings.

V3: DBHTREE - For FWOP, assumed best case scenario for all forested areas. For FWP, assumed total loss of forested areas. For FWP on mitigation lands, assumed minimal dbh growth until 25 years after plantings.

V4: NUMTREESP - For FWOP, assumed nearly best case scenario for all forested areas based on info in 2005 EIS. For FWP, assumed total loss of forested areas. For FWP on mitigation lands, assumed no trees meeting dbh criteria until 25 years after plantings.

V5: VEGSTRATA - For FWOP, assumed similar conditions for all forested areas based on info in 2005 EIS. For FWP, assumed total loss of forested areas. For FWP on mitigation lands, assumed habitat strata, particularly mid and overstory, isn’t formed until 25 years after plantings.

Landscape Component of Forest Community

V6: ADJLANDUSE – all conditions assume pasturelands are nearest neighbor, although ag/croplands may be more likely in several areas.

V7: CORE – FWOP assumed 20 acres based on 2005 EIS information, although actual field conditions and habitat fragmentation are likely to exhibit smaller core areas. FWP assumed complete loss of CORE. FWP on mitigation lands assumed no increase in habitat until 25 years after plantings.

V8: DISTOPW – all conditions assumed water was within 200 meters due to the habitat type's dependency on water.

V9: NEIGHBOR - all conditions assumed nearest neighbor was within 600 meters due to the patchy nature of bottomland hardwood forest along the riverbanks.

V10: PATCHSIZE – average patch size impacted was assumed to be 100 acres for all conditions as a worst-case scenario for impacts and targeted size of mitigation lands.

Bottomland HSI

The resulting HSI for the bottomland hardwood forest is the mean of the FBIOTA and FLANDSCAPE life requisite suitability indices:

$$Forest\ HSI = \frac{FBIOTA + FLANDSCAPE}{2}$$

2.2.1.2 Bottomland Hardwood Forest Modeling

<u>Existing/Future-Without Project Conditions</u>

Bottomland Hardwood Forest (BLHF) brackets the Arkansas River throughout the study area. Few areas, such as river front communities and infrastructure breakup the BLHF corridor. However, the width the of the BLHF corridor on either side can vary dramatically due to adjacent land uses. Pasture and agriculture use generally dominates the landscape based on cursory aerial imagery surveys. Bottomland Hardwood Forest, as well as Upland Forest and grasslands, patches sporadically balloon away from the riverbanks in varying sizes. Table 2 shows BLHF habitat model outputs assuming BLHF habitat conditions described in 2005 EIS have persisted into the future producing 45 AAHUs across 74 acres that may be impacted from the construction of upland placement of dredged material.

Target years (TY) of 0, 1, 5, 25, and 50 were utilized to annualize habitat changes over time. Years 0, 1, and 50 were based on the start of a project, one year after construction begins, and 50-year planning horizon of projects. Year 5 was selected to early forest development, or lack thereof, while Year 25 was selected due to it's the likely earliest period where substantial forest development in terms of mast production and canopy cover can be expected.

Table 2. Future-Without Project Conditions

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
BLHF	0	74	0.61	45.14		
	1	74	0.61	45.14	45.14	
	5	74	0.61	45.14	180.56	
	25	74	0.61	45.14	902.80	
	50	74	0.61	45.14	1128.50	**45**

Future-With Project Conditions

Table 3 below assumes a complete loss of the 74 acres of BLHF resulting from upland disposal site construction and associated activities of dredged material being placed there. This is expected to be the worst-case scenario. The project design continues to be refined and get smaller in footprint. The results indicate a loss of 45 AAHUs between the FWOP and FWP conditions. Thus, compensatory mitigation for BLHF is required.

Table 3. Future-With Project Conditions: Upland Disposal Sites Utilized

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
BLHF	0	0	0.00	0.00		
	1	0	0.00	0.00	0.00	
	5	0	0.00	0.00	0.00	
	25	0	0.00	0.00	0.00	
	50	0	0.00	0.00	0.00	**0**

Bottomland Hardwood Forest Mitigation

Ideally, a single large tract of land with minimal habitat presence, such as pasture or agriculture/crop lands, would identify with suitable hydrological connectivity to support BLHF. Tables 4 and 5 demonstrate the need for 135 acres of land to be planted and managed for BLHF in order to produce the needed 45 AAHUs of BLHF to offset the loss of 74 acres of BLHF. The larger acreage needed is driven by the long maturation time of forest growth with habitat output. BLHF habitat output is not anticipated to occur for 25 years post planting.

Table 4. Future-Without Project Conditions: Agriculture/Barren/Non-Forested Area

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
BLHF	0	135	0.02	2.70		
	1	135	0.02	2.70	2.70	
	5	135	0.02	2.70	10.80	
	25	135	0.02	2.70	54.00	
	50	135	0.02	2.70	67.50	**3**

Table 5 shows habitat modeling that assumes small, bare root trees planted in high densities would, after 25 years, begin to produce mast, considerable canopy cover, and multiple layers of habitat from overstory, mid-story, and shrub and herbaceous ground cover.

Table 5. Future-With Project Conditions: Planting Bare Root Trees for BLHF

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
BLHF	0	135	0.02	2.70		
	1	135	0.02	2.70	2.70	
	5	135	0.02	2.70	10.80	
	25	135	0.48	64.80	675.00	
	50	135	0.52	70.20	1687.50	**48**

2.2.2 Aquatic Models

To update the 2005 aquatic habitat modeling efforts into USACE-certified models, the ECO-PCX certified marsh models were utilized. While it is referred to as the “marsh model,” marsh, wetland, shallow backwater habitat, and emergent wetlands were considered synonymous descriptions of the targeted habitat. Data collected and agency expertise noted in the previous 2005 EIS modeling efforts as well as current aerial imagery were used to inform model metrics. It is important to note that all assumptions and strategies employed in this process are conservative and favor overestimating adverse impacts and the mitigation efforts required. Impacts to natural resources are anticipated to lessen as designs are further refined, therefore this mitigation plan likely presents a worst-case scenario. As final design and construction efforts are underway, the mitigation plan would be executed commensurate with actual impacts.

2.2.2.1 Marsh Habitat Suitability Index

Similar to the bottomland hardwood forest model, the Marsh HSI utilizes two major components to evaluate the quality of this habitat type:

1. Biota Component of a Marsh Community, and
2. Landscape Component of a Marsh Community.

The following variables contribute to each component.

<u>Biota Component of a Marsh Community</u>

V1: CANEMERG - percent emergent herbaceous vegetative canopy cover.

V2: CANWOOD6 - percent canopy cover of woody vegetation that is less than 6-m in height.

V3: DEPTHWATER - average water depth measured in cm.

V4: DIVERSVEG - identifies the indicator species of the marsh. The indicator species categories are 1) cattails, cordgrasses, bulrushes; 2) bluejoint reedgrass, reed canary-grass, sedges; 3) buttonbush, mangrove; and 4) other growth form not listed.

V5: REGIME - identifies the hydrologic regime of the marsh cover type sampling area. Using the Cowardin Classification System, the predominant hydrologic regime is documented for the site. The Cowardin Classification System categories are permanently flooded, intermittently exposed, semi permanently flooded, seasonally flooded, temporarily flooded, saturated, and intermittently flooded.

Landscape Component of a Marsh Community

V6: ADJLANDUSE - identifies the land use type for the area adjacent to the sampling points (pristine/uninhabited areas, parks, pasture lands, utility rights-of-way and railroads, dirt and gravel roads/oil and gas fields, agricultural croplands, residential and golf courses, paved roads/highways, and commercial/industrial areas).

V7: NEIGHBOR - measure of the distance to the nearest neighbor of similar cover type measured in meters.

V8: PATCHSIZE - size of the sampling area polygon for each cover type measured in acres.

Model Assumptions

Biota Component for the Marsh Community

The Biota Component for the Marsh Community (MBIOTA) is comprised of four main and equally important metrics: the emergent species present (DIVERSVEG), the emergent canopy cover (CANEMERG), the depth of the water (DEPTHWATER), and the timing and duration of the water (REGIME). These factors are weighted down by the percent of woody vegetation (CANWOOD6). Diversity, cover, and water must be optimal to achieve a score of 1.0. Shortcomings can be offset (compensated for) by the other variables. The overall score is weighed down by the competition of woody vegetation overtaking the marsh. The equation for the MBIOTA life requisite is:

$$MBIOTA = \frac{V_{DIVERSVEG} + V_{CANEMERG} + V_{DEPTHWATER} + V_{REGIME}}{4} \times V_{CANWOOD6}$$

As mentioned above, information and agency expertise identified in the 2005 EIS was used to calculate the USACE-certified Marsh HSI metrics. Because the dredged material placement areas and river training structure exact locations are still being designed and located, the assumption was made that aquatic habitat value and acreage impacted would be greater than what is expected to actually occur. The following list depicts the FWOP condition biota assumptions made for each metric, and these conditions were expected to persist in the future.

V1: DIVERSVEG: Smartweed, millet, sedges, and barnyard grass species were selected based on the assumption that the riverbank, side channel, and adjacent habitats have native emergent wetland habitat.

V2: CANEMERG: Emergent vegetation cover of 50% was selected in alignment with the assumption made in the metric above.

V3: DEPTHWATER: Average water depth of 20 centimeters was assumed due to its ability to support aquatic vegetation and within the optimum water depths for emergent habitat.

V4: REGIME: Regime was assumed to be intermittently exposed as it, at a minimum, accurately depicts the range of flood stage to low water drought conditions experienced within the system.

V5: CANWOOD6: A woody vegetation cover of 20% was assumed due to proximity to adjacent banks and other island or river training structure features.

