APPENDIX 11
AQUATIC ANALYSIS

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A11-1 Abstract

An aquatic analysis of constructing borrow areas adjacent to the main line levees in the lower Mississippi River was conducted as part of Supplemental II to the Final Environmental Impact Statement. The habitat evaluation procedure (HEP) was used to evaluate alternatives (i.e., number, size, and morphology of borrow areas) of Work Items to estimate gains and losses of aquatic habitat for fishes. A habitat suitability index (HSI) model was developed to predict fish species richness based on rotenone collections as a function of the morphometry and water quality of borrow areas riverside of the levees. The HSI score was multiplied by acres of borrow areas created during construction to obtain habitat units (HU) for each alternative and environmental features incorporated in the design to optimize fish diversity were identified. A relative value index (RVI) was also calculated based on fish collections in 1997 and 2019 using seines and gillnets to compare the habitat value between riverside and landside borrow areas. Both the HSI model and RVI were certified for use by the U.S. Army Corps of Engineers (USACE) National Ecosystem Restoration Planning Center of Expertise specifically for borrow areas within the project area. This analysis indicated that riverside borrow area fish assemblages were more diverse than landside. Both alternatives being considered (Alternative 2 - Traditional Construction and Alternative 3 – Avoid and Minimize) resulted in a substantial gain of borrow area habitat up to approximately 1,400 acres and 865 HUs. Environmental features identified by the model that increase both fish species richness and overall habitat heterogeneity include the shape of the pit (e.g., bowl-shaped with deep water rather than long rectangular with shallower water), the availability of littoral areas for fish spawning and rearing, using best management practices such as tree screens and bank stabilization to lower turbidity, adding islands, and creating sinuous shorelines. Incorporation of these environmental features by willing landowners and non-Federal sponsors will increase HUs. The project results in an overall gain in aquatic habitat by creating permanent or semi-permanent water bodies on the floodplain of the lower Mississippi River that our research indicates may be occupied by at least 75 species of fish on a seasonal or permanent basis.

A11-2 Introduction

The USACE is preparing a supplemental environmental impact statement (SEIS II) to address the impacts associated with the construction of remaining authorized work on the Mississippi River mainline levees (MRL) feature of the Mississippi River and Tributaries (MR&T) project. The project includes raising and widening deficient portions of the levee to its authorized design grade and cross-section using material from borrow areas (also referred to as pits) or other sources, and installing measures to manage seepage during periods of high water in those areas at risk of losing levee foundation materials (Mike Thron, Memphis District, pers.com, May 2018). Measures to avoid and minimize impacts, such as prioritizing borrow area excavation and placement, will be included in the alternative analyses. The project extends along the MRL from Cape Girardeau, Missouri to Head of Passes, Louisiana.

This report summarizes the aquatic analysis of constructing borrow areas adjacent to the MRL in the lower Mississippi River. The report is divided into two parts: HSI model and impact assessment, including environmental design concepts.

A11-3 PART I – HABITAT SUITABILITY INDEX MODEL

A11-3.1 Purpose and Objective

The HEP was used to evaluate alternatives (i.e., number, size, and morphology of borrow areas), including environmental design features, to optimize aquatic habitat of borrow areas. The HEP multiplies a HSI value ranging from 0 (no habitat value) to 1.0 (optimum habitat value), by area (e.g., acres) of Work Item locations to obtain HUs (USFWS 1980). Comparison of HUs before and after construction provides a measure of impacts or benefits to the aquatic ecosystem.

Regression models were developed to predict changes in fish diversity as a function of morphological and water quality attributes of borrow areas. The model with the best fit was standardized to a HSI to evaluate environmental consequences of constructing these permanent or semi-permanent water bodies in the lower Mississippi River batture (i.e., floodplain). Converting a statistical model to a HSI value conforms to the application of the HEP to analyze an array of alternatives and conduct incremental analysis of project benefits.

Data used in model development were derived from 1-acre rotenone samples in 25 borrow pits collected in 1981 for the lower Mississippi River Environmental Program, and eight borrow areas in the mid-1990s for the original MRL project. All of these data were collected riverside of the levee (i.e., batture). In addition, riverside and landside borrow areas were sampled in 1997 and 2019 using seines and gillnets for a total of 15 sampling events to compare differences in fish assemblages on both sides of the levee. These data were used to develop a RVI for landside borrow areas not connected to the Mississippi River. The final HSI models were used in Part II of this report to quantify changes in fishery habitat as borrow areas are being created, enlarged, or deepened to raise the elevation of the MRL. Models were also used to provide guidance on environmental design of borrow areas to maximize fish diversity.

A11 3.2 Methods

<u>Geographic Location</u>

Ecological surveys of 25 MRL borrow areas along the lower Mississippi River were conducted in the early 1980s using rotenone to collect fishes. Results were published in a series of four reports, one of which summarized fishery investigations (Cobb et al. 1984) and another provided environmental design considerations for borrow areas (Aggus and Plosky 1986). In 1996-97, eight riverside borrow areas, seven of which were previously sampled by Cobb et al. (1984), were sampled with rotenone. These databases were combined for a total of 33 sampling events in the batture bordering Missouri, Tennessee, Arkansas, Mississippi, and Louisiana (Table A11-1). We assumed that each sampling event in the same borrow area represented an independent observation since at least a decade had passed between events. In addition, five riverside and four landside borrow areas were sampled with seines and gillnets in 1997 to compare fish diversity among the two locations and develop a RVI (USFWS 1980). The same five riverside borrow areas were sampled in 2019 using seines and gillnets, and an additional borrow area was added in 2019 at Modoc, Arkansas, for a total sample size of 15 (Table A11-1).

Habitat Variables

Borrow areas were sampled in mid- to late summer during the three decades when isolated from the Mississippi River. The same water quality, hydrologic, and morphometric variables measured by Cobb et al. (1984) were obtained during the 1996-97 and 2019 sampling periods. Water quality was measured at the water's surface with calibrated multi-parameter meters. Variables included water temperature, dissolved oxygen, pH, specific conductivity, and turbidity. In 1981 and 1996-97, bathymetric and ground surface elevations were measured by survey teams to calculate mean depth, maximum depth, area, volume, percent area with depth greater than 5 feet, and percent area with depth greater than 10 feet. In 2019, bathymetric data were collected using a YSI i3XO EcoMapper ® autonomous underwater vehicle (AUV) supplemented by stadia rod readings with GPS coordinates in shallow water (< 2 feet.) and paired with bare ground LiDAR data downloaded from The National Map (DOI and USGS 2018). The controlling elevation for each borrow area was used as the water surface elevation in calculating surface area and volume. The controlling elevation is the low point of the borrow area basin rim and is the elevation below which water cannot drain out by gravity, or conversely, the elevation of the river above which water must rise to enter the area. Borrow area flooding, or days flooded, was assumed to occur when river stage exceeded the controlling elevation, taking into account major topographic features that could influence stages in the borrow area vicinity (Cobb et al. 1984).

Borrow area morphometry was expressed as a volume development index (VDI) and shoreline development index (SDI). VDI is the ratio of the calculated volume of the borrow area to the volume of a cone with basal area and height equal to the surface area and maximum depth. Thus, if VDI=1, the borrow area basin would resemble a cone; if VDI< l, the borrow area basin would be very slender or rectangular; if VDI > 1, it would be more bowl-shaped. SDI is the ratio of the actual borrow area shoreline length to the circumference of a circle with the same area. Circular borrow areas have an SDI near 1.0, and SDI increases as it becomes more elongated. The degree of shoreline irregularity and amount of littoral zone increase with increasing values of SDI (Cobb et al. 1984).

To calculate the Cobb et al. (1984) and Killgore et al. (1998) variables for the borrow pits sampled in 2019, a terrain surface model was created from the LiDAR data, borrow pit bed elevation, and a polygon of the LiDAR water's edge (ESRI 2016). The polygon of the water's edge was designated as a soft line to separating the LiDAR and bathymetric data with no change in slope. To calculate the borrow pit bed elevation for the model, the EcoMapper and stadia rod depth readings were subtracted from the water surface elevation. Water surface elevation was determined by intersecting GPS points collected at the water's edge with the LiDAR data and/or from a surveyor's level set up on the nearby levee slope. The levee point elevation was determined from the LiDAR data. If multiple water surface elevations could be calculated for one borrow pit, values were averaged.

