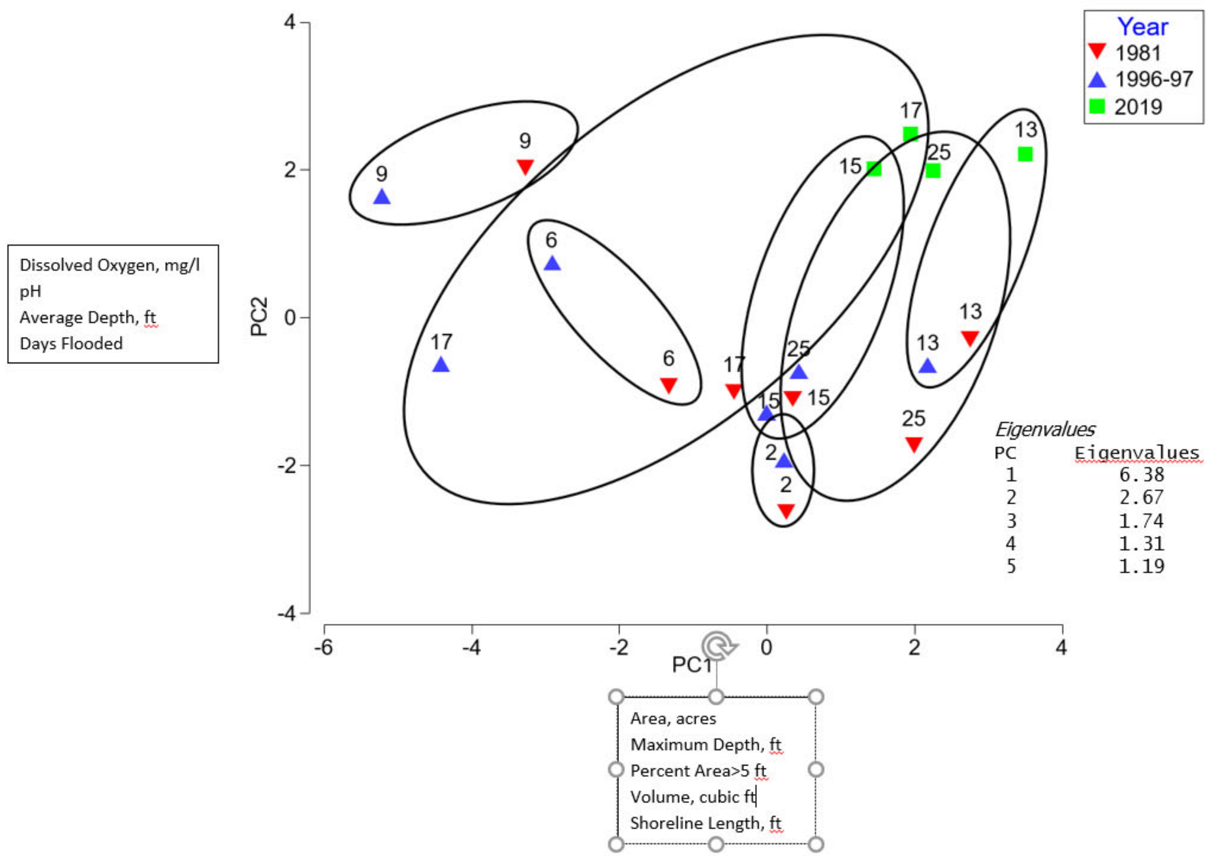
Table A11-11. Summary of fish species diversity measures for gillnets set in landside and riverside borrow areas sampled in 1997 and 2019.				
Variable	Mean	Std Dev	Minimum	Maximum
	Landside 1997, n=23			
Total species observed, S*	4.0	2.6	0.0	8.0
Standardized species richness, S/12 individuals	3.8	2.4	0.0	8.0
Evenness, J'	0.9	0.2	0.5	1.0
Dominance, D	0.7	0.3	0.0	1.0
Number of fish per gillnet	7.9	6.1	0.0	22.0
	Riverside 1997, n=30			
Total species observed, S*	7.1	3.1	2.0	12.0
Standardized species richness, S/12 individuals	5.7	2.0	2.0	9.0
Evenness, J'	0.9	0.1	0.7	1.0
Dominance, D	0.8	0.1	0.6	1.0
Number of fish per gillnet	16.4	9.3	2.0	34.0
	Riverside 2019, n=36			
Total species observed, S*	5.5	2.4	1.0	13.0
Standardized species richness, S/12 individuals	5.1	1.8	1.0	8.6
Evenness, J'	0.9	0.1	0.7	1.0
Dominance, D	0.8	0.1	0.5	1.0
Number of fish per gillnet	10.4	6.0	1.0	27.0