Landscape Component for the Marsh Community

The Landscape Component of the Marsh Community (MLANDSCAPE) consists of the patch size (PATCHSIZE) and influenced by the distance to the nearest like cover type (NEIGHBOR). These factors are weighted by the degree of disturbance from the adjacent land uses (ADJLANDUSE). Both the patch characteristics and the outside influences on the system must be optimal to score a 1.0. Shortcomings of one element cannot be offset or compensated by another element. Rather, each element can weigh down the overall score. If one element is absent or significantly detrimental, the suitability is entirely lost. The equation for the MLANDSCAPE life requisite is:

$$MLANDSCAPE = V_{PATCHSIZE} \times \frac{V_{ADJLANDUSE} + V_{NEIGHBOR}}{2}$$

The following list depicts the FWOP landscape condition assumptions made for each metric, and these conditions were expected to persist in the future.

V6: ADJLANDUSE: Pasture lands assumed based on current aerial imagery, although a large portion may in fact be agricultural lands.

V7: NEIGHBOR: Nearest marsh habitat assumed to be 200 yards based on aerial imagery.

V8: PATCHSIZE: Patch sizes vary throughout the system from a few acres to hundreds of acres within potential impact areas, but 35 acres was selected as it was assumed larger patches of habitat would be impacted, therefore this was the conservative estimate.

Marsh HSI

The resulting HSI for the marsh community is the mean of the MBIOTA and MLANDSCAPE life requisite suitability indices:

$$Marsh\ HSI = \frac{MBIOTA + MLANDSCAPE}{2}$$

2.2.2.2 Aquatic Habitat Modeling

The 2005 FR/EIS utilized habitat models that were developed to evaluate the environmental impacts of the increasing the depth of the Arkansas River navigation channel from 9 to 12 feet. Field studies were conducted to establish baseline conditions of fish and aquatic habitat. In addition, primary impacts of the project identified by an interagency team of biologists and engineers were evaluated, including dike filling rates and associated effects on habitat quality, and the potential of degrading or removing gravel during dredging activities. The model methodology used in the 2005 FR/EIS was based on the Habitat Evaluation Procedure (HEP), and Appendix C-6 of the 2005 EIS – "*Aquatic Habitat Evaluation Procedures*" provides a detailed explanation of how habitat suitability index models were developed for impacts to aquatic resources.

As discussed previously, USACE Civil Works policy requires that only standard habitat models already certified by the USACE Ecosystem PCX be used to determine mitigation, or that models proposed for use undergo the model certification process outlined by the USACE. As the model developed and utilized in the 2005 EIS was not certified, the USACE used the Marsh HSI, which was approved on August 11, 2023, for single use, and effective through August 10, 2030, to model marsh or wetland mitigation needs. For the modeling efforts, marsh, wetlands, shallow backwater habitat, emergent wetlands were considered synonymous descriptions of the targeted habitat.

Existing/Future-Without Project Conditions

The amount of dredging and placement, as well as the number and location of river training structures is still undergoing refinement. However, it is expected that refinements will result in fewer actual adverse impacts. Therefore, this modeling effort utilized the same level of acreage impacts to aquatic habitat as the 2005 modeling efforts as it would represent more impacts than what are expected to occur. Table 6 shows 4,974 acres of aquatic habitat that is anticipated to be impacted. Based on the Marsh HSI models, the FWOP habitat value was 0.76. Target years (TY) of 0, 1, 5, 25, and 50 were utilized to annualize habitat changes over time. Years 0, 1, and 50 were based on the start of a project, one year after construction begins, and 50-year planning horizon of projects. Year 5 was selected due to marsh habitat's ability to quickly mature relative to other habitat types. Year 25 was selected based on the 2005 EIS efforts demonstrating rates of deposition within dike fields.

Table 6. Future-Without Project Conditions

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
MARSH	0	4,974	0.76	3,780.24		
	1	4,974	0.76	3,780.24	3,780.24	
	5	4,974	0.76	3,780.24	15,120.96	
	25	4,974	0.76	3,780.24	75,604.80	
	50	4,974	0.76	3,780.24	94,506.00	**3,780**

Future-With Project Conditions

The same habitat metric assumptions from the FWOP were applied to the FWP aquatic habitat modeling, thus the same habitat value of 0.76 was anticipated to persist into the FWP. However, in 2005, the interagency team and engineers identified deposition rates within the dike fields (Table 7). Using this information, it was assumed that as the percentage of dike field filled with sediment, aquatic habitat acreage would be reduced. For example, an unnotched dike field would fill to 76% capacity over a period of 50 years, while a notched dike field would fill to 38% capacity over the same timeframe. Therefore, it was assumed that if the dike field filled to 76% capacity, a like percentage of aquatic habitat would be lost, and this was reflected in the FWP aquatic acres. The result was a loss of 2,416 AAHUs, or 3,781 acres, over a 50-year period (Table 8).

Table 7. Conversion of Estimated Fill Rates of Dike Fields to Filling Coefficients Used to Annualize HSI Values Over Project Life

	Maintain 9-ft Channel	Dredge 12-ft Channel
Percent full at 50 years	43%	76%
Percent full at 50 years (notched dikes/revetments)	21.5%	38%
Percent full at 25 years	21.5%	38%
Percent full at 25 years (notched dikes/revetments)	10.75%	19%

Table 8. Future-With Project Conditions: Aquatic Disposal with No New Dike Notches

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
MARSH	0	4,974	0.76	3,780.24		
	1	4,974	0.76	3,780.24	3,780.24	
	5	4,974	0.76	3,780.24	15,120.96	
	25	3,084	0.76	2,343.75	61,239.89	
	50	1,194	0.76	907.26	40,637.58	**2,416**

Aquatic Mitigation

Due to the loss of marsh/shallow backwater habitat within dike fields, compensatory mitigation would be required. To determine mitigation requirements, the same modeling process was utilized to calculate necessary acreage that would be required to offset the 1,365 AAHUs lost. Aquatic mitigation efforts would involve notching existing dikes to allow return of flow, scour, aquatic vegetation, and river connectivity, and prevent accretion and associated conversion of aquatic habitat to terrestrial or forested habitat. Although the notches implemented with the FWP slow the rate of dike field filling, wetland acreage is still expected to decrease over the life of the project. However, as water flows through the notched dikes, over time the habitat value is anticipated to increase as productive habitat conditions develop.

The ideal location to implement the notching and reopening mitigation measures would be existing dike fields that have lost all backwater habitat due to sedimentation and when mitigation features are constructed, exhibits an HSI of 0.76. However, as a conservative approach to habitat mitigation requirements, the habitat model metrics assumed mitigation would occur on lands with existing habitat that is anticipated to lose habitat value over time as water flow is restricted by existing accretion process. The accretion would also be expected to produce a loss of shallow backwater acreage at the aforementioned rate by TY25 and TY50. Table 9 below depicts the FWOP conditions of a dike field to be notched and reopened for shallow backwater mitigation. Initial marsh/backwater habitat acreage within the dike fields needed to offset anticipated impacts would begin at 5,854 acres in TY0 and, after applying dike filling rates for non-notched dikes over 50-years, result in 1,405 acres of marsh/backwater habitat in TY50.

Table 9. Future-Without Project Conditions: Low Quality/Non-Wetland Habitat

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
MARSH	0	5,854	0.76	4,449.04		
	1	5,854	0.67	3,922.18	4,185.61	
	5	5,854	0.64	3,746.56	15,337.48	
	25	3,629	0.50	1,814.74	54,574.89	
	50	1,405	0.47	660.33	30,660.33	**2,095**

The FWP conditions followed the same assumptions as previous. Aquatic habitat acreage is expected to decrease as the dike fields sediment in at the rates identified in Table 3 above by TY25 and TY50. Some habitat value improvement can be realized by improving the hydrologic regime via dike notching and targeted re-opening of tributary and backwater flow. Marsh HSI metrics "DIVERSVEG," "REGIME", and "DEPTHWATER" improvements are expected over time, resulting in an increased habitat value from 0.47 to 0.76 after 50 years.

Opportunities to notch existing dikes and remove sediment from filled in backwaters and tributaries are abundant throughout the MKARNS. The 2005 EIS identified numerous locations that can be reconnected to the Arkansas River flow regime to restore shallow backwater habitats. Future agency coordination efforts would refine that list to identify the most appropriate sequence of sites that avoid and minimize adverse impacts to recreation, navigation, and adjacent non-aquatic lands while maximizing aquatic habitat output and success. Throughout the MKARNS, a total of 2,225 acres would need to be restored through the above mitigation efforts to offset the loss of 1,365 AAHUs throughout the 50-year project life. This was demonstrated in the habitat models through the dike notching and opening of previously sedimented-in waterways utilizing the same dike field filling in rates from the 2005 EIS. An estimated 5,854 acres of existing marsh/backwater habitat across dike fields would initially be required at TY0 and, after dike fill rates for notched dikes are applied, would result in a total of 3,629 acres of marsh/backwater habitat at TY50. As more backwater areas are restored, future efforts would document habitat acreage and output to ensure the mitigation need is met. Future efforts also include inspecting any previously constructed mitigation features to assess their current outputs. If viable, their outputs would count towards the mitigation need.

The dike notching and reconnecting of aquatic habitat to river flow would restore 2,225 acres and fulfill the aquatic mitigation need, see Table 10 below.

Table 10. Future-With Project Conditions: Dike Notching

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
MARSH	0	5,854	0.76	4,449.04		
	1	5,854	0.67	3,922.18	4,185.61	
	5	5,854	0.64	3,746.56	15,337.48	
	25	4,742	0.76	3,603.72	73,947.73	
	50	3,629	0.76	2,758.40	79,526.59	**3,460**

2.2.3 Gravel Bar Models

To update the 2005 gravel bar habitat modeling efforts into USACE-certified models, the ECO-PCX certified Paddlefish HSI models were utilized. Paddlefish (*Polyodon spathula*), native to the Arkansas River system, are highly migratory fish preferring deep water habitat to winter in. Paddlefish migrate upstream to spawn over gravel and cobble substrates. Because of this preference for gravel bars as spawning habitats, the ECO-PCX certified Paddlefish Habitat Evaluation Procedures (HEP) Reproductive Habitat model will be used as a surrogate to model impacts to gravel bars resulting from dredging efforts.