To calculate the variables, one-foot contours were created from the terrain using the Cobb et al. (1984) controlling elevation as the index contour so area and volume would be comparable between the 1984, 1996/97 and 2019 data sets. Because the Cobb et al. (1984) contours relied on widely spaced transect data, small features were not included, thus for the 2019 data, the minimum contour length was 65 feet. The other morphometric variables were calculated as per Cobb et al. (1984), with the following changes:

- The Add Surface Information tool in Arc GIS (ESRI 2019) was used to calculate the mean depth below the controlling elevation.
- The maximum depth was the deepest elevation recorded by the EcoMapper subtracted from the controlling elevation.
- The SDI was calculated per the Cobb et al. (1984) verbal explanation "ratio of the shoreline length to the circumference of a circle with an equivalent area" rather than the published equation.

All other variables were calculated with no modifications.

Connection Frequency

Floodplain water bodies provide critical habitat for riverine fishes, and thus the frequency and timing of connection (connection frequency) between the river and the water body is an important factor in determining the fish community. The connection frequency of the riverside borrow areas was defined as the number of days that the river's water surface exceeded the borrow pit's controlling elevation over a defined time period. Connection frequency was determined using gage data, river miles, controlling elevation and sampling date (Oliver et al. 2016). For each borrow pit, the nearest upstream and downstream gages with data from 1970 to 2019 were used. For Borrow pits 16, 18, 20, 22, 24, 25 and Bayou Goula, gage data began at March 1987 for Baton Rouge and December 1997 for Reserve gages. The average slope between Natchez and Baton Rouge and Baton Rouge and Reserve was calculated from the available data. The average slope was then used to calculate earlier data for Baton Rouge and Reserve from the Natchez gage data. The river mile location of the gages was retrieved from rivergages.com and for borrow pits with published river miles from Cobb et al. (1984), Killgore et al. (1998). For Bayou Goula, and Modoc river mile was determined from the point where the connecting channel reached the river. For 1981 and 1996-97 data, Cobb et al. (1984) controlling elevations were used. Controlling elevations for pits sampled in 2019 were determined from LiDAR data (DOI & USGS 2018) by locating the low areas connecting the borrow pit to the river. Once low areas were located, the LiDAR point data were investigated to find the lowest point elevation (controlling elevation) or the water surface elevation (if the low area was submerged during LiDAR acquisition) (Oliver et al. 2016). The borrow pits and connection areas were investigated by field crews during the summer of 2019. During field investigations, low areas were investigated to determine submerged controlling elevations.

To calculate connection frequency, the river stage at the borrow pit was calculated for each day from 1 January 1970 to 31 December 2019 using the upstream and downstream gage river mile and stage and the river mile of the borrow pit. Once the river stage at each borrow pit was calculated, the connection frequencies for 1 month, 6 months, overwintering 6 months, 1 year, 5, years and 10 years prior to the sampling date were calculated. These time periods were chosen because they capture short-term movements, spawning, overwintering (6 month period prior to spawning 6 months), overwintering and spawning, and longer-term changes reflecting water year variability. To evaluate the relationship between changes in area and volume and connection frequency, the connection frequency between the 1981 sampling date and the 1996/97 or 2019 sampling date was also calculated.

Fish Sampling

All borrow areas were sampled from June to mid-September. For riverside borrow areas, two 1-acre plots were blocked off by nets with 0.5-inch mesh and rotenone applied to achieve a minimum of 1-2 mg/l concentration. Potassium permanganate was applied around the periphery of the plot to detoxify rotenone drifting outside the target area. Surfacing fish were collected, identified to species, measured (total length to the nearest mm), and weighed (Davies and Shelton 1983). Fish pickup occurred for two consecutive days after rotenone was applied. Fish assemblage of each borrow area was expressed on a per acre basis, which is the traditional method of reporting fish standing crop. However, number of fish per acre-ft can be calculated if volumetric estimates are required. These data were used to develop the HSI model for riverside borrow areas.

Seines and gillnets were used in both riverside (1997 and 2019) and landside borrow areas (Table A11-1). These data were used to compare fish assemblages between riverside borrow areas seasonally contiguous with the river and landside borrow areas permanently isolated from the river to develop the RVI. Shoreline fishes were collected using a 20' by 8' seine with 3/16" mesh; standard effort was 10 hauls stratified among all apparent macrohabitats. Pelagic (offshore) fishes were collected with gillnets (90' X 6' with 0.75, 1.5, 2.0, 2.5, 3.0, 3.5" stretch mesh); standard effort was overnight sets of 5-6 gillnets set perpendicular to shore. Shoreline fishes were preserved in 10 percent formalin. Larger fishes were identified in the field and released. In the laboratory, fishes were washed, identified, and counted. Specimens were catalogued and deposited as holdings in the Mississippi Museum of Natural Science, Jackson, MS.

Model Development

Fish diversity of borrow areas was calculated from all fish collections using Primer 7.0 (Clarke and Gorley 2015). Diversity is a collective property of fish communities and reflects species-abundance relationships of the collection. It is responsive to both species richness (the number of species) and species evenness (the distribution of individuals among those species). Diversity can be measured in various ways, but is typically expressed as "heterogeneity indices" that incorporate species richness and evenness into a single value, showing varying sensitivity to either richness or evenness components (Magurran 1988).

Diversity measures used in this evaluation are standardized species richness (S), Pielou's evenness index (J'), and Simpson's dominance index (D) (Magurran 1988; Ludwig and Reynolds 1988). Standardized species richness is a probability-based method that addresses disparate numbers of individuals in a series of collections by quantifying the number of species expected in a random sub-sample of individuals taken from each collection. It is calculated by a process called rarefaction, is expressed as the number of species expected for a sub-sample of given size, and can range from one to the total number of species in the community (S*) that is assumed to be the number observed in each collection. Mean abundance (i.e., number per acre) was used in calculating standardized species richness.

Evenness quantifies how individuals in a collection are distributed among species, specifically how they diverge from an equitable distribution among all the species. Pielous evenness index (J') is a ratio of an observed logarithmic function (Shannon's H') to a hypothetical community in which all species are equally common (H'_{max}): $J' = H' / \log_e S$, where S is total number of species. It ranges from values near 0.00 (numerical domination by one or a few species to values near 1.00 (comparable abundance of all species).

Dominance (D) is similar in concept to evenness but is an exponential function rather than a logarithmic function. This index quantifies the probability that two individuals drawn at random from a collection will be members of the same species. Dominance used in this analysis is designated as 1-Lambda' in Primer 7.0. It ranges from values near 0.00 (almost inevitable that two sequential draws will be from the same species) to values near one (unlikely that two sequential draws will be from the same species). Dominance (λ) is calculated as:

$$1-\lambda' = 1 - ((\textstyle\sum_i N_i(N_i - l)) / (N(N-1))$$

where the abundance of the ith species is denoted by N, (i = 1, 2, .., S) and divided by their sum (N).

Multiple regression models were developed to predict diversity (dependent or response variable) as a function of habitat parameters (the independent or predictor) that describe the morphology and water quality of riverside borrow areas (Table A11-2). Multiple regression equations are empirical, do not entail *a priori* decisions regarding relationships between habitat parameters and fishes, and thus reduce institutional bias. Instead, habitat value is assessed directly from baseline relationships between fish abundance (density or biomass) and physical habitat (area morphometry, connection frequency, and water quality). Multiple regression eliminates irrelevant variables from the final predictive model and quantifies correlation between habitat variables and fish abundance.

Multiple regression equations were generated with the REG Procedure in SAS v. 9.4 (SAS Institute Inc., Cary, NC, USA). A two-tailed entry level selection value of the independent variables was set at $\alpha = .05$, and any independent variable entered would remain in the model at a significance level of $\alpha < 0.05$. The final model is achieved when no variables outside of the model meet these criteria. These criteria aid in retaining independent variables that may be important in the final model. Not all model intercepts were statistically different from zero. Adjusted R-squared value ($R^{2)}$) that was based on Pearson product-moment correlation coefficients and includes a penalty for over-fitting was used to assess model fit after stepwise selection. Multicollinearity among independent variables was assessed by examining variance inflation factor, which estimates how much the variance of a regression coefficient is inflated due to multicollinearity in the model. Influence of outliers was determined objectively using a combination of two statistical tests: studentized residual values greater than three, which are calculated by dividing the residual by an estimate of its standard deviation, and Cook's distance (D) depending on the point spread in each data set. For Cook's D value, a possible outlier is generally more than three times the mean (Cook 1977). Residual plots on predicted values were used to evaluate suitability of the final model. The model was determined suitable based on the symmetrical pattern and constant spread observed in the range of the residuals indicating that the variables used in the model adequately predict the response in fish diversity. A HSI value was determined by dividing the calculated diversity value from the regression equation by the maximum value observed from the field data to normalize the output between 0 (no value) to 1.0 (maximum value).

