Chapter 8
Impacts Summary & Mitigation

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CHAPTER 8:

IMPACTS SUMMARY & MITIGATION

8.1 Introduction

The following summarizes the potential environmental consequences of the alternatives developed and discussed in Chapters 5, 6, and 7. Potential environmental impacts are identified by resource category and are characterized by their relative magnitude as described in Section 5.1. A summary of mitigation measures follows the summary of impacts. The first result of implementation of the mitigation measures proposed is that where possible adverse impacts were avoided or minimized. When avoidance or minimization of impacts was not achievable, adverse impacts to the environment resulting from an action alternative would be mitigated through compensation, rectification and reduction. Determination of the required function and value of the impact and mitigation was performed through analytical and quantitative analysis. The final result is that implementation of the mitigation measures will serve to avoid, minimize, reduce, compensate or rectify all potential adverse impacts to the environment if any of the project alternatives are carried out. In addition, to ensure the desired results of the mitigation measures are achieved, a long-term monitoring program is being established and an adaptive management plan was developed to make modifications to measures when necessary to achieve the intended quality outputs.

8.2 Summary of Impacts

Impacts to all resource categories are summarized on Table 8-1. This table is a consolidated index of impacts; for a full detail of impacts refer to Table ES-3 or Chapters 4, 5, and 6.

Table 8-1. Summary of Environmental Consequences

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Air Quality	**No Impact**	**No Impact**	**No Impact**	**No Impact**	**No Impact**

Table 8-1. Summary of Environmental Consequences					
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**	**Alternative E**
Noise	**No Impact**	**No Impact**	**No Impact**	**Minor Adverse**	**Minor Adverse**
Geology and Soils	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
Surface Water	**No Impact**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
			Minor Beneficial	**Minor Beneficial**	**Minor Beneficial**
Land Use	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
			Minor Beneficial	**Minor Beneficial**	**Minor Beneficial**
		Minor Adverse Cumulative	**Minor Adverse Cumulative**	**Minor Adverse Cumulative**	**Minor Adverse Cumulative**
Infrastructure	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
		Minor Beneficial	**Minor Beneficial**	**Major Beneficial**	**Major Beneficial**
	Minor Adverse Cumulative		**Minor Beneficial Cumulative**	**Minor Beneficial Cumulative**	**Minor Beneficial Cumulative**

Table 8-1. Summary of Environmental Consequences					
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**	**Alternative E**
Biological Resources					
T & E Species	**Minor Adverse**	**Minor Adverse**	**Minor Beneficial**	**Minor Beneficial**	**Minor Beneficial**
			Minor Adverse	**Minor Adverse**	**Minor Adverse**
Wetlands	**Minor Adverse**	**No Impact**	**No Impact**	**No Impact**	**No Impact**
Aquatic Resources	**No Impact**	**Minor Adverse**	**Minor Adverse**	**Major Adverse**	**Major Adverse**
				Minor Adverse	**Minor Adverse**
Terrestrial Resources	**Major Adverse**	**Minor Adverse**	**Minor Adverse**	**Major Adverse**	**Major Adverse**
	Minor Adverse Cumulative	**Minor Adverse Cumulative**	**Minor Adverse Cumulative**	**Minor Adverse Cumulative**	**Minor Adverse Cumulative**
Recreation and Aesthetic Values	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
			Minor Beneficial	**Minor Beneficial**	**Minor Beneficial**

Table 8-1. Summary of Environmental Consequences					
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**	**Alternative E**
Cultural Resources	**No Impact**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
	Minor Cumulative Adverse	**Minor Cumulative Adverse**	**Minor Cumulative Adverse**	**Minor Cumulative Adverse**	**Minor Cumulative Adverse**
Sociological Resources	**No Impact**	**No Impact**	**Minor Beneficial**	**Minor Beneficial**	**Minor Beneficial**
				Minor Adverse	**Minor Adverse**
Economic Resources	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**	**Minor Adverse**
		Minor Beneficial -	**Major Beneficial**	**Major Beneficial**	**Major Beneficial**

8.3 Mitigation Summary

Mitigation measures would be implemented by the USACE to eliminate or reduce the impact of adverse impacts as defined in 40 CFR 1508.20: "Mitigation" includes:

1) Avoiding the impact altogether by not taking a certain action or parts of an action;
2) Minimizing impacts by limiting the degree of magnitude of the action and its implementation;
3) Compensating for the impact by replacing or providing substitute resources or environments;
4) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; and/or
5) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

Only those mitigation measures that are practicable (i.e., can be accomplished using existing technology with a reasonable commitment of resources) have been identified. In addition to the mitigation commitments identified in this EIS, the USACE would continue to use a wide range of ongoing environmental management programs, Best Management Practices (BMPs), Standard Operating Procedures (SOPs), monitoring programs, and permit compliance procedures to lessen the type and magnitude of adverse impacts identified in this EIS. The USACE would adhere to all permit conditions in effect at the time the action occurs, under any circumstance.

8.3.1 No Action Alternative

As discussed throughout Chapters 5-7, implementation of the No Action Alternative may result in adverse impacts to the environment. In general these impacts are associated with the routine maintenance of the MKARNS. The USACE would implement the following mitigation measures for adverse impacts associated with the No Action Alternative as they might occur:

- Adhere to all permit conditions associated with MKARNS maintenance activities;
- Continue natural resources management programs including, endangered species management plan provisions, land management, pest control, forest management, and soil erosion control. Continued close coordination with other Federal and state agencies; and
- Continue the dike-notching program in coordination with Arkansas Game and Fish Commission (AGFC) and state agencies to improve aquatic habitat within the MKARNS.

8.3.2 Action Alternatives

Mitigation for adverse impacts associated with the implementation of the proposed action is summarized below for the following resource categories:

- Biological/Geomorphological Resources, and
- Cultural Resources.

8.3.2.1 Biological/Geomorphological Resources

Mitigation would be conducted for adverse impacts associated with implementing the proposed action. Mitigation for terrestrial and aquatic impacts would consist of a combination of avoidance, minimization, and compensation. The mitigation has been developed in coordination with the USFWS, the Arkansas Game and Fish Commission (AGFC), and the Oklahoma Department of Wildlife and Conservation (ODWC). Mitigation would be associated with:

- Terrestrial habitat loss associated with the disposal of dredged material;
- Aquatic habitat loss associated with dredging and dredged material disposal;
- Aquatic habitat loss associated with raising and extending dikes and revetments;
- Impacts to mussel beds from dredging and disposal; and
- Federal threatened and endangered species.

8.3.2.1.1 Terrestrial Habitat Mitigation

Avoidance and Minimization

As part of the mitigation process, dredged material disposal sites were selected based upon criteria for avoidance and minimization. Wherever possible, potential dredged material disposal

sites were not located where they would impact mature upland forest, bottomland hardwoods, or wetlands. Where sites could not be located outside these three habitat types, the design of the pit was configured to reduce 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. This ultimately reduced the acreage of land needed for mitigation.

Compensation, Rectification, and Reduction

The USACE and the Oklahoma resource agencies developed a list of ten potential mitigation sites. These sites were evaluated to determine the amount and type of habitat that could be created to mitigate for habitat lost during dredged material disposal on terrestrial sites. All of the potential mitigation sites are currently agricultural land. Two sites were selected that satisfied all agencies involved and fulfilled the acreage and habitat quality requirement needed to mitigate for the projected habitat loss. These sites were preferred because they are adjacent to Oklahoma Department of Wildlife Conservation (ODWC) currently managed lands. These sites would form a contiguous wildlife corridor with ODWC property, and allow ODWC to easily maintain and operate the mitigation sites. Figure C.5-2 in Appendix C shows a map of the mitigation sites selected.

The Engineer Research and Development Center's Environmental Laboratory (ERDC-EL) used the Habitat Evaluation Procedure (HEP) to evaluate impacts from dredged material disposal and determine mitigation needs. The full HEP analysis used to determine the mitigation needs is described in Appendix C. In HEP, a Habitat Suitability Index (HSI) model is a quantitative estimate of habitat conditions for an evaluation species or community. The HEP is designed to evaluate the future changes in quantity (acres) and quality (habitat suitability and functional capacity) of terrestrial ecosystems. Outputs are calculated in terms of annualized changes anticipated over the life of the project [i.e., Average Annual Habitat Units (AAHUs)].

The assumptions for mitigation were as follows:

- All terrestrial disposal areas would be continually disturbed and have no fish and wildlife value.
- All mitigation sites begin as agricultural cropland (AGCROP).
- Under the No Action Alternative all mitigation sites remain the same cover type and quality over time.
- The USACE and the resource agencies agreed that the mitigation sites would be flooded and maintained to facilitate development of marsh and bottomland forest habitat. Between the time the sites are flooded with water and the time that bottomland hardwood forest (BLHFOREST) would develop, the sites would be considered newly created marsh (NEWMARSH). ERDC suggested using the Marsh Wren Habitat Suitability Index (HSI) model published by the USFWS with the modifications of adding the landscape parameters to capture the NEWMARSH creation.
- BLHFOREST could only be replaced with newly created BLHFOREST (NEWBLHFOREST).
- Upland forest (UPFOREST) could only be replaced with NEWBLHFOREST.
- Old field (OLDFIELD) and open field (OPENFIELD) could be replaced with NEWBLH forest and/or NEWMARSH.

Table 8-2 shows the total acres and Annual Average Habitat Units (AAHUs) of terrestrial habitat that could potentially be lost during 50 years of dredged material disposal.

Table 8-2. Acres and AAHUs of Each Habitat Type Potentially Lost Via Dredged Material Disposal Over the Entire 50 Years of the Project.