Data collected and agency expertise noted in the previous modeling efforts were used to inform model metrics. It is important to note that all assumptions and strategies employed in this process are conservative and favor overestimating the mitigation efforts required. As previously stated, impacts to natural resources are anticipated to lessen as dredging locations and quantities are further refined, therefore this mitigation plan likely presents a worst-case scenario regarding impacts to gravel bars. As final design and construction efforts are underway, the mitigation plan will be executed commensurate with actual impacts.

2.2.3.1 Paddlefish Habitat Suitability Index

The paddlefish reproductive habitat HSI formula focuses on the following individual life requisite suitability variables (V#):

<u>Reproduction Life Requisite Suitability Variables</u>

- V1: Yearly frequency of at least a 21-day period of rising water temperatures between 10 to 17 degrees (°) Celsius (C).
- V2: Yearly frequency of spring access to upstream spawning river (>40m wide and 1m deep)
- V3: Accessible area of gravel and cobble substrate (>80% of 15-100 millimeter diameter) in spawning river within 200 kilometers of winter habitat
- V4: Average magnitude of spring water rise/average midwinter flow for a period exceeding 10 days with water temperatures 10-17°C
- V5: Average current velocity (0.3 meters above substrate over potential spawning substrate) during spring water rise
- V6: Minimum dissolved oxygen (DO) in potential spawning areas while water temperatures are 10-17°C

<u>Assumptions</u>

As with the aquatic and terrestrial HSI models, information and agency expertise identified in the 2005 EIS was used to inform the USACE-certified Paddlefish HSI metrics. Because the dredged material placement areas and river training structure exact locations are still being designed and located, the assumption was made that gravel bar habitat acreage impacted would be greater than what is expected to actually occur. It was assumed that all water regime and quality metrics were optimal as paddlefish naturally occur in this system. However, V3, which measures availability of gravel bars in the paddlefish model, was used as the primary metric to capture impacts to gravel bars in the MKARNS system. The estimated 165 acres of gravel bars that were identified in the 2005 modeling efforts through aerial imagery and surveying are conservatively assumed to remain the area impacted.

The following list depicts the FWOP condition reproduction life requisite assumptions made for each metric, and these conditions were expected to persist in the future.

- V1: Yearly frequency of 0.45 of at least a 21-day period of rising water temperatures between 10-17°C. It was assumed that because paddlefish utilize the Arkansas River, water temperature fluctuations are suitable for habitat and reproduction, therefore a value maximizing this metric was selected.
- V2: Yearly frequency of 0.45 of spring access to upstream spawning river. Because the Arkansas River is such a large system fed by many streams and other rivers, access to suitable upstream spawning habitat is expected, therefore the V2 metric was set to a maximum value.
- V3: 66 hectares of accessible area of gravel and cobble substrate in spawning river within 200 kilometers of winter habitat. This number was derived from the 165 acres estimated in the 2005 modeling efforts.
- V4: Average magnitude of 3 meters of spring water rise/average midwinter flow for a period exceeding 10 days with water temperature of 10-17°C. The Arkansas River seasonal water level variability is expected to be suitable for paddlefish, therefore this metric was set to a maximum value.
- V5: Average current velocity of 0.4 meters per second during spring water rise. For the purpose of gravel bars, the Arkansas River is large system fed by many other systems. Spring brings lots of rain, and flows are not a limiting factor for gravel bar availability, therefore the maximum value of the metric was assumed.
- V6: Minimum DO of 6 mg/l assumed in potential spawning areas while water temperatures are 10-17°C as the water quality of the Arkansas River is generally acceptable. While there are some known fish kills from low DO pocket bursting during hot summer months, their proximity to gravel bars is unknown. DO is assumed to not be a factor inhibiting gravel bar use in the study area.

Reproduction HSI Formula:

$$Paddlefish\ Reproduction\ LRSI = (V1 * V2 * V3 * V4 * V5 * V6)^{\frac{1}{6}}$$

2.2.3.2 Gravel Bar Modeling

The 2005 FR/EIS utilized the environmentally conservative assumption to mitigate gravel bars at a 1:1 ratio to result in a no-net-loss of pure gravel bars either be relocating gravel that is dredged to a nearby suitable area or transporting dredged gravel to other sites within the project area. Aerial imagery and field surveys conducted during the 2005 EIS development determined the quantities and locations of gravel bars that may be impacted. The model methodology used in the 2005 FR/EIS is located in Appendix C-6 of the 2005 EIS – “Aquatic Habitat Evaluation Procedures” and provides a detailed explanation of these efforts.

As discussed previously, USACE Civil Works policy requires habitat models already certified by the USACE ECO-PCX be used to determine mitigation, or that models proposed for use undergo the model certification process outlined by the USACE. The Paddlefish Reproductive Habitat HSI was utilized at a requisite for gravel bar modeling efforts as it relies on those metrics tied to gravel bars. Additionally, the Paddlefish model is an existing USACE certified model.

Based on the 2005 surveys, there were 165 acres of gravel bars in the system anticipated to be impacted. This modeling effort conservatively assumed that all 165 of those acres would be adversely impacted; however, designs and locations of dredging and structures are still being refined. Final designs and impacts are expected to be less than the 165 acres of gravel bar loss assumed in the modeling efforts.

Existing/Future-Without Project Conditions

The location and amount of dredging to occur, as well as the number and location of river training structures is still in development, therefore this modeling effort utilized the same level of acreage impacts to gravel bars as the 2005 modeling efforts. Table 11 shows 165 acres of gravel bar habitat that is anticipated to be impacted. Based on the Paddlefish HSI models, the FWOP habitat value was 1.00 as it was assumed that all water regime and quality metrics were optimal as paddlefish naturally occur in this system. However, Variable 3 (V3) which measures availability of gravel bars in the paddlefish model, was used as the primary metric to capture impacts to gravel bars in the MKARNS system. A total of 165 AAHU gravel bar AAHUs exist within the action area. Target years (TY) of 0, 1, 2, 5, and 50 were utilized to depict that gravel bar habitat acreage and value is not expected to change over time. TY0 depicts the start of construction while TY50 reflects the 50-year planning horizon of projects.

Table 11. Future-Without Project Conditions

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
Gravel Bar	0	165	1.00	165.00		
	1	165	1.00	165.00	165.00	
	2	165	1.00	165.00	165.00	
	5	165	1.00	165.00	495.00	
	50	165	1.00	165.00	7,425.00	**165**

Future-With Project Conditions

The future-with project conditions assume that, without mitigation, all 165 acres of existing gravel bar habitat within the action area would be removed. Because the HSI value was 1.00, the result would be a loss of all acreage and habitat value, a total of 165 AAHUs (Table 12).

Table 12. Future-With Project Conditions

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
Gravel Bar	0	0	0.00	0.00		
	1	0	0.00	0.00	0.00	
	2	0	0.00	0.00	0.00	
	5	0	0.00	0.00	0.00	
	50	0	0.00	0.00	0.00	**0.00**

Mitigation

Due to the loss of gravel bar habitat, compensatory mitigation would be required. To determine mitigation requirements, the same modeling process was utilized to calculate necessary acreage that would be required to offset the 165 AAHUs lost. Gravel bar mitigation would involve relocating existing gravel substrate in identified gravel bars to nearby suitable locations or providing new substrate of the appropriate composition to create gravel bar acreage and value in a different, suitable location.

Throughout the MKARNS, a total of 165 acres would need to be restored through the above mitigation efforts to offset the loss of 165 AAHUs throughout the 50-year project life. This was demonstrated in the habitat models through the relocation or creation of gravel bar habitat as described above. Opportunities to accomplish this mitigation are abundant throughout the MKARNS system. Future agency coordination efforts will refine that list to identify the most appropriate sites that avoid and minimize adverse impacts to recreation, navigation, and adjacent non-aquatic lands while maximizing aquatic habitat output and success. Additionally, future site-specific coordination efforts will establish more specific success criteria to ensure the long-term viability of gravel bar mitigation.

The existing habitat type on which the constructed gravel bars would be located is expected to be open water substrates in areas where this habitat type currently does not exist, but conditions are suitable for it. Flow charactersitsics of the existing gravel bars will be evaluated, and proposed mitigation sites may be associated with new or modified dike fields to ensure flows allow for the longevity of the gravel bar mitigation. Because of this, the FWOP condition for anticipated mitigation would be open water with an HSI of 0 to reflect that no gravel bars exist in that area (Table 13).

Table 13. Future-Without Project Conditions

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
Open Water	0	165	0.00	0.00		
	1	165	0.00	0.00	0.00	
	2	165	0.00	0.00	0.00	
	5	165	0.00	0.00	0.00	
	50	165	0.00	0.00	0.00	**0.00**

Mitigation of gravel bars is assumed to occur in advance of or simultaneously to the impacts to gravel bars. This approach provides for nearly instant offsets of gravel bar habitat whereas other habitat types such as those that involve establishing vegetation take time to grow and mature prior to habitat out is expected. Therefore, it is expected that gravel bar mitigation efforts would be complete at TY0. These assumptions are reflected in the fact that the full 165 HUs needed for mitigation is achieved by TY0 and sustained through TY50 (Table 14).

Table 14. Future-With Project Conditions: Replacing Gravel Bars

Cover Type	Target Year	Acres	HSI	HUs	CHUs	AAHUs
Gravel Bar	0	165	1.00	165.00		
	1	165	1.00	165.00	165.00	
	2	165	1.00	165.00	165.00	
	5	165	1.00	165.00	495.00	
	50	165	1.00	165.00	7,425.00	**165**

2.3 Ecological Modeling Results

The sections below summarizes the overall habitat modeling efforts, mitigation requirements, and acreage needed to offset habitat impacts.

2.3.1 Impact Assessment

The impact of a project can be quantified by subtracting the FWP scenarios benefits/impacts from the FWOP benefits/impacts. 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, where a positive number results in net benefits and a negative result in net loss.