A RVI was calculated to determine the difference in fish habitat benefits between landside and riverside borrow pits. Standardized species richness was calculated for the seine and gillnet data collected in 1997 and 2019. Mean values were compared between riverside and landside borrow areas. A RVI (USFWS 1980) was calculated as follows:

$$((\Sigma xi) / n) / ((\Sigma yi) / n)$$

where x = richness value of landside borrow areas, y = richness values of riverside borrow areas, and n is the number of observations for each category. The RVI was used to weight the difference in HSI values between riverside and landside borrow areas.

<u>Model assumptions and Uses</u>

1) Model provides guidance on the construction of environmentally-enhanced borrow areas by identifying and quantifying correlations between physical habitat variables and species diversity.
2) Model only accounts for a portion of the variability in fish diversity and is sensitive to outliers.
3) Model does not imply causality.
4) Sampling methods must be similar for two samples to be compared by these indices and the communities to be compared should be taxonomically similar (Ludwig and Reynolds 1988). Since rotenone was used to collect fish to develop regression equations for HSI development, seines and gillnets were used to develop the RVI, and all sampling was conducted in the lower Mississippi River either riverside or landside of the levee, these two requirements were met.
5) The model is not predictive for individual borrow areas over time because it does not address successional changes in physical habitat or hydrologic regime due to extremities in wet and dry periods. However, if successional changes can be identified, then short-term and long-term habitat-based shifts in fish diversity can be forecast by adjusting habitat inputs in the model.

A11-3.3 Results and Discussion

<u>Habitat</u>

Borrow areas sampled in the batture represented a wide range of morphometric and water quality characteristics. They ranged in size from 3 to 53 acres, with mean depths of approximately 3 feet during all three sampling periods (Table A11-2). Maximum depth measured in any one borrow area was 17.7 feet, but mean percent area greater than 10 feet was only 3 percent. Overall, the typical borrow area in the lower Mississippi River batture was less than 20 acres and averaged 3 feet in depth. The mean SDI ranged from 2.1 to 2.7 depending on sampling years with a maximum value measured of 5.8. Most borrow areas are rectangular or bowl-shaped (i.e., VDI>1.0) and shorelines often become more irregular over time, increasing SDI above 2.0. Water quality was typical for summer conditions in relatively shallow, permanent water bodies in the batture. Mean water temperature was high (>31 ºC), with no observable flow, and some borrow areas were hypoxic (< 3 mg/l dissolved oxygen) and turbid (> 50 NTU).

The mean (± 1 standard deviation) connection frequency per year was 90 ± 101 days including all sampling periods (Table A11-3). The variation of connection frequencies among the three sampling periods contributed to the high standard deviation. The mean annual connection frequency for the 1981 data was just 23 days, increased to 91 days for the 1996-97 period, and rose to 254 days for the 2019 period illustrating changes in flood frequency over the last few decades. Other connection frequencies follow the same trend (Table A11-3). Based on recent flood frequency data, most borrow areas will be connected to the river annually as floodwaters approach the levees mixing both riverine and wetland fish species creating a more diverse assemblage.

Long-term changes in habitat were evaluated by multvariate comparisons of those borrow areas sampled more than once (Table A11-4). . Borrow areas 2, 6, and 9 were sampled in 1981 and 1996-97, and borrow areas 13, 15, 17 and 25 were sampled during all three time periods. Comparing the four borrow areas sampled in 1981 and 2019 (38 years) showed moderate differences in average depth, decreasing 17 percent overall indicating patterns of sedimentation. However, surface acres were similar during the evaluation period. The mean percent area greater than 5 feet and the VDI showed substantial decreases of 33 percent and 40 percent, respectively. The mean shoreline length and Shoreline Development Index increased 38 percent and 39 percent, respectively. Number of days flooded annually increased during this same time period. Multivariate comparison of these morphological, bathymetric, and water quality variables over the 38-year period indicate that the shorelines of most borrow areas become more sinuous over time. PCA demonstrates that water depth and overall volume decreases, probably from vertical accretion of sediments during flood events (Figure A11-1). More frequent floods may exacerbate this long-term trend. Despite these changes, relative positions of borrow pits along the first principal component axis, the one accounting for most data set variance, were approximately the same, and did not change appreciably over time, suggesting that successional changes in physical habitat were comparable in all borrow pits studied.

Fish Community – Rotenone Samples

Overall, 75 species of fishes were collected with rotenone from riverside borrow areas in 1981 and 1996-1997 (Table A11-5). The number of species collected per borrow area ranged from 18 to 50, with a mean (±1 SD) of 31 ± 8. The number of fish per acre ranged from 829 to 62,160, with a mean of 11,320 ± 11,579. Taxonomically dominant groups were minnows (16 spp) and sunfishes (13 spp). Catfishes, suckers, and darters were moderately speciose (7-8 spp.). Invasive carps (minnow family) were only collected in 1996-97: grass carp, silver carp, and bighead carp. Numerically abundant species were forage fishes, including gizzard shad, threadfin shad, and juvenile sunfishes. None of the species collected are federally listed as threatened or endangered (Anonymous 1997), but several species are regionally imperiled (Robison and Buchanan 1988; Jelks et al. 2008). Borrow areas with riverine connections function similarly to oxbow lakes and may provide alternate habitat and refugia during high water events for riverine and wetland species declining elsewhere in their range (Miranda et al. 2013).

Borrow area fish communities were described using three different measures of species diversity. Standardized species richness ranged from 18 to 44 species/11,500 individuals (i.e., approximates mean number of fish per acre), similar to total observed number of species that ranged from 18 to 50 (Table A11-6). However, rarefaction is less biased to sample size than raw species richness. Pielou's evenness index ranged from 0.2, indicating the presence of a few dominant species, to 0.7 indicating similarity in abundances among the species. Simpson dominance index ranged from 0.2 to 0.9 corresponding to the evenness metric that some borrow areas are dominated by only a few species. Gizzard Shad, Threadfin Shad, and juvenile sunfishes comprised almost 75 percent of the total individuals in borrow areas, contributing to low evenness and high dominance. Other species represented 5 percent or less of the total individuals.

Comparison of the diversity measures between decades showed species richness increasing from 1981 to 1996-97, evenness remaining steady, but dominance shifting either up or down (Table A11-4). In addition to the three dominant species mentioned previously, bluegill sunfish, channel catfish, orangespotted sunfish, and white crappie were common in the collections and further contributed to low evenness and high dominance of riverside borrow area fish communities. These species are widespread throughout the lower Mississippi River and most are considered generalists in their tolerance to habitat and water quality fluctuations. Reductions in the depth of borrow areas are more than compensated by increases in shoreline complexity (e.g., shoreline length, SDI) so that habitat suitability, along with species richness, increases over time.

Habitat Suitability Index Model – Rotenone Samples

The calculated values from the multiple regression equations for the three measures of diversity were investigated to select the most robust HSI model. Models for species evenness and dominance had low to moderate predictive capability with adjusted R^2 values less than 0.45 even with outliers removed (Table A11-7). Significant variables used in the model required an entry level of $\alpha = .05$ and retention selection value of $\alpha = .05$, thus weighting their importance in predicting species richness. Turbidity was the only independent variable that met these criteria for evenness and dominance. Low predictive capability and selection of only one independent variable may be due to the restricted range of possible values (as compared to species richness) and inherent bias of ratio-based measures.

The multiple regression with standardized species richness as the response variable was highly significant, and with outliers removed, the adjusted R^2 increased from 0.14 to 0.83. Six outliers were removed, decreasing the sample size from 33 to 27, to increase R^2 while retaining significant independent habitat variables influencing species richness. Outliers removed either had high dominance of one or two species (i.e., threadfin shad, gizzard shad, and small sunfish), or spurious correlations to the independent habitat variables. A final set of observations highly influential to the coefficient values were removed if they had a high predictive residual (> 7), high studentized residual (>3), or high Cook's D value (>0.3) (Zuur et al. 2010). These measures were used to maximize the coefficient of determination resulting in the removal of the six borrow areas to achieve a R^2 of 0.83. Residuals did not show an obvious pattern, indicating that errors have constant variance and there was no indication of correlated or missing variables

(Figure A11-2). Therefore, the model met the assumption of independence for parametric analysis and errors were normally distributed.