BLHFOREST		UPFOREST		OLDFIELD		OPENFIELD	
Acres Lost	AAHUs Lost	Acres Lost	AAHUs Lost	Acres Lost	AAHUs Lost	Acres Lost	AAHUs Lost
-15	**-7.3**	**-287**	**-76.4**	**-220**	**-123.8**	**-170**	**-71.0**

Source: ERDC-EL, 2004b

The mitigation sites were analyzed with HEP, which resulted in the identification of 130 acres of newly created bottomland forest and 248 acres of newly created marsh (Table 8-3).

Table 8-3. Acres and AAHUs Gained by Habitat Type at Two Mitigation Sites Over the Entire 50 Years of the Project.

	BLHFOREST		UPFOREST		OLDFIELD		OPENFIELD		MARSH	
Mitigation Site	Acres Gained	Net AAHUs Gained	Acres Gained	AAHUs Gained	Acres Gained	AAHUs Gained	Acres Gained	AAHUs Gained	Acres Gained	AAHUs Gained
OK408.9L-M	**69**	**48.3**	0	0.0	0	0.0	0	0.0	**91**	**66.6**
OK405.0L-M	**61**	**42.7**	0	0.0	0	0.0	0	0.0	**157**	**131.3**
Totals	**130**	**91.0**	0	0.0	0	0.0	0	0.0	**248**	**197.9**

Source: ERDC-EL, 2004b

It was determined through the HEP analysis that 302 acres of forested habitat and 390 acres of grassland habitat would be lost with the use of all potential dredged material disposal sites over the 50-year project life. A total of 130 acres of higher quality bottomland forest habitat and 248 acres of higher quality marsh habitat would mitigate for these lost acres through wetland creation along portions of the MKARNS.

The "Net HSI Gain" column in Table 8-3 is the level of quality that the mitigation would be designed to meet. The new bottomland forest and marsh habitat created would mitigate for the impacts from disposing dredged material on the terrestrial sites because the quality of the habitat created through mitigation (HSI = 0.70-0.75) is much higher than that lost through dredged material disposal (0.28-0.50), and therefore, far fewer acres of new habitat is required to compensate for it.

The actual acreages needed to fully mitigate for the forest and grassland habitat lost is 120 acres of bottomland forest and 258 acres of marsh (0.7 HSI * 120 acres = 84 AAHUs of bottomland forest; 0.75 HSI * 258 acres = 194 AAHUs). Approximately 10 surplus acres of NEWBLHFOR created and a shortage of 10 acres of NEWMARSH would be created, resulting in no total surplus or shortage of acres. Table 8-4 shows these results.

Table 8-4. Summary of Acres, AAHUs, and Annual HSI Lost on Dredged Material Disposal Sites and Gained on Mitigation Sites.

Mitigation Sites Selected: OK408.9L-M, OK405.0 L-M

Cover Type Mitigated For	Sum of Acres Lost	Sum of AAHUs Lost	Average Annual HSI of Acres Lost	Total Acres of Proposed Mitigation Sites Combined	Net Gain in AAHUs from Mitigation Plans	Net HSI Gain	# Acres Needed to Fully Mitigate	Surplus or Shortage of Acres	Mitigation Ratio
FOREST (BLHFOREST, UPFOREST)	**-302**	**-83.7**	**0.28**	**130 (NEWBLHFOR)**	**91.0**	**0.70**	**120**	**10**	**0.4:1**
GRASSLAND (OLDFIELD, OPENFIELD)	**-390**	**-194.0**	**0.50**	**248 (NEWMARSH)**	**187.0**	**0.75**	**258**	**-10**	**0.7:1**
							Total Surplus or Shortage of Acres:	**0**	

Source: ERDC-EL, 2004b

8.3.2.1.2 Aquatic Habitat Mitigation

Introduction

The primary impacts to aquatic habitat as a result of dredging and deepening the channel were determined to be the following:

- The loss of side channel/slack water habitat resulting from open water dredge disposal in dike fields;
- The loss of side channel/slack water habitat resulting from raising dikes and revetments, which accelerates fill rates;
- Removal or alteration of gravel bars through dredging; and
- Impacts to aquatic organisms and habitat through dredging.

Due to the lack of available baseline data on the MKARNS, the scope of the proposed action, and uncertainty of success of some mitigation measures, long term monitoring and adaptive management will be required to insure all impacts are identified and mitigated for. The proposed long term monitoring and adaptive management plan is presented in Appendix C.

ERDC-EL performed an aquatic HEP analysis for potential dike field impacts in coordination with the USFWS, AGFC, ODWC, and the Tulsa and Little Rock USACE Districts. This interagency group provided ERDC with all available information and expertise and developed the following mitigation measures.

Mitigation measures were grouped into the following eight broad categories:

- Relocate disposal areas to avoid valuable aquatic habitat and lessen impacts;
- Notch dikes and revetments to reduce fill rates and create side channel habitat;

- Relocate gravel from in-channel to adjacent to the channel to prevent loss from the system;
- Reconnect/improve connections to backwaters and side channels;
- Create islands where feasible with disposal material for aquatic diversity and tern habitat;
- Create marsh habitat to minimize disposal impacts;
- Perform long-term monitoring and adaptive management.
- Mitigate for impacts to the mussel fauna of the MKARNS (see Appendix C for details).

Impacts. The engineering and HEP analysis for dike field impacts concluded that Pool 2 (NM 19-50) contained the most proposed dredge disposal areas, but due to anticipated higher filling rates, Pools 12 (NM 257-292) and 10 had the greatest aquatic impacts for the Alternative D (66.1 AAHU impacted) and Alternative E (112.6 AAHU impacted) alternatives, respectively. Pool 2 also provided for the most benefits of any one pool with 135.3 AAHU gained with mitigation Alternative D and 104.3 AAHU gained for Alternative E. Pool 14 (NM 319-336) and the Post Canal (NM 19 to White River) contained only proposed mitigation and did not contribute to the overall project impacts. For the entire project (Arkansas and Oklahoma combined), Alternative D would result in a loss of 391 AAHU. However, mitigation for Alternative D would result in a gain of 494 AAHU. Impacts from Alternative E would result in a loss of 664 AAHU while approved mitigation projects equaled 772 AAHU for a net yield of 108 AAHU.

Table 8-5. Summary of HEP Analysis for Aquatic Disposal Impacts and Mitigation

Location	Total Existing AAHUs	AAHUs Impacted by Alt D	Total AAHUs, Alt D, with Mitigation	Change in AAHUs Relative to Baseline, Alt D with Mitigation	AAHUs Impacted by Alt E	Total AAHUs, Alt E, with Mitigation	Change in AAHUs Relative to Baseline, Alt E with Mitigation
Arkansas							
Canal	22	0	26	4	0	26	4
Pool 2	700	-47	836	136	-63	805	104
Pool 3	93	-4	110	17	-10	100	7
Pool 4	108	-2	170	62	-3	169	61
Pool 5	374	-51	392	18	-85	343	-31
Pool 6	55	0	87	32	0	87	32
Pool 7	395	-57	432	36	-78	385	-10
Pool 8	151	-21	161	11	-29	149	-1
Pool 9	536	-42	559	22	-110	472	-64
Pool 10	440	-45	526	86	-113	438	-2
Pool 12	425	-66	399	26	-107	351	-74

Table 8-5. Summary of HEP Analysis for Aquatic Disposal Impacts and Mitigation							
Location	**Total Existing AAHUs**	**AAHUs Impacted by Alt D**	**Total AAHUs, Alt D, with Mitigation**	**Change in AAHUs Relative to Baseline, Alt D with Mitigation**	**AAHUs Impacted by Alt E**	**Total AAHUs, Alt E, with Mitigation**	**Change in AAHUs Relative to Baseline, Alt E with Mitigation**
Pool 13	24	0	39	14	0	39	14
Oklahoma							
Pool 13	12	0	24	12	0	24	12
Pool 14	91	0	131	41	0	131	41
Pool 15	32	-14	16	16	-17	14	-18
Pool 16	134	-17	161	26	-21	156	21
San Bois Creek	46	-23	29	17	-28	23	-23
Pool 17	128	0	165	37	0	165	37
Pool 18	11	0	11	0	0	11	0
Arkansas	3326	-337	3,737	411	-598	3,364	38
Oklahoma	455	-54	538	83	-66	525	70
TOTAL	3,780	-391	4,275	494	-664	3,889	108
Source: ERDC-EL, 2005							

Additional impacts for the Verdigris River were identified. The Verdigris River was straightened and channelized to provide a reliable navigation channel. The channel was shortened from cutoffs, high spoil banks were created on both sides for 50 miles, and the floodplain and associated backwaters became isolated from the river. Isolation of backwaters prevents transfer of organic matter and nutrients between river and floodplain and reduces important spawning and rearing areas for fishes. The navigation channel is 150 feet wide in the Verdigris River compared to a 250-foot channel in the Arkansas River. Therefore, impacts of navigation-related activities have been proportionally greater in the narrow, incised channel of the Verdigris River compared to the wider channel in the Arkansas River. To quantify this impact, the number of acres associated with the navigation channel in Verdigris River pools (i.e., 909.1 acres) was multiplied by an HSI of 0.1, indicating low habitat quality for existing conditions, to obtain impacts of 91 AAHU for both alternatives. These additional impacts when compared to the mitigation resulted in a net gain of 403 (494-91) and 17 (108-91) AAHU for Alternatives D and E, respectively. Impacts from aquatic disposal and mitigation are summarized in Tables 8-5. The complete Aquatic Evaluation Report and HEP analysis are located in Appendix C.