Table 15 summarizes bottomland hardwood forest, shallow/backwater marsh, and gravel bar habitat impacts. These habitats are those anticipated to both be adversely impacted by the proposed actions and require compensatory mitigation.

A total of 74.0 acres of bottomland hardwood forest habitat, or 45 AAHUs, are anticipated to be lost from the construction of upland dredge disposal sites and associated activities. Impacts to marsh habitats are projected to affect 3,780 acres, resulting in a net loss of 1,365 AAHUs from impacts associated with river training structure construction and associated deposition within the dike fields. Finally, up to 165 acres, or 165 AAHUs, of gravel bar habitat are expected to be lost from dredging operations. The results of the ecological modeling the project's impact assessment by habitat type are provided in Table 15. Specific habitat modeling metrics used in the analysis are provided as an Attachment 1 to this appendix.

Table 15. Net Change in Acres and AAHUs per Habitat Type

Habitat	Existing/FWOP		FWP		Net Change (AAHU)
	Acres	AAHU	Acres	AAHU	
Bottomland Hardwood Forest	74	45	0	0	-45
Wetland/Marsh	4,974	3,780	4,974*	2,416	-1,365
Gravel Bars	165	165	0	0	-165
Total	**5,213**	**3,990**	**4,974**	**2,416**	**-1,575**

* In the FWP scenario without mitigation, dikes would be constructed and modified without notches. Over time, dike fields would fill in and wetland/marsh habitat acreage would decrease accordingly. In this FWP scenario, 4,974 acres of wetland/marsh habitat would be impacted by project construction efforts at TY0. Without dike notching, 1,194 acres of this habitat would remain by TY50 as dike fields fill in at the rates depicted in Table 9.

2.3.2 Mitigation Summary

Compensatory mitigation is required for unavoidable impacts to the environment that are caused by the recommended plan. To ensure that the mitigation plan would adequately compensate for bottomland hardwood forest, emergent wetland/marsh, and gravel bar losses, the USACE used the HEP methodology to determine the average annual habitat units to quantify adverse impacts and benefits of the project and mitigation efforts (stated in terms of AAHU) to determine the functional value project site. Note, while riverine habitat is being impacted via dredging, those impacts are expected to be temporary and only occur while dredging is occurring. No net loss of riverine habitat is expected to occur, thus, no compensatory mitigation is required.

Dredging needs continue to be refined, however, several opportunities exist to beneficially use dredged material from the riverbed to build adjacent sandbar islands to benefit migratory birds and would be implemented where feasible.

Implementation of the recommended plan is expected to have unavoidable adverse impacts to bottomland hardwood forest, emergent wetlands/marsh, and gravel bars as indicated by a net loss in AAHUs in the previous section and in the last column in Table 15. Up to an estimated 135 acres of bottomland hardwood forest mitigation would be required to offset the net loss of 45 AAHUs and up to 2,225 acres of emergent wetland/marsh mitigation would be required to offset the net loss of 1,365 AAHUs (Table 16). Also shown below, up to 165 acres of gravel bars would need to be in place prior to/during gravel bar impacts to avoid additional gravel bar mitigation. Habitat metrics used in models are provided as Attachment 1 to this document.

Table 16. Amount of Mitigation Needed to Off-Set Unavoidable Adverse Impacts

Habitat	Existing/FWOP at Mitigation Sites		FWP- w/ Mitigation		Net Change (AAHU)	Mitigation Need (AAHU)
	Acres	AAHU	Acres	AAHU		
Bottomland Hardwood Forest	135	3	135	48	+45	45
Wetland/Marsh	5,854*	2,095	5,854**	3,460	+1,365	1,365
Gravel Bars	165	0	165	165	+165	165
Total	**6,154**	**2,098**	**6,154**	**3,673**	**+1,575**	**1,575**

* Wetland/marsh mitigation would largely consist of notching dikes. An estimated 5,854 acres is the initial acreage required within dike fields to implement compensatory mitigation. Due to dike field filling rates, the resulting wetland/marsh acreage at existing/FWOP mitigation sites is

estimated at 1,405 acres at the end of the 50-year period of analysis as habitat availability reduces over time corresponding to sedimentation (see Table 9).

** To reduce habitat loss as a result of dike fields filling in over time, dike fields will be notched to allow water flows to naturally scour sediment. An estimated 5,854 acres is the initial wetland/marsh habitat acreage required within dike fields to implement compensatory mitigation. By applying the filling rates of notched dikes, a total of 3,629 acres of wetland/marsh habitat will exist on the landscape with dike notching mitigation implemented at the end of the 50-year period of analysis.

Note: While 5,854 acres is the total existing acreage required for compensatory mitigation, the resulting 1,405 acres in the FWOP and 3,629 acres in the FWP are reported as the final total acreages remaining after taking filling rates into account over the 50-year period of analysis.

3.0 HABITAT MITIGATION PLAN

3.1 Mitigation Objective

The primary objective of the habitat mitigation plan is to provide commensurate compensation for the unavoidable impacts to bottomland hardwood, emergent wetland/marsh, and gravel bar habitats from the construction of the MKARNS 12-foot Deepening Project.

3.2 Formulation of Mitigation Measures

3.2.1 Measure Identification

To offset unavoidable impacts to aquatic habitats, numerous methods were considered including mitigation banks and in-lieu fee programs, habitat restoration, and habitat preservation.

In accordance with Section 2036(c) of WRDA 2007, as amended (33 U.S.C. 2317b), the Corps will consider available and potential in-kind credits from mitigation banks and in-lieu fee programs that have service areas that include the location of project impacts, as potential strategies to address compensatory mitigation for unavoidable ecological impacts. Cursory searches for in-kind credits availability at mitigation banks along the MKARNS in the USACE Regulatory In-Lieu Fee and Bank Information Tracking System (RIBITS) found several banks within the primary and secondary service areas. Few in-kind credits were available to meet the project needs into the future. Combining credit purchase with some other form of mitigation was considered, however with few credits remaining, purchasing the remaining credits may hinder other smaller projects from utilizing this mitigation strategy in the region. Thus, mitigation bank credit purchase was screened out from further consideration.

Numerous onsite wetland/marsh, bottomland hardwood forest, and gravel bar restoration opportunities are present throughout the MKARNS allowing for any displaced fauna to seek refuge in nearby restored areas. Additionally, several state and federal managed areas exist along the MKARNS allowing for opportunities to expand contiguous habitats.

Table 17. Measures Considered to Mitigate for Habitat Losses

Measure	Description	Carried Forward	Rationale
Mitigation Bank Credits	Purchase in-kind credits for bottomland hardwood, emergent wetland, and gravel bar habitats	No	Few in-kind credits are available throughout several mitigation banks in the vicinity of the MKARNS and would not meet the mitigation needs of the project. Additionally, the mitigation banks would not support natural resources within the MKARNS where the impacts are occurring.
On Site Marsh/ Backwater mitigation	Restoration and enhancement of degraded backwater wetlands along the MKARNS. Structural Measures: dike notching, opening of sediment filled channels	Yes	On site wetland/marsh mitigation opportunities are present throughout the MKARNS and can be integrated into existing and future dike fields with minimal construction efforts. Several channel

Measure	Description	Carried Forward	Rationale
	Non-Structural Measures: native aquatic plantings; invasive species removal.		mouths can be re-opened to provide restoration to larger backwater and tributary habitats within minimal construction footprints. Substantial cost savings would likely occur by using USACE lands for mitigation.
Off Site Marsh/ Backwater mitigation	Restoration and enhancement of degraded backwater wetlands on rivers, backwaters, and tributaries outside of the MKARNS system. Structural Measures: opening of sediment filled channels and backwater areas Non-Structural Measures: native aquatic plantings; invasive species removal.	No	This method would restore habitats where fauna impacted by the MKARNS project may not have access to and leave habitat within the MKARNS in a degraded state. Additionally, cost savings would not be realized by utilizing off site locations. Lastly, off site locations often pose challenges for access during construction, monitoring, and O&M phases, reducing likelihood of success.
On site Bottomland Hardwood Forest mitigation	Restoration and enhancement of bottomland hardwood forest. Structural Measures: grading, where necessary, to support water regime for optimal tree growth Non-Structural Measures: native tree plantings; invasive species removal (nuisance species removed or controlled)	No	Project sites for dike fields and upland disposal sites would only provide small footprints for forest development. Meaningful bottomland hardwood forest entails contiguous forest acreage to support various fauna that rely on it. Additionally, this effort would require multiple, costly mobilization and monitoring efforts throughout the MKARNS.
Off site Bottomland Hardwood Forest mitigation	Restoration and enhancement of bottomland hardwood forest. Structural Measures: grading, where necessary, to support water regime for optimal tree growth Non-Structural Measures: native tree plantings; invasive species removal (nuisance species removed or controlled)	Yes	The 2005 EIS identified non-USACE owned sites near the MKARNS, adjacent to lands owned/managed by state resource agencies, where bottomland hardwood forest mitigation can be implemented to expand contiguous forested habitat.
On site Gravel Bar mitigation	Replace valuable submerged spawning habitat within the MKARNS system. Structural Measures: relocate and/or replace impacted gravel bars as close to the impacted sites as possible.	Yes	The 2005 EIS identified several gravel beds that would potentially be impacted. This effort would relocate or place new gravel beds adjacent to existing sites where future dredging impacts would be avoided and where sedimentation of gravel beds would be at least no different than current site.

3.3 Site Selection and Baseline Information

3.3.1 Bottomland Hardwood Forest Site Selection

Several rationales were considered while identifying potential sites for compensatory mitigation, which include:

- Site must be easily accessible by vehicle, all-terrain vehicle, boat, or utility terrain vehicle.
- Site must be within the Arkansas River Watershed and be within close proximity to habitat types adversely impacted.
- Site must have appropriate soil characteristics, topography, and hydrologic conditions to achieve objectives for bottomland hardwood, forested wetland, and emergent wetland habitats.
- Site must be able to remain self-sufficient upon implementation of mitigation.