The species richness multiple regression analysis retained four independent variables: VDI, maximum depth, percent area greater than 5 feet, and turbidity. VDI and maximum depth were positively correlated to species richness, while percent area greater than 5 feet and turbidity were negatively correlated, possibly due to low dissolved oxygen near the bottom. This combination of variables indicates that high species richness is associated with borrow areas more bowl-shaped than rectangular, areas with deep water (>6-7 feet), and lower turbidity. The negative correlation of percent area greater than 5 feet suggests that borrow areas with a combination of deep water and some areas less than 5 feet optimize species richness.

The model was highly significant ($F=31.74$, $p<0.0001$) with parameter estimates indicating that borrow area morphometry (i.e., VDI) has the greatest influence on HSI scores followed by maximum depth (Table A11-8). The presence of some shallow areas and reduced turbidity were statistically significant but were less influential on overall HSI scores. The variance inflation estimates, which indicate how much the variance of regression coefficients are inflated due to multicollinearity in the model, was low (1) to moderate (4), suggesting a moderate to high reliability in predicting species richness from a combination of these habitat variables (Table A11-8).

The predicted standardized species richness was divided by the maximum richness value to normalize the HSI score between 0 and 1. There were 43 species observed in the 27 borrow areas that were retained in the analysis. Thus, the species richness multiple regression equation was divided by 43 (Equation 1).

Equation 1:

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

The calculated HSI may occasionally exceed 1.0 or fall below zero when using habitat values outside the range of those measured in the borrow areas; these values will be rescaled to 0.1 or 1.0. For application to the MRL project, HSI values will be multiplied by area (acres of borrow areas) to express alternatives as HU.

Relative Value Index for Landside Borrow Areas

Rotenone sampling was not conducted in landside borrow areas. Borrow areas were similar in morphometry between riverside and landside. However, hydrology differs in that precipitation maintains water levels in most landside pits along with drainage ditches and relief wells that may provide some level of hyporheic flows. Most landside borrow areas were surrounded by agricultural fields. Conversely, periodic connection to the river and hyporheic flow from the Mississippi alluvial aquifer maintains water levels in riverside areas and most are surrounded by trees.

Seining and gillnet data were used to compare species assemblage differences between riverside and landside borrow areas. Overall, fishes were more abundant and diverse in riverside borrow areas than landside. A total of 18 species were collected with gillnets in landside borrow areas during 1997 compared to 31 and 30 species in riverside borrow areas during 1997 and 2019, respectively (Table A11-9). Gizzard Shad was the most abundant species in all borrow areas. Species associated with riverine environments were not unusual, and sometimes frequent, in riverside borrow areas, but were absent, and almost always in low abundance in landside borrow areas. These include mooneye, alligator gar, white bass, river carpsucker, and sauger. Seining had similar results. A total of 17 species were collected landside, compared to 38 and 44 species riverside during the 1997 and 2019 collections, respectively (Table A11-10). Four species comprised over 80 percent of the total individuals in landside borrow areas: orangespotted sunfish, largemouth bass, Mississippi silverside, and bluegill. With the exception of Mississippi silverside, the three remaining species are habitat generalists and often found in isolated ponds and lakes. Species composition between riverside and landside borrow areas was similar to that described by Miranda et al (2013) in that riverside borrow areas tended to have fish assemblages with a higher representation of rheophilic species that depend on flow, or simply the flooding, afforded by large tributaries to complete their life cycle in lacustrine systems. In contrast, landside oxbow lakes with reduced or no connectivity tended to have a higher representation of lacustrine species, partly because of the loss of rheophilic species and partly because of a more stable lacustrine environment that was less influenced by periodic floods.

Species diversity measures showed the same trends (Tables A11-11 and A11-12). For gillnets, species richness was 25 to 33 percent higher and catch-per-unit-effort (i.e., number per 5/6 nets) was more than twice as high in riverside borrow areas. However, landside borrow areas were more likely to be dominated (i.e., lower D score) by one species, usually gizzard shad (Table A11-9). Seining data were even more pronounced. Species richness was twice as high in riverside borrow areas for both sampling periods. Evenness was higher in riverside borrow areas characterized by a more equitable abundance among a more diverse assemblage. Mean catch-per-unit-effort was three times higher in riverside borrow areas. Similar to gillnet data, landside pits were more likely to be dominated by only a few tolerant species (Table I-10).

The average percent difference in standardized species richness between landside and riverside borrow areas was calculated separately by gear type, and the mean value was designated as the RVI. The two gears sample a different component of the fish assemblage and taking the mean value provides a more complete description of both small, littoral fish (seining) and larger pelagic fish (gillnets).

The RVI was calculated as follows:

Percent difference using gillnets: 3.8 / 5.4 = 0.70
Percent difference using seines: 9.5 / 18.5 = 0.51
RVI, Mean of gillnets and seines: 0.6

For landside borrow areas, the HSI value calculated from Equation 1 should be multiplied by 0.6 prior to calculating HUs. The resulting value takes into account lower species richness in landside borrow areas based on seining and gillnet data collected in each type.

Table A11-1. Location of 31 borrow areas sampled in 1981, 1996-97, and/or 2019. Borrow areas with an asterisk designated as outliers for the standardized species richness model (see Table A11-7). The four Lake Providence sites were the landside borrow areas.

Borrow Area	Location	River Mile	Descending Bank	Distance to River (Miles)	Year Sampled Rotenone		Year Sampled Gillnet/Seine		USACE District
					1981	1996-97	1997	2019	
1*	Madison Parish, LA	431	R	0.3	X*				Vicksburg
2	Tensas Parish, LA	407	R	2.4	X	X			Vicksburg
3	East Carroll Parish, LA	469	R	0.4	X				Vicksburg
4*	East Carroll Parish, LA	482	R	0.4	X*				Vicksburg
5	East Carroll Parish, LA	462	R	0.6	X				Vicksburg
6	Madison Parish, LA	433	R	1.3	X	X			Vicksburg
7	Warren County, MS	460	L	0.9	X				Vicksburg
8	Bolivar County, MS	593	L	0.3	X				Vicksburg
9	Bolivar County, MS	595	L	1.1	X	X			Vicksburg
10	Madison Parish, LA	456	R	0.1	X				Vicksburg
11*	Bolivar County, MS	602	L	2.1	X*				Vicksburg
12	Concordia & Tensas Parish, LA	377	R	0.7	X				Vicksburg
13*	Phillips County, AR	656	R	0.3	X	X*	X	X	Memphis
14	Desha County, AR	584	R	4.3	X				Memphis
15	Coahoma County, MS	659	L	1.8	X	X	X	X	Memphis
16	Concord Parish, LA	355	R	0.2	X				Vicksburg
17*	Mississippi County, AR	773	R	2.3	X*	X	X	X	Memphis
18	Concord Parish, LA	323	R	1.8	X				New Orleans
19	New Madrid County, MO	877	R	0.8	X				Memphis
20	Concord Parish, LA	305	R	0.3	X				New Orleans
21	New Madrid County, MO	881	R	2.5	X				Memphis
22	Concord Parish, LA	315	R	0.4	X				New Orleans
23	Shelby County, TN	720	L	1	X				Memphis
24	St. James Parish, LA	151	L	0.1	X				New Orleans
25*	Ascension Parish, LA	180	L	0.1	X*	X	X	X	New Orleans
Bayou Goula	Iberville Parish, LA	194	R	0.1		X	X	X	New Orleans
Lake Providence - 1	East Carroll Parish, LA	497	R	3.6			X		Vicksburg

Lake Providence - 2	East Carroll Parish, LA	494	R	3.5			X		Vicksburg
Lake Providence - 3	East Carroll Parish, LA	493	R	2.3			X		Vicksburg
Lake Providence - 4	East Carroll Parish, LA	492	R	1.8			X		Vicksburg
Modoc	Phillips County, AR	634	R	1.0				X	Memphis

Table A11-2. Comparison of morphometric and water quality variables for riverside borrow areas in the Mississippi River measured during summer of 1981 (Cobb et al. 1984), 1996-1997, and 2019. Abbreviations include standard deviation (Std Dev), minimum (Min), and maximum (Max) values.