Table 8-6. Summary of Final Dredging and Disposal Impacts and Mitigation							
Location	**Total Existing AAHUs**	**AAHUs Impacted by Alt D**	**Total AAHUs, Alt D, with Mitigation**	**Change in AAHUs Relative to Baseline, Alt D with Mitigation**	**AAHUs Impacted by Alt E**	**Total AAHUs, Alt E, with Mitigation**	**Change in AAHUs Relative to Baseline, Alt E with Mitigation**
Arkansas	3326	-337	3,737	411	-598	3,364	38
Oklahoma	546	-145	538	-8	-157	525	-21
TOTAL	3,872	-482	4,275	403	-755	3,889	17
Adjusted for Incremental Cost Analysis							
TOTAL	3,872	-482	4,275	403	-755	3,880	8

The mitigation for dike field/slackwater impacts includes approximately 200 dike/revetment notches, maintaining or dredging the openings to 30 backwaters or side channels, modifying or moving 75 disposal areas, and constructing islands in 30 locations. Table 8-6 summarizes the mitigation by location, category, description and if it was technically acceptable. Developing the mitigation was a sequential process. Measures such as purchasing oxbow lakes were not considered feasible due to costs. All measures that were considered feasible were evaluated in the HEP analysis. Approximately 20 recommended measures were not approved from an engineering technical standpoint primarily because they either threatened the stability of the shoreline or the navigation channel. Finally, all approved mitigation measures were analyzed according to their cost effectiveness. In Oklahoma, all mitigation features were retained since they had a net AAHU deficit. In Arkansas, only two measures, dredging Rector Brake at NM 131.0L and dredging a small backwater area at NM 116.2R, were eliminated due to cost effectiveness. The remainder of the measures, including five that were not as cost effective as those chosen, were retained as part of the USACE environmental sustainability initiative. The Incremental Cost Analysis is discussed in more detail in Appendix C. A final summary of mitigation measure outputs for dredging and disposal impacts is shown in Table 8-7.

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
Canal			
15.3R	Compensate	Reconnect Lower Merrisach Lake to river with culvert or water control structure for fish passage	Approved
Pool 2			

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
19.0R	Minimize	Construct island with disposal material	Approved-recommend constructing on existing island so it will stay
19.8L	Compensate	Notch existing revetment (1)	Approved
22.8R	Compensate	Maintain entrance to Coal Pile backwater by periodically dredging	Approved
23.6 R	Avoid	Avoid right bank disposal	Approved
23-24L	Minimize	Construct string of islands with disposal material	Approved
23-24L	Minimize	Construct string of islands with disposal material	Approved
24-25L	Minimize	Notch modified revetment (2) and modified dike (1)	Approved-recommend fish notch only in modified dike
27L	Avoid	Avoid aquatic disposal, utilize land	Approved
27.5-29R	Minimize	Notch modified dikes (4) and existing dike (1)	Approved-10' notches instead of 20' due to narrow channel
27.8-28.5L	Minimize	Notch modified revetment (1) and existing dike (1)	Approved-20' revetment notch, 10' dike notch
31.7-32.8R	Minimize	*Existing tern island – enhance/create islands where feasible and avoid June-August construction, utilize disposal area and extend downstream to NM 31.0R	Approved
32.2R	Avoid & Compensate	Maintain entrance to oxbow lake channel by avoiding disposal and periodically dredging	Approved
32L	Minimize & Compensate	Notch revetments (4) and existing dike (1)	Approved
31.8-33.1L	Avoid & Minimize	Avoid left bank disposal, utilize right bank, notch modified revetment (4) and existing dike (1) across backwater	Approved
35R	Minimize	Notch modified dikes (2)	Not approved-due to bend and bank erosion, however, engineers stated that this area would not likely fill due to its location.
35.3-36.5L	Minimize	*Existing tern island – enhance/create islands with disposal material where feasible and avoid June-August construction	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
36-36.5L	Minimize & Compensate	Notch modified dikes (3) and existing dike (1)	Partially approved-due to proximity to bank, engineers agreed that two longest dikes could be notched, but not all four.
36.4-37.0R	Minimize	Extend disposal area upstream to 38.1R, avoid blocking entrance to chute at 36.4R and 38.1R	Approved
37.5-38.6L	Minimize	Notch raised L-dikes	Not Approved due to short length of dikes
37.8-38.4L	Avoid & Minimize	Avoid disposal, utilize right bank.	Approved
38.8L	Avoid & Minimize	Avoid disposal, utilize right bank, notch modified revetment	Approved
39.8L	Minimize	Notch modified revetment at 39.3L and 39.7L	Approved
38.8-39.6R	Minimize & Compensate	*Existing tern island, notch existing dikes (5) and enhance/construct tern islands where feasible	Approved
40R	Minimize	Notch existing revetment/dike (1)	Not approved-erosion problem area
39.8-40.0L	Avoid	Avoid disposal, utilize right bank	Approved
42.1-42.7L	Minimize	*Existing tern island, use disposal to enhance/construct tern islands, notch backside of existing dikes to maintain flow and islands 42.5L	Approved
42.3-43.3L	Minimize & Compensate	Construct islands with disposal material and notch existing (3) dikes	Approved
42.8-44.6R	Minimize & Compensate	Notch existing and modified dikes (10-12)	Not approved-this is one of worst depositional areas on river and notches would make short dikes ineffective.
42.8-43R	Avoid & Minimize	Utilize this disposal area, notch existing and modified dikes (10-12) and extend disposal upstream	Partially Approved-utilizing this area for disposal is approved, but notching dikes is not.

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
43.4-44.1L	Avoid & Minimize	Avoid disposal in left bank aquatic areas, utilize land and right bank disposal, notch existing dikes/revetments (3)	Partially Approved-avoiding disposal in this area is approved, but engineers only want most downstream part of revetment notched in 1 place rather than 3 places as recommended since this area has an erosion problem.
44-44.7R	Minimize	Utilize AR44.3R-D for disposal and extend downstream to 43.0R	Approved
44.6L	Compensate	Maintain a 1/2 mile entrance to Little Bayou Meto (44.6L) and 1/2 mile entrance at upstream end of Bayou Meto by periodically dredging	Approved
46.2R	Minimize	Notch modified revetment/dike (1)	Not approved-engineers do not want notches on right bank
45.4-46L	Avoid	Avoid disposal in aquatic areas of AR45.3L-D, dispose on land or preferably on right bank	Approved
46.5-46.7L	Minimize	Notch modified revetment (1)	Not approved-see note below
45.4-47.3R	Minimize & Compensate	Construct islands with disposal material where feasible in AR46.5R-D, utilize two most downstream cells for disposal first, notch dikes/revetments (4-8)	Partially approved-disposal in this area is approved, but engineers do not want any notches
48.7-48.9R	Minimize	Notch modified dikes (4)	Approved
46.8-49.2L	Avoid & Minimize	Utilize land within cells for disposal at AR48.0L-D, avoid aquatic areas	Approved
48.7-50.2R	Avoid & Minimize & Compensate	Utilize land within cells for disposal in 49.4R-D, avoid aquatic areas, notch existing revetments/dikes in two most upstream cells (2)	Approved
49.6-49.9	Avoid	Utilize existing in-channel disposal	Approved
Pool 3			
50.9L	Compensate	Maintain entrance to Swan Lake backwater by periodically dredging	Approved
58.3L	Compensate	Notch revetment at 58.3L	Approved-need to check, there may be another levee inside the revetment