The proposed mitigation sites are within proximity of the bottomland hardwood and wetland impact areas, replacement of lost habitat functions and values would occur locally to where habitat impacts are occurring throughout the MKARNS. Refer to Appendix A, MKARNS 12-foot Channel Deepening Map Book, to the SEA for maps depicting the locations of the proposed dredging sites, upland and aquatic dredge material disposal sites, existing and proposed structures (dikes and revetments), proposed sandbar islands, and known gravel bars.

The site selection analysis conducted for the 2005 FR/EIS has been utilized for this revised mitigation plan. A team of USACE, USFWS, AGFC, and ODWC biologists identified ten sites in Oklahoma as potential mitigation sites. The two proposed upland disposal sites in AR would be constructed on agricultural ground, thus mitigation is not required. The team evaluated these sites to determine the amount and type of habitat that could be created to mitigate for habitat lost during dredge disposal on terrestrial sites. Many of the potential mitigation sites occurred on agricultural land. Incremental costs analyses were conducted using the procedures identified in the USACE procedures manual for conducting cost effectiveness and incremental cost analyses (IWR Report #95-R-1, Corps, May 1995).

Two sites were ultimately selected that both satisfied all members of the team and fulfilled the acreage and habitat quality requirement needed to mitigate for the potential habitat loss. These sites were adjacent to ODWC currently managed lands, with opportunities to manage both areas holistically. Map 4 (page 5) in Appendix A to the SEA shows the locations of the two bottomland hardwood forest mitigation sites selected.

3.3.2 Marsh Habitat Site Selection

Compensatory mitigation for the loss of aquatic habitat resulting from the introduction of new dike fields would involve notching existing dikes to allow the return of flow, scour, aquatic vegetation, and river connectivity while preventing accretion and associated conversion of aquatic habitat to terrestrial or forested habitat. Opportunities to accomplish this mitigation are abundant throughout the MKARNS system. The 2005 EIS identified numerous locations that can be reconnected to the Arkansas River flow regime to restore shallow backwater habitats. Future agency coordination efforts would refine that list to identify the most appropriate sites that avoid and minimize adverse impacts to recreation, navigation, and adjacent non-aquatic lands while maximizing aquatic habitat output and success.

The ideal location to implement the notching and reopening mitigation measures would be an existing dike field that has lost all backwater habitat due to sedimentation and when constructed, exhibits an HSI of 0.76. Sites that may be selected for dike notching mitigation efforts are expected to be those dike fields with existing habitat that is anticipated to lose habitat value over time as water flow is restricted by existing accretion process.

The figures below show the progression of an existing dike field with no notches on the Arkansas River near Little Rock, AR, over the span of 20 years. Figure 2 depicts the dike field in 1994, where water was diverted to each cell between the dikes. Figure 3 depicts the dike field in 2004, where the cells are beginning to fill in and access to freshwater flows is becoming restricted. Figure 4 depicts the dike field in 2023, where the two westernmost cells are almost completely cutoff from freshwater flows. No cuts exist to allow for flows through each of the cells to create a contiguous backwater habitat, and the size of each cell has drastically decreased due to sedimentation that can be attributed to a lack of water flow throughout the system. This progression portrays the evolution of a dike field that is not notched, and therefore loses aquatic habitat area and productivity over time. Dike fields such as these are prime candidates for notching to return waterflow, increase sediment scour, and slow sedimentation to improve the quantity and quality of habitat available in these backwater areas for aquatic species. Essentially, it would reverse the filling in of dike fields in specific areas to create and maintain the backwater wetland areas that are present in Figures 2 and 3 below.

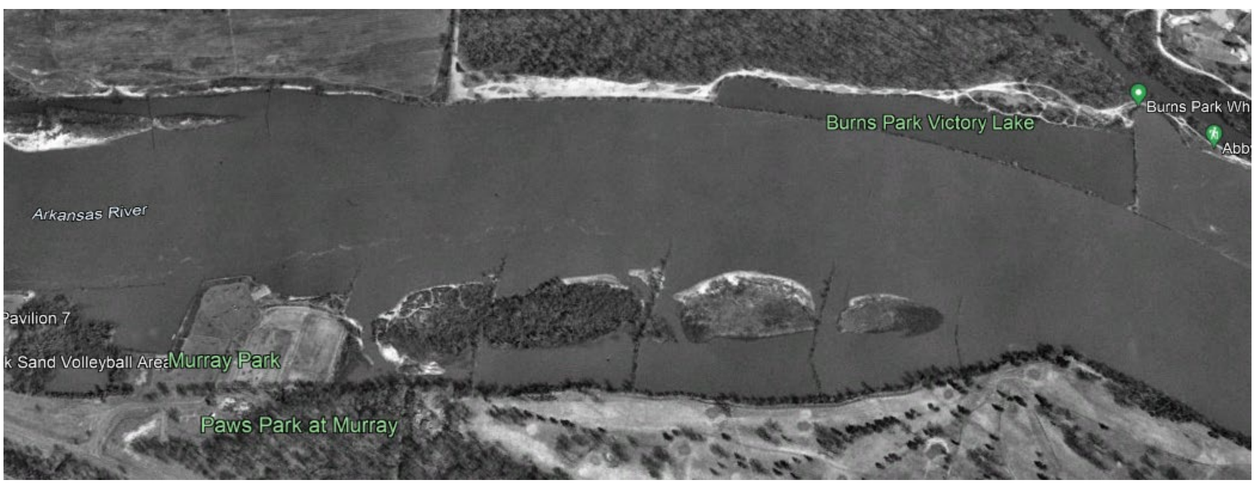

Figure 2. Conceptual Condition of a New Dike Field (1994)

Figure 3. Conceptual Condition of a Partially Filled-in Dike Field (2004)

Figure 4. Conceptual Condition of a Filled-in Dike Field (2023)

3.3.3 Gravel Bar Habitat Site Selection

Gravel bar compensatory mitigation would involve relocating existing gravel substrate in identified gravel bars to nearby suitable locations or providing new substrate of the appropriate composition to create gravel bar acreage and value in a different suitable location. The locations of known gravel bars are depicted in the maps included in Appendix B to the SEA. Throughout the MKARNS, opportunities to accomplish this mitigation are abundant. Future agency coordination efforts will refine that list to identify the most appropriate sites that avoid and minimize adverse impacts to recreation, navigation, and adjacent non-aquatic lands while maximizing aquatic habitat output and success. The existing habitat type on which the constructed gravel bars would be located is expected to be open water substrates in areas where this habitat type currently does not exist, but conditions are suitable for it.

3.4 Mitigation Work Plan

The ecological mitigation work would be done using contracted services, or USACE's Engineer Research and Development Center, or a combination of both. Grading and permanent fence installation may be necessary to create the most-appropriate site conditions for forested areas, and emergent and forested wetlands, but will be site specific. The proximity to agricultural properties is a risk to mitigation success, so five-string barbed wire fence may be installed to protect the areas from cattle and adjacent land uses.

The mitigation sites would be designed to improve habitat by introducing native vegetation, managing exotic invasive or nuisance species, creating microtopography appropriate for wetlands, and diversifying vertical stratification through herbaceous vegetation, shrubs, and trees upon the conclusion of grading and fencing.

Gravel bars would either be placed in appropriate locations in the MKARNS or relocated immediately adjacent to their current locations. Any new material used for gravel bars would be sourced commercially to match existing gravel bar qualities and contain no contaminants or invasive species.

As site specific detailed designs are developed , the following efforts would be completed, in coordination with the appropriate agencies and Tribes during the design phase:

- In accordance with Section 106 of the National Historic Preservation Act (as amended) (NHPA), develop a Cultural Resources research design, conduct intensive surveys of all project components, and perform deep testing in areas where grading and contouring are proposed;
- Develop haul route plan and haul schedule that avoids school zones and school bus stops during pickup and drop off periods. Identify areas for temporary traffic control, if needed; and
- Develop site security plans to secure construction, staging, and laydown areas so they do not create child or public safety concerns.

Upon completion of planning, additional mitigation efforts will be required to be complete prior to construction. Those efforts include:

- Ensure all construction staff are familiar with protected and natural resources to avoid unnecessary impacts;
- Develop avoidance and protection measures, as needed, based on results of cultural resources survey conducted during the planning phase, in coordination with the SHPO and Tribal Nations;
- Delineate areas to be avoided, including archaeological sites with surrounding buffer zones, such that construction equipment may not impact avoidance areas;
- Delineate construction areas with flagging, reflective tape, and fencing for child and public safety and to limit construction impacts, where appropriate;
- Ensure a Storm Water Pollution Prevention Plan (SWPPP) is prepared; and

During construction, ongoing efforts may be needed to avoid and limit adverse impacts. Those efforts include, but are not limited to:

- Conduct cultural resources surveys of areas in which any changes to design or additional ground disturbance must occur to ensure no cultural resources will be adversely impacted.
- Ensure all stipulations of the Endangered Species Act, Clean Water Act, National Historic Preservation Act, among others, are implemented.

- Revegetate all disturbed areas with native species, where appropriate;
- Ensure all environmental and cultural resource compliance efforts have been met;
- Ensure no insecticides or pesticides are used within or adjacent to natural areas;
- Limit herbicide use to only areas dominated by invasive species;
- Implement the SWPPP and applicable BMPs regarding stormwater runoff.
- Implement construction and staging site boundary marking and safety measures;
- Implement traffic flagging and haul route restrictions, where appropriate, to minimize safety concerns;
- Implement avoidance techniques where practicable for vegetation removal, if vegetation removal cannot be avoided it will occur outside of the migratory bird nesting and breeding season if surveys indicate presence; and

The mitigation sites shall be designed, to the maximum extent practicable, to be self-sustaining once performance standards have been achieved. The dependence on engineering features such as water control structures, pumps, stop-logs, and irrigation will be limited to ensure natural hydrology will support long-term sustainability. In addition, control of invasive species will be limited to the monitoring and adaptive management period. Upon establishment of native vegetation, invasive species propagation is expected to be limited, unless future unknown natural disturbances occur.