	1981, n=25					1996-97, n=8					2019, n=6				
Variable	Mean	Median	Std Dev	Min	Max	Mean	Median	Std Dev	Min	Max	Mean	Median	Std Dev	Min	Max
Water Temperature, °C	31.7	31.8	2	27	35.5	31.4	31.7	4.4	24.2	37.9	32.0	32	1.7	29.7	34.4
Conductivity, µmhos/cm	310.7	315	89.3	75	505	281	283	49	205	344	409.0	408	81.8	277.0	536.0
Dissolved Oxygen, mg/l	6.8	6.5	2.5	0.6	11	6.8	7.3	1.7	3.6	8.6	11.2	10	4.3	7.2	19.9
pH	8.1	8.2	0.6	7	9.4	8	8	0.4	7.5	8.4	9.6	10	0.5	8.9	10.5
Turbidity, NTU	26.6	18	21	8	85	26	26.6	14	7	50	20.8	20	12.1	8.3	43.2
Surface Area, acres	19.2	12.7	16.5	3.3	53.4	17	17.2	13.3	3.3	41	38.5	43.9	18.5	6.1	55.6
Average Depth, ft	3.1	2.8	1.8	0.5	7.2	3.3	3.4	1.5	1.3	5.8	3.5	3.3	0.6	2.8	4.5
Maximum Depth, ft	6.5	5.5	4.2	1.1	17.7	6.5	5.7	3.5	2.6	12.4	9.6	10.0	2.7	6.3	12.8
Percent Area > 5 ft	27.5	17.1	27.6	0	71.7	15.9	10.9	19.6	0	53.8	26.2	21.5	11.6	14.8	41.6
Percent Area > 10 ft	3.2	0	7.9	0	33	2.9	0	6.4	0	18	1.5	0.0	3.1	0.0	7.7
Shoreline Length, ft	6,471	4,839	3,941	1,916	15,224	8,456	7,677	6,491	1,751	20,297	16,716	17,120	8,193	2,676	27,851
Shoreline Development Index	2.1	2	0.7	1.2	3.7	2.7	2.4	1.5	1.3	5.8	3.5	3.9	1.2	1.5	5.1
Volume, yds^3	102,687	61,516	106,288	4,056	348,228	88,249	77,550	77,519	7,075	175,935	208,717	235002	92135	39,037	294,576
Volume Development Index	1.5	1.6	0.3	0.7	1.9	1.6	1.6	0.3	0.9	2	1.2	1.3	0.5	0.6	1.9
Basin Slope	0.04	0.03	0.03	0.01	0.14	0.03	0.01	0.04	0.00	0.10	0.05	0.05	0.01	0.04	0.07

Table A11-3. Riverside borrow areas sampled in 1981, 1996, 1997 and 2019 with the controlling elevation (ft. NGVD) and river mile (RM). The upstream and downstream gage were used to calculate the river stage at the borrow pit. The connection frequency represents the number of days that the borrow pit river stage exceeded the connection threshold elevation over the 1 month (31 days), 6 months etc. prior to sampling.

Pit	Sample Date	Control		Gage		Conn. freq. month			Conn. freq. years			After 1981
		RM	Elev. ft	Upstream	Downstream	1	6	6 - 12	1	5	10	
1	6/10/1981	431	73.0	Vicksburg	Natchez	14	14	0	14	359	1053	
2	6/16/1981	400	68.8	Vicksburg	Natchez	0	0	0	0	195	679	
2	7/24/1996	400	68.8	Vicksburg	Natchez	10	60	0	60	473	849	1212
3	6/6/1981	469	89.0	Arkansas City	Vicksburg	10	10	0	10	293	911	
4	6/19/1981	482	90.5	Arkansas City	Vicksburg	25	25	0	25	418	1182	
5	6/17/1981	462	84.0	Arkansas City	Vicksburg	22	22	0	22	386	1104	
6	9/23/1981	432.6	79.8	Vicksburg	Natchez	0	0	0	0	177	634	
6	7/22/1996	432.6	79.8	Vicksburg	Natchez	10	57	0	57	400	707	1031
7	6/23/1981	460	79.8	Arkansas City	Vicksburg	30	30	0	30	493	1319	
8	6/29/1981	593	139.8	Helena	Arkansas City	23	27	0	27	278	862	
9	6/29/1981	595.1	137.2	Helena	Arkansas City	31	37	0	37	414	1150	
9	7/29/1996	595.1	137.2	Helena	Arkansas City	4	103	3	106	657	1185	1761
10	7/6/1981	456	81.6	Arkansas City	Vicksburg	25	35	0	35	401	1125	
11	7/6/1981	609	143.7	Helena	Arkansas City	25	38	0	38	405	1124	
12	7/10/1981	377	55.0	Vicksburg	Natchez	26	39	0	39	429	1157	
13	7/10/1981	652.4	171.0	Helena	Arkansas City	0	0	0	0	148	513	
13	7/21/1997	652.4	171.0	Helena	Arkansas City	0	40	0	40	322	479	747
13	8/21/2019	652.4	170.8	Helena	Arkansas City	0	149	46	195	413	646	1738
14	7/15/1981	584	137.0	Helena	Arkansas City	8	18	0	18	219	747	
15	7/13/1981	656.8	173.0	Helena	Arkansas City	0	0	0	0	150	516	
15	7/29/1997	656.8	173.0	Helena	Arkansas City	0	40	0	40	319	476	743
15	8/19/2019	656.8	167.5	Helena	Arkansas City	12	162	122	284	620	1090	3258
16	7/20/1981	355	49.1	Natchez	Baton Rouge	17	40	0	40	431	1154	
17	7/20/1981	767.6	235.0	MS HW 152	Memphis	0	0	0	0	43	155	

17	8/6/1997	767.6	235.0	MS HW 152	Memphis	0	27	0	27	78	97	170
17	9/11/2019	767.6	232.8	MS HW 152	Memphis	0	71	32	103	181	264	690
18	7/23/1981	323	41.8	Natchez	Baton Rouge	15	42	0	42	451	1204	
19	7/26/1981	877	279.1	New Madrid	MS HW 152	0	7	0	7	200	632	
20	7/27/1981	305	40.0	Natchez	Baton Rouge	8	38	0	38	397	1076	
21	7/28/1981	881	287.0	New Madrid	MS HW 152	0	0	0	0	92	254	
22	7/29/1981	315	47.0	Natchez	Baton Rouge	0	8	0	8	218	709	
23	7/31/1981	720	195.0	Memphis	Helena	0	39	0	39	417	1146	
24	8/5/1981	151	14.0	Baton Rouge	Reserve	1	40	0	40	431	1158	
25	8/4/1981	178.6	21.0	Baton Rouge	Reserve	0	28	0	28	301	880	
25	8/18/1997	178.6	21.0	Baton Rouge	Reserve	0	130	53	183	773	1289	1863
25	9/24/2019	180	18.3	Baton Rouge	Reserve	0	142	181	323	890	1580	5137
Goula	8/12/1997	196.6	25.0	Baton Rouge	Reserve	0	127	35	162	641	1048	
Goula	9/25/2019	197.4	18.2	Baton Rouge	Reserve	0	144	184	328	965	1820	
Modoc	8/20/2019	633.8	156.9	Helena	Arkansas City	12	162	128	290	648	1141	

Table A11-4. Comparison of morphometric, water quality, and species diversity variables for the same riverside borrow areas in the Mississippi River measured during summer of 1981 (Cobb et al. 1984), 1996-1997, and 2019. Only borrow areas 13, 15, 17 and 25 were sampled during all three years. Species diversity variables are only reported for the 1981 and 199-97 sampling periods when rotenone was used to collect fish.

Variable	Number 25			Number 2		Number 6		Number 9		Number 13			Number 15			Number 17		
	1981	1997	2019	1981	1996	1981	1996	1981	1996	1981	1997	2019	1981	1997	2019	1981	1997	2019
Surface Area, acres	36.9	26.5	32.3	18.6	18.76	4.5	4.5	3.3	3.26	53.4	22.7	54.7	53.4	41	54.7	38.1	15.6	43.9
Mean Depth, ft	5.6	3.7	4.5	5.7	5.8	3.8	2.7	1.7	1.3	3.8	3.8	3.1	3.9	4.2	3.3	3	1.5	2.8
Maximum Depth, ft	10.3	7.1	10	10.4	10.7	6	5.3	3.5	2.6	16.9	12.4	12.1	7.5	6.1	6.7	5.7	2.6	12.8
Percent Area > 5 ft	66.9	26.7	41.5	71	53.8	55.5	0	1.6	0	30.9	21.7	14.8	44.6	25	14.9	21.9	0	21.5
Percent Area > 10 ft	7.6	0	0	21.4	5.1	0	0	0	0	8.3	18	7.7	0	0	0	0	0	0
Shoreline Length, ft	15,224	12,196	16,771	4,839	5336	5,737	3,135	1,916	1,751	14,008	20,297	27,965	8,881	12,626	17,365	10,498	10,015	19,445
Shoreline Development	3.4	3.2	4	1.5	1.7	1.5	2	1.4	1.3	2.6	5.8	5.1	1.6	2.7	3.1	2.3	3.5	4
Volume, cubic yards	325,348	160,000	269,410	178,733	176,080	6,241	19,708	9,780	7,075	309,178	131,476	275,393	348,228	170,985	294,576	183,100	123,624	199,576
Volume Development Index	1.6	1.6	1.3	1.6	1.6	1.9	1.6	1.5	1.6	0.7	0.9	0.8	1.6	2	1.5	1.6	1.8	0.6
Mean Basin Slope	0.07	0.1	0.07	0.05	0.048	0.02	0.001	0.03	0.012	0.05	0.012	0.04	0.02	0.0028	0.04	0.03	0.0025	0.05
Number of Days Flooded Annually	81	130	180	71	60	89	80	84	62	56	82	195	56	82	284	25	46	109
Dissolved Oxygen, mg/l	5.2	4.1	10.5	5.6	5.3	4.2	5.6	10.2	11.6	8.9	7.3	12.2	5.6	8.2	7.2	9.5	3.6	7.2
pH	7.9	7.4	9.5	8.1	7.7	7.6	8.1	8.2	8.9	8.4	7.5	8.9	7.7	8.4	9.3	8.1	7.5	7.2
Conductivity, µmhos/cm	336	282	536	205	344	341	342	432	287	318	269	440	368	228	455	234	205	367
Water Temperature, °C	32	31.6	31.8	32	31	32	32	31	29	34	35	34	33	36	32	33	24	29
Turbidity, NTU	10	35	24	42	22	18	15	13	44	8	7	8	10	33	9	16	27	25
Standardized Species Richness, S[1]	26	40		28	40	33	38	27	26	29	44		32	43		20	33	
Pielou's Evenness, J'	0.21	0.23		0.58	0.36	0.52	0.32	0.6	0.54	0.47	0.44		0.52	0.5		0.42	0.52	
Simpson's Dominance, D	0.29	0.64		0.73	0.49	0.74	0.43	0.8	0.76	0.71	0.69		0.72	0.69		0.65	0.74	

[1] Number of species predicted for a random sample of 11,500 individuals based on rarefaction.

Table A11-5. Species abundance (number/acre) for fishes collected with rotenone in borrow areas during 1981 (n=25) and 1996-97 (n=8).					
Family	Genus, Species	Common Names	1981	1996-1997	Totals
Polyodontidae (paddlefish)	*Polyodon spathula*	Paddlefish	44	41	85
Lepisosteidae (gars)	*Atractosteus spatula*	Alligator Gar		1	1
	Lepisosteus oculatus	Spotted Gar	587	407	994
	Lepisosteus osseus	Longnose Gar	7	7	14
	Lepisosteus platostomus	Shortnose Gar	289	11	300
	Lepisosteus sp.	Juvenile gar	20	3	23
Amiidae (bowfin)	*Amia calva*	Bowfin	42	49	91
Hiodontidae (mooneyes)	*Hiodon alosoides*	Goldeye	15	6	21
	Hiodon sp.	Juvenile Hiodontidae		24	24
Anguillidae (freshwater eels)	*Anguilla rostrata*	American Eel	9		9
Clupeidae (herrings)	*Alosa chrysochloris*	Skipjack Herring	1	10	11
	Dorosoma cepedianum	Gizzard Shad	135590	25021	160611
	Dorosoma petenense	Threadfin Shad	50285	7573	57858
	Dorosoma sp.	Juvenile shad	10	3529	3539
Cyprinidae (minnows)	*Ctenopharyngodon idella*	Grass Carp		2	2
	Cyprinella lutrensis	Red Shiner	20		20
	Cyprinella venusta	Blacktail Shiner		2	2
	Cyprinus carpio	Common Carp	6942	75	7017
	Hybognathus nuchalis	Mississippi Silvery Minnow		1	1
	Hypophthalmichthys molitrix	Silver Carp		1	1
	Hypophthalmichthys nobilis	Bighead Carp		2	2
	Lythrurus fumeus	Ribbon Shiner	160		160
	Macrhybopsis storeriana	Silver Chub		20	20
	Notropis atherinoides	Emerald Shiner	100	1	101
	Notemigonus crysoleucas	Golden Shiner	212	196	408
	Notropis blennius	River Shiner	10		10
	Notropis maculatus	Taillight Shiner	186	873	1059
	Notropis shumardi	Silverband Shiner	67	8	75
	Opsopoeodus emiliae	Pugnose Minnow	191	1151	1342
	Pimephales vigilax	Bullhead Minnow	140	16	156
	Notropis sp.	Juvenile minnow/shiner	30	1	31
Catostomidae (suckers)	*Carpiodes carpio*	River Carpsucker	357	11	368
	Carpiodes cyprinus	Quillback	3		3
	Carpiodes velifer	Highfin Carpsucker	11		11
	Ictiobus bubalus	Smallmouth Buffalo	775	192	967
	Ictiobus cyprinellus	Bigmouth Buffalo	1355	216	1571

	Ictiobus niger	Black Buffalo	138	72	210
	Minytrema melanops	Spotted Sucker	7	4	11
	Catostomidae	Juvenile suckers	90		90
	Ictiobus sp.	Juvenile buffalo		2	2
Ictaluridae (catfishes)	*Ameiurus natalis*	Yellow Bullhead	335	66	401
	Ameiurus melas	Black Bullhead	1304	14	1318
	Ameiurus nebulosus	Brown Bullhead	2		2
	Ictalurus furcatus	Blue Catfish	17	1	18
	Ictalurus punctatus	Channel Catfish	2344	703	3047
	Noturus gyrinus	Tadpole Madtom	158	66	224
	Noturus miurus	Brindled Madtom[1]	10		10
	Pylodictis olivaris	Flathead Catfish	15	5	20
Esocidae (pikes)	*Esox americanus*	Grass or Redfin Pickerel		6	6
	Esox niger	Chain Pickerel	1		1
Aphredoderidae (pirate perch)	*Aphredoderus sayanus*	Pirate Perch		22	22
Muglidae (mullets)	*Mugil cephalus*	Striped Mullet	2	2	4
Atherinopsidae (silversides)	*Labidesthes sicculus*	Brook Silverside	1379	37	1416
	Menidia audens	Mississippi Silverside	3035	260	3295
	Atherinopsidae	Juvenile silversides		11	11
Fundulidae (topminnows)	*Fundulus chrysotus*	Golden Topminnow	11	17	28
	Fundulus dispar	Starhead Topminnow		16	16
	Fundulus notatus	Blackstripe Topminnow	31	140	171
	Fundulus olivaceus	Blackspotted Topminnow	283		283
Poeciliidae (livebearers)	*Gambusia affinis*	Western Mosquitofish	4561	77	4638
Moronidae (temperate basses)	*Morone chrysops*	White Bass	49	99	148
	Morone mississippiensis	Yellow Bass	728	245	973
Centrarchidae (sunfishes)	*Centrarchus macropterus*	Flier		9	9
	Lepomis cyanellus	Green Sunfish	36	83	119
	Lepomis humilis	Orangespotted Sunfish	13035	2397	15432
	Lepomis gulosus	Warmouth	2907	1280	4187
	Lepomis macrochirus	Bluegill	14515	6562	21077
	Lepomis marginatus	Dollar Sunfish		131	131
	Lepomis megalotis	Longear Sunfish	4226	206	4432
	Lepomis microlophus	Redear Sunfish	97	682	779
	Lepomis miniatus	Redspotted Sunfish	32	47	79
	Lepomis symmetricus	Bantam Sunfish		213	213
	Micropterus salmoides	Largemouth Bass	647	983	1632
	Pomoxis annularis	White Crappie	8320	1016	9336
	Pomoxis nigromaculatus	Black Crappie	852	901	1753

	Lepomis sp.	Juvenile sunfish	44702	12951	57653
	Pomoxis sp.	Juvenile crappie		50	50
Percidae (perches)	*Etheostoma asprigene*	Mud Darter		9	9
	Etheostoma chlorosoma	Bluntnose Darter		3	3
	Etheostoma proeliare	Cypress Darter		3	3
	Percina caprodes	Logperch	1	11	12
	Percina shumardi	River Darter		2	2
	Sander canadense	Sauger	4	11	15
Sciaenidae (drums)	*Aplodinotus grunniens*	Freshwater Drum	1943	1372	3315
Totals	75 Species		303275	70237	373512

Table A11-6. Statistical properties of fish species diversity measures for 33 rotenone sampling events in 1981 and 1996-97.

Variable	Mean	Std Dev	Minimum	Maximum
Total species observed, S*	31	8	18	50
Standardized species richness, S/11,500 individuals	29.1	6.8	18.0	44
Evenness, J’	0.5	0.1	0.2	0.7
Dominance, D	0.6	0.2	0.2	0.9
Number of fish per acre	11330	11575	829	62160

Table A11-7. Multiple regression equations and statistical properties of diversity measures for riverside borrow areas in the Lower Mississippi River sampled in 1981 and 1996-97 with rotenone.

Diversity Index	n	Model - Parameter Estimates	Adj-R^2	F	Pr > F	OUTLIERS REMOVED (Borrow Area number/date)
Pielou's Evenness	29	0.004(Turbidty_{NTU}) + 0.41	0.43	22.17	0.0001	3/81, 21/81, 25/81, 23/81
Simpson Dominance	30	0.003(Turbidy_{NTU}) + 0.60	0.17	7.09	0.0127	3/81, 21/81, 23/81
Standardized Richness (Rarefaction)	27	31.2(VDI) + 2.2 (Maximum Depth_{ft}) - 0.2(Percent Area>5ft) - 0.1(Turbidity_{NTU})- 24.3	0.83	31.74	0.0001	1/81, 4/81, 11/81, 13/97, 17/81, 25/81

Table A11-8. Statistical output of the multivariate regression analysis for the dependent variable species richness (determined by rarefaction) including parameter estimates and variance inflation scores for riverside borrow areas sampled with rotenone in 1981 and 1996-97. Abbreviations include Volume Development Index (VDI), maximum depth (MAXDEP), percent area greater than 5 feet (AR_5FT), and surface turbidity (Turb_S).

Number of Observations Read	27
Number of Observations Used	27

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	934.89242	233.72310	31.74	<.0001
Error	22	161.98586	7.36299		
Corrected Total	26	1096.87827			

Root MSE	2.71348	R-Square	0.8523
Dependent Mean	29.16257	Adj R-Sq	0.8255
Coeff Var	9.30468		

Parameter Estimates							
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	-24.35035	5.47527	-4.45	0.0002	0
VDI	VDI	1	31.24932	3.03813	10.29	<.0001	2.48816
MAXDEP	MAXDEP	1	2.16802	0.27708	7.82	<.0001	4.18732
AR_5FT	AR_5FT	1	-0.20313	0.03719	-5.46	<.0001	3.18759
Turb_S	Turb_S	1	-0.13290	0.02848	-4.67	0.0001	1.18358

Table A11-9. Number of fishes collected by species with gillnets in landside (1997) and riverside (1997 and 2019) borrow areas. Species are arranged in order of abundance. Columns for each respective sampling period are highlighted for frequency of occurrence (F) and relative percent occurrence (P).

Landside 1997, n=23			Riverside 1997, n=29			Riverside 2019, n=36		
Common Name	F	P	Common	F	P	Common	F	P
Gizzard Shad	68	37.36	Gizzard Shad	98	21.03	Gizzard Shad	74	18.78
Bigmouth Buffalo	21	11.54	Spotted Gar	78	16.74	Spotted Gar	71	18.02
Common Carp	21	11.54	Common Carp	59	12.66	Smallmouth Buffalo	46	11.68
Spotted Gar	15	8.24	Bigmouth Buffalo	32	6.87	Shortnose Gar	41	10.41
White Crappie	9	4.95	Smallmouth Buffalo	30	6.44	Channel Catfish	31	7.87
Channel Catfish	7	3.85	Bowfin	27	5.79	Black Buffalo	25	6.35
Bowfin	6	3.3	Channel Catfish	27	5.79	River Carpsucker	14	3.55
Freshwater Drum	6	3.3	Black Buffalo	16	3.43	Bigmouth Buffalo	12	3.05
Black Bullhead	5	2.75	Freshwater Drum	14	3	Bowfin	10	2.54
Largemouth Bass	5	2.75	Largemouth Bass	14	3	Common Carp	10	2.54
Threadfin Shad	4	2.2	White Crappie	9	1.93	Silver Carp	10	2.54
Warmouth	4	2.2	Warmouth	8	1.72	Black Crappie	8	2.03
Black Crappie	3	1.65	Black Crappie	6	1.29	Longnose Gar	7	1.78
Bluegill	3	1.65	Bluegill	6	1.29	Threadfin Shad	6	1.52
Black Buffalo	1	0.55	Mooneye	6	1.29	Freshwater Drum	5	1.27
Blue Catfish	1	0.55	Black Bullhead	4	0.86	Striped Mullet	4	1.02
Paddlefish	1	0.55	Dollar Sunfish	4	0.86	Blue Catfish	3	0.76
Smallmouth Buffalo	1	0.55	Paddlefish	4	0.86	Orangespotted Sunfish	3	0.76
Yellow Bass	1	0.55	Shortnose Gar	4	0.86	Bluegill	2	0.51
			Yellow Bass	4	0.86	Flathead Catfish	2	0.51
			Flathead Catfish	2	0.43	White Crappie	2	0.51
			Spotted Sucker	2	0.43	Lepomis sp.	1	0.25
			Threadfin Shad	2	0.43	Morone sp.	1	0.25
			Yellow Bullhead	2	0.43	Paddlefish	1	0.25
			Alligator Gar	1	0.21	Quillback	1	0.25
			Blue Catfish	1	0.21	Skipjack Herring	1	0.25
			Redear Sunfish	1	0.21	Spotted Sucker	1	0.25
			River Carpsucker	1	0.21	Warmouth	1	0.25
			Sauger	1	0.21	White Bass	1	0.25
			White Bass	1	0.21			

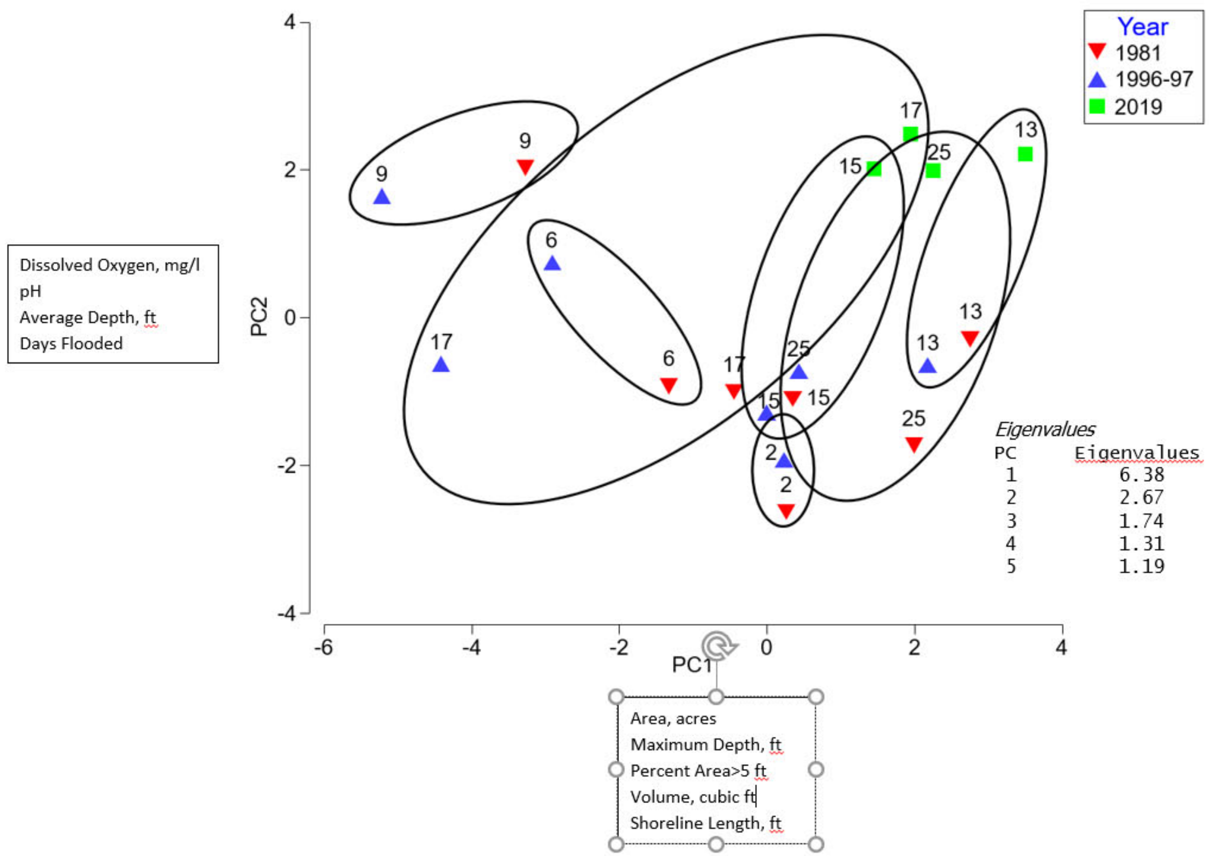
Table A11-10. Number of fish collected by species with seines in landside and riverside borrow areas. Species are arranged in order of abundance.

Landside 1997, n=4			Riverside 1997, n=5			Riverside 2019, n=6		
Common Name	Frequency	Percent	Common Name	Frequency	Percent	Common Name	Frequency	Percent
Orangespotted Sunfish	713	36.3	Threadfin Shad	2632	31.79	Lepomis sp.	2453	34.39
Largemouth Bass	404	20.57	Orangespotted Sunfish	1267	15.3	Orangespotted Sunfish	2375	33.3
Mississippi Silverside	282	14.36	Bluegill	935	11.29	Mississippi Silverside	369	5.17
Bluegill	235	11.97	Pugnose Minnow	804	9.71	Western Mosquitofish	284	3.98
Golden Shiner	112	5.7	Western Mosquitofish	776	9.37	Threadfin Shad	281	3.94
White Crappie	61	3.11	Lepomis sp.	471	5.69	Bullhead Minnow	277	3.88
Golden Topminnow	37	1.88	Mississippi Silverside	415	5.01	Bluegill	189	2.65
Gizzard Shad	34	1.73	Gizzard Shad	152	1.84	Longear Sunfish	176	2.47
Threadfin Shad	33	1.68	Warmouth	96	1.16	Channel Catfish	149	2.09
Western Mosquitofish	28	1.43	Largemouth Bass	90	1.09	Shoal Chub	70	0.98
Channel Catfish	9	0.46	Longear Sunfish	89	1.08	Channel Shiner	64	0.9
Black Bullhead	5	0.25	Taillight Shiner	88	1.06	Freshwater Drum	58	0.81
Freshwater Drum	5	0.25	Bantam Sunfish	69	0.83	Blacktail Shiner	51	0.71
Bigmouth Buffalo	2	0.1	Blackstripe Topminnow	60	0.72	Silver Chub	40	0.56
Green Sunfish	2	0.1	Redear Sunfish	45	0.54	MS Silvery Minnow	37	0.52
Bantam Sunfish	1	0.05	White Crappie	43	0.52	Gizzard Shad	27	0.38
White Bass	1	0.05	Bullhead Minnow	39	0.47	Warmouth	25	0.35
			Silver Chub	34	0.41	Silverband Shiner	24	0.34
			Channel Catfish	28	0.34	Black Crappie	22	0.31
			Golden Shiner	23	0.28	Redspotted Sunfish	21	0.29
			Golden Topminnow	21	0.25	Taillight Shiner	21	0.29
			Green Sunfish	18	0.22	Blackstripe Topminnow	20	0.28
			Black Crappie	17	0.21	Smallmouth Buffalo	19	0.27
			Blackbanded Darter	8	0.1	White Crappie	12	0.17

			Smallmouth Buffalo	8	0.1	Blackspotted Topminnow	10	0.14
			Sailfin Molly	7	0.08	Brook Silverside	10	0.14
			Pirate Perch	6	0.07	Pugnose Minnow	9	0.13
			Freshwater Drum	5	0.06	Bluntnose Darter	7	0.1
			Yellow Bass	5	0.06	Blue Catfish	5	0.07
			Bluntnose Darter	4	0.05	Green Sunfish	4	0.06
			Redspotted Sunfish	4	0.05	Pirate Perch	3	0.04
			Tadpole Madtom	4	0.05	Spotted Gar	3	0.04
			Mud Darter	3	0.04	Flathead Catfish	2	0.03
			Silverband Shiner	3	0.04	River Carpsucker	2	0.03
			Starhead Topminnow	3	0.04	Spotted Bass	2	0.03
			Bowfin	2	0.02	Tadpole Madtom	2	0.03
			Gulf Pipefish	2	0.02	White Bass	2	0.03
			Longnose Gar	2	0.02	Bantam Sunfish	1	0.01
			Common Carp	1	0.01	Emerald Shiner	1	0.01
				1	0.01	Longnose Gar	1	0.01
				1	0.01	Mud Darter	1	0.01
				1	0.01	Sauger	1	0.01
				1	0.01	Shortnose Gar	1	0.01
				1	0.01	Walleye	1	0.01
				1	0.01	Yellow Bass	1	0.01

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.

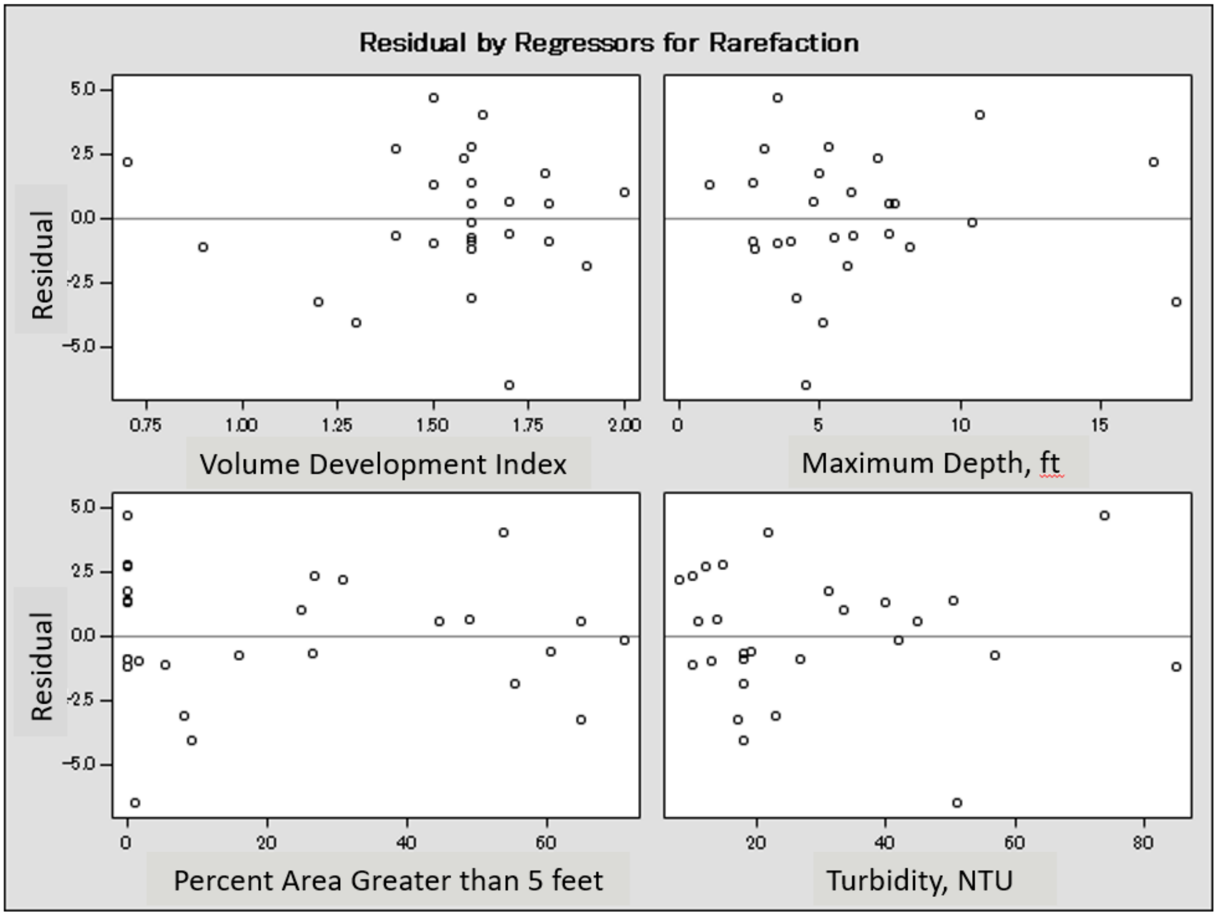


Figure A11-2. Plot of (predictive or studentized) residuals between predicted standardized species richness and each independent variable for rotenone samples collected from riverside borrow areas in 1981 and 1996-97.

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

<u>Acres</u>

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.

<u>Habitat Suitability Index Values</u>

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):

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

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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