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
61.0-62.1L	Minimize	*Probable tern island on right bank, avoid aquatic areas in AR61.4L-D, utilize land within disposal cells or enhance/create tern islands on right bank	Approved
61.5-62.5R	Minimize	Place disposal in string of islands along right bank	Approved
64-65R	Avoid & Compensate	Avoid disposal in AR64.5R-D, notch existing revetments and/or dikes (3)	Approved
64.8-65.3L	Avoid & Minimize	Utilize AR65.2L-D or in-channel disposal at AR65.5Channel-D	Approved
65.2-65.6	Avoid & Minimize	Utilize AR65.2L-D or in-channel disposal at AR65.5Channel-D	Approved
Pool 4			
70.0-70.7L	Minimize	Notch two longest existing dikes (2)	Approved
70.6L	Compensate	Maintain channel to backwater by periodically dredging	Approved
71.3L	Compensate	Dredge canals that connect to Lake Langhofer	Approved
75.3L	Compensate	Maintain channel to backwater by periodically dredging	Approved
78.7L	Compensate	Dredge mouth of Pastoria Bend chute and periodically dredge to maintain and notch existing dike (1) if needed to open access to backwater	Approved
78.9-79.7L	Avoid & Minimize	79.0L - First option - Inquire about upland disposal on Pine Bluff Arsenal property first to avoid any impacts, second option - investigate island disposal upstream on left bank at 80.1, third option to place in proposed location and notch modified dikes (4)	Approved-third option (AR79.0L-D) is most likely since there are security issues with disposing on PB Arsenal property and engineers do not want dikes on left bank notched for island construction upstream at 81L.
80.0-82.0L	Minimize & Compensate	Place disposal along dike fields to create islands and notch backside of dikes (9) at 80-82L	Not approved-see comment above.
82.6R	Compensate	Notch existing dike and maintain entrance to backwater at 82.6R by periodically dredging	Approved
82.5-85.5R	Compensate	Notch existing dikes along right bank (14)	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
85.5-85.8R	Avoid & Minimize	Avoid disposal if possible and utilize in-channel disposal	Approved
85.6-85.8	Minimize	Utilize in-channel disposal	Approved
Pool 5			
87.7L	Compensate	Investigate dredging channel into oxbow lake	Not approved-this is highly unlikely due to ownership issues.
88.2R	Compensate	Maintain entrance to Tar Camp Creek by periodically dredging	Approved
90.5-91.0L	Minimize	Construct island(s) at 90.5-91.0L behind underwater revetment	Approved
91.4-91.7R	Avoid & Minimize	Recommend constructing island downstream at 90.5-91.0L behind underwater revetment, if proposed location must be utilized, place disposal off bank and create island(s) and notch backside of existing dikes	Approved-see comment above, island will be constructed on left bank.
91.5L	Compensate	Bank stabilization and revetment at 91.5 is needed (current – 0.3)	Approved
92.6L	Compensate	Notch existing revetment (1) and maintain entrance to backwater with periodic dredging	Approved
94	Compensate	Notch existing revetment (1)	Approved
94.3-96.3L	Avoid & Minimize & Compensate	Avoid aquatic disposal in uppermost cells of AR95.5L-D, extend disposal area downstream to create a series of islands for a braided system and terns, notch existing dikes (5) to enhance backwater areas	Approved
96.0-98.2R	Minimize	Enlarge and utilize right bank disposal, investigate disposing behind modified revetment and dikes	Approved
98.5R	Compensate	Notch existing revetment to access backwater (1)	Approved
99.4L	Compensate	Notch existing revetment to access backwater (1)	Approved-engineers recommended fish notch
100.3-101.1L	Compensate	Notch existing dikes (2), *existing tern island on left bank, avoid work during nesting season	Partially approved-engineers are okay with notch at 100.3L, but not 101.1L.
100.6-101.3R	Minimize	Utilize this area as alternative disposal site	Approved
102-104R	Minimize	Utilize right bank disposal as alternative, construct/enhance tern islands if feasible	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
101.5-103.7L	Avoid & Compensate	Avoid disposal, notch existing dikes (10-12) for flow-through and to enhance diversity	Partially approved-engineers approved notching the 6 longest most downstream L-dikes, but not all of the dikes since notching the short ones might cause an erosion problem.
105.2-106.0L	Avoid & Compensate	*Existing tern island(s), avoid work during nesting season, construct high water notches in dikes (4) to restore and maintain islands	Approved
106.5-107.7L	Avoid	Avoid aquatic disposal in AR107.1L, utilize land areas or in-channel disposal	Approved
Pool 6			
110.4L	Compensate	Connect Willow Beach Park backwater to river for fish passage	Approved
110.4	Compensate	Connect Willow Beach Lake oxbow to river for fish passage	Approved
113-114L	Compensate	Notch underwater dikes on backside of islands (4)	Approved
116.2R	Compensate	Dredge backwater at 116.2R	Approved
116.6-116.8R	Compensate	Notch existing dikes 116.6 to 116.8R (2) *may have already been done	Approved
117.1-117.7R	Compensate	Notch existing dikes (3)	Approved
122.9-123.6R	Compensate	Notch existing dikes (2-4) for flow-through and access	Approved-engineers noted that a lot of bank fishermen use this area, so do not restrict their access.
123.7L	Compensate	Notch existing dike for access and fish passage	Approved-engineers recommended a fish notch here
124.2-124.5L	Avoid	Avoid disposal in AR124.8L-D, utilize in-channel disposal	Approved
124.8-125.1	Minimize	Utilize in-channel disposal at AR124.8 Channel-D	Approved
Pool 7			
126.7-127.4L	Minimize	Utilize left bank for disposal and notch modified dikes (4)	Approved
126.6-127.0R	Avoid	Avoid disposal on right bank	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
131.0L	Compensate	Dredge upper end of Rector Brake backwater to improve habitat	Approved
131.8-132.5R	Minimize	Notch upper end of modified revetment (1)	Not approved-engineers noted bad erosion problem inside revetment
132.2L	Compensate	Maintain entrance to Rector Chute by periodically dredging	Approved
133.5-135.2L	Avoid & Minimize	Avoid aquatic disposal on left bank, utilize land disposal on island or construct another island on right bank, notch longest existing dike for flow-through (*potential existing tern site)	Approved
134.2R	Compensate	Notch existing revetment (1) at 134.2R	Approved
134.5R	Compensate	Notch existing dike (1) at 134.7R for fish passage and access to Mill Bayou	Approved
135-138.2R	Avoid & Compensate	Avoid disposal in aquatic areas, utilize island disposal, (*potential existing tern site), notch two lower dikes	Approved
139.5-141R	Avoid & Minimize	Avoid disposal from 140R upstream to 141R to prevent blockage of opening between islands, utilize 140R downstream to tip of island	Approved
141.5-142.5R	Minimize	Utilize disposal behind raised and extended L-dikes at 142.0R	Approved
142.5-143.4R	Minimize	Notch modified dikes (2) at entrance to beaver dam channel for flow-through	Approved
143.7-144.2L	Compensate	Construct L-dike or revetment and use disposal to slope and protect bank	Approved
145.2-146.2L	Minimize	Notch modified dikes (7)	Approved
146.5-147.5L	Avoid & Minimize	* Existing tern island – enhance/construct a series of islands along left bank where feasible, notch dikes (5), move disposal from left bank to right bank for excess disposal	Approved
146.3R	Avoid	Avoid disposal in this area	Approved-Note: 3 dikes are already notched in this area, so fill rate should be reduced.
146.6-147.8R	Minimize	Utilize land within disposal cells	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
147.8-150L	Avoid & Minimize	Avoid disposal from 149-150L that would block the entrance to backwater area, utilize disposal area downstream of 149L	Approved
148.7-150.4R	Avoid & Compensate	Avoid disposal, notch dike at 149R	Approved
150-151.7L	Avoid & Minimize	Avoid disposal from 150-151L that would block side channel and backwater entrance, construct a series of tern islands where feasible, notch existing dike at 150.8L for fish passage and backwater entrance	Approved
154-154.6L	Avoid	Avoid right bank disposal, Utilize land disposal within cells at AR154.1L-D	Approved
155.4L	Minimize	Utilize land within cell at AR155.4L-D	Approved
155.6R	Compensate	Notch existing revetment (2)	Approved-engineers recommended not restricting bank fishermen with notches
Pool 8			
158.8-159.2R	Minimize	Utilize existing island for disposal and/or construct tern islands	Approved
161.2-162.2L	Compensate	Notch existing dikes (3-4) from 161.2-162.2L	Approved-engineers stated that dikes should be notched close to the island-check with Regulatory regarding obstruction
163.6-165.2R	Compensate	163.6-165.3 - Revetment is needed for bank stabilization	Approved
164.2-164.7L	Avoid	Avoid left bank disposal, utilize disposal behind revetment on right bank	Approved
164.5-165.2L	Minimize & Compensate	165 - Notch on upstream end of revetment for flow in and out of Plummerville cutoff, and notch raised dikes (3), maintain entrance by periodically dredging	Partially approved, maintaining entrance is approved, notches are not
165.5-166.2R	Avoid	Avoid disposal in AR166.0R-D	Approved
165.8-167.0L	Avoid & Minimize & Compensate	Avoid aquatic disposal, dispose on land within cells, notch existing revetment (4)	Approved-engineers stated they recommend fish notches only at this location

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
169.2-169.8R	Minimize	Utilize AR169.4R-D for disposal first, AR169.0L-D second, construct tern islands where feasible	Approved
168.7-169.5L	Minimize	Utilize AR169.4R-D for disposal first, AR169.0L-D second, construct tern islands where feasible	Approved
169.4-169.7L	Minimize	Notch raised dikes (4)	Approved
169.6-172L	Minimize	Notch raised dike at 170.1L and existing dikes at 170.7L and 171L, utilize land within cells for disposal or create/enhance tern island, (*existing tern island)	Partially approved-engineers approved the notch at 170.1, but not the notches at 170.7 or 171.0
174.1-176.7R	Avoid & Compensate	Utilize land disposal on Lentz property, notch existing dikes (4))	Approved
176.2-176.4	Avoid	Avoid disposal in AR176.2L-D, utilize right bank land disposal on Lentz property	Approved
Pool 9			
179.3-179.7R	Minimize	Utilize disposal at 179.6R behind revetment	Approved
180.2R	Compensate	Notch existing dike at 180.2R for fish passage and access to backwater	Approved
180.4-181.3R	Minimize	Extend disposal area upstream to raised dike at 181.5R and dispose along bank downstream of dike, notch existing dikes (2)	Approved
181.8-184.9R	Minimize	Notch existing and raised dikes (8-10) and create a series of islands for braided system and terns	Approved
185.8-186.4	Avoid & Minimize	Avoid disposal in AR186.2L-D, create artificial gravel bar downstream of dikes from 185L-186L	Approved
187.2R	Compensate	Notch long L-dike at 187.2R (2)	Not approved-engineers do not want to notch this dike
186.9-189.9R	Avoid & Minimize & Compensate	*Existing least tern island - avoid construction during nesting, limited disposal to avoid elevating island and maintain fish access to backwater, notch revetment and dikes (3-6) for flow-through, fish passage and access	Partially approved-disposal will be limited, however, engineers do not want to create a series of notches. They did agree to notch the revetment in two places from 189 to 189.5R.
189.2	Minimize	189.2 - Notch revetment and dikes for fish passage and access to backwater	This part approved - See above

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
188.9-190.4L	Avoid & Minimize & Compensate	*Existing least tern island, avoid disposal, notch raised revetment (1) and existing dike (1), utilize area upstream at 191R for disposal	Approved-engineers prefer to notch revetment in 2 places
190R	Minimize	Notch Sweeden island dike in chute on right bank lowest for fisheries and rec access	Not approved
190.5-192R	Minimize	New dredge disposal alternative to 189.5L will create elevated vegetated shoreline on Sweeden Island	Approved
189.9.190.5L	Minimize	Notch modified revetment in two places (2)	Approved
193.6-195L	Compensate	Notch existing dikes (5) in AR194.1L-D	Approved
200.2L	Avoid & Minimize	Utilize land disposal within cells from 200.8L downstream to 200L, avoid disposal upstream of 200.8L	Approved
204.6-205.1R	Minimize	Utilize in-channel disposal (gravel)	Approved
Pool 10			
222.5R	Minimize	Construct islands along right bank	Approved-no adverse impact
225.5L	Minimize	Construct islands along left bank	Approved-no adverse impact
227.2,229,230, 233.5,233.3, 234	Minimize	Construct islands where feasible	Approved-no adverse impact
232R	Compensate	No adverse impact, bank stabilization is needed at this area	Approved-no adverse impact
233L	Avoid	Utilize land disposal in AR233.0L-D if needed	Approved
235-236.8R	Minimize & Compensate	Notch existing dike and raised dike (2-3) in AR236.0R-D, place dredged material on existing islands within disposal area	Approved-engineers approved notches, but only after some channel work has been performed and the channel is moved toward left bank.
236.6L	Avoid	Utilize this site for disposal	Approved
238.5-239.9L	Avoid & Minimize	*Existing tern island at 239.5L, avoid disposal in AR238.5L-D, alternately use 240.1-241.0 , investigate terrestrial disposal, create and/or extend island, notch land side of dikes, do not cut off backwater at 241.1L	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
238.5-241.2	Minimize	Maintain and/or notch existing and modified dikes (3)	Approved
239.5R	Minimize	239R-Maintain fish access through revetment. Modified revetment along right bank will have no adverse impacts	Approved
241.8-242.2R	Minimize	Utilize this site for disposal	Approved
242-244.1L	Avoid & Minimize	Avoid disposal in AR242.2L-D at entrance to Hartman Lake, utilize AR241.8R-D and AR244.0R-D if needed, deepen notch in modified revetment	Approved
243.7-244.2L	Minimize & Compensate	Notch revetment and install structure through dike at upstream end of Hartman lake to allow flow-through and fish passage	Approved. Check for road, possible culvert
244R	Minimize & Compensate	Utilize two downstream cells for disposal if needed and notch two existing upper dikes for fish passage and access	Approved
243.8-246.8L	Avoid & Compensate	Avoid disposal (none currently scheduled) in AR245.6L-D, notch dike downstream of most downstream island at 244.5L	Not approved-engineers do not want dike at 244.5L notched
249.7L	Minimize	Alternative disposal site for AR248.0R-D	Approved
254.1-254.5L	Minimize	Alternative disposal site inside closed revetment at 254.1L, no previously approved disposal area indicated on map	Approved
251.8-253.8L	Compensate	Notch dikes (5-10) on left and right bank up and downstream	Approved
255.7-256.1R	Avoid	Avoid, use AR256.2L-D for disposal instead of AR256.0R-D	Approved
255.9-256.2L	Avoid	Prefer to use this terrestrial area for disposal	Approved
Pool 12			
271.2-273R	Minimize	Utilize this right bank site for disposal	Approved
273.7-276L	Avoid	Avoid disposal in AR274.0L-D and AR275.0L-D, alternatively use right bank disposal to create or enlarge islands,	Approved
275-276L	Minimize	Notch modified dikes (3)	Approved
275.7-276.4R	Minimize	Notch modified dikes (2) that connect to shoreline and extend right bank disposal downstream within dike field	Partially approved-engineers do not want dikes notched, constructing islands is approved.

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
275.2-276.6R	Minimize	Notch dikes (2) that connect to shoreline	Not approved-see comment above
276.0R	Compensate	Maintain entrance to Courthouse Slough by periodically dredging	Approved
276.8-277.5R	Avoid	Avoid backwater disposal in 277.0R-D, place disposal on land and downstream along bottom end to extend island	Approved
278.9-280.3L	Avoid	At AR279.5L-D avoid disposal in aquatic areas, utilize land within disposal area and AR280.0R-D,	Approved
279-280.1L	Minimize	Notch modified revetment at 279L and 280.2L to maintain high value for backwater area	Approved
279-280.1R	Minimize	Utilize AR280.0R-D for disposal and construction of string of islands, notch modified dikes (4) to create and maintain backwater channel	Approved-engineers varied slightly on this, they want to notch the revetment and 3 dikes.
280.6-280.9	Minimize	280.8L - Notch modified dikes (3)	Approved
281.9-283.3L	Avoid	Place disposal on lower end of disposal area on existing sand bars, construct islands where feasible, avoid disposal from 283.2-283.5L	Approved
283.1-283.9L	Minimize	283.9L - Notch modified revetment in upper cell (High priority)	Approved
283.5-284.7R	Avoid	Recommend constructing new disposal at 284R	Approved
284.7-287.4	Avoid	Avoid disposal in downstream cells on left bank and right bank, prefer disposal downstream in new area	Approved
285.6-286.2L	Avoid & Minimize	Extend disposal area to 286.2L dike, place disposal behind dikes on left bank from 286.2-285.6L to create islands and maintain gravel instream, notch modified (2) and existing (2) dikes	Approved
288.4-289L	Avoid	Avoid disposal in AR289.0L-D and place dredged gravel along right bank downstream and extend downstream gravel bar at 289.7R	Approved
288.8-289.8R	Minimize	Utilize this alternative disposal area	Approved
290R	Compensate	Notch existing dike if feasible	Not approved-probably not feasible, appears dike is totally covered

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
290.5-291.4R	Minimize	Utilize dry cells in this disposal area	Approved
291.8-292.3L	Avoid	Avoid disposal at 292.3L	Approved
Pool 13			
305.3-306R	Compensate	Notch revetment at 305.7 and 306R	Approved
Oklahoma			
309.8-310.3	Compensate	Notch 4 dikes for scour	Approved
310.4	Compensate	Notch parallel dikes (1) for scour	Approved
311.5-313.7	Minimize	New Dikes, designed to maintain variable habitat (J-hook)	Approved
314.8-315.8	Minimize	New & existing dikes LD recommend J-hook design	Approved
Pool 14			
320-321	Compensate	Notch 3 interior dikes	Approved
321-323	Compensate	Notch 5 dikes	Approved
323.7 - 323.9	Compensate	Notch 2 dikes	Approved
323-324	Compensate	Notch 9 dikes	Approved
326.7-328.1	Compensate	Notch 7 dikes interior/exterior	Approved
Pool 15			
336.4	Avoid	NOTE: Site will be avoided to preserve mussel bed	Approved
336.4		None	Approved
348.3		Add to existing island + riprap	Approved
353.5-354.3		Aquatic area converted to terrestrial	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
355	Minimize	Create 3 - 10 acre tern island w/riprap	Approved
360.6	Compensate	Notch 2 dike	Approved
361-363	Compensate	Relocate gravel to dike field on left descending bank at 360.6. Relocate downstream between rm 360 - 361; monitor & adapt as needed	Approved
Pool 16			
367.5-367.7	Avoid	No action	Approved
367.4	Minimize	Alternative disposal site for 367.5 - create tern island/w riprap	Approved
374-375	Compensate	Relocate gravel downstream to rm 373; monitor & adapt as needed	Approved
379 - 380	Compensate	Dredge upper end of oxbow; maintain upper/lower openings	Approved
383.2	Compensate	Dredge mouth of Hopewell Creek	Approved
392.1-393.0	Minimize	Notch dikes, create tern island in middle cell	Approved
393	Compensate	Relocate gravel to dike fields created on Right descending bank at rm 392.1-393.0; monitor & adapt as needed	Approved
393.2 - 394.1	Avoid & Minimize	1st priority dispose in terrestrial cell, notch internal & lower end dikes; 2nd priority dispose in dike cell above and below bridge. l	Approved
393.8-394.6	Minimize	Notch added dikes to avoid fill, design to minimize fill (J-hook)	Approved
395	Compensate	Relocate gravel to dike fields on left descending bank at rm 393.8; monitor & adapt as necessary	Approved
sbc 0.4	Minimize	Aquatic disposal; create HQ marsh; variable depth 6-in - 2 ft; mussels will be protected from impacts resulting from disposal	Approved
sbc.4.8	Minimize	NOTE: site will be redesigned to preserve mussel patch. aquatic disposal will only occur if mussels won't be impacted; create HQ marsh; variable depth 1 - 2 ft;	Approved
sbc 6.6	Avoid & Minimize	Expand island, design to avoid impacts to mussels; height of disposal will be 1 - 2 ft below water surface	Approved

Table 8-7. Aquatic Disposal and Dredging Mitigation Summary.			
Location - Navigation Mile	**Mitigation Category**	**Mitigation Description**	**Technically Acceptable to USACE**
sbc 6.9	Avoid & Minimize	Expand island, design to avoid impacts to mussels; height of disposal will be 1 - 2 ft below water surface	Approved
398.8	Compensate	Dredge upper/lower end Okay oxbow install culvert structure	Approved
Pool 17			
402	Compensate	Relocate gravel upstream to rm 403.5 - 404; monitor & adapt as necessary	Approved
407	Compensate	Dredge Upper/lower end Tullahassee Loop; rework culvert structure	Approved
408.8	Compensate	Dredge mouth of Strawberry Creek	Approved
408.9	Compensate	Dredge mouth of Billy Creek Cutoff	Approved
414.7	Compensate	Dredge at culvert structure	Approved
416.7	Compensate	Dredge/rework culvert structure	Approved
418.8	Compensate	Dredge/rework culvert structure	Approved
419.5	Compensate	Dredge mouth of Bull Creek	Approved
421	Compensate	Relocate gravel to rm 417-418.5; monitor & adapt as needed	Approved
Pool 18			
426.7	Compensate	Dredge mouth of Commodore Creek	Approved
439.7	Compensate	Dredge lower end of oxbow	Approved
442	Compensate	Dredge lower end of oxbow	Approved

L - left descending bank
R – right descending bank
Source: ERDC-EL, 2005

Gravel bar surveys in proposed dredging locations indicated that 165 acres of gravel would be impacted, as shown in Table 8-7 and would require mitigation by relocating or creating gravel bars. Gravel substrate is important habitat to aquatic life for spawning, food production, shelter, and hydrologic diversity. The Aquatic Evaluation Report explains the protocol used to survey the gravel areas and the mixtures of gravel identified.