3.4.1 Grading Plan

The objective of the grading plan is to adjust the topography of mitigation sites to accommodate emergent and forested wetland vegetation. Grading will establish the proper subgrade elevations associated with wetland communities. Upon specific site investigations, if grading of the selected mitigation site be needed, USACE will develop a detailed grading plan that identifies the areas requiring grading and amount required.

3.4.2 Desired Plant Community

A combination of species will be planted at each mitigation site. Because there are two habitat types that will have to be mitigated, there will be varying wetland and bottomland hardwood forest species. The vegetation list below represents the priority plants used for USACE's mitigation efforts. This list is preliminary, and species may be added or removed from it during design and implementation of the mitigation features.

Table 18. Desired Plant Community for the Mitigation Plan

Scientific name	Common name	Growth form	Habitat*
Aquatic, wetland, and grassland herbaceous			
Acmella oppositifolia var. repens	Oppositeleaf spotflower	Emergent	E
Andropogon glomeratus	Bushy bluestem	Graminoid	E
Asclepias sp.	Milkweeds	Herb/wildflower	E

Scientific name	Common name	Growth form	Habitat*
Bacopa monnieri	Water hyssop	Emergent	E
Carex sp.	Sedges	Emergent	E, FW
Chasmanthium latifolium	Inland sea oats	Graminoid	E, BLH
Echinodorus berteroi	Tall burhead	Emergent	E, FW
Echinodorus subcordatum	Creeping burhead	Emergent	E, FW
Eleocharis acicularis	Slender spikerush	Emergent	E
Eleocharis macrostachya	Flatstem spikerush	Emergent	E
Eleocharis quadrangulata	Squarestem spikerush	Emergent	E
Equisetum	Horsetail	Emergent	E
Heteranthera dubia	Water stargrass	Submerged	E
Juncus spp.	Soft rush	Emergent	E
Justicia americana	Water willow	Emergent	E
Nymphaea mexicana	Mexican water lily	Floating-leaved	E
Nymphaea odorata	American water lily	Floating-leaved	E
Panicum virgatum	Switchgrass	Graminoid	E
Peltandra virginica	Arrow arum	Emergent	E, FW
Phyla lanceolata	Lanceleaf frogfruit	Herb/wildflower	E, FW
Polygonum hydropiperoides	Water smartweed	Emergent	E, FW
Pontederia cordata	Pickerelweed	Emergent	E
Potamogeton illinoensis	Illinois pondweed	Submerged	E
Potamogeton nodosus	American pondweed	Submerged	E
Sagittaria platyphylla	Delta arrowhead	Emergent	E
Sagittaria latifolia	Arrowhead	Emergent	E, FW
Schoenoplectus californicus	Giant bulrush	Emergent	E
Schoenoplectus pungens	American bulrush	Emergent	E
Schoenoplectus tabernaemontani	Softstem bulrush	Emergent	E
Tripsacum dactyloides	Eastern gamagrass	Graminoid	E
Vallisneria americana	Wild celery	Submerged	E
Woody			
Acer negundo	Box elder	Tree	FW, BLH
Acer saccharinum	Silver maple	Tree	BLH
Betula nigra	River birch	Tree	FW, BLH
Callicarpa americana	American beautyberry	Shrub	BLH
Carya cordiformis	Bitternut hickory	Tree	BLH
Carya illinoinensis	Pecan	Tree	BLH
Carya ovata	Shagback hickory	Tree	BLH
Carya tomentosa	Mockernut hickory	Tree	BLH

Scientific name	Common name	Growth form	Habitat*
Catalpa speciosa	Northern catalpa	Tree	BLH
Celtis laevigata	Sugarberry	Tree	FW, BLH
Cephalanthus occidentalis	Buttonbush	Shrub	FW, BLH
Cercis canadensis	Eastern redbud	Tree	BLH
Cornus drummondii	Roughleaf dogwood	Shrub	FW, BLH
Crataegus spp.	Hawthorn	Tree	BLH
Diospyros virginiana	Common persimmon	Tree	FW, BLH
Fraxinus pennsylvanica	Green ash	Tree	FW, BLH
Ilex decidua	Deciduous holly	Tree	BLH
Juglans nigra	Black walnut	Tree	BLH
Maclura pomifera	Osage-orange	Tree	BLH
Morus rubra	Red Mulberry	Tree	FW, BLH
Nyssa sylvatica	Blackgum	Tree	FW, BLH
Platanus occidentalis	American sycamore	Tree	FW, BLH
*Populus deltoides***	Cottonwood	Tree	FW
Prunus mexicana	Mexican plum	Tree	BLH
Prunus serotina	Black cherry	Tree	BLH
Quercus macrocarpa	Bur oak	Tree	FW, BLH
Quercus muehlenbergii	Chinquapin oak	Tree	BLH
Quercus nigra	Water oak	Tree	FW, BLH
Quercus phellos	Willow oak	Tree	FW, BLH
Quercus palustris	Pin oak	Tree	BLH
Quercus shumardii	Shumard oak	Tree	BLH
*Salix nigra***	Black willow	Tree	FW
Sambucus nigra	Elderberry	Shrub	FW, BLH
Sideroxylon lanuginosum	Gum bumelia	Tree	BLH
Ulmus americana	American elm	Tree	BLH
**E = emergent wetland, FW = forested wetland, BLH = bottomland hardwood forest*			
***Expecting recruitment and will monitor; may not transplant*			

Any desirable plants or wildlife structures, such as snags, will be left in place where practical. A final review of the planting areas will occur after completion of contouring to ensure soil, topographic, and hydrologic conditions are appropriate.

The draft design of the plant community will be structured as shown below:

<u>Emergent Wetlands</u>

- Seeding in disturbed/graded/appropriate areas
- Estimate acres needed for seeding

- Transplants estimated 10 - 15-foot centers at appropriate depths
- One submerged aquatic vegetation founder colony installation per tract/site

Forested Wetlands & Bottomland Hardwoods

- 100 (one to two years old, 0.6 gallon) transplants per acre
- Stakes/germinated-acorns/bare-root seedlings as appropriate
- Estimated >50 per acre average

3.4.2.1 Control of Invasive Species

Prevalent invasive species at the mitigation sites can include a number of plant species such as Chinese privet (*Ligustrum sinense).* Various methods can be used to manage and eradicate invasive species presence including manual removal with hand tools near sensitive sites, mechanical removal with heavy equipment for larger infestations, and herbicide treatments, where appropriate. Each site would require a specific plan to account for local conditions. Invasive species management plans would be developed prior to construction and implementation of the mitigation efforts. Performance metrics to ensure invasive species do not take over mitigation sites are included in the monitoring plan.

3.4.2.2 Maintenance Plan

The proposed mitigation sites have demonstrated that they are capable of supporting natural habitats. Grading and contouring within some of the mitigation areas will provide a lower base elevation and create a minor impoundment. The slight modification of the areas will create hydrologic conditions on a larger scale and add to the duration of water inundation, as well as the establishment of native vegetation.

Upon completion of initial construction, the mitigation sites will be monitored as described in the next section. Corrective actions in addition to those described in the previously mentioned sections may be required and can include:

- Maintaining security fencing;
- Maintaining mitigation site information signs;
- Protecting mitigation sites from human disturbances, such as encroachments, illegal agriculture use, and vandalism; and
- Any other actions that may be triggered by the adaptive management plan described in later sections.

3.5 Monitoring and Adaptive Management

An effective monitoring program will be required to determine if the project outcomes are consistent with original project goals and objectives. The power of a monitoring program developed to support adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management. A carefully designed monitoring program is the central component of the project adaptive management program because it supplies the information to assess whether the project is functioning as planned.

Monitoring must be closely integrated with the adaptive management components because it is the key to the evaluation of adaptive management needs. Objectives must be considered to determine appropriate indicators to monitor. In order to be effective, monitoring must be able to distinguish between ecosystem responses that result from project implementation (i.e. management actions) and natural ecosystem variability.

In general, monitoring will be established for no less than five years after mitigation construction completion for emergent wetland habitats. A longer monitoring period must be required for aquatic resources with slow development rates, such as forested wetlands so the monitoring will be no less than 10 years for forested wetland and bottomland hardwood forest habitat. However, following project implementation, the district engineer may reduce or waive the remaining monitoring requirements upon a determination that compensatory mitigation has achieved its performance standards. Annual monitoring reports will be submitted to the district engineer by USACE Environmental Staff.

The USACE Environmental Staff be the responsible party for ensuring monitoring is conducted and coordinated annually with resource agencies.

Monitoring reports must include the progress of the compensatory mitigation, and can include plans, maps, and photographs to illustrate site conditions at the time of the report. They may also include the results of functional, condition, or other assessments used to provide quantitative or qualitative measures of the functions provided by the compensatory mitigation site. Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The locations of photo points will be identified in the pre-construction monitoring report. Photographs taken at each photo point will be included in monitoring reports. Any reports submitted to the district engineer must be provided to Federal, Tribal, state, and local resource agencies, and the public, upon request.

Results of monitoring will be assessed in comparison to project objectives and decision-making triggers to evaluate whether the project is functioning as planned, and whether adaptive management actions are needed to achieve project objectives. The results of the monitoring would be utilized to evaluate and compare data to project objectives and decision-making triggers. The USACE would use the monitoring results to assess habitat responses to management, evaluate overall project performance, and make recommendations for adaptive management actions, as appropriate. If monitoring results, as compared to desired outcomes and decision-making triggers, show that project objectives are not being met, USACE will evaluate causes of failure and execute adaptive management actions to remedy the underlying problems.

Decision criteria, also referred to as adaptive management triggers, are used to determine if and when adaptive management should be implemented. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. Desired outcomes can be based on reference sites, predicted values, or comparison to historic conditions.

This mitigation plan including its monitoring and adaptive management efforts involves active manipulation (as needed) to sustain project goals and objectives, primarily by applying an iterative process of assessing and learning from the results of management actions. The application of adaptive management principles in this project will provide decision support tools to address site changes that may occur as the project progresses, as well as integrate additional project resources or technologies as needed. In some cases, additional resources may be needed to address issues that occur (such as management of new infestations of invasive species), but in most cases reallocation of resources (e.g., modifying planting lists/species selection based upon successes and failure of earlier plantings) can be used to meet or exceed project goals as defined by tree, shrub, vine, and herbaceous plant establishment combined with nuisance plant control.

In contrast, periodic monitoring of performance criteria which contain trigger values informs the iterative process of implementing specified adaptive management measures to help achieve ecological success. However, the project area is susceptible to several uncertainties that could significantly impact the ecological success of constructed restoration features as described.

Decisions on the implementation of adaptive management actions are informed by the assessment of monitoring results. The information generated by the monitoring plan will be used by USACE to guide decisions on adaptive management that may be needed to ensure that the mitigation achieves success.

3.5.1 Performance Standards

The following discussion outlines the performance standards associated with the monitoring plan that will support the MKARNS 12-foot Channel compensatory mitigation. The plan identifies performance measures along with desired outcomes and monitoring design in relation to specific objectives. A performance measure includes specific feature(s) to be monitored to determine project performance. Monitoring entails tracking performance metrics of both structural and non-structural features to ensure desired outcomes are being met over time or interject early with adaptive management to address performance issues.

Such criteria, or decision-making triggers, are related to each performance measure and desired outcome and identify the need to discuss potential implementation of adaptive management actions.

Overall, monitoring results will be used to evaluate the progress of habitat mitigation toward meeting project objectives, and to inform the need for adaptive management actions to ensure successful restoration is achieved.

Performance Measure 1: Restore up to 135 acres of bottomland hardwood habitat and 3,629 acres of total marsh habitat. Bottomland hardwood forest would be restored via native plantings, invasive species management and sited in areas with conducive water regime to support the habitat.

Wetland/marsh habitat would be facilitated by notching existing dike fields to restore water connectivity and wetland plantings. Of the 3,629 acres of marsh, 2,225 of those acres coming from restoring back water flows in existing dike fields where flow regime connectivity had been previously lost. The remaining acres would result from notching dikes where total connectivity has not been lost yet to restore habitat function and prevent further loss.

Success Criteria: One year following completion of final construction activities achieve 80% survival of planted woody and herbaceous species on 135 acres of bottomland hardwood habitat. The 80% survival criteria would continue to 10 years after construction.

One year following completion of final construction activities achieve 80% survival of planted emergent wetland and bottomland hardwood habitat plants. The 80% survival criteria would continue to five years after construction. Water depth and river connectivity would also be monitored during growing season months. Frequency of monitoring would be site specific and subject to adjustments for normal, flooding, and drought conditions to establish a range of conditions present in the mitigation area.

Monitoring Design and Rationale: Planted woody and emergent wetland species will be assessed each year during site surveys to determine what percentage of each species of plants have survived. Sites will be evaluated annually from post-construction until success is determined. To determine the increase in acreage, satellite, aerial imagery, and/or handheld GPS devices would be used to identify change pre- and post-construction in years 1-5. Vegetated habitats should be classified using digital aerial imagery and field observation. Monitoring would continue for up to 5 years for wetland habitats and up to 10 years for forested habitats.

Since water regime is paramount to aquatic plant survival, various water related parameters would also be monitoring in areas where dike notches and clearing sediment plugs are meant to facilitate adequate water regime.

Possible Causes for Not Meeting Success Criteria Potential: Failure mechanisms for the successful establishment for the habitats mentioned above may include drought or extreme storm events, predators (invertebrates and vertebrates), incompatible plant species selection, design errors/flaws resulting in inadequate hydrology, and/or reinfestation of non-native invasive and native noxious species.

Additionally, water regime via the dike notches may provide too little (depth and flow) or too much river flow. This can result in either desiccation of aquatic plants or flooding beyond tolerable levels. Dike notches could be too high or low for a site and need adjustments or damages may occur from intense flooding and associated sedimentation.

Adaptive Management Measures: Adaptive management measure would include irrigation or soil amendments during drought conditions; predator control (i.e., enclosures) to ensure the vitality and survival of the plantings; changing the target plant species to those that are more tolerant of site specific abiotic conditions; and modifying the active ingredient/surfactant or application rates of herbicides, changing the treatment methodology (chemical, mechanical, or biocontrol), reinitiating grading, and/or the refinement of the integrated pest management strategy to manage invasive and noxious plant species in the restoration areas.

To manage water regime, dike notching height and removal of flood deposits may be needed to reach success criteria.

Performance Measure 2: Establish overall site biodiversity through increasing plant species taxa richness.

Success Criteria: One year following completion of final construction activities achieve a minimum of a 75% plant species taxa richness depending on initial site conditions, comprised of native species. Five years following construction, maintain or increase level of taxa richness achieved during vegetation establishment efforts during construction phase, comprised of native species.

Monitoring Design and Rationale: The species composition of each site will be sampled annually at the permanent vegetation monitoring sites. Sites will be sampled annually post construction until success is determined. Diversity metrics may consist of species richness, species evenness, and/or other species diversity metrics such as the Shannon Weiner or Simpson Index. This metric is necessary to ensure diverse native vegetation establishes and not a monoculture of native species.

Possible Causes for Not Meeting Success Criteria Potential: Failure mechanisms associated with meeting the species diversity performance measure includes those listed above for performance measure 1.

Adaptive Management Measures: Potential adaptive management measures include those listed above for performance measure 1; however, modifying the plant species used to replace unsuccessful plantings would be the most likely adaptive management measures. This is especially the case when survival of a species is significantly lower than other species planted in the restoration area.

Performance Measure 3: Manage non-native/noxious/nuisance invasive vegetation within mitigation sites.

Success Criteria One year following completion of final construction activities achieve less than 25% average cover of non-native invasive species. Years 2 to 5 following completion of final construction activities achieve average cover of less than 5% non-native invasive species with no area greater than 0.25 acres in size with greater than 10% non-native invasive species.

Monitoring Design and Rationale: Vegetation will be sampled annually at the mitigation site. Permanent vegetation monitoring stations will be established for assessing the vegetation community at each site. Sites will be sampled annually post-construction until success is determined. Initial control/removal of unwanted plants will be evaluated, and determinations made on an annual or semi-annual basis on whether additional action will be needed.

Possible Causes for Not Meeting Success Criteria Possible: Failure modes for invasive species management include ineffective treatment of the invasive species, root sprouting of the invasive plant, reestablishment of invasive species from the seed bank in the restoration areas, or other means such as immigration of invasive species seeds from animals or floodwaters.

Adaptive Management Measures: Adaptive management measures to address failures in invasive species control include modifying the active ingredient/surfactant or application rates of herbicides, changing the treatment methodology (chemical, mechanical, or biocontrol), or modifying the integrated pest management strategy.

Performance Measure 4: Establish up to 165 acres of gravel beds within the Arkansas River

Success Criteria Following completion of final construction activities, establish gravel beds matching the impacted gravel beds gravel quality, depth, and sedimentation rates within 10% variability of the impacted gravel bed sites. Years 2 to 5 following completion of final construction activities, the constructed gravel beds should have similar (within 10%) availability as reference site gravel beds to demonstrate sedimentation is occurring similar to natural conditions in the area and not burying the gravel bars. Any gravel beds built away from reference sites should maintain at least 80% availability through years 2-5.

Monitoring Design and Rationale: Handheld probes, dredges, underwater cameras, and other forms of direct investigation would be used, dependent upon site conditions, to assess and ensure gravel beds are available for spawning use.

Possible Causes for Not Meeting Success Criteria Possible: Failure modes for maintaining gravel bars include incorrect placement of gravel bars in areas where normal sedimentation rates are higher than the area when they currently occur, resulting in a loss of constructed gravel bars. Sedimentation due to large storm events are more unpredictable and less likely to impact year-to-year availability of gravel bars.

Adaptive Management Measures: Adaptive management measures to address failures in gravel bar availability include placing gravel in more favorable hydrologic conditions, or placing gravel in varying depths to create varying flow paths over the beds. This would help maintain sediment free gravel bars.

3.5.2 Vegetation Monitoring

Vegetation sampling associated with the monitoring efforts will occur annually within the mitigation unit for the duration of the monitoring period (5-10 years). Sampling will occur during the peak of the growing season. Permanent 1/10th-acre, field monitoring plots will be located randomly within the mitigation plot. Monitoring will measure percent cover of native and non-native plant species and structural diversity. Photograph stations are also important for documenting vegetation conditions. All plots and photograph stations would be documented via GPS coordinates to replicate in each year of monitoring.

General observations, such as fitness and health of plantings, survival, growth, soil moisture, precipitation, phenology, native plant species recruitment, and signs of drought stress should be noted during the surveys. Additionally, potential soil erosion, flood damage, vandalism, intrusion, trampling, and pest problems would be qualitatively identified. Efficacy of invasive plant management will also be monitored.

A general inventory of all wildlife species observed and detected using the project area would be documented. Nesting sites, roosting sites, animal burrows, and other signs of wildlife use of the newly created habitat and habitat structures would be recorded. The notes would be important for early identification of species colonization patterns.

3.5.3 Long-term Management Plan

The party responsible for ownership and all long-term management of the compensatory mitigation project is USACE. The funding for long-term maintenance will be identified by USACE as needs are identified and appropriated by Congress each fiscal year. The funding for maintenance is established by the fiscal year and will be dependent on the extent of any future needs. Intensive long-term management is not anticipated beyond the required monitoring and maintenance period because all mitigation associated with the MKARNS 12-Foot Channel Project is designed for self-sustainment. The MKARNS 12-Foot Channel Project mitigation plan does not include long-term diversion of water, wetland cell pumps, stop-logs, or any other common water control structures. Impacts to the mitigation site as a result of public disturbance can be addressed under USACE's Title 36 – Parks, Forests, and Public Property. The rules and regulations govern the public use of water resources development projects administered by the Chief of Engineers and all visitors are bound by these Title 36 regulations.