Table A11-12. Summary of fish species diversity measures for seining in landside and riverside borrow areas sampled in 1997 and 2019.				
Variable	Mean	Std Dev	Minimum	Maximum
	Landside 1997, n=4			
Total species observed, S*	9.5	2.4	8.0	13.0
Standardized species richness, S/1160 individuals	9.5	2.4	8.0	13.0
Evenness, J'	0.5	0.1	0.4	0.6
Dominance, D	0.6	0.1	0.5	0.6
Number of fish per 10-hauls	491	222	199	724
	Riverside 1997, n=5			
Total species observed, S*	19.4	3.8	14.0	24.0
Standardized species richness, S/1160 individuals	18.5	3.3	14.0	22.0
Evenness, J'	0.7	0.1	0.6	0.7
Dominance, D	0.8	0.0	0.8	0.9
Number of fish per 10-hauls	1656	1716	298	3991
	Riverside 2019, n=6			
Total species observed, S*	19.8	7.2	9.0	29.0
Standardized species richness, S/1160 individuals	18.4	5.9	9.0	26.0
Evenness, J'	0.6	0.1	0.3	0.7
Dominance, D	0.7	0.1	0.5	0.8
Number of fish per 10-hauls	1189	1431	66	3237



Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	6.38	39.9	39.9
2	2.67	16.7	56.6
3	1.74	10.9	67.4
4	1.31	8.2	75.6
5	1.19	7.4	83.1

Figure A11-1. Principal Component (PC) Analysis of morphometric and water quality variables measured in seven borrow areas sampled in 1981, 1996-97, and 2019. Ellipses illustrate the relative position of the same borrow areas sampled in the three sampling periods. Boxes next to PC axis indicate high loading variables. Cumulative variation accounted for by each PC axis is shown in the inset table.

Figure A11-2. Plot of (predictive or studentized) residuals between predicted standardized species richness and each independent variable for rotenone samples collected from riverside borrow areas in 1981 and 1996-97.Figure A11-1. Principal Component (PC) Analysis of morphometric and water quality variables measured in seven borrow areas sampled in 1981, 1996-97, and 2019. Ellipses illustrate the relative position of the same borrow areas sampled in the three sampling periods. Boxes next to PC axis indicate high loading variables. Cumulative variation accounted for by each PC axis is shown in the inset table.