Table 8-8 Gravel Survey Results for MKARNS					
Pool	**River Mile**	**Gravel (acres)**	**Total per pool**	**Sand/Gravel mix (acres)**	**Total per pool**
Pool 5	108	1.6	-	7.47	-
	-	-	1.6	-	7.47
Pool 7	140	0.11	-	4.94	-
	146	3.42	-	36.45	-
	150	17.44	-	36.88	-
	150.5	20.43	-	1.4	-
	-	-	41.4	-	79.67
Pool 9	186	23.36	-	144.25	-
	205	27.8	-	6.77	-
	-	-	51.16	-	151.02
Pool 10	229	0.61	-	54.15	-
	-	-	0.61	-	54.15
Pool 15	361	36.7	-	154.15	-
	-	-	-	-	154.15
Pool 16	374	1.23	-	55.81	-
	393	0.83	-	41.06	-
	395	3.54	-	32.93	-
	-	-	5.6	-	129.8
Pool 17	402	7.24	-	32.14	-
	421	20.69	-	11.82	-
	-	-	27.93	-	43.96
Total	-	165	-	620	-

The goal of mitigation would be no net loss of gravel substrate/habitat. This would be accomplished through strategic redeposition of gravel from within the navigation channel to

locations adjacent to the channel and side channel locations, which would be determined by the involved agencies. The Tulsa District USACE has completed some preliminary modeling to determine the optimum locations to relocate gravel near dredge sites. Gravel deposition sites would then be monitored in subsequent years to determine what, if any, movement has occurred, or the level of sediment deposition on the re-deposited gravel substrates.

Mussel (unionid) surveys concluded that the largest impacts to beds would be in the Arkansas Post Canal. Surveys estimated that there are approximately 2 million individuals in the Canal and the majority of these mussels would be destroyed through dredging. Mitigation for these impacts includes: relocating approximately 30,000 individuals to Piney Bay in Lake Dardanelle where populations have been depleted by commercial harvesters, relocating approximately 60,000 individuals to backwater areas in Pool 2 and then using these individuals to recolonize the Canal, and perform monitoring to determine survival rates and health of the population. Throughout the remainder of the system, only scattered beds and patches of mussels were noted. Table 8-8 shows the location of the beds and patches that are located near construction areas and the mitigation measures that will be used to protect these animals. Mitigation will primarily consist of avoiding specific areas, utilizing silt curtains, performing additional surveys, and monitoring and relocating bed or patches as needed, particularly in areas such as San Bois and Sallisaw Creek that have been identified as sensitive.

Table 8-9 Mussel Mitigation		
Location	**Description**	**Year**
Arkansas Post Canal-NM 10.5 to 19.0 (Beds 2-1, 2-2, 2-3)		
Relocation sites	Survey Lake for relocation site potential, 5-min qualitative dives to delineate areas and 1m2 quantitative samples to determine density. If additional area is needed survey Moore Bayou and Post Lake.	2006
Post Canal	Quantitative survey to determine actual density in Beds 2-1, 2-2, 2-3	2006
Post Canal	Relocate 60,000 unionids from Post Canal to Sites selected during above survey	2006
Post Canal	Relocate 30,000 unionids from Post Canal to Piney Bay	2006
Relocation Areas	Monitor relocated unionids in Merrisach, Moore Bayou, Post Lake, Piney Bay, and Beds 2-1, 2-2, 2-3 for once a year for three years, then every other year till year 2015 (6 monitoring events) or until habitat in Post Canal is suitable for recolonization	2007-2015
Post Canal	Relocate 60,000 animals back into suitable habitat areas within the canal.	2016
Post Canal	Monitor relocated unionids in Canal once for 3 years, then every other year until 2025	2017-2025
Post Canal	Propagate and release 3,000,000 juvenile unionids into Post Canal	2016-2018
Arkansas Post Canal to L&D 3-NM 19.0 to NM 75.2		
B4-1 (NM 23-24)	Protect from future disposal	
P4-1 & P4-2 (NM 23.5) (	Protect from future disposal	
P5-1 (NM32.2)	Protect from future disposal	
B6-1 (NM 38.6)	Protect from future disposal; Baseline (2007) and monitoring following three high water events of bed near a disposal site	2006-2009
P6-3 (NM 36.3)	Protect from future disposal	
P6-2 (NM 37.6)	Protect from future disposal	
P6-1 (NM 38.6)	Protect from future disposal	
P7-2 (NM 48.0)	Protect from future disposal	

Table 8-9 Mussel Mitigation		
Location	**Description**	**Year**
P7-1 (NM 48.5)	Protect from future disposal	
Mud Lake (NM 48.5)	Survey to determine unionid distribution prior to dredging for channel to boat ramp	2006
Reach 3	NM 119.5 to 220.3	
B11-1 (NM 126.5)	Keep dredge material at least 100m riverward of bed; Baseline (2007) and monitoring following three high water events of bed near a disposal site	2006-2009
P13-2 (NM 146.5)	Keep dredge material out of tributary; Baseline (2007) and monitoring following three high water events of bed near a disposal site	2006-2009
Reach 5 Pool 13	NM 308.5 to 394.8 NM 308.5 to 319.5	
309.8 – 310.3	Sample proposed dike modification area for mussels	2006
310.4	Sample proposed dike modification area for mussels	2006
311.5 – 313.7	Sample proposed dike modification area for mussels	2006
311.5 – 312.5	Sample dredge site	2006
Pool 14	NM 319.5 to 336.5	
320-321	Sample proposed dike modification area for mussels	2006
321-323	Sample proposed dike modification area for mussels	2006
323.7 – 323.9	Sample proposed dike modification area for mussels	2006
323 – 324	Sample proposed dike modification area for mussels	2006
326.7- 328.1	Sample proposed dike modification area for mussels	2006
334.2 (P32-1)	Stop dredging 300m upstream of this patch	
Pool 15	NM 336.5 to 366.6	
336.4 (P33-1)	Avoid Disposal Right Descending Bank to protect Mussel Bed. Sample for possible relocation site, if selected, monitor at least three years following relocation then yr 5, 7, and 9	2006-2015
SBC 4.8 (P35-1)	Mussel patch will be delineated and the disposal area will be designed to avoid impacts to mussel patch. Mussel patch will be protected during in-water disposal by silt curtain. Disposal will not occur within 100 meters of mussel patch. Patch will be monitored before disposal, within 6mo. of disposal, and 1 yr of disposal.	2006-2007
SBC 6.6 (P35-2)	Mussel patch will be protected by a silt curtain prior to dredging. Patch will be sampled before dredging, and within 6mo. and 1 yr. after dredging.	2006-2007

Table 8-9 Mussel Mitigation		
Location	**Description**	**Year**
SBC 8.0 (P35.4)	Mussel patch will be protected by silt curtains prior to dredging. Patch will be sampled before dredging, and within 6mo. and 1 yr. after dredging.	2006-2007
341.5–344.5 (DR-1)	Relocate mussels in dredge location to mussel patch 36-1 in Sallisaw Creek or mussel bed 33-1 right descending bank above Kerr L&D	2006
343 (P36-1)	Sample for possible relocation site, if selected, monitor at least three years following relocation then yr 5, 7, and 9	2006-2015
345 (DR-2)	Relocate mussels in dredge location to mussel patch 36-1 or mussel bed 33-1	2006
353.5 – 354.3	Sample dredge disposal/riprap area	2006
360.6	Sample proposed dike modification area	2006
361 – 363	Sample dredge, overdredge area	2006
365.6–365.6 (P39-3, P39-4)	Mussel patches will be protected by silt curtains prior to dredging. Patches will be sampled before dredging, and within 6mo. and 1 yr. after dredging.	2006-2007
Pool 16	NM 366.6 to 394.0	
367 (Site 40)	More intensive search of Site 40 (least tern mitigation)	2006
380.5 – 381.8	Sample dredge area and disposal site	2006
382.5 – 384.5	Sample dredge sites, including mouth of Hopewell Creek	2006
Reach 6 Pool 16	NM 394.0 to above navigation NM 394.0 to 401.5	
392.1 – 392.0	Sample dike modification area	2006
393.2 – 394.1	Sample dike modification area	2006
393.8 – 394.0	Sample dike modification area	2006
398.8	Sample oxbow mouth; investigate for possible mussel rehabilitation site	2006
Pool 17	NM 401.5 to 421.5	
407	Sample upstream and downstream mouths of loop; investigate for possible mussel rehabilitation site	2006
407.5	Sample dredge area	2006

Table 8-9 Mussel Mitigation		
Location	**Description**	**Year**
408.8	Sample mouth of Strawberry Creek	2006
408.9	Sample mouth of Billy Creek cutoff	2006
418.8	Sample mouth of oxbow	2006
Pool 18	NM 421.5 to above navigation	
421.5 – 422.0	Sample dredge area	2006
426.7	Sample mouth of Commodore Creek	2006
429 –430	Sample dredge area	2006
437 (P49-2)	Investigate for mussel relocation site; monitor yr 1, 2, 3, 5, 7, 9	2006-2015
442.8 (P50-1)	Relocate mussel patch at dredge to mussel patch P49-2 at RM437.0	2006
450 – 455	Investigate for possible mussel rehabilitation site	2006

Cost Effectiveness and Environmental Sustainability

Environmental sustainability is one of the USACE's seven Environmental Operating Principles. It is characterized by the statement that an environment maintained in a healthy, diverse, and sustainable condition is necessary to support life. The Arkansas River supports a very healthy sport fishery as well as a number of in-stream islands which create diversity for both terrestrial and aquatic organisms and nesting areas for the Federally endangered interior least tern. The sport fishery is due in part to the backwater lakes and oxbows that connect to the river. These areas provide refuge during high flow events, spawning areas during the spring and summer, and foraging areas all year long. For these reasons and through coordination with the resource agencies, the USACE will include five mitigation measures that are not as cost effective as the mitigation measures that were selected to meet complete mitigation in the HEP analysis. Although they are not as cost effective, the USACE would be able to construct them relatively inexpensively since they would be associated with ongoing construction activities. These five mitigation features include: constructing islands with disposal material in Lake Dardanelle, constructing islands with disposal material in Pool 3, dredging and maintaining the entrance to Moody Old River oxbow lake in Pool 2, dredging sediment out of the canals that connect to Lake Langhofer, and connecting Willow Beach oxbow lake to the river. The breakdown of the costs for these measures is located in the incremental cost analysis summary in Appendix C.

Long Term Monitoring and Adaptive Management

The MKARNS riparian, wetland, and aquatic ecosystems are complex and dynamic. Understanding of these ecosystems and the ability to predict how the river will respond to

management actions is limited. This limited knowledge gaps results in uncertainty over how best to implement mitigation measures to achieve the desired outcome. Despite these uncertainties, USACE must make decisions and implement plans. The purpose of long term monitoring and adaptive management is to develop a process framework for monitoring and managing the biological mitigation measures. The MKARNS Adaptive Management Plan will serve as a template for task requirements to achieve defined goals and measurable objectives to accomplish mitigation results. It is the ultimate goal of the Corps to achieve a functioning, self-sustainable ecosystem by mitigating for impacts as a result of the navigation deepening and flow modification project. The Long Term Monitoring and Adaptive Management Plan is included in Appendix C. Tables 8-10 and 8-11 provide summaries of long term monitoring and adaptive management, respectively.

Table 8-10 Summary Of Long-Term Monitoring

Monitoring Task	Target Parameters	Sampling
Sediment Dynamics		
Bathymetry	Trends – Depth changes over time	Select areas at the following times (baseline, 4 water years with an attempt at one each low, medium, high)
Backwater & Tributary Mouth	HSI values	Reduce excessive sedimentation that is degrading aquatic habitat through dredging.
Substrate Sampling	Classification and diversity of river bottom habitat	Select areas to include dike fields and backwaters, four sampling periods for comparison, sites determine by executive committee for appropriate representation.
LIDAR/GIS	General Trends of deposition and vegetation growth; Aquatic habitat volume and acreage.	Entire river (3 time periods: preconstruction, immediately following construction, post construction)
Aquatic Habitat		
Backwater reevaluations	HSI values from mitigation measure assumptions – Based on 11 year target	Delphi committee re-evaluates some reference areas and dredged areas – baseline and 3 times post baseline
Tributary Mouths	Diversity and Presence	Delphi committee re-evaluates some reference areas and dredged areas – baseline and 3 times post baseline
Gravel Modeling	Areas of sustainable substrate	Baseline models
Gravel Monitoring	Habitat quality and diversity	Baseline core sampling for depth and classification, invertebrate presence/absence (baseline / two post construction). Fish use of the gravel habitat
Fish Sampling	Diversity, relative abundance, presence, and sportfish stock descriptors	Backwaters and Dike fields (baseline season and 3 water years varied)

Table 8-10 Summary Of Long-Term Monitoring		
Monitoring Task	**Target Parameters**	**Sampling**
Mussel Bed Monitoring	Sustainability of relocated populations and turbidity at mussel beds during in-stream disposal operations adjacent to known large populations	Patch will be sampled before dredging, 6 mo and 1 yr after dredging This appears to be different from what was said above.
Terrestrial Habitat		
Hardwoods	Habitat Quality and Sustainability	EC re-evaluates using ExHEP protocol on new sites. Monitoring 3 inspections/yr for 3 years and then 3 additional survey cycles on 5 year intervals for a total of 6 years.
Marshlands	Healthy functions and values	EC evaluates site using ExHep protocol. Monitoring includes 3 inspections/year for 3 years and then 3 additional cycles on 5 yr intervals for a total of 6 years.
Physical and Chemical Water Parameters		
Water Quality (all Gravel beds, representative backwaters, representative dike fields)	Dissolved Oxygen, Turbidity, Temperature.	Baseline, plus 3 water years

Table 8-11 Summary Of Adaptive Management		
Habitat	**Target Parameters**	**Adaptive Management**
Backwater & Tributary Mouth	Improve HSI values over baseline	If degradation of aquatic habitat is occurring from sedimentation, then dredging would be implemented
GRAVEL BARS	No net loss	If gravel bars are not able to be relocated additional modeling and relocation activities will be implemented
DIKE FIELDS	HSI values minimize sedimentation	If desired results are not achieved, additional notching would occur or exploration of advanced techniques. Other aquatic mitigation measures would need to be identified and implemented.
MUSSEL BEDS	Re-colonization	If relocated mussels are not thriving habitat improvement and additional relocations would be implemented
Terrestrial	HSI value goals	If desired results are not achieved, additional plantings and adjustment to management techniques would be implemented.

8.3.2.1.3 Threatened and Endangered Species Mitigation

Based upon the best available information, the USACE has evaluated the impacts of its continued operation of its existing projects, operation of proposed projects, studies, and cumulative impacts on the 17 Federally listed species that have the potential to occur or do occur within the study area, and concluded there would be no effect on the following Federally-listed

species: American alligator, gray bat, Indiana bat, Ozark big-eared bat, whooping crane, scaleshell mussel, piping plover, ivory-billed woodpecker, Arkansas River shiner, *Geocarpon*, western prairie fringed orchid, and harperella. This is due to the fact that the range of many of these species does not extend to the project area, the species is no longer found in the area, suitable habitat is not present on project lands, or the impacts were considered to be inconsequential.

The ivory-billed woodpecker was thought to be extinct until recently found in Monroe County, Arkansas within the Cache River National Wildlife Refuge and adjacent areas. Therefore, this Federally listed endangered species was not included in the Biological Assessment. However, the USFWS determined in their Biological Opinion that the proposed action is not likely to adversely affect this species.

The evaluation also concludes that continued operation of existing projects, proposed projects, studies, and cumulative impacts may have an affect on the following Federally listed species and/or their habitats: interior least tern, pallid sturgeon, bald eagle, and American burying beetle. The USFWS concluded that there is currently not enough available information to issue an opinion on the pallid sturgeon, and they are awaiting sediment-testing results before issuing an opinion on the bald eagle. Therefore, this opinion only addresses the least tern and the American burying beetle

Section 7(a)(2) of the Act requires federal agencies to ensure that any action authorized, funded, or carried out by such agency is not likely to: 1) jeopardize the continued existence of any endangered or threatened species, or 2) result in the destruction or adverse modification of critical habitat. The term "jeopardize the continued existence of" means to reduce appreciably the likelihood of both the survival and recovery of listed species in the wild by reducing the species' reproduction, numbers, or distribution. Jeopardy biological opinions must present reasonable evidence that the project would jeopardize the continued existence of the listed species or result in destruction or adverse modification of critical habitat.

After reviewing the current status of the American burying beetle and least tern, the environmental baseline, the effects of the proposed action, and the cumulative effects, it is the USFWS' Biological Opinion (BO) that the action, as proposed, is not likely to jeopardize the continued existence of either species and is not likely to destroy or adversely modify designated critical habitat. No critical habitat has been designated for these species, and therefore, none would be affected. However, the proposed action would likely result in incidental take of American burying beetles and least terns.

The threatened and endangered species mitigation focuses on the least tern and American burying beetle. Per the USFWS' BO, mitigation measures for the least tern include a series of in-channel islands to be created through dredged material disposal within each river pool. For the burying beetle, the emphasis would be on avoidance and minimization of impacts.

Interior Least Tern

Avoidance and Minimization

The Corps and SWPA would work with the USFWS to immediately establish a least tern coordination team (LTCT) to identify and implement the goals of this BO. The team would be responsible for ensuring implementation of future conservation measures; tracking, evaluating, and documenting the results of those measures; and tracking and documenting sufficient progress

in conserving listed species. The LTCT would involve additional agencies or groups, as appropriate, with biological and engineering expertise.

The USACE shall monitor and map, on a periodic basis (at least every 3 years), all potential tern nesting habitat on the Arkansas River within the Action Area. The mapping information would be used to determine the quantity and quality of least tern habitat over time. Habitat monitoring would follow methods similar to the study plan developed under the previous biological opinion and would include estimates, by reach, of the average channel width, and area of vegetated and relatively unvegetated (<30%) sandbars and islands at flows that represent maximum hydropower releases, and relatively minor flood release flows that would occur during the least tern nesting season. A new habitat-monitoring plan would be developed through coordination with the USFWS for each river system by March of 2006. Monitoring would be initiated during the 2006 nesting season. Mapping products or updates on data collection would be provided in the annual report.

The USACE would utilize all of its authorities and operational flexibility in adjusting flows and other pertinent actions to reduce the flooding and land bridging of least tern nesting sites. The USACE would coordinate frequently and in a timely manner with the USFWS when it has determined that increased flow releases may flood terns or decreased flows may result in land bridges to tern nesting sites. During these consultations, the USACE would provide the USFWS its recommendations to reduce flooding and land bridging. Nesting habitat shall be provided as a priority and other management actions implemented to meet or exceed the minimum adult and fledgling numbers for each river reach.

The USACE Little Rock District would develop least tern management guidelines similar to those developed by the USACE Tulsa District. At a minimum, this document would include least tern management guidelines for each project and coordination procedures and contacts for April-September of each year. The USACE would coordinate the development of this document with the USFWS to minimize take of terns. This document, once approved by the USFWS, would be incorporated into the USACE future actions.

The USACE would conduct annual least tern monitoring at all nesting sites on the Arkansas River within the Action Area, including reservoirs and the river reaches between reservoirs. The USACE would develop a monitoring plan with specific information on how monitoring would be conducted; this plan would be approved by the USFWS. Information to be collected would include, but not be limited to, number of adult terns, elevation of nests and freeboard representing the highest and lowest nests at each nesting site, location (as measured with a global positioning system) of nesting colonies, and number of nests, eggs, chicks and fledglings. In conducting the annual least tern surveys, the USACE would continue to collect information on mortality, injury, and productivity. The number and type of mortality (in categories currently used by the USACE) would be recorded for adults, chicks, eggs, and nests along with any other useful observations. The USACE would record mortality caused by its operations, any measures taken to reduce mortality, and the effectiveness of these measures to reduce take. The USACE also would collect information on annual productivity, including the number of fledglings per breeding pair.

In accordance with other annual reporting requirements in the BO, the USACE would provide to the USFWS, by December 31 of each year, the information collected as described by these Terms and Conditions along with analyses, conclusions, and recommendations.

Compensation, Rectification, and Reduction

Suitable nesting habitat would be established and maintained by provision of appropriate river flows and/or mechanically enhanced, constructed, and maintained. All constructed nesting habitat would be at locations approved by the USFWS and meet the following criteria:

- Substrate – Nesting substrates consist of well drained particles ranging in size from fine sand to stones < 1 in. (2.5 cm) in diameter.
- Size/Shape – Nesting areas would be a minimum of 1 ac (.4 ha), and preferably 10 ac (4 ha); circular to oblong in shape, maximizing surface area; recommended slopes of 1:25 with maximum slopes not exceeding 1:10; surface height above water to exceed 18 in. (45.7 cm) at nest initiation (usually May or June).
- Visibility – Smooth topography with < 10 percent early successional vegetation.

At least 50 percent of the constructed nesting habitat would be in place by April 2008 and 100 percent by April 2010.

Arkansas River, Oklahoma, Kaw Reservoir to Muskogee - Nesting habitat would be provided and maintained to support the minimum population (currently at least 420 adults). Habitat for at least 200 adults (100 nesting pairs) should be at an elevation that would not flood at 20,000 cfs flows. Least terns would not use created nesting habitat exclusively and existing data indicate it is not realistic to expect nesting colonies to average more than 20 nests per site. About 8 existing nesting sites in this reach average 20 or more nests and these sites could be enhanced. At least 6 nesting sites with suitable habitat above water levels at a 20,000 cfs flow would be required to maintain 100 nesting pairs.

Arkansas River, Muskogee to Oklahoma/Arkansas state line, including the lower Canadian River below Eufaula Reservoir - Nesting habitat would be provided and maintained to support the minimum population (currently at least 80 adults). Habitat should be at elevations that would not flood on at least a ten-year frequency (as measured over the period of record and including the water elevation fluctuations due to barge traffic). This would require at least 3 nesting sites with suitable habitat.

Arkansas River, Arkansas - Nesting habitat would be established and maintained to support the minimum population (currently at least 300 adults). All suitable dredge spoils would be utilized to create potential least tern nesting habitat at sites approved by the USFWS. Sites that are utilized by nesting terns would be maintained as defined by the above criteria. At least one nesting island per pool would be constructed and maintained to provide nesting habitat above an elevation that would not flood on at least a ten-year frequency (as measured over the period of record and including the water elevation fluctuations due to barge traffic).

The USACE would monitor and evaluate the created or enhanced island/sandbar habitat annually to determine if physical and biological requirements of the least tern are being achieved. The USACE shall report the data for created or vegetation-managed nesting habitat separately from natural nesting habitat. If the created island/sandbars are not providing habitat as anticipated, then the USACE would evaluate and implement methods to improve the habitat suitability. The USACE would coordinate these actions with the USFWS.

Following three years of creating, evaluating, and monitoring sandbar habitat, the USACE would report the results and conduct a peer review of habitat creation methods and outcomes. The

USACE would provide a copy of its report and the results of the peer review to the USFWS and U.S. Geological Survey (USGS).

American Burying Beetle

Avoidance and Minimization

Adverse effects to American burying beetles should be minor if protective measures recommended by the USFWS are incorporated into the proposed action and implemented. Despite the protective measures, some American burying beetles may be disturbed or killed during dredged material disposal pit construction, dredged material disposal, or other ground disturbance activities. However, most of the effects are expected to be infrequent and of short duration. Approximately 1,100 acres of soil disturbance is anticipated with the proposed action. In the BO, the USFWS determined that this level of anticipated take is not likely to result in jeopardy to Federally-listed species or an adverse modification of critical habitat.

The USACE would implement all measures in the Biological Opinion related to American burying beetles to minimize incidental take. These are standard protective measures recommended by the USFWS and incorporated into the USACE's proposed action. Prior to construction activities implemented in the American burying beetle's active season, the USACE would determine the presence or absence of the American burying beetle in the project county and immediate vicinity of the project site. A presence/absence survey for the American burying beetle may be conducted. If American burying beetles are known to be in the area, then measures would be implemented to remove American burying beetles from the project site prior to soil disturbance. This would minimize or avoid adverse impacts to the American burying beetle. Projects implemented during the American burying beetle's inactive season would incorporate measures listed above to minimize soil disturbance, contamination, or compaction. Prior to the onset of the American burying beetle's inactive seasons, American burying beetles would be removed from the project site.

The USACE would provide an annual report of the area impacted by construction of dredged material disposal pits, and deposition of dredged materials on terrestrial habitat. This report would include a copy of all American burying beetle survey results and a description of trap and relocation and baiting away activities.

Compensation, Rectification, and Reduction

Minimal, if any, American burying beetles are expected to be lost due to implementing the proposed action alternatives because of efforts to minimize or avoid adverse impacts. However, if during on-site surveys, the species is found or there are known impacts, the USACE would coordinate with the USFWS regarding compensation for impacts.

8.3.2.2 Cultural Resources

Avoidance and Minimization

Mitigation measures reduce adverse effects on cultural resources. The assumed (and preferred mitigation) is avoidance. In some cases, avoidance of archaeological sites may be accomplished through redesign of dikes and revetments. Avoidance preserves the integrity of archaeological sites and protects their research potential (i.e., their NRHP eligibility). Avoidance also avoids costs and potential construction delays associated with data recovery. Avoidance of architectural

resources may be accomplished through project redesign or construction of flood-control dikes or coffer dams around architectural resources.

Historically, Phase III data recovery of archaeological sites through professional techniques such as surface collection, mapping, photography, subsurface excavation, technical report preparation and dissemination, has been the standard mitigation measure. However, data recovery is labor intensive (i.e., costly) but may be necessary if NRHP-eligible sites cannot be avoided. Data recovery of archaeological information is now considered, in and of itself, an adverse effect under the revised Section 106 regulations (36 CFR 800.5(a)(2)(i)).

Intact shoreline prehistoric and historical archaeological resources that may contain sufficient information to be NRHP-eligible may occur in the APEs at pools and upstream reservoirs within the existing operations levels. Mitigation measures may include, but not be limited to, Phase I survey, Phase II evaluation studies, Phase III data recovery, if required, monitoring the condition of archaeological sites on a yearly basis, and stabilizing archaeological sites.

Because intact prehistoric and historical archaeological resources that may contain sufficient information to be NRHP-eligible may occur, a Phase I archaeological survey is recommended prior to dredging, construction and/or modification of dikes and revetments, and creation of new disposal locations. The Phase I survey for terrestrial resources may consist of surface surveys in areas with good visibility or a series of shovel probes and/or backhoe trenches in heavily vegetated areas, to identify archaeological sites and to determine their extent and integrity.

Because submerged resources may be present that may contain sufficient information to be NRHP-eligible, a modified Phase I survey is recommended prior to dredging, construction and/or modification of dikes and revetments and use of new disposal locations. This modified Phase I survey would consist of intensive archival research to determine the potential for submerged resources in the study area; preparation of a predictive model to determine low, moderate or high probability areas; and implementation of a Phase I remote sensing survey based on a sampling strategy for low, moderate and high probability areas. Intensive archival research using historic maps, navigation charts, the *Annual Report of the Chief Engineer* (the USACE annual report), newspapers, archives, diaries, and local histories among other sources, would provide a large body of invaluable data for resources throughout the MKARNS. Such a survey may include the use of differential global positioning system equipment, a magnetometer, a side scan sonar array, and a fathometer for bathymetric profiling, all deployed from a motorized watercraft. In addition, coring or auger-testing may also be useful for locating some submerged archaeological sites.

Compensation, Rectification, and Reduction

If intact terrestrial or submerged archaeological sites are identified, Phase II cultural resources studies should be designed in consultation with the USACE, Arkansas State Historic Preservation Office (SHPO), the Arkansas Archeological Survey (AAS), the Oklahoma Archeological Survey (OAS), and the Oklahoma SHPO, and implemented to determine the NRHP eligibility of the cultural resources. If NRHP-eligible resources occur and cannot be avoided through project redesign, Phase III data recovery investigations should be designed in consultation with USACE, Arkansas SHPO, the AAS, the OAS, and the Oklahoma SHPO, and implemented prior to construction.

It is likely that submerged cultural resources would be impacted by construction of dikes and revetments no matter how effective the remote sensing surveys are. Therefore, monitoring of all dredging by a cultural resource professional to record information on the location and types of cultural resources encountered is recommended.

For NRHP-eligible architectural resources within the APE, mitigation measures may include, but not be limited to, avoidance through project redesign, engineered erosion and flood control measures, and vegetative screening. Erosion and flood-control measures may consist of protecting affected areas with fabric, fill, and/or rip-rap, or other measures. Adverse effects caused by audio or visual intrusions to associated historic settings or cultural landscapes of architectural resources may be mitigated by screening the alterations from the resources through landscape design, for example, by planting vegetation such as trees, bushes, or vines consistent with the historic setting and uses of the resource.

8.4 Irreversible or Irretrievable Commitments of Resources

The Council on Environmental Quality (CEQ) regulations for implementing NEPA requires consideration of irreversible and irretrievable commitments to resources that would result from implementing any of the study alternatives. However, CEQ has not defined these terms. For the purposes of this document, irreversible and irretrievable resources are those that cannot be recovered if the project is implemented.

Irreversible and irretrievable resources commitments are related to the use of nonrenewable resources and the effects that use of these resources would have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and mineral) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (e.g., extinction of a threatened or endangered species).

The No Action Alternative (Alternative A) and action alternatives (Alternatives B, C, D, and E) would not result in any irreversible or irretrievable commitment of resources.