Impacts to Cultural Resources within mitigation sites will be addressed under the appropriate legislation, regulations, and executive orders, including, but not limited to the National Historic Preservation Act (NHPA) of 1966, as amended, the ARPA of 1979 (as amended), and the Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 (as amended) and their implementing regulations. The ARPA compels federal land-holding agencies to protect archaeological sites and artifacts on government land from looting, vandalism, and trafficking, impose and enforce penalties, both Civil and Criminal, against violators of the Act, and better manage archeological sites on public land. The NAGPRA directs federal land-holding agencies to protect Native American burials and burial sites on federal fee lands.

Any wetlands created as an act of compensatory mitigation will fall under regulatory jurisdiction of Section 404 of the Clean Water Act and potentially Section 408 to account for modifications to federal projects depending on any alterations proposed by non-USACE entities.

3.5.4 Costs of Mitigation

The funds necessary to carry out this mitigation plan are provided by the MKARNS 12-foot Deepening Project construction funds. In total, an estimated $119,705,329 would be needed over 10 years to complete the mitigation plan, see Table 19 below for line-item estimates. This estimate includes land acquisition, mitigation construction, funds for USACE staff to monitor success, and contingency for adaptive management implementation.

Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) efforts are not anticipated since the mitigation sites would be designed to be self-sustaining and adaptive management would address any deficiencies that are preventing the site from achieving ecological success. Only in an extreme unforeseen instance, such as by a natural disaster, where the site is degraded after ecological success has been determined would OMRR&R be required. There is no way to potentially predict if or what type of OMRR&R may be required. Therefore, that potential expense is not included in the cost estimates.

Table 19. Mitigation Plan Costs

Task	Cost ($)	Portion of Total Cost
Structural Total	**58,537,128**	**49%**
Construction (dike notches, grading, dredging, etc.)	34,756,116	29%
Adaptive Management	23,781,012	20%
Non-Structural Total	**23,892,208**	**20%**
Vegetation Planting (aquatic and forested)	21,400,000	18%
Non-Structural Adaptive Management	2,492,208	2%
Monitoring Total (Structural and Non-Structural)	**37,275,993**	**31%**
Total	**119,705,329**	**100%**

3.5.5 Design and Construction

Construction details for the elements of the mitigation work plan will be developed during design phases as part of the development of plans and specifications for procurement of services to construct the proposed mitigation. Design dimensions and construction specifications would be shared and coordinated with state resources agencies, USFWS, NRCS, and other resource agencies for input. Design is anticipated to begin as soon as late 2024 on mitigation plan sequencing and monitoring planning efforts.

3.6 Schedule

Construction of some mitigation features has already occurred. Updated restored footprints, their performance status, and mitigation accounting of completed efforts would begin in 2024 to refine future mitigation needs, construction timing, and monitoring needs. Construction, monitoring, and adaptive management efforts would continue for approximately 10 years with varying completions date based on when each mitigation feature completed initial construction.

4.0 REFERENCES

Engineer Regulation 1105-2-100 Planning Guidance Notebook. Appendix C – Environmental Evaluation and Compliance. (Note: expected to be replaced by EP 1105-2-60 later in 2022)

Implementation Guidance for Section 906 of WRDA 1986, as amended by Section 1040 of WRRDA 2014 and Section 1162 of WRDA 2016. Fish and Wildlife Mitigation. Issued 8-Mar-2019.
https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll5/id/35384

Implementation Guidance for Section 906 of WRDA 1986 as amended by Section 2036(a) of WRDA 2007. Fish and Wildlife Mitigation. Issued 31-Aug-2009.
https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll5/id/386

Implementation Guidance for Section 2036(c) of WRDA 2007, as amended by Section 1163 of WRDA 2016. Mitigation Banks and In-Lieu Fee Arrangements. Issued 8-Mar-2019. https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll5/id/35385

USACE. 2004. Aquatic Resources Mitigation Plan Required Elements [33 CFR 332].
California Soil Resource Lab. 2008. SoilWeb Earth. Accessed on 23 May 2021.

5.0 LIST OF PREPARERS

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Attachment 1: Habitat Modeling Data

Bottomland Hardwood Forest Habitat

Habitat Modeling

Table 1. Future-Without Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	HSI	HUs	CHUs	AAHUs
BLHF	0	74	1.00	1.00	0.88	1.00	0.63	0.80	0.66	0.67	0.65	0.52	0.43	0.61	45.14		
	1	74	1.00	1.00	0.88	1.00	0.63	0.80	0.66	0.67	0.65	0.52	0.43	0.61	45.14	45.14	
	5	74	1.00	1.00	0.88	1.00	0.63	0.80	0.66	0.67	0.65	0.52	0.43	0.61	45.14	180.56	
	25	74	1.00	1.00	0.88	1.00	0.63	0.80	0.66	0.67	0.65	0.52	0.43	0.61	45.14	902.80	
	50	74	1.00	1.00	0.88	1.00	0.63	0.80	0.66	0.67	0.65	0.52	0.43	0.61	45.14	1128.50	**45**

Table 2. Future-With Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	HSI	HUs	CHUs	AAHUs
BLHF	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	5	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	25	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	50	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0**

Mitigation Modeling

Table 3. Future-Without Project Conditions: Agriculture/Barren/Non-Forested Area

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	HSI	HUs	CHUs	AAHUs
AG	0	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70		
	1	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70	2.70	
	5	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70	10.80	
	25	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70	54.00	
	50	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70	67.50	**3**

Table 4. Future-With Project Conditions: Planting Bare Root Trees for BLH Forest

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	HSI	HUs	CHUs	AAHUs
BLHF	0	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70		
	1	135	0.00	0.00	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70	2.70	
	5	135	0.15	0.05	0.00	0.00	0.13	0.80	0.30	0.67	0.00	0.52	0.43	0.02	2.70	10.80	
	25	135	0.60	0.50	0.75	0.94	0.38	0.80	0.48	0.67	1.00	0.52	0.43	0.48	64.80	675.00	
	50	135	0.75	0.75	0.75	0.94	0.38	0.80	0.57	0.67	0.83	0.52	0.43	0.52	70.20	1687.50	**48**

Marsh Habitat

Habitat Modeling

Table 1. Future-Without Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	HSI	HUs	CHUs	AAHUs
Marsh	0	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24		
	1	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24	3780.24	
	5	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24	15120.96	
	25	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24	75604.80	
	50	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24	94506.00	**3780**

Table 2. Future-With Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	HSI	HUs	CHUs	AAHUs
Marsh	0	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24		
	1	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24	3780.24	
	5	4974	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3780.24	15120.96	
	25	3083.88	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	2343.75	61239.89	
	50	1193.76	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	907.26	40637.58	**2416**

Mitigation Modeling

Table 3. Future-Without Project Conditions: Low Quality/Non-Wetland Habitat

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	HSI	HUs	CHUs	AAHUs
Marsh	0	5854	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	4449.04		
	1	5854	0.75	0.21	1.00	0.60	0.89	0.80	0.90	0.90	0.67	3922.18	4185.61	
	5	5854	0.50	0.21	1.00	0.60	0.89	0.80	0.90	0.90	0.64	3746.56	15337.48	
	25	3629.48	0.50	0.08	1.00	0.10	0.55	0.80	0.90	0.90	0.50	1814.74	54574.89	
	50	1404.96	0.00	0.08	1.00	0.10	0.55	0.80	0.90	0.90	0.47	660.33	30660.33	**2095**

Table 4. Future-With Project Conditions: Dike Notching

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	V7	V8	HSI	HUs	CHUs	AAHUs
Marsh	0	5854	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	4449.04		
	1	5854	0.75	0.21	1.00	0.60	0.89	0.80	0.90	0.90	0.67	3922.18	4185.61	
	5	5854	0.50	0.21	1.00	0.60	0.89	0.80	0.90	0.90	0.64	3746.56	15337.48	
	25	4741.74	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	3603.72	73947.73	
	50	3629.48	1.00	0.75	1.00	0.60	0.89	0.80	0.90	0.90	0.76	2758.40	79526.59	**3460**

Gravel Bar Habitat

Habitat Modeling

Table 1. Future-Without Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	HSI	HUs	CHUs	AAHUs
GB	0	165	0.45	0.45	66	3	0.4	6	1.00	165.00		
	1	165	0.45	0.45	66	3	0.4	6	1.00	165.00	165.00	
	2	165	0.45	0.45	66	3	0.4	6	1.00	165.00	165.00	
	5	165	0.45	0.45	66	3	0.4	6	1.00	165.00	495.00	
	50	165	0.45	0.45	66	3	0.4	6	1.00	165.00	7425.00	**165**

Table 2. Future-With Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	HSI	HUs	CHUs	AAHUs
GB	0	0	0.45	0.45	0	3	0.4	6	0.00	0.00		
	1	0	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	
	2	0	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	
	5	0	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	
	50	0	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	**0**

Mitigation Modeling

Table 3. Future-Without Project Conditions

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	HSI	HUs	CHUs	AAHUs
GB	0	165	0.45	0.45	0	3	0.4	6	0.00	0.00		
	1	165	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	
	2	165	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	
	5	165	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	
	50	165	0.45	0.45	0	3	0.4	6	0.00	0.00	0.00	**0**

Table 4. Future-With Project Conditions: Replacing Gravel Bars (1:1)

Cover Type	TY	Acres	V1	V2	V3	V4	V5	V6	HSI	HUs	CHUs	AAHUs
GB	0	165	0.45	0.45	66	3	0.4	6	1.00	165.00		
	1	165	0.45	0.45	66	3	0.4	6	1.00	165.00	165.00	
	2	165	0.45	0.45	66	3	0.4	6	1.00	165.00	165.00	
	5	165	0.45	0.45	66	3	0.4	6	1.00	165.00	495.00	
	50	165	0.45	0.45	66	3	0.4	6	1.00	165.00	7425.00	**165**