Appendix R

Mitigation Technical Appendix

U.S. Army Corps of Engineers
Memphis District

This appendix is presented to discuss, in detail, the determination of mitigation necessary to compensate for significant impacts to resources for the tentatively selected plan (TSP).

Wetlands

Compensatory mitigation is based on impacted wetland functions, expressed as functional capacity unit(s) (FCU), and not on impacted acreage. Annualized functional capacity index(cies) (FCI) per acre of mitigated area were calculated for each respective basin to determine potential mitigation necessary to compensate for impacts to the tentatively selected plan (Tables 1 and 2). Since tract size is important to some wetland functions, two tract size scenarios were developed for the low gradient riverine backwater (LGRB) subclass. One tract size assumed that mitigation would be accomplished on large, 1,200-acre tracts connected to similarly sized blocks of existing habitat. For example, mitigation areas surrounding Big Oak Tree State Park assumed a large tract size. The other tract size would be accomplished on smaller (less than 1,200 acres), more isolated tracts. A small tract size was assumed for the low gradient riverine overbank (LGRO) subclass, since the majority of existing LGRO sites are isolated and relatively small. A large tract size was assumed for connected depression (CD) restoration sites, since the majority of these sites are located adjacent to existing connected depression areas, such as those found in Big Oak Tree State Park and the Bogle Woods tracts. In all cases, assumptions were made that wetland mitigation would restore suitable microtopographic features, would restore site specific hydrology to the extent allowable, would be planted in the first year of the project, and would be allowed to grow to forest. As with the wetland reserve program (WRP) projections (Appendix M, Part 1), FCIs were annualized using the following year intervals: 0, 1, 5, 15, 25, and 50.

Table 1. FCI/acre used in mitigation calculations in the St. Johns Bayou Basin.

HGM Subclass	LGRB		LGRO	CD
Tract Size	Small	Large	Small	Large
Function	FCI	FCI	FCI	FCI
Detain Floodwater	0.578	0.578	0.636	0.581
Detain Precipitation	0.925	0.925	0.902	N/A
Cycle Nutrients	0.722	0.722	0.622	0.668
Export Organic Carbon	0.702	0.702	0.614	0.629
Maintain Plant Communities	0.749	0.749	0.653	0.635
Fish and Wildlife Habitat	0.265	0.599	0.442	0.602

N/A - Not Applicable

Table 2. FCI/acre used in mitigation calculations in the New Madrid Floodway.

HGM Subclass	LGRB		LGRO	CD
Tract Size	Small	Large	Small	Large
Function	FCI	FCI	FCI	FCI
Detain Floodwater	0.598	0.598	0.636	0.601
Detain Precipitation	0.925	0.925	0.902	N/A
Cycle Nutrients	0.722	0.722	0.622	0.668
Export Organic Carbon	0.722	0.722	0.614	0.649
Maintain Plant Communities	0.736	0.736	0.667	0.579
Fish and Wildlife Habitat	0.246	0.587	0.444	0.588

N/A - Not Applicable

St. Johns Bayou Basin

Table 3 provides a summary of impacts associated with channel modifications and operation of the pumping station in the St. Johns Bayou Basin as well as the amount of mitigation required to compensate for impacts. Mitigation acres are determined by dividing the impact by the corresponding FCI/acre estimated in Table 1. For example, there are 116 FCU impacted in the detain flood water function. Restoring one acre of LGRB provides 0.578 FCU. Therefore, 201 (116/0.578) acres are required to compensate for the impact to the detain floodwater function for the LGRB subclass. Mitigation necessary to compensate for impacts to wetlands is based on the function that requires the greatest amount of mitigation. Therefore, remaining functions would be over-compensated. The greatest amounts of acreage required are highlighted in bold font. Therefore, 201 acres and 623 acres of LGRB and LGRO mitigation, respectively, would be required to compensate for impacts to wetlands as a result of the project.

Table 3. St. Johns Bayou Basin impacts and mitigation necessary to compensate for impacts. Mitigation assumes small tracts of LGRB.

	Impacts (FCU)		Mitigation (acres)	
Function	LGRB	LGRO	LGRB	LGRO
Detain Flood Water	-116	-397	**201**	**623**
Detain Precipitation	0	-307	0	340
Cycle Nutrients	0	-344	0	552
Export Organic Carbon	-115	-319	164	519
Maintain Plant Communities	-50	-374	67	573
Provide Fish and Wildlife Habitat	0	-210	0	476

Although only 201 LGRB acres and 623 LGRO acres are required to compensate for impacts to wetlands, compensating for significant unavoidable impacts to fish and wildlife resources, most notably fish, would also provide wetland mitigation credit. Table 4 provides the gains to wetland functions, by proposed mitigation zone, as a result of all compensatory mitigation measures. Since mitigation to these resources requires a greater amount of acreage, losses to wetlands would be over-compensated. Table 5 provides the gains to wetland functions as a result of all compensatory mitigation measures.

Table 4. Alternative 3.1 compensatory mitigation zone gains to wetlands expressed as FCU in St. Johns Bayou Basin.

Mitigation Zone	HGM Subclass	Acres	Detain Floodwater	Detain Precipitation	Cycle Nutrients	Export Organic Carbon	Maintain Plant Communities	Fish & Wildlife Habitat
BLH Restoration <285'	LGRB	400	232	372	288	280	300	108
BLH Restoration <5-year	LGRB/LGRO[1]	1193/623	690/396	638/562	859/450	835/437	891/467	315/373
Riparian Buffer Strips (Woody)	LGRO	70	44	63	43	43	46	31
Riparian Buffer Strips (Grass)	LGRO	N/C	N/C	N/C	N/C	N/C	N/C	N/C
Ecologically Designed Borrow pits	CD[2]	194	37	N/A	81	76	29	29
Seasonally Inundated Farmland		244	N/C	N/C	N/C	N/C	N/C	N/C

[1]Depending on location, mitigation could be LGRO or LGRB. However for the purpose of this table, 623 acres were assumed to be LGRO. Regardless, a minimum of 397 LGRO FCU is required to compensate for impacts to jurisdictional wetlands.
[2]Borrow pits would be designed so that half of each pit would have an average depth of less than three feet. Wetland vegetation is expected. 387 acres are proposed. Therefore, 194 acres of wetland functions would be provided.
N/A – not applicable
N/C – not calculated but would be calculated during the completion of site specific detailed mitigation plans, if applicable and necessary.

Table 5. Wetland impacts and benefits from compensatory mitigation in the St. Johns Bayou Basin.

	Impacts (FCU)		Compensatory Mitigation (FCU)			Net Gain (FCU)		
Function	LGRB	LGRO	LGRB[1]	LGRO[2]	CD[3]	LGRB	LGRO	CD
Detain Flood Water	**-116**	**-397**	**+922**	**+440**	+37	**+806**	**+43**	+37
Detain Precipitation	0	-307	+1010	+625	NA	+1010	+318	NA
Cycle Nutrients	0	-344	+1147	+493	+81	+1147	+149	+81
Export Organic Carbon	-115	-319	+1115	+480	+76	+1000	+161	+76
Maintain Plant Communities	-50	-374	+1191	+513	+29	+1141	+139	+29
Provide Fish and Wildlife Habitat	0	-210	+423	+404	+29	+423	+194	+29

[1]Caluclated by adding FCU from benefits attributed to BLH restoration below an elevation of 285 and LGRB sites below the 5-year flood frequency.
[2]Calculated by adding FCU from benefits attributed to BLH LGRO sites below the 5-year flood frequency and woody riparian buffer strips.
[3]Calcualted by benefits attributed to ecologically designed borrow pits.

New Madrid Floodway

Table 6 provides a summary of impacts associated with closure of the New Madrid Floodway and operation of the pumping station, a summary of FCU changes as a result of changes to wetland subclass, and the amount of mitigation required to compensate for impacts for the tentatively selected plan. Mitigation acres are determined by dividing the impact by the corresponding FCI/acre estimated in Table 2. For example, there are 3,481 FCU impacted in the detain flood water function for the LGRB subclass. Restoring one acre of LGRB provides 0.598 FCU in the New Madrid Floodway. Therefore, 5,818 acres are required to compensate for the impact to the detain floodwater function for the LGRB subclass. Mitigation necessary to compensate for impacts to wetlands is based on the function that requires the greatest amount of mitigation. Therefore, other functions are over-compensated. The greatest amount of acreage required is highlighted in bold font. Therefore, 5,818, 57, and 215 acres of LGRB, LGRO, and CD mitigation are required to compensate for impacts to wetlands as a result of the project, respectively.

Table 6. New Madrid Floodway impacts and mitigation necessary to compensate for impacts. Mitigation assumes large tracts of LGRB.

	Losses in FCU			Gains in FCU		Mitigation (acres)		
Function	LGRB	LGRO	CD	Flats	UCD	LGRB	LGRO	CD
Detain Flood Water	-3,487	-35	-97	NA	NA	**5,828**	55	161
Detain Precipitation	-2,423	0	0	1,910	NA	2,619	0	NA
Cycle Nutrients	-2,092	0	-94	2,088	110	2,899	0	141
Export Organic Carbon	-3,558	-35	-118	NA	NA	4,929	**57**	182
Maintain Plant Communities	-2,582	-35	-124	2,183	113	3,511	52	**215**
Provide Fish and Wildlife Habitat	-1,970	-12	-89	1,616	71	3,356	26	152

<u>Big Oak Tree State Park Restoration</u>

A mitigation priority for the project would be to restore hydrology to Big Oak Tree State Park. Restoration would involve the construction of a gated culvert in the Mississippi River Frontline Levee to the south of the park and construction of interior channels to deliver Mississippi River surface water. Gates would be operated to allow for connectivity and inundation of the park to an elevation of 291 feet (less than a 2-year flood frequency). Although the park would likely be managed to allow for prolonged inundation after Mississippi River elevations fall, an outlet structure would also be constructed to allow the park to drain to an elevation of 288 feet. The purpose of this structure would be for water-level management to mimic a natural hydrologic regime. Compensatory mitigation benefits are attributed to a reduction in impacts[1] as well as restored hydrologic conditions[2] (Table 7). Therefore, restoring hydrology to Big Oak Tree State Park would reduce the mitigation acreage requirements by 1,615 and 83 acres, respectively for LGRB and CD.