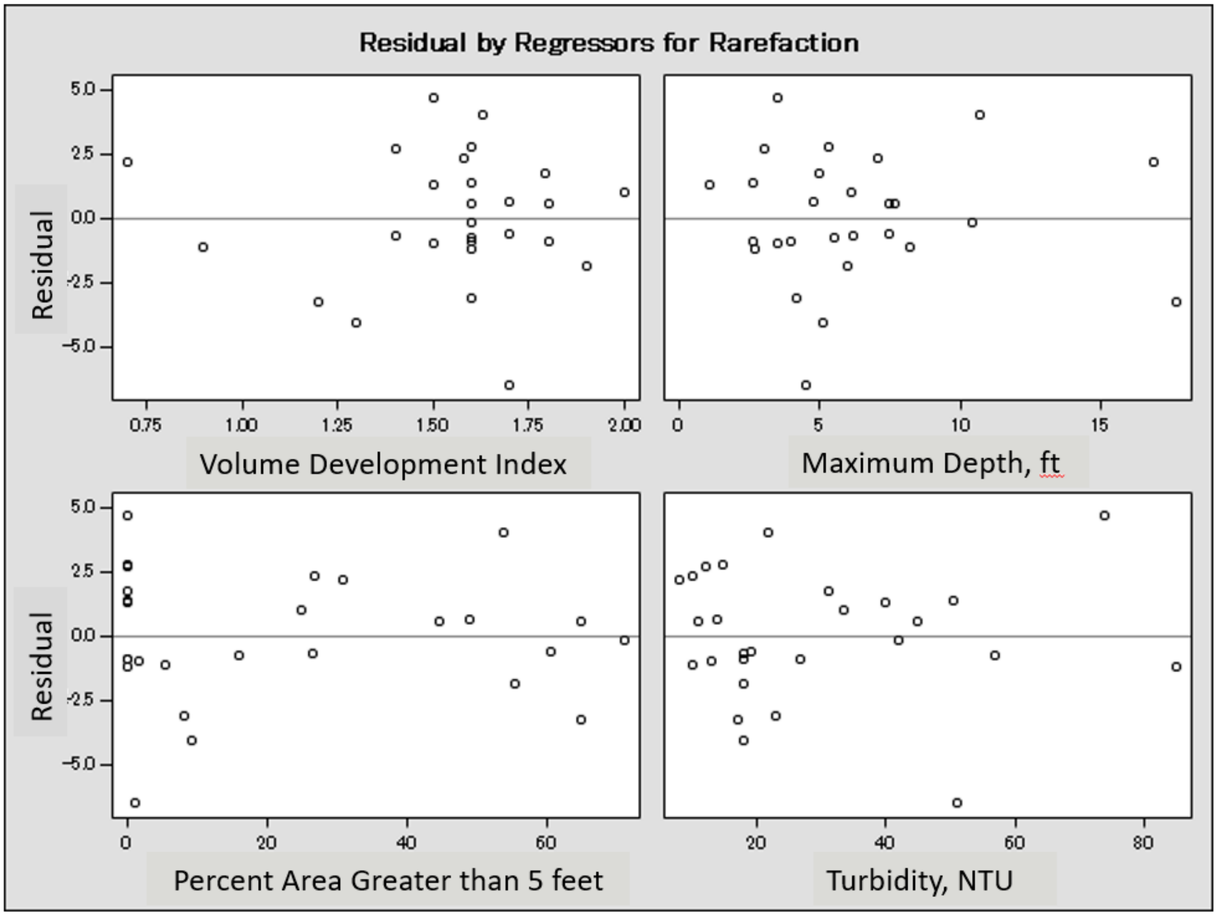


Figure A11-2. Plot of (predictive or studentized) residuals between predicted standardized species richness and each independent variable for rotenone samples collected from riverside borrow areas in 1981 and 1996-97.

A11-4 PART II: IMPACT ANALYSIS

A11-4.1 Purpose and Objective

Part II analyzes changes in fish habitat using the HEP. Two alternatives are being considered: Alternative 2 (Traditional Construction) and Alternative 3 (Avoid and Minimize). Acres of borrow areas created, enlarged, or deepened for each alternative was provided by Mississippi Valley Division – Memphis, Vicksburg, and New Orleans Districts. The HSI for fish diversity described in Part I was multiplied by acres to calculate HUs gained as result of borrow area construction. Other than filling in existing borrow areas from road construction or enlargement of levees, impacts of construction on other resources (terrestrial, wetlands, and waterfowl) were considered in the other appendices to the SEIS II.

A11-4.2 Methods

The proposed levee work will create new open water habitat and, in a few areas, deepen or fill existing open water within the active floodplain (riverside) and on land protected by the levee (landside). For the aquatic fisheries analysis, effects greater than 0.09 acres were analyzed. The existence of open water habitat and its acreage were determined using a land cover classification developed from false color infrared aerial photography with a 5 m resolution collected in 2014. The minimum mapping unit was 20 acres though smaller areas of land cover were often classified. Land cover classified as open water includes all aquatic features (borrow pits, scour holes, lakes, and channels) thus 2016 and 2017 National Agriculture Imagery Program images (NAIP 2017) were investigated to determine the type of aquatic feature affected by the project. Open water was assumed to be a borrow area if the feature was generally rectangular, near the levee, and/or had occasional peninsulas or traverses (narrow strips of land separating adjacent open water); any questionable open water was classified as borrow area.

Acreages were determined for Alternative 2 and 3. Alternative 2 will consist of traditional construction methods to raise and stabilize the deficient sections of the levees and floodwalls and to control seepage. Borrow areas would normally be located riverside of the levee at the nearest sites with suitable soils. This plan would require no special criteria for siting the location of borrow areas other than for engineering provisions. No provisions would be made for environmental enhancement features for the borrow areas. Alternative 3 differs in the placement of some haul roads and borrow areas. During scoping, the major issues identified were: location of borrow sites, loss of bottomland hardwood forest and associated wetlands, and landowner input. This alternative seeks to avoid and minimize these impacts by placing borrow areas in less environmentally sensitive areas when practicable. Additional environmental features (e.g., irregular shorelines, islands, variable depths, etc.) that could be incorporated into borrow area designs to increase habitat value would be explored with willing landowners and non-Federal sponsors during project design.

A11-4.3 Results and Discussion

Acres

Overall gains in borrow area acreage were the same for both alternatives. A grand total of 1,403.9 acres of borrow area will be constructed under the traditional Alternative 2 without environmental features (Table A11-13). Of this total, 525.6 acres and 877.7 acres will be gained for landside and riverside borrow areas, respectively. Avoid and Minimize Alternative 3, without environmental aquatic features, will construct 1,404.5 acres of borrow area with 414.3 of those acres occurring landside and 987.7 acres riverside (Table A11-13). The grand totals in Table A11-13 include gains and losses of borrow area due to other proposed work. Fill for levee enlargements and haul roads results in a loss of borrow area ranging from 3.3 to 4.2 acres, depending on alternative and whether it's landside or riverside of the levee (Table A11-13). Excavation from relief wells and deepening of existing borrow areas will result in a gain of 4.8 acres for both alternatives.

Habitat Suitability Index Values

HSI values were calculated for each alternative. The four habitat variables in the HSI model (VDI, maximum depth, percent area less than 5 feet, and turbidity) were estimated from borrow areas previously sampled and a HSI value calculated using equation 1 (Part I):

$$HSI = \frac{31.2(VDI) + 2.2\,(\text{Maximum Depth}_{ft}) - 0.2(\text{Percent Area}>5ft) - 0.1(\text{Turbidity}_{NTU}) - 24.3}{43}$$

Alternative	VDI	Maximim Depth, ft	Percent Area>5ft	Turbidity, NTU	HSI
Traditional and Avoid and Minimize without Environmental Features	1.4	7.5	23	24	0.7
Avoid and Minimize with Environmental Features	1.7	10	25	10	1.0

A HSI of 0.7 was calculated for both alternatives without environmental features. The independent variables used in the model were the grand mean values for the three sampling periods (See Table A11-14) and represented the basic design criteria of borrow areas for both alternatives without environmental features incorporated. Avoid and Minimize Alternative 3 will reduce placement of borrow areas in wetlands or bottomland hardwood forests, but does not necessarily consider the design of the borrow area itself for aquatic benefits. However, additional environmental features would be considered when working with willing landowners and non-Federal sponsors during project design. These features would include consideration of the model variables thus increasing the HSI to 1.0 (i.e., avoid and minimize with environmental features). These design parameters include: higher VDI, making the borrow area more cone shaped with deeper water; increasing percent area less than 5 feet, suggesting moderate sloping banks rather than steep sides; and reducing turbidity by creating riparian buffers around the borrow area to filter sediment runoff, provide additional windbreaks to reduce wave action, or implement some level of bank stabilization. These design features have multiple benefits. Deeper water is occupied by large-bodied individuals, overwintering fishes, and can moderate water temperatures during warmer months. Moderate sloping shorelines benefit nest-building fishes, such as sunfish, promote growth of aquatic vegetation used by smaller-bodied fishes, including larvae, juveniles, and many species of minnow and shiners, and vegetation is a preferred substrate to deposit eggs by larger fishes such as buffalo. Other features not included in the model would also benefit the aquatic community by increasing the heterogeneity of the borrow area including irregular shorelines and islands. Shields and Knight (2013) reported that larger-bodied fishes and some piscivores were more common in larger, more elongated pits with more sinuous shorelines and lower turbidity supporting the addition of these features in borrow area design. Diversity in engineering of borrow areas can contribute to diversity in fish assemblages (Miranda et al. 2013).

Habitat Units

Alternative 2 results in a grand total HU gain of 223 and 611.1 for landside and riverside borrow areas, respectively (Table A11-13). Lower proportional gains in HUs for landside borrow areas were due to application of the RVI of 0.6, indicating reduced species diversity in borrow areas landside of the levee (see Part I). Alternative 3 without environmental features will result in a HU gain of 176 and 688.7 for landside and riverside borrow areas, respectively (Table A11-13). The grand total includes other construction activity resulting in losses (i.e., fill from haul roads and levee enlargement) and gains (i.e., deepening existing borrow areas). Considering both gains and losses overall, approximately 1,400 acres of borrow area will be created during the project for each alternative, and up to 865 HUs gained for the Avoid and Minimize alternative without environmental features. However, if environmental features were incorporated in each borrow area, the gain in HUs would be 1,236 (Table A11-14). Although this scenario is hypothetical, field collections in borrow areas since 1981 confirm that incorporation of environmental design features will increase fish diversity, increase HUs gained, and benefit multiple ecological resources in the lower Mississippi River.

Table A11-13. A summary of the borrow area acres that will be created on the landside or riverside of the levee under Alternative 2 (Traditional Construction) and Alternative 3 (Avoid and Minimize) without environmental features. Habitat Suitability Index values were calculated from equation 1, Section I. Habitat values used in this analysis were VDI=1.4, maximum depth=7.5 feet, percent area > 5 feet = 23, and average turbidity=24 NTU's resulting in a HSI=0.7. Relative Value Index (RVI) indicating reduced species diversity was applied to all landside borrow areas by multiplying Habitat Units by 0.6.									
District	Location (proposed work)	Alt. 2 (Traditional Construction) without Environmental Features				Alt. 3 (Avoid and Minimize) without Environmental Features			
		Acres	HSI	RVI	Habitat Units	Acres	HSI	RVI	Habitat Units
Gains (+) of open water due to land cover conversions with new borrow areas									
MVM	Landside (borrow)	+349.5	0.7	0.6	+147	+43.5	0.7	0.6	+18
MVM	Riverside (borrow)	+207.9	0.7		+146	+513.1	0.7		+359
MVK	Landside (borrow)	+77.9	0.7	0.6	+33	+147.6	0.7	0.6	+62
MVK	Riverside (borrow)	+479.7	0.7		+336	+409.6	0.7		+287
MVN	Landside (borrow)	+98.2	0.7	0.6	+41	+223.2	0.7	0.6	+94
MVN	Riverside (borrow)	+190.1	0.7		+133	+65	0.7		+46
TOTAL	Landside (borrow)	+525.6			+221	+414.3			+174
TOTAL	Riverside (borrow)	+877.7			+614	+987.7			+691
NET TOTAL		+1403.3			+835	+1402			+865
Gains (+) or losses (-) of existing open water due to other proposed work									
MVM	Riverside: (fill of open water from levee enlargement)	-0.4	0.7		-0.3	-0.4	0.7		-0.3
MVM	Landside: (excavation from relief wells)	+5.7	0.7	0.6	+2.4	+5.7	0.7	0.6	+2.4
MVK	Riverside: (deepening of existing borrow area)	+0.2	0.7		+0.1	+0.2	0.7		+0.1
MVK	Riverside: (fill of open water from haul roads)	-3.8	0.7		-2.6	-2.9	0.7		-2.0
MVN	Riverside: (fill of open water from levee enlargement)	-0.2	0.7		-0.1	-0.2	0.7		-0.1
MVN	Landside: (fill of open water from levee enlargement)	-0.9	0.7	0.6	-0.4	-0.9	0.7	0.6	-0.4
TOTAL	Landside	4.8			+2.0	4.8			+2.0
TOTAL	Riverside	-4.2			-2.9	-3.3			-2.3
NET TOTAL		**0.6**			**-0.9**	**1.5**			**-0.3**
TOTAL	**Landside**	**+530.4**			**+223**	**+419.1**			**+176**
TOTAL	**Riverside**	**+873.5**			**+611.1**	**+984.4**			**+688.7**
GRAND TOTAL		**+1403.9**			**+834.1**	**+1403.5**			**+864.7**

Table 11-14. Avoid and Minimize Alternative 3 with Environmental Features. Habitat Suitability Index values were calculated from equation 1, Part I. Habitat variables used in this analysis were VDI=1.7, maximum depth=10 feet, percent area > 5 feet=25, and average turbidity=10 NTU's resulting in an HSI of 1.0. Relative Value Index indicating reduced species diversity was applied to all landside borrow areas by multiplying Habitat Units by 0.6.

District	Location	Acres	HSI	RVI	Habitat Units
MVM	Landside	43.5	1	0.6	26
MVM	Riverside	513.1	1		513
MVK	Landside	147.6	1	0.6	89
MVK	Riverside	409.6	1		410
MVN	Landside	223.2	1	0.6	134
MVN	Riverside	65	1		65
TOTAL	Landside	414.3			249
TOTAL	Riverside	987.7			988
GRAND TOTAL		1402			1236

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