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[1] Closure of the New Madrid Floodway and pumping station would also impact the park. Impacts were already quantified for each specific alternative.

[2] Due to the existing levee system and drainage features around the park, Big Oak Tree State Park does not flood at a frequency that benefits the park's native vegetation. See McCarty (2005) for additional information regarding the park's altered hydrology and associated vegetative changes.

Table 7. Compensatory mitigation benefits from restoring hydrology to Big Oak Tree State Park.

	LGRB (976 acres)			CD (49 acres)			Mitigation (reduced acres)	
Function	Reduced Impact	Restored Hydrology	Total (FCU)	Reduced Impact	Restored Hydrology	Total (FCU)	LGRB	CD
Detain Flood Water	810	156	966	34	7	**41**	**-1,615**	-68
Detain Precipitation	976	0	976	NA	NA	NA	-1,055	NA
Cycle Nutrients	869	0	869	33	0	33	-1,204	-50
Export Organic Carbon	869	176	1,044	34	7	41	-1,447	-63
Maintain Plant Communities	927	29	957	44	4	48	-1,301	**-83**
Provide Fish and Wildlife Habitat	732	29	761	33	1	34	-1,297	-59

Big Oak Tree State Park Surrounding Land

In addition to restoring hydrology to Big Oak Tree State Park, 1,800 acres of cropland surrounding the park would also be specifically targeted for mitigation. Since these lands would also be influenced by the park's restored hydrology, compensatory mitigation would accrue at a higher rate than remaining portions of the basin (Table 8). Mitigation sites would be expected to consist of large tracts of LGRB.

Table 8. Benefits to FCU from restoring land surrounding Big Oak Tree State Park.

Function	FCI/acre	FCU (1,800 acres x FCI)
Detain Flood Water	0.598	1,076
Detain Precipitation	0.925	1,665
Cycle Nutrients	0.722	1,300
Export Organic Carbon	0.722	1,300
Maintain Plant Communities	0.759	1,366
Provide Fish and Wildlife Habitat	0.599	1,078

Remaining Fish and Wildlife Mitigation

Compensating for significant unavoidable impacts to fish and wildlife resources would also provide wetland mitigation credit. Table 9 provides the gains to wetland functions as a result of all compensatory mitigation measures. Estimates regarding mitigation values for lands that occur within the St. Johns Bayou Basin or the New Madrid Floodway assumed post-project hydrologic conditions. Since mitigation involves compensating for multiple resources, impacts to wetlands would be over-compensated (Table 10).

Table 9. Alternative 3.1 compensatory mitigation zone gains to wetlands expressed as FCU in the New Madrid Floodway.

Mitigation Zone	HGM Subclass	Acres	Detain Floodwater	Detain Precipitation	Cycle Nutrients	Export Organic Carbon	Maintain Plant Communities	Fish & Wildlife Habitat
Big Oak Tree State Park	LGRB	976	966	976	869	1044	957	761
Big Oak Tree State Park	CD	49	41	NA	33	41	48	35
Big Oak Tree State Park Surrounding Land	LGRB	1,800	1076	1665	1300	1300	1366	1078
BLH Restoration <285'	LGRB	387	232	360	279	279	286	228
BLH Restoration <5-year	LGRB	1,970	1,182	1,832	1,418	1,418	1,457	1,162
Batture Land Reforestation	LGRB	2,800	1,952	1,769	2,592	1,860	2,043	1,403
Batture Land Reforestation	LGRO	250	159	226	156	154	167	111
Ecologically Designed Borrow pits	CD[2]	30	6	N/A	20	20	17	18
Seasonally Inundated Farmland	tbd	1,286	N/C-tbd	N/C-tbd	N/C-tbd	N/C-tbd	N/C-tbd	N/C-tbd
Ten Mile Pond CA	tbd	1,917	N/C - tbd	N/C-tbd	N/C-tbd	N/C-tbd	N/C-tbd	N/C-tbd
Floodplain Lake Restoration	CD[3]	144	84	N/A	96	91	91	87

[1] Impacts are combined by summing across all agricultural lands, forested areas, and future WRP sites as well as LGRB, LGRO, CD, and UCD wetland types. Note there were impacts and gains to some categories. The value in the table is the sum of all categories. [2]Borrow pits would be designed so that half of each pit would have an average depth of less than three feet. Wetland vegetation is expected. 60 acres are proposed. Therefore, 30 acres of wetland functions would be mitigated. [3]Similar to borrow pits, it is assumed that one third of restored floodplain lakes would have an average depth of less than three feet. Wetland vegetation is expected. 432 acres of floodplain lakes are anticipated. Therefore, 144 acres of CD are expected.
N/A – not applicable, N/C – not calculated, tbd – to be determined during the development of site specific detailed mitigation plans.

Table 10. Impacts and benefits to the New Madrid Floodway.

	Losses in FCU			Compensatory Mitigation (FCU)[4]			Net Gain (FCU)		
Function	LGRB	LGRO	CD	LGRB[1]	LGRO[2]	CD[3]	LGRB	LGRO	
Detain Flood Water	**-3,487**	-35	-97	+5,408	+159	+131	**+1,921**	+62	+34
Detain Precipitation	-2,423	0	0	+6,602	+226	NA	+4,179	+226	NA
Cycle Nutrients	-2,092	0	-94	+6,458	+156	+149	+4,366	+156	+55
Export Organic Carbon	-3,558	**-35**	-118	+5,901	+154	+152	+2,343	**+36**	+34
Maintain Plant Communities	-2,582	-35	**-124**	+6,109	+167	+156	+3,527	+43	**+32**
Provide Fish and Wildlife Habitat	-1,970	-12	-89	+4,632	+111	+140	+2,662	+99	+51

[1]Caluclated by adding FCU gains associated with LGRB Big Oak Tree State Park, lands surrounding Big Oak Tree State Park, reforesting lands below 284 and the five-year frequency, and LGRB **batture** land
[2]Caluclated by adding FCU gains to 250 acres of batture land mitigation
[3]Calculated by adding FCU gains to Big Oak Tree State Park, half of the ecologically designed borrow pits, and a third of restored floodplain lakes.
[4]Note – mitigation values do not include gains attributed to a shift to different subclasses, seasonally inundated farmland, or Ten Mile Pond CA.

Terrestrial Wildlife

Habitat suitability index (HSI) values for any particular mitigation tract depend on the overall mitigation method and the species of vegetation restored on the site. For example, mitigation tracts with a high abundance of mast producing trees would generally result in high HSI values for fox squirrel. In contrast, mast producing trees do not tolerate long periods of inundation and, therefore, would not necessarily result in high HSI values for mink. Therefore, different mitigation zones provide different HSI values due to different species of vegetation restored. Habitat variables and associated HSI scores for the six mitigation zones were projected over the 50-year project life for future with- and future without-project conditions to determine appropriate compensation for unavoidable impacts to terrestrial resources. To maintain consistency, the same evaluation species for bottomland hardwood and riparian ditchbank habitats were used in the impact analysis and compensation analysis. Those species included fox squirrel, barred owl, Carolina chickadee, pileated woodpecker, and mink. Brief descriptions of the six mitigation zones used for the HEP analysis are discussed below. Additional details regarding mitigation can be found in Sections 5 and 7 of the draft EIS.

Mitigation Zone 1:

A priority would be given to Big Oak Tree State Park. This includes increasing the footprint of the park by 1,800 acres and restoring hydrology by means of a gated structure located in the Mississippi River Frontline Levee. Restoration of the 1,800 acres includes site preparation (e.g., deep disking, sub-soiling), restoration of site-specific hydrology by plugging drainage ditches, removing farm drains, and other techniques in addition to re-establishment of the Mississippi River connection, restoration of microtopography through shallow excavation of deeper areas and filling higher areas to create topographical heterogeneity, and planting of appropriate vegetation according to the site-specific hydrologic zones detailed in the Big Oak Tree State Park Natural Resource Management Plan (McCarty, 2005). Utilizing GIS, assumptions for this restoration were based on elevation data and included the following composition: 39 percent of the area planted with cypress/tupelo (hydrologic zone II), 5 percent of the area planted with cypress, pumpkin ash, and tupelo (hydrologic zone III), and 56 percent of the area planted with various oak and hickory species (hydrologic zones IV and V). A total of 1,744.20 average annual habitat units (AAHU) would be expected by the restoration of 1,800 acres surrounding Big Oak Tree State Park for a net benefit of 0.97 AAHU/acre (Table 11).

Although restoring hydrology to the park itself would result in changes to species composition and thus produce ecological benefits, no benefits were calculated for the restoration of hydrology to the park for this particular model. Benefits of restoring hydrology to the park are described in the sections that discuss the fish, wetland, and waterfowl models.

Mitigation Zone 2:

This analysis included a hypothetical 100-acre tract of land below an elevation of 285 feet. Restoration would include site preparation, restoration of hydrology, restoration of microtopography, and plantings of appropriate seedlings according to the site-specific hydrological regime. Assumptions for this restoration include the following composition: 50 percent of the area planted with cypress/tupelo seedlings, 25 percent of the area allowing for natural succession of herbaceous vegetation, and 25 percent of the area remaining in open water. A total of 72.80 AAHU would be gained through the restoration of a hypothetical 100-acre tract in Zone 2 for a net benefit of 0.73 AAHUs/acre (Table 11).

Mitigation Zone 3 and Zone 4:

This analysis included a hypothetical 100-acre tract of land within Zone 3, those lands within the maximum flood elevation (primarily lands still connected to Mississippi River or within post-project interior inundated zones), and Zone 4, those lands located above the post-project maximum flood elevation. Restoration would include site preparation, restoration of hydrology, restoration of microtopography, and planting of appropriate seedlings according to the site-specific hydrological regime. Assumptions for this restoration included the following composition: 10 percent of area allowing for natural succession of herbaceous vegetation, 30 percent of area planted with drier oak/hickory species (e.g. cherrybark oak and pignut hickory), and 60 percent of area planted with wetter oak/hickory species (e.g. overcup oak and nuttal oak). A total of 82.15 AAHU would be gained through the restoration of a hypothetical 100-acre tract in Zones 3 and 4 for a net benefit of 0.82 AAHU/acre (Table 11).

Mitigation Zone 5:

This analysis included restoration of a hypothetical 100-acre tract from cleared lands located within the batture of the Mississippi River. The assumptions for this restoration were that 100 percent of the land would revert to cottonwood/willow communities through natural succession. A total of 80.40 AAHU would be gained through the restoration of a hypothetical 100-acre tract in Zone 5 for a net benefit of 0.80 AAHU/acre (Table 11).

Mitigation Zone 6:

This analysis included a hypothetical 10-mile reach of stream which would be buffered by planting warm season grasses. Although there would be numerous benefits to terrestrial wildlife such as northern bobwhite quail and rabbit, and water quality by the establishment of warm season grasses, habitat could not be quantified by the methods utilized in this particular model. Therefore, according to this model, establishment of warm season grass buffers on area ditches would not result in a benefit.

Mitigation Zone 7:

No benefits to terrestrial wildlife are anticipated from the Ten Mile Pond CA due to the model. Although this area is intensively managed for wildlife, the model does not show any credit for farmland and moist soil units. In the event that future analysis indicates otherwise, mitigation values would be adjusted during the completion of tract specific detailed mitigation plans.

Table 11. Average annual habitat units (AAHU) gained for each mitigation zone (hypothetical 100-acre tract) in the St. Johns Bayou Basin and New Madrid Floodway project area.

Mitigation Zone	Estimated Total Benefits (AAHU)	AAHU gained/acre
Zone 1	+1744.20	+0.97
Zone 2	+72.80	+0.73
Zones 3 and 4	+82.15	+0.82
Zone 5	+80.40	+0.80
Zone 6	0	0
Zone 7	0	0

It is anticipated that mitigation would be conducted in multiple zones with a priority given to Big Oak Tree State Park. Tables 12 and 13 provide the compensatory gains to terrestrial wildlife in AAHU as compared to project impacts. As can be seen, impacts to terrestrial wildlife are over-compensated due to mitigation required for other ecological resources.

Table 12. Impacts from alternative 3.1 and gains to terrestrial wildlife in the St. Johns Bayou Basin.

Mitigation	Acres	Zone	AAHU
Impacts	-	-	-765.70
BLH Restoration < 285'	400	2	292.00
BLH Restoration < 5-Year	1,816	3	1,489.12
Riparian Buffer Strips	182	6	0.00
Ecologically Designed Borrow Pits	387	-	-
Seasonally Inundated Farmland	244	4	-
Net Gain	-	-	1,015.42

Table 13. Impacts from alternative 3.1 and gains to terrestrial wildlife in the New Madrid Floodway.

Mitigation	Acres	Zone	AAHU
Impacts	-	-	-16.88
Big Oak Tree State Park	1,000	1	970.00
Area Surrounding Big Oak Tree State Park	1,800	1	1,746.00
BLH Restoration < 285'	387	2	282.51
BLH Restoration < 5-Year	1,970	3	1,615.40
Batture Land Reforestation	3,050	5	2,440.00
Ecologically Desgined Borrow Pits	60	-	-
Seasonally Inundated Farmland	1,245	-	-
Floodplain Lake	432	-	-
Net Gain	-	-	7,037.03

Waterfowl

As stated in Section 3 and Section 4 of the draft DEIS, waterfowl is significant in the project area due to a variety of reasons. Although the tentatively selected plan provides waterfowl gains during the waterfowl season (December – January) as a result of waterfowl management, operation plans still result in impacts during the February and March time periods. Since waterfowl is considered a significant resource to the project area and Nation, mitigation is proposed to compensate for the impact to ensure that all specific time periods do not result in significant impacts to waterfowl resources according to the model.

The tentatively selected plan would result in a loss of 117,186 duck-use-days (DUD) in the St. Johns Bayou Basin. Table 14 shows DUD/acre for selected habitat types during the November, December-January, and February-March time periods used to calculate mitigation acreage. Acres of proposed mitigation were multiplied by the appropriate DUD/acre to determine DUD benefits from potential mitigation scenarios. Table 15 provides likely gains to waterfowl habitat (DUD) by compensatory mitigation features in the St. Johns Bayou Basin. The tentatively selected plan would result in a decrease of 1,856,442 DUD in the New Madrid Floodway. Table 16 provides likely gains to waterfowl habitat by compensatory mitigation features in the New Madrid Floodway.

The following assumptions were made in determining the benefits from compensatory mitigation to waterfowl resources:

- Bottomland hardwood restoration below an elevation of 285 feet would be predominantly cypress-tupelo.

- Bottomland hardwood reforestation on 1,800 acres of land surrounding Big Oak Tree State Park would be 44 percent CT and 56 percent various oaks and hickories.

- Bottomland hardwood restoration below the post-project 5-year flood frequency would be 10 percent natural revegetation and 90 percent various oaks and hickories.

- Ecologically designed borrow pits would be considered as the 0.99 three consecutive day recurrence interval.

- Ten Mile Pond Area's moist soil units were considered as the 0.99 three consecutive day recurrence interval.

Table 14. DUD/acre for habitat type by specific time period and flood frequency.

	Cypress - Tupelo (CT)			Bottomland Hardwoods			Riverfront/Floodplain Forest			Open Water			Moist Soil Unit		
Flood Freq.	Nov	Dec-Jan	Feb-Mar	Nov	Dec-Jan	Feb-Mar	Nov	Dec-Jan	Feb-Mar	Nov	Dec-Jan	Feb-Mar	Nov	Dec-Jan	Feb-Mar
0.99	286.8	210.4	322.8	1465.6	1582.6	1255.2	406	439.8	413.8	901	652	559.4	2,022.6	1,676.2	1,375.6
0.5	143.4	105.2	161.4	732.8	791.3	627.6	203	219.9	206.9	450.5	326	279.7	1,011.3	838.1	678.8
0.2	57.4	42.1	64.6	293.1	316.5	251	81.2	88	82.8	180.2	130.4	111.9	404.5	335.2	275.1
0.1	28.7	21	32.3	146.6	158.3	125.5	40.6	44	41.4	90.1	65.2	55.9	202.3	167.6	137.6
0.04	11.5	8.4	12.9	58.6	63.3	50.2	16.2	17.6	16.6	36	26.1	22.4	80.9	67.0	55.0
0.02	5.7	4.2	6.5	29.3	31.7	25.1	8.1	8.8	8.3	18	13	11.2	40.5	33.5	27.5
0.01	2.9	2.1	3.2	14.7	15.8	12.6	4.1	4.4	4.1	9	6.5	5.6	20.2	16.8	13.8

Table 15. Impacts from alternative 2.1 and DUD gains from proposed mitigation in the St. Johns Bayou Basin.

Mitigation	Acres	November	December-January	February-March	Total
Impacts/Benefits	-	-100,891.00	978,809.00	-995,104.00	-117,186.00
DUD Losses from Agricultural Land Removed for Mitigation	2,785.37	-449,022.33	-345,234.09	-324,344.02	-1,118,600.43
Total DUD Losses	-	-549,913.33	633,574.91	-1,319,448.02	-1,235,786.43
BLH Restoration (<285')	400.00	114,720.00	84,160.00	129,120.00	328,000.00
BLH Restoration (<5-year)	1,816.00	1,390,447.40	1,494,929.40	1,196,046.10	4,081,422.90
Riparian Buffer Strips (Grass)	112.23	11,064.31	9,329.94	9,360.43	29,754.68
Riparian Buffer Strips (Woody)	70.14	19,330.80	16,067.52	16,368.96	51,767.28
Ecologically Designed Borrow Pits	387.00	348,687.00	252,324.00	216,487.80	817,498.80
Seasonally Inundated Farmland	243.64	43,562.83	41,991.35	42,789.28	128,343.46
Mitigation DUD	-	1,927,812.34	1,898,802.21	1,610,172.57	5,436,787.12
Net DUD Gain	-	1,377,899.01	2,532,377.12	290,724.55	4,201,000.69

Table 16. Impacts from alternative 3.1 and DUD gains from proposed mitigation in the New Madrid Floodway.

Mitigation	Acres	November	December-January	February-March	Total
Impacts/Benefits		57,590.00	1,376,754.00	-3,290,786.00	-1,856,442.00
DUD Losses from Agricultural Land Removed for Mitigation	7,267	-1,032,135.04	-857,152.50	-866,226.96	-2,755,514.50
Total DUD Losses		-974,545.04	519,601.50	-4,157,012.96	-4,611,956.50
Big Oak Tree State Park	1,000	732,800.00	791,300.00	627,600.00	2,151,700.00
Area Surrounding Big Oak Tree State Park	1,800	852,235.20	880,948.80	760,449.60	2,493,633.60
BLH Restoration (<285')	387	83,243.70	61,068.60	93,692.70	238,005.00
BLH Restoration (<5-year)	1,970	1,508,359.78	1,621,702.08	1,297,472.92	4,427,534.78
Batture Land Reforestation	3,050	2,125,697.50	1,765,492.50	1,797,060.00	5,688,250.00
Ecologically Designed Borrow Pits	60	54,060.00	39,120.00	33,564.00	126,744.00
Floodplain Lake	432	389,232.00	281,664.00	241,660.80	912,556.80
Seasonally Inundated Farmland	1,286	229,924.28	221,630.04	225,841.46	677,395.78
Ten Mile Pond CA	993	2,008,441.80	1,664,466.60	1,365,970.80	5,038,879.20
Mitigation DUD		7,983,994.26	7,327,392.62	6,443,312.27	21,754,699.15
Net DUD Gain		7,009,449.22	7,846,994.12	2,286,299.32	17,142,742.65

Shorebirds

As a group, shorebirds are on the decline nationally. Therefore, they are considered a significant resource. Although the loss of inundated habitat would not likely significantly impact overall shorebird populations in the region or nation, compensatory mitigation is offered to replace the potential shorebird habitat impacted by the project. Table 17 provides optimal shorebird acres impacted by project alternatives.

Table 17. Impacted area (acres) of optimally equivalent shorebird habitat during spring and fall migration periods for project alternatives.

	St. Johns Bayou Basin		New Madrid Floodway	
Alternative	Spring	Fall	Spring	Fall
Alternative 2.1/2	116.46	5.69	851.71	24.05
Alt. 3.1	116.46	5.69	614.67	23.39
Alt. 3.2	116.46	5.69	742.00	23.36
Alt. 4	116.46	5.69	323.05	0.00

One acre of optimal habitat is equivalent to one acre (sparsely vegetated) inundated at optimal depths (3.6 inches or less) for every day during the optimal time period (24 April – 23 May). Although the highest gain in shorebird value can be provided by clearing, draining, and leveling bottomland hardwoods (bottomland hardwoods do not provide suitable shorebird habitat) and make them subject to flooding during the spring, this technique would likely meet strong opposition from advocates of other ecological resources (*e.g.*, wetlands, fish). Therefore, land use changes would not be pursued to compensate for shorebird impacts. However, duration of inundation would be managed on existing agricultural areas to compensate for impacts.

Moist soil units are a common management technique utilized throughout the region and especially in the project area (*i.e.*, Ten Mile Pond Conservation Area). Moist soil units can be managed for both shorebirds and waterfowl. However, during the IEPR review, the panel indicated that the cost of management of moist soil units could be problematic for this project. Therefore, a decision was made not to pursue new moist soil management but instead rely on less intensive management techniques. However, the moist soil management units that exist in the Ten Mile Pond Conservation Area were quantified. New moist soil units can still be utilized if a future determination warrants the use during the development of tract specific plans.

As opposed to constructing new moist soil units, inundated farmland could also provide the necessary habitat to compensate for impacts.[3] Water management is a common practice on many of the agricultural lands in the project area. Management features consist of laser leveled fields, perimeter levees, water control structures, and irrigation equipment (groundwater pumps). All of these common farm features are conducive to

[3] In fact, inundated farmland is what is impacted by the project.

shorebird management and can easily be incorporated into mitigation. Likewise, many existing fields utilize this approach to manage for waterfowl habitat during waterfowl season. However, flooding does not continue during the shorebird season. Therefore, changes in overall inundation time periods can be used to compensate for shorebird impacts. Agricultural lands that are subject to floods after project construction (within the post-project 50-year floodplain) still provide shorebird habitat.[4] Therefore, agricultural lands at higher elevations in the floodplain would be pursued for compensatory mitigation.[5]

A hypothetical 100-acre tract of farmland that would no longer be subject to flooding as a result of the project was used to determine habitat gains to shorebirds from compensatory mitigation methods. Shorebird mitigation lands would be acquired in fee or through a flowage/conservation easement. Although the 100-acre field has likely been laser leveled, the field would be divided into four different zones to account for slope and depth of water. It is estimated that each zone would have an average elevation difference of 2-inches.

- Zone 1 – would be located closest to the water control structure. Therefore, depths would be greatest at this location. An assumption was that 10 percent of the 100-acre hypothetical tract would fall into this zone.
- Zone 2 – would be shallower than Zone 1 but deeper than Zone 3. An assumption was that 40 percent of the site would be located in Zone 2.
- Zone 3 – would be shallower than Zone 2 but deeper than Zone 4. An assumption was that 40 percent of the site would be located in Zone 3.
- Zone 4 – would be located on the outer fringe and consist of mudflat habitat or dry conditions. An assumption was that 10 percent of the area would be located in this zone.

The goal of shorebird management is to provide shallow water/mudflat interface. Stop logs would be inserted to capture rainfall to shallowly flood the entire site by 15 March. Each stop log would be approximately two-inches high. Groundwater/surface water pumps could be used to augment precipitation, if applicable. Water would be managed in two-inch increments over the shorebird season. Although stop logs would be used to manage water levels, water levels would still fluctuate due to precipitation events.

For the period 15 March – 2 April, the entire site would be inundated (all stops logs in place). Therefore, one 1 would be at a depth of 8 inches (suitability index (SI)=0, too deep for shorebirds), Zone 4 would likely be at a depth of less than 3 inches (SI = 1.0), and Zones 2 and 3 would fall somewhere in between (Zone 2 SI = 0.6 and Zone 3 SI = 0.8). Management would be variable and water levels would fluctuate. Therefore, during the period 15 March – 3 April the equivalent of 33 acres of optimal habitat would be expected. This is calculated as the following:

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[4] Duration is likely reduced, thus, the lands would not provide the overall acres of optimal habitat.
[5] This translates into lands greater than an elevation of 295.7 and 290.3 in the St. Johns Bayou Basin and New Madrid Floodway, respectively.

Zone 1 = 0 acres, too deep to be available for shorebirds.
Zone 2 = 24 (40 acres * 0.6)
Zone 3 = 32 (40 acres * 0.8)
Zone 4 = 10 (10 acres * 1.0)
Sum of all zones = 66
To account for migration: 33 equivalent acres (66 acres * 0.5 SI for time period)

One stop log would be removed during the period 3 April to 23 April. Therefore, depths would decrease by two inches. The following SI values were estimated per zone: Zone 1 = 0.6, Zone 2 = 0.8, Zone 3 = 1.0, and Zone 4 = 0.4 (variable mudflat that would constantly fluctuate due to rainfall). Therefore, during the period 3 April – 23 April one could expect the equivalent of 73.8 acres. This is calculated as follows:

Zone 1 = 6 acres (10 acres * 0.6)
Zone 2 = 32 acres (40 acres * 0.8)
Zone 3 = 40 acres (40 acres * 1.0)
Zone 4 = 4 acres (10 acres * 0.4, mudflat)
Sum of all zones = 82
To account for time period = 73.8 (82 acres * 0.9 SI)

One stop log would be removed during the period 24 April – 23 May. Therefore, depths would decrease by two inches. Thus, one could expect the following SI values per zone: Zone 1 = 0.8, Zone 2 = 1.0, Zones 3 = 0.4 (variable mudflat due to precipitation), and Zone 4 would be too dry to be of value to shorebirds. The period 24 April – 23 May is the optimal time period for shorebirds (SI=1.0). The associated equivalent acreage values are presented in Table 18.

An additional stop log would be removed during the period 24 May –8 June. Therefore, depths would decrease by an additional two inches. Thus, the following SI values per zone are expected: Zone 1 = 1.0, Zone 2 = 0.4 (variable mudflat that fluctuates with precipitation), and Zones 3 and 4 would be too dry to be of significant benefit.

All stop logs would be removed by 9 June and the site would be allowed to be farmed for the remainder of the year.

Table 18. Predicted gains to shorebird habitat (hypothetical 100-acre tract) from compensatory mitigation.

	15 March – 2 April	3 April – 23 April	24 April – 23 May	24 May – June 8
Zone 1 (10% of tract)	0	6	8	10
Zone 2 (40% of tract)	24	32	40	16
Zone 3 (40% of tract)	32	40	16	0
Zone 4 (10% of tract)	10	4	0	0
Total	66	82	64	26
Time Period SI	0.5	0.9	1.0	0.9
Equivalent Optimal Acres	33	73.8	64	23.4

The following is used to calculate the annual average acres:

- There are 93 days in the spring shorebird period (15 March to 15 June).
- From Day 1 (15 March) to Day 19 (2 April) there are 627 total acres (19 days * 33 equivalent acres).
- From Day 20 (3 April) to Day 40 (23 April) there are 1,549.8 total acres (21 days * 73.8 equivalent acres)
- From Day 41 (24 April) to Day 70 (23 May) there are 1,920 total acres (30 days * 64 equivalent acres)
- From Day 71 (24 May) to Day 86 (8 June) there are 351 (15 days * 23.4 equivalent acres).
- From Day 87 (9 June) to Day 93 (15 June) there are 0 total acres.
- There are a total of 4,447.8 acre equivalent days for the year (627 + 1,549.8 + 1,920 + +351 +0).
- The average annual optimal equivalent is 47.8 acres (4,096.8/93 day spring shorebird season).

Therefore, 47.8 average equivalent acres would be expected for every 100 acres of farmland managed as above. Table 19 provides the acres required to offset impacts for each alternative managed as stated above to compensate for impacts to shorebirds as a result of the project in the St. Johns Bayou Basin and New Madrid Floodway.

Table 19. Area (acres) of managed shorebird habitat during spring and fall migration periods required to mitigate for project alternatives.

	St. Johns Bayou Basin		New Madrid Floodway	
	Spring	Fall	Spring	Fall
Alternative 2.1/2	243.64	11.89	1,781.83	50.32
Alt. 3.1	243.64	11.89	1,285.93	48.94
Alt. 3.2	243.64	11.89	1,552.31	48.86
Alt. 4	243.64	11.89	675.84	0.00

The 993 acres of moist soil units located within the Ten Mile Pond Conservation Area provide significant shorebird habitat. Utilizing the same mitigation assumptions, the shorebird habitat provided in the Ten Mile Pond Conservation Area would reduce mitigation requirements to a total of 243.6 acres and 292.9 acres in the St. Johns Bayou and New Madrid Floodway, respectively.

It is anticipated that a portion of the spring shorebird compensation sites would also be used to provide the necessary shorebird habitat during the fall migration. Some agricultural commodities such as rice require inundation during different periods of the year as well as water management. Although soybeans would require planting past 8 June (sub-optimal return), commodities such as rice may be complementary to shorebird management if periods of inundation for rice overlap periods that are required for shorebirds, as long as the rice has not grown to a point that it becomes un-desirable for shorebirds. Management options that complement both rice production as well as shorebird management would be investigated during the completion of site-specific mitigation plans. Compensatory mitigation benefits/needs would be adjusted accordingly.

The IEPR panel provided the following comment concerning potential mitigation for other ecological resources and wetlands:

"The panel understands that the project area is highly modified from its historic conditions. These conditions notwithstanding, the goal of the mitigation plan is to compensate for losses in ecological function measured by comparing current without-project conditions to future with-project conditions. Importantly, this mitigation becomes part of the project and, therefore, all wildlife habitat losses that would result from the project, including those directly attributable to mitigation activities for other resource types, should be mitigated. The panel will concur if USACE states that all wildlife habitat impacts, including those resulting from mitigation of other project impacts, will be fully mitigated."

USACE position as related to mitigation for shorebirds is as follows:

a. Mitigation is a means to compensate for unavoidable impacts over the project life. Mitigation is not based on any one species or assemblage of a type of species such as shorebirds. It is based on unavoidable functional impacts from an ecosystem and adequately replacing those unavoidable ecosystem functional losses. Habitat units reflect an overall functional value, based on a collection of different species, assemblages, and uses.

b. Shorebirds inhabit the area more frequently now only because the bottomland hardwoods that were on the land have been cleared due to agricultural activity. Had the clearing not occurred, the birds would not be present in greater numbers than seen historically. Mitigation is a means to attempt to restore/replace/create natural habitat that occurred prior to alteration. Therefore, there would be a significant amount of bottomland hardwood/riverfront forest mitigation.

c. The mitigation plan would restore habitat to a historic condition. Similar to the way the shorebirds have relocated/exploited the farmland in the project area, the shorebirds would likely relocate to other agricultural fields, sand bars, and marshlands in the Mississippi River Valley and elsewhere.

d. The loss of additional farmland through compensatory mitigation would not result in a significant impact to shorebirds due to the abundance of flooded farmland post-project.

The issue regarding conflicting resources for ecosystem restoration projects or compensatory mitigation is not uncommon. Restoring benefits for one resource usually comes at a cost to another. Sparks (1995) recognized this problem of impacts to different species and groups of animals and their human advocates. Sparks further stated that the goal of ecosystem management[6] should be to maintain and recover the biological integrity of the ecosystem. Biological integrity was defined as “the capability of supporting and maintaining a balanced, integrated adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of a natural habitat of the region (emphasis added)” (Angermeier and Karr 1994, Sparks 1995).

Leveled cleared farmland does not fit the definition of “natural habitat of the region.” Proposed mitigation for other resources would restore the natural habitat of the region. Additional mitigation for shorebird habitat would not be required, as any needed mitigation would be provided through compensatory actions for impacts to waterfowl, fish, wetlands, and terrestrial wildlife.

Fish

Alternative 3.1 would result in an impact of 386.6, 441.3, and 245.3 AAHU in the St. Johns Bayou Basin for the early, mid, and late season spawning and rearing periods, respectively. Alternative 3.1 would result in an impact of 1,729.5, 2,061.1, and 1,165.8 AAHU in the New Madrid Floodway during the early, mid, and late fish spawning and rearing seasons, respectively.

A consistent methodology was applied to determine potential benefits to fish spawning and rearing habitat as was used to determine project-induced impacts. Benefits from compensatory mitigation to fish spawning and rearing habitat can basically occur in three ways. The first is the conversion of one habitat type to another type of habitat that is of higher value to fishes (*i.e.*, HSI value). An example is converting agricultural areas (HSI = 0.2) to bottomland hardwoods (HSI = 1.0). Another method is to restore river connectivity. For example, restoring hydrology to Big Oak Tree State Park without any change to overall land use would result in gains to spawning and rearing habitat. The third method is to increase duration of flooding (*i.e.*, increase in average daily flooded acres (ADFA)).

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[6] Compensatory mitigation for this particular case.

The habitat value for newly planted bottomland hardwood sites would not reach full habitat value (HSI = 1.0) for a period of time. Therefore, a transition period would be necessary. A reforested bottomland hardwood would take many years of growth to reach maximum benefit for floodplain fishes, although some benefits would potentially accrue prior to maturity. A factor considered in determining the length of transition was the cover a forest would provide (trunk, leaves, and twigs). Transition periods were separated into two different types for bottomland hardwood/riverfront forest restoration (*i.e.,* fast growing and slow growing).

Black willow and cottonwood are representative fast growing species. A length of 10 years was used to achieve maximum benefit for floodplain fishes that would be planted in fast growing species on agricultural areas.

Bald cypress and red oaks are representative slow growing species. A length of 20 years was used to achieve maximum benefit for floodplain fishes that would be planted in slow growing species on agricultural areas. Many slow growing varieties of trees are more beneficial to terrestrial wildlife and waterfowl due to the food they provide (*i.e.*, acorns). However, this is not the case for fish spawning and rearing habitat. Both slow and fast growing varieties provide equal habitat value at maturity.

Similar to existing project lands, mitigation lands may not be flooded continuously during the spawning and rearing season. In addition to transition periods, the ADFA that any particular area would provide must be calculated. Hydraulic and hydrology (H+H) analysis was conducted to determine the percent of ADFA that would be available for each one-foot contour for associated mitigation credit for impacts that would result from the implementation of the tentatively selected plan (Tables 20 and 21).

Table 20. Alternative 3.1 ADFA percent according to elevation, St. Johns Bayou Basin.

St. Johns Authorized Elevation	Early Season % ADFA	Mid Season % ADFA	Late Season % ADFA
280	38.4	36.9	16.9
281	34.9	32.9	14.7
282	30.5	29.8	12.8
283	27.4	27.6	10.8
284	24.7	25.3	9.5
285	21.8	22.4	7.5
286	18.4	19.4	6.3
287	16.5	17.3	5.1
288	14.1	14.8	4.4
289	12.3	11.4	3.9
290	8.5	8.0	3.2
291	4.1	5.2	2.3
292	2.1	4.0	1.7
293	1.8	3.4	1.0

Table 21. Alternative 3.1 ADFA percent according to elevation, New Madrid Floodway.

NMF Alt. 3.1 Elevation	Early Season % ADFA	Mid Season % ADFA	Late Season % ADFA
280	54.7	51.3	14.8
281	50.5	47.7	13.5
282	45.6	44.2	12.1
283	41.7	34.3	6.2
284	38.6	21.6	0.7
285	34.0	18.4	0.0
286	27.4	14.7	0.0
287	19.4	9.1	0.0
288	4.5	1.4	0.0
289	0.9	0.1	0.0

Impacts and mitigation were enumerated as AAHU, and the difference between pre- and post-project AAHUs were defined as the impact of the project. Therefore, mitigation would be required to compensate for reduced AAHU, which would depend on the habitat value (i.e. HSI value) of the techniques used in the mitigation plan. AAHU, not ADFA, were the key unit used to determine mitigation requirements. Benefits to fish rearing habitat from mitigation measures would be calculated by the following equations:

Habitat Gains = AAHU per tract with mitigation – AAHU per tract without mitigation

Where AAHU are averaged over a 50-year project life, and multiplied by a fish access coefficient

AAHU = Cumulative HUs/50 years x fish access coefficient, where fish access coefficient = 0.73

and Cumulative HU are calculated by,

$$\text{Cumulative HU} = \sum_{n=1}^{2} \left[(T_{n+1} - T_n) * (\text{ADFA}) * \left[\frac{\text{HSI}_n + \text{HSI}_{n+1}}{2}\right]\right]$$

Where:
T_n = first target year of time interval
T_{n+1} = last target year of time interval
ADFA = acres * percent ADFA according to elevation
HSI_n = HSI at beginning of time interval
HSI_{n+1} = HSI at end of time interval

Big Oak Tree State Park and 1,800 Surrounding Acres (Mitigation Zone 1)

Although it would take an approximate 5-year flood under existing conditions to inundate Big Oak Tree State Park, the tentatively selected plan would remove Big Oak Tree State Park from the five-year floodplain. Therefore, under with project conditions, Big Oak Tree State Park would not provide any fish spawning and rearing habitat. These impacts are included in the previous impact calculations.

ADFA was calculated for the park and the surrounding 1,800 acres of farmland by restoring Mississippi River hydrology to the park and surrounding areas. Based on H+H analysis, restoring Mississippi River hydrology to the park and surrounding 1,800 acres of cropland would provide 1,490.8, 1,450.6, and 941.4 ADFA for the early, mid, and late fish spawning and rearing seasons, respectively. An assumption was that slow growing trees would be planted on the adjacent cleared areas. Therefore, HSI would increase from 0.2 to 1.0 over a 20-year transition.

Likewise, fish access through the culverts would likely take place because of the following reasons:

- Water would be flowing into the basin during many open-gate periods, so excessive water velocity would not be an impediment to movement during these periods. In addition, those fishes that were spawned or are rearing in the basin could be easily transported back to the river when water direction through the culvert is reversed during falling Mississippi River stages.
- There would be no outlet or inlet drop in elevation from the connecting channels.
- Culvert slope would be nearly level.
- A relatively short distance would be required for fish to access the backwater.
- Water depth would be equal to the river stage up to the 5-foot height of the culvert, which would be more than adequate for swimming fishes.
- The utilization of similar sized culverts elsewhere to promote fish passage.
- Documented fish passage in the St. Johns Bayou Basin.

Therefore, fish access was assumed to be equal to that of the New Madrid Floodway (0.73).

The following steps were used to determine mitigation benefits for the early season period:

BLH Transition: 17,889.6 HU = (20 years) * (1,490.8) * [(0.2+1.0)/2]
BLH for remainder of project life: = 44,724 HU (30 years) * (1,490.8) * [1.0]
Cumulative HU: 62,613.6 (17,889.6 HU + 44,724 HU)
AAHU: 1,252.3 (62,613.6 cumulative HU/50 years)
Fish Access Coefficient: 914.0 AAHU (1,252.3 * 0.73)

The following steps were used to determine mitigation benefits for the mid season period:

BLH Transition: 17,407.2 HU = (20 years) * (1450.6) * [(0.2+1.0)/2]
BLH for remainder of project life: = 43,518 HU (30 years) * (1,450.6) * [1.0]
Cumulative HU: 60,925.2 (17,407.2 HU + 43,518 HU)
AAHU: 1,218.5 (60,925.2 cumulative HU/50 years)
Fish Access Coefficient: 889.5 (1,218.5 * 0.73)

The following steps were used to determine mitigation benefits for the late season period:

BLH Transition: 11,296.8 HU = (20 years) * (941.4) * [(0.2+1.0)/2]
BLH for remainder of project life: = 28,242 HU (30 years) * (941.4) * [1.0]
Cumulative HU: 39,538.8 (11,296.8 HU + 28,242 HU)
AAHU: 790.8 (39,538.8 cumulative HU/50 years)
Fish Access Coefficient: 577.3 (790.8 * 0.73)

AAHUs with compensatory mitigation benefits for restoring Big Oak Tree State Park in the New Madrid Floodway were assumed to mitigate impacts. These benefits could also be used to compensate for impacts to the St. Johns Bayou Basin, if warranted. Any changes would be described in the site-specific detailed mitigation plan.

Vegetated Wetland Restoration

Historically, the lower Mississippi River Valley was comprised of bottomland hardwood forests that frequently flooded during the spring. The aquatic communities that evolved under these conditions became pre-adapted to flooding, utilizing the structurally complex habitats formed by woody debris from surrounding trees and herbaceous vegetation that would form in ridge-swale topography for reproduction, feeding, and avoiding predators. Therefore, one of the primary mitigation tools would be to convert agricultural lands back to forested habitat and or herbaceous wetlands.

Lands Less Than an Elevation 285 (Mitigation Zone 2)

Consistent with the determination of impacts, compensatory mitigation benefits were a function of underlying land use (HSI values), flood frequency (within the 2-year or 5-year floodplain), and flood duration and area extent (ADFA). Agricultural lands that would be reforested at the lowest elevations in the St. Johns Bayou Basin and New Madrid Floodway are of greater value (per unit area) than those reforested at higher elevations. Therefore, secondary priority[7] would be given to lands at the lowest elevations. There are approximately 1,654 (57 percent of total area) and 1,547 (50 percent of total area) acres of agricultural lands at or below an elevation of 285 feet in the St. Johns Bayou Basin and New Madrid Floodway, respectively. An assumption was that 25 percent of these lands would be acquired for compensatory mitigation.[8] Another assumption was that reforesting would consist of slow growing species (20-year transition period).

<u>St. Johns Bayou Basin</u>

The hypothetical 400 acres of farmland would provide a minimum of 12.7, 13.1, and 4.6 AAHU for the early, mid, and late season periods, respectively (400 acres * applicable ADFA/ percentage from Table 20 ***** 0.2 HSI *0.73 Access).

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from reforesting 400 acres[9] (approximately 25 percent of available lands) of agricultural lands below an elevation of 285 feet in the early-season period:

BLH Transition: 1,046.4 HU = (20 years) * (87.2) * [(0.2+1.0)/2]
BLH for remainder of project life: = 2,616 HU = (30 years) * (87.2) * [1.0]

[7] Primary priority will be to lands surrounding Big Oak Tree State Park.
[8] Lands at the lowest elevations in both basins would still remain subject to flooding due to their respective elevations. Therefore, it is assumed that these lands would be made available from willing sellers.
[9] 400 acres translates into 87.2 ADFA (see Table 20 and the corresponding value of 21.8%). This estimate assumes all lands would be at an elevation of 285 feet. This was considered a conservative estimate since some lands would probably be located at elevations below 285 feet which would result in greater mitigation value.

Cumulative HU: 3662.4 (1,046.4 HU + 2,616 HU)
Early Season AAHU: 73.2 (3,662.4 cumulative HU/50 years)
Fish Access Coefficient: 53.4 (73.2 AAHU * 0.73)
Mitigation Benefit = 40.7 AAHU (53.4 with mitigation AAHU – 12.7 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from reforesting 400 acres[10] (approximately 25 percent of available lands) of agricultural lands below an elevation of 285 feet in the mid-season period:

BLH Transition: 1,075.2 HU = (20 years) * (89.6) * [(0.2+1.0)/2]
BLH for remainder of project life: = 2,688 HU (30 years) * (89.6) * [1.0]
Cumulative HU: 3,763.2 (1,075.2 HU + 2,688 HU)
Mid-Season AAHU: 75.3 (3,763.2 cumulative HU/50 years)
Fish Access Coefficient: 55.0 (75.3 AAHU * 0.73)
Mitigation Benefit = 41.9 AAHU (55.0 with mitigation AAHU – 13.1 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from reforesting 400 acres[11] (approximately 25 percent of available lands) of agricultural lands below an elevation of 285 feet in the late-season period:

BLH Transition: 379.2 HU = (20 years) * (31.6) * [(0.2+1.0)/2]
BLH for remainder of project life: = 948 HU (30 years) * (31.6) * [1.0]
Cumulative HU: 1,327.2 (379.2 HU + 948 HU)
Late Season AAHU: 27.4 (1,372.2 cumulative HU/50 years)
Fish Access Coefficient: 20.0 AAHU (27.4 AAHU * 0.73)
Mitigation Benefit = 15.4 AAHU (20.0 with mitigation AAHU – 4.6 without mitigation AAHU)

New Madrid Floodway

The hypothetical 387 acres of farmland would provide 19.3, 10.5, and 0 AAHUs for the early, mid and late season fish spawning and rearing period, respectively (387 acres * applicable ADFA/percentage from Table 21 ***** 0.2 HSI * 0.73 fish access coefficient).

The following steps were used to determine compensatory mitigation benefits in the New Madrid Floodway from reforesting 387 acres[12] (approximately 25 percent of available lands) agricultural lands below an elevation of 285 feet in the early-season period:

[10] 400 acres translates into 89.6 ADFA (see Table 20 and the corresponding value of 22.4%). This estimate assumes all lands would be at an elevation of 285 feet. This was considered a conservative estimate since some lands would probably be located at elevations below 285 feet which would result in greater mitigation value.
[11] 400 acres translates into 31.6 ADFA (see Table 20 and the corresponding value of 7.5%). This estimate assumes all lands would be at an elevation of 285 feet. This was considered a conservative estimate since some lands would probably be located at elevations below 285 feet which would result in greater mitigation value.

BLH Transition: 1,584 HU = (20 years) * (132) * [(0.2+1.0)/2]
BLH for remainder of project life: = 3,960 HU (30 years) * (132) * [1.0]
Cumulative HU: 5,544 (1,584 HU + 3,960 HU)
Early Season AAHU: 110.9 (5,544 cumulative HU/50 years)
Fish Access Coefficient: 81.0 (110.9 * 0.73)
Mitigation Benefit = 61.7 AAHU (81.0 with mitigation AAHU – 19.3 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the New Madrid Floodway from reforesting 387 acres[13] (approximately 25 percent of available farmlands) of agricultural lands below an elevation of 285 feet in the mid-season period:

BLH Transition: 859.2 HU = (20 years) * (71.6) * [(0.2+1.0)/2]
BLH for remainder of project life: = 2,148 HU (30 years) * (71.6) * [1.0]
Cumulative HU: 3,007.2 (859.2 HU + 2,148 HU)
Mid-Season AAHU: 60.1 (3,007.2 cumulative HU/50 years)
Fish Access Coefficient: 81.0 (110.9 * 0.73)
Mitigation Benefit = 70.5 AAHU (81.0 with mitigation AAHU – 10.5 without mitigation AAHU)

There are no compensatory mitigation benefits from reforesting lands below an elevation of 285 in the late-season period because the ADFA percent is 0 (see Table 21).

Lands Within the Post Project 5-year Floodplain (Mitigation Zone 3)

Alternative 3.1 would lower the 5-year floodplain to an elevation of 292.6 and 288.7 in the St. Johns Bayou Basin and the New Madrid Floodway, respectively. Lands must be within the post-project 5-year floodplain to be of value to fish. Due to the weighting factor conducted for impact analysis, agricultural lands do not provide any fish spawning and rearing value at the 5-year frequency. As can be seen in Table 20 and 21**,** site specific areas need to be known to determine the amount of ADFA per acre of habitat. Lands at lower elevations that flood more frequently and have longer durations provide more value to fish per unit area.

<u>St. Johns Bayou Basin</u>

A hypothetical 100-acre tract of land located at an elevation of 288 was used to estimate mitigation. An assumption was that slow growing species of trees would be planted on the mitigation tract. The hypothetical 100-acre tract of land would provide 2.1, 2.2, and

[12] 387 acres translates into 132 ADFA (see Table 21 and the corresponding value of 34.1%). This estimate assumes all lands would be at an elevation of 285 feet. This was considered a conservative estimate since some lands would probably be located at elevations below 285 feet which would result in greater mitigation value.
[13] 387 acres translates into 71.6 ADFA (see Table 21 and the corresponding value of 18.5%). This estimate assumes all lands would be at an elevation of 285 feet. This was considered a conservative estimate since some lands would probably be located at elevations below 285 feet which would result in greater mitigation value.

0.6 AAHUs for the early, mid, and late fish spawning and rearing periods, respectively (100 * applicable ADFA percentage from Table 20 ***** 0.2 HSI * 0.73 Access).

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from reforesting a hypothetical 100 acres[14] of agricultural lands at an elevation of 288 feet in the early season period:

BLH Transition: 169.2 HU = (20 years) * (14.1) * [(0.2+1.0)/2]
BLH for remainder of project life: = 423 HU (30 years) * (14.1) * [1.0]
Cumulative HU: 592.2 (169.2 HU + 423 HU)
Early Season AAHU: 11.8 (592.2 cumulative HU/50 years)
Fish Access Coefficient: 8.6 AAHU (11.8 AAHU * 0.73 Access)
Mitigation Benefit = 6.7 AAHU (8.6 with mitigation AAHU **–** 2.1 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from reforesting a hypothetical 100 acres[15] of agricultural lands at an elevation of 288 feet in the mid season period:

BLH Transition: 177.6 HU = (20 years) * (14.8) * [(0.2+1.0)/2]
BLH for remainder of project life: = 444 HU (30 years) * (14.8) * [1.0]
Cumulative HU: 621.6 (177.6 HU + 444 HU)
Mid-Season AAHU: 12.4 (621.6 cumulative HU/50 years)
Fish Access Coefficient : 9.1 AAHU (12.4 AAHU * 0.73 Access)
Mitigation Benefit = 6.9 AAHU (9.1 with mitigation AAHU **–** 2.2 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from reforesting a hypothetical 100 acres[16] of agricultural lands at an elevation of 288 feet in the late season period:

BLH Transition: 52.8 HU = (20 years) * (4.4) * [(0.2+1.0)/2]
BLH for remainder of project life: = 132 HU (30 years) * (4.4) * [1.0]
Cumulative HU: 184.8 (52.8 HU + 132 HU)
Late Season AAHU: 3.7 (184.8 cumulative HU/50 years)
Fish Access Coefficient: 2.7 AAHU (3.7 AAHU * 0.73)
Mitigation Benefit = 2.1 AAHU (2.7 with mitigation AAHU **–** 0.6 without mitigation AAHU)

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[14] 100 acres translates into 14.1 ADFA (see Table 20 and the corresponding value of 14.1%). This estimate assumes all lands would be at an elevation of 288 feet.
[15] 100 acres translates into 14.8 ADFA (see Table 20 and the corresponding value of 14.8%). This estimate assumes all lands would be at an elevation of 288 feet.
[16] 100 acres translates into 4.4 ADFA (see Table 20 and the corresponding value of 4.4%). This estimate assumes all lands would be at an elevation of 288 feet.

New Madrid Floodway

A hypothetical 100-acre tract of farmland located at an elevation of 287 was used to estimate compensatory mitigation in the New Madrid Floodway. An assumption was that slow growing species of trees would be planted on the mitigation tract. The hypothetical 100-acre tract of land would provide 2.8, 1.3, and 0.0 AAHUs for the early, mid, and late fish spawning and rearing periods, respectively (100 * applicable ADFA percentage from Table 21 ***** 0.2 HSI * 0.73 access).

The following steps were used to determine compensatory mitigation benefits in the New Madrid Floodway from reforesting a hypothetical 100 acres[17] of agricultural lands at an elevation of 287 feet in the early season period:

> BLH Transition: 232.8 HU = (20 years) * (19.4) * [(0.2+1.0)/2]
> BLH for remainder of project life: = 582 HU = (30 years) * (19.4) * [1.0]
> Cumulative HU: 814.8 (232.8 HU + 582 HU)
> Early Season AAHU: 16.3 (814.8 cumulative HU/50 years)
> Fish Access Coefficient: 11.9 (16.3 * 0.73)
> **Mitigation Benefit = 9.1 AAHU** (11.9 with mitigation AAHU – 2.8 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the New Madrid Floodway from reforesting a hypothetical 100 acres[18] of agricultural lands at an elevation of 287 feet in the mid-season period:

> BLH Transition: 110.4 HU = (20 years) * (9.2) * [(0.2+1.0)/2]
> BLH for remainder of project life: = 276 HU (30 years) * (9.2) * [1.0]
> Cumulative HU: 386.4 (110.4 HU + 276 HU)
> Early Season AAHU: 7.7 (386.4 cumulative HU/50 years)
> Fish Access Coefficient: 5.6 (7.7 * 0.73)
> **Mitigation Benefit = 4.3 AAHU** (5.6 with mitigation AAHU **–** 1.3 without mitigation AAHU)

There are no compensatory mitigation benefits from reforesting lands below an elevation of 287 in the late season period because the ADFA percent is 0 (see Table 21).

Batture Land (Mitigation Zone 5)

The Phase 2 IEPR panel stated that batture land mitigation is suitable to compensate for fish impacts if access were determined to be an issue. No access impacts would be

[17] 100 acres translates into 19.4 ADFA (see Table 21 and the corresponding value of 19.4%). This estimate assumes all lands would be at an elevation of 288. Therefore, this is a conservative estimate since some lands would be below this elevation so ADFA would likely be greater.
[18] 100 acres translates into 9.2 ADFA (see Table 21 and the corresponding value of 9.2%). This estimate assumes all lands would be at an elevation of 287. Therefore, this is a conservative estimate since some lands would be below this elevation so ADFA would likely be greater.

associated with the St. Johns Bayou Basin portion of the project, because the gate was previously constructed. Therefore, a consistent fish access coefficient (0.73) was applied to pre-project conditions as well as post-project conditions. However, another situation would occur in the New Madrid Floodway. Pre-project conditions do not include a fish access coefficient in habitat calculations. Remaining habitat value after construction of the preliminary recommended plan (within the post-project 2-year floodplain for sub-optimal habitat and within the post-project 5-year floodplain for optimal habitat) was reduced by the fish access coefficient (0.73). No associated fish access issues would occur with batture land mitigation. Therefore, no reduction in value was calculated.

Many areas within the batture lands offer suitable habitat for spawning and rearing fish. The approximate 2-year floodplain located at river mile 900 (tip of Donaldson Point) is approximately 297.6 feet. Based on H+H analysis, approximately 29 percent, 29 percent, and 13 percent ADFA per acre would result for the early, mid, and late season, respectively. An assumption was that agricultural areas would be allowed to regenerate naturally or would be planted in early successional varieties. Therefore, a 10-year transition would be expected for the HSI value to increase from 0.2 (agriculture HSI) to 1.0 (bottomland hardwood HSI).

A hypothetical 100-acre plot of farmland was used on Donaldson Point. The 100 acres of farmland provide 5.8 AAHU (29 ADFA * 0.2 HSI), 5.8 AAHU (29 ADFA * 0.2 HSI), and 0.03 AAHU (13 ADFA * 0.2 HSI) under the pre-mitigation scenario for the early, mid, and late seasons, respectively. Fish access is not constrained in the batture.

Mitigation involves natural regeneration of black willow and cottonwood. Therefore, HSI increases from 0.2 to 1.0 over a 10-year transition. The following steps are used to determine with mitigation benefits during the early and mid seasons:

> BLH transition period: 186 HU = (10 years) * (31 ADFA) * [0.2 + 1.0)/2]
> BLH for remainder of project life: = 1,240 HU (40 years) * (31 ADFA) * (1.0)
> Cumulative HU: 1,426 = (186 HU + 1,240 HU)
> AAHU = 28.52 (1,426 cumulative HU/50 years)
> **Mitigation Benefit = 22.7 AAHU** (28.5 AAHU with mitigation) – 5.8 AAHU (without mitigation)

Therefore, 22.7 AAHU would be provided by reforesting 100 acres of farmland within the batture land for the early- and mid-season spawning and rearing period.

Riparian Buffer Strips (Mitigation Zone 6)

The Missouri Stream Mitigation Method (MSMM) is being used to calculate impacts from channel modification to reaches in the St. Johns Bayou Basin as well as the associated mitigation credits from riparian buffer strip establishment (see DEIS Section 4.11). The proposed buffer strips would consist of woody vegetation establishment along one bank and warm season grass establishment on the opposite bank. In addition to compensating for impacts to channel modification, buffer strips would also provide spawning and rearing habitat for fisheries resources (depending on the elevation of the buffer strips). A 50-foot buffer along 11.9 miles (93 acres) of St. Johns and Setback Levee Ditches would be established for Alternative 3.1. For planning purposes, it was assumed that half of the 93 acres (46.5 acres) would be located at or below an elevation of 288 feet. It was also assumed that native warm season grasses would provide an HSI value of 0.5 (fallow) and woody vegetation would provide an HSI value of 1.0. Therefore, there would also be a net increase to spawning and rearing habitat.

The 46.5 acres of farmland provides 0.96, 1.0, and 0.3 AAHU for the early, mid, and late fish spawning and rearing period, respectively (46.5 * applicable ADFA/percentage from Table 20 ***** 0.2 HSI * 0.73 Fish Access Coefficient). The transition to warm season grasses was assumed to take one year, while the transition to BLH would take 15 years (MSMM).

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from planting a buffer on 46.5 acres[19] of agricultural lands at an elevation of 288 feet in the early-season period:

> BLH Transition: 62.1 HU = (15 years) * 6.9 * [(0.2+1.0)/2]
> Grass Transition: 2.4 HU = (1 year) * (6.9) * [(0.2+ 0.5)/2]
> BLH buffer for remainder of project life: 241.5 HU = (35 years) * (6.9) * [1.0]
> Grass buffer for remainder of project life: 169.1 HU = (49 years) * 6.9 * 0.5
> Cumulative HU: 475.1 (62.1 HU + 2.4 HU +241.5 HU + 169.1 HU)
> Early Season AAHU: 9.5 (475.1 cumulative HU/50 years)
> Fish Access Coefficient : 6.9 (9.5 AAHU * 0.73)
> **Mitigation Benefit = 5.9 AAHU (**6.9 with mitigation AAHU **–** 0.96 without mitigation AAHU)

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from planting a buffer on 46.5 acres[20] of agricultural lands at an elevation of 288 feet in the mid-season period:

> BLH Transition: 59.4 HU = (15 years) * 6.6 * [(0.2+1.0)/2]
> Grass Transition: 2.3 HU = (1 year) * (6.6) * [(0.2+ 0.5)/2]
> BLH buffer for remainder of project life: 231.0 HU = (35 years) * 6.6 *[1.0]
> Grass buffer for remainder of project life: 161.7 HU = (49 years) * (6.6) * [0.5]
> Cumulative HU: 454.4 (59.4 HU + 2.3 HU + 231.0 HU + 161.7 HU)
> Mid-Season AAHU: 9.1 (454.4 cumulative HU/50 years)
> Fish Access Coefficient : 6.6 AAHU (9.1 AAHU * 0.73)
> **Mitigation Benefit = 5.6 AAHU (**6.6 with mitigation AAHU **–** 1.0 without mitigation AAHU)

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[19] 46.5 acres translates into 6.9 ADFA (see Table 20 and the corresponding value of 14.8%). This estimate assumes all lands would be at an elevation of 288.
[20] 46.5 acres translates into 6.6 ADFA (see Table 20 and the corresponding value of 14.1%). This estimate assumes all lands would be at an elevation of 288.

The following steps were used to determine compensatory mitigation benefits in the St. Johns Bayou Basin from planting a buffer on 46.5 acres[21] of agricultural lands at an elevation of 288 feet in the late-season period:

> BLH Transition: 18.9 HU = (15 years) * 2.1 * [(0.2+1.0)/2]
> Grass Transition: 0.7 HU = (1 year) * (2.1) * [(0.2+ 0.5)/2]
> BLH buffer for remainder of project life: 73.5 HU = (35 years) * 2.1 * [1.0]
> Grass buffer for remainder of project life: 51.5 HU = (49 years) * (2.1) * [0.5]
> Cumulative HU: 144.6 (18.9 HU + 0.7 HU + 73.5 HU + 51.5 HU)
> Mid-Season AAHU: 2.9 (144.6 cumulative HU/50 years)
> Fish Access Coefficient: 2.1 AAHU (2.9 AAHU * 0.73)
> **Mitigation Benefit = 1.8 AAHU (**2.1 with mitigation AAHU – 0.3 without mitigation AAHU)

Ecologically Designed Borrow Pits

Ecologically designed borrow pits are an excellent measure to compensate for impacts associated with the project (J. Jackson, personal communication, Battelle, 2010). Compensatory mitigation benefits provided from borrow pit construction compensates for project impacts including impacts to waterbodies and inundated floodplain habitat. Approximately 387 and 60 acres of borrow pits would be constructed for the project in the St. Johns Bayou Basin and New Madrid Floodway, respectively. Borrow pits and waterbodies provide high quality spawning and rearing habitat for a variety of species (Baker *et al.*, 1991). When access is available during flood events in the project area (*i.e.,* within the 5-year floodplain), adult fish would be attracted to the borrow pits because of deep water and abundant forage fishes that often concentrate in them after flood waters recede. In addition, to maximize the benefit, each pit would be located above the post project 2-year floodplain (agriculture HSI = 0 above the two year) but within the 5-year floodplain (Mitigation Zone 3). Many of these adult fish would spawn in shallow, structurally complex littoral areas of the borrow pits, since plankton densities are usually high in waterbodies; once eggs hatched, larval fish would have an abundant food source. Since high densities of fish are characteristic of waterbodies/borrow pits, many of these individuals would eventually be transported or would move into the Mississippi River during subsequent floods.

The ecological design of borrow pits would follow the guidelines established by Aggus and Ploskey (1986), which recommends some areas of deep water (*e.g.,* 6-10 feet deep), a sinuous shoreline, establishment of islands, and a variable bottom topography. Average depth of each pit would influence fish assemblages. Shallow areas are suitable for characteristic wetland species such as fliers, pirate perch, taillight shiners, and young-of-year fishes. Deeper areas are more conducive for sport and commercial species. Therefore, construction of each pit would recognize the importance of providing shallow water and deep water to benefit the maximum number of species and life stages. However, existing oxbow lakes that are protected from flooding by the river levees and

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[21] 46.5 acres translates into 2.1 ADFA (see Table 20) and the corresponding value of 4.4%). This estimate assumes all lands would be at an elevation of 288 feet.

are partly or entirely surrounded by agricultural lands typically experience changed drainage patterns, increased turbidity, and accelerated sedimentation. Cooper and McHenry (1989) reported sediment accumulations in Moon Lake, MS and predicted that in 50 years such deposition would reduce the area of the lake by 3–7 percent, progressing from the two shallow ends. To reduce the possibility of sedimentation in constructed borrow pits, USACE proposes that a 25-foot bottomland hardwood buffer be established around each pit. Schoonover et al. (2005) reported that a 22-foot forest buffer strip reduced sediment loads from agricultural areas to adjacent waters by 86 percent. Therefore, extensive sedimentation is not anticipated.

The ecological design of borrow pits would be as follows:

- 50 percent of each pit would have an average depth of at least six feet to provide habitat for species that are commercially and recreationally valuable.
- 50 percent of each pit would have an average depth of at least three feet to provide habitat for fishes that require shallower habitat.
- All borrow pits would be constructed within the post-project 5-year floodplain. Therefore, they would be considered as fish spawning and rearing habitat benefits.
- Islands and diverse topography would be created.
- Aquatic vegetation would propagate naturally in shallow areas.
- Bottomland hardwoods would be restored around each pit to provide a buffer.
- Structure (trees, limbs, etc.) would be placed within newly constructed pits when practical. Structure would be obtained from cleared sites necessary for other construction. No vegetation would be cleared for the sole purpose of obtaining structure.
- Connection to existing borrow pits would be made to the extent practical.
- Public access would be made available to the extent practical.

Material necessary for the Setback Levee grade raise would be provided from construction of ecologically designed borrow pits (387 acres) located in the lower portion of the St. Johns Bayou Basin. The material necessary for the closure levee and Frontline Levee raise would be provided from the construction of ecological designed borrow pits located in the lower portion of the New Madrid Floodway. In addition, to maximize the benefit, each pit would be located above the post project 2-year floodplain (agriculture HSI = 0 above the two year) but within the 5-year floodplain (Mitigation Zone 3). HSI would increase from zero to 1.0. A five-year transition period is also assumed to obtain an HSI value of 1.0. Therefore, AAHU is calculated as follows:

<u>St. Johns Bayou Basin</u>

Borrow Pit Transition: 967.5 HU = (5 year) * (387) * [(0.0+ 1)/2]
Borrow Pit for remainder of project life: = 17,415 HU = (45 years) * (387) * [1.0]
Cumulative HU: 18,382.5 (967.5 HU + 17,415 HU)
AAHU: 367.7 (18,382.5 cumulative HU/50 years)

Fish Access Coefficient: 268.4 AAHU (367.7 AAHU * 0.73)
Mitigation Benefit = 268.4 AAHU (268.4 with mitigation AAHU – 0.0 without mitigation AAHU)

<u>New Madrid Floodway</u>

Borrow Pit Transition: 150 HU = (5 year) * (60) * [(0.0+ 1)/2]
Borrow Pit for remainder of project life: = 2,700 HU = (45 years) * (60) * [1.0]
Cumulative HU: 3,000 (150 HU + 2,700 HU)
AAHU: 57 (3,000 cumulative HU/50 years)
Fish Access Coefficient: 41.6 AAHU (57 AAHU * 0.73)
Mitigation Benefit = 41.6 AAHU (41.6 with mitigation AAHU – 0.0 without mitigation AAHU).

The overall design and specific location would be coordinated with the development of a site-specific detailed mitigation plan.

Ten Mile Pond CA Moist Soil Management

Due to fish access constraints in the existing Ten Mile Pond CA, no fish spawning and rearing habitat is provided.

Seasonally Inundated Farmland

It is anticipated that seasonally inundated farmland would be located above the post-project 5-year flood frequency elevation. Therefore, no fish spawning and rearing compensatory mitigation benefit would be provided. However, seasonally inundated areas within the post-project 5-year floodplain would accrue the applicable compensatory mitigation benefits coordinated through a site-specific detailed mitigation plan.

Floodplain Lakes

As previously stated, there are several floodplain lakes located within the Lower Mississippi River Valley within the State of Missouri that have been degraded by anthropogenic impacts (Appendix A, Figure 4.7). Similar to ecologically designed borrow pits, compensatory mitigation benefits provided from restoring floodplain lakes compensates for project impacts, including impacts to waterbodies and inundated floodplain habitat. The Mississippi River floodplain can be inundated for prolonged periods between winter and early summer. Fish respond to floods by moving laterally onto the floodplain to feed, avoid predators, and seek suitable areas for reproduction. A pulsed hydrograph during the winter and spring provides opportunities for fish to access floodplain habitats and reside for extended periods to feed and reproduce. Floodplain lakes can harbor both resident and transient fish, but must be within the 5-year floodplain to be of benefit to Mississippi River (*i.e.*, transient) fish.

Floodplain lakes, such as Riley Lake, exist in the batture area adjacent to the project area (Appendix A, Figure 4.7). Normally these lakes become very shallow or completely dry after floods recede. Larval fish abundance can be high in floodplain lakes for feeding and reproductive purposes. Efforts to maintain suitable water depths after flood waters recede would improve the survival rate and contribute to overall recruitment of fish once a lake was reconnected to the Mississippi River during subsequent flood pulses. Riley Lake is just one example of numerous opportunities to reconnect or manage water levels of floodplain lakes to enhance the survival of early life history stages of fish. For example, the Lower Mississippi River Resource Committee has published a list of backwaters in the Mississippi River floodplain that state and Federal resource agencies have identified as restoration sites. The interagency mitigation team could consider restoring some of these other lakes as mitigation in addition to or in lieu of Riley Lake.

To create viable agricultural land similarly to the vast majority of land within the project area, a ditch was dug in an attempt to drain Riley Lake for agricultural purposes (Robert Henry, personal communication). A rock weir could be constructed within the outlet to restore historic surface elevations and negate the effects of the ditch. Land use around the 36-acre lake is currently agriculture (216 acres) and a cottonwood plantation (180 acres). Table 22 provides the existing AAHU of Riley Lake and the proposed restoration footprint (*i.e.,* elevation of 287 feet).

Table 22. Riley Lake, existing AAHU.

Land Use	Acres	ADFA[1]	HSI	AAHU
Tree Farm	180	55.8	1.0	55.8
Agriculture	216	67	0.2	13.4
Water	36	36	1.0	36
TOTAL	**432**	**158.8**		**105.2**

[1]Based on H+H analysis, ADFA is approximately 31% per acre.

A weir could be constructed to restore Riley Lake to an elevation of 287 feet. Therefore, the lake would be restored to 432 acres, providing 432 AAHU (432 ADFA * 1.0 HSI) by restoring surface elevations to an elevation of 287 feet. Thus, the restoration of Riley Lake would provide a benefit of 326.8 AAHU (432 AAHU – 105.2 AAHU) for each of the three spawning and rearing periods.

Conclusion

Tables 23 and 24 provide the overall mitigation results. Additional details regarding mitigation are found in Sections 5 and 7.

Table 23. Fisheries compensatory mitigation benefits (AAHU) in the St. Johns Bayou Basin.

Mitigation	Acres	Early	Mid	Late
Impacts		-386.6	-441.3	-245.3
BLH Restoration < 285'	400	40.7	41.9	15.4
BLH Restoration < 5-year	1,816	124.2	127.9	50.1
Riparian Buffer Strips	47	5.9	5.6	1.8
Ecologically Designed Borrow Pits	387	268.4	268.4	268.4
Net Gain		52.6	2.5	90.4

Table 24. Fisheries compensatory mitigation benefits (AAHU) in the New Madrid Floodway.

Mitigation	Acres	Early	Mid	Late
Impacts		-1,729.5	-2,061.1	-1,165.8
Big Oak Tree State Park and Surrounding Area	2,800	914.0	889.5	577.3
BLH Restoration < 285'	387	61.7	70.5	0.0
BLH Restoration < 5-year	1,970	179.3	84.7	0.0
Batture Land Reforestation	3,050	692.4	692.4	310.2
Ecologically Designed Borrow Pits	60	41.6	41.6	41.6
Floodplain Lake	432	326.8	326.8	326.8
Net Gain		486.2	44.4	90.1

Additional opportunities could be explored during the development of site-specific mitigation plans. Any changes would be coordinated in a site specific mitigation plan and applicable NEPA documentation would be prepared.

Ditches

Consistent with the determination of impacts, the Missouri Stream Mitigation Method (MSMM) was used to determine credits generated from mitigation techniques. Compensatory stream mitigation generally means the manipulation of the physical, chemical, and/or biological characteristics of a stream with the goal of repairing or replacing its natural functions. The purpose is to compensate for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization measures have been achieved and should be designed to restore, enhance, and maintain stream uses that are adversely impacted by authorized activities.

River rehabilitation projects are now widespread throughout the United States and Europe, which employ techniques to restore natural river features that have been lost through channelization by narrowing and re-meandering channelized reaches, re-profiling banks that are very steep, and creating specific features such as riffles and backwaters (Pretty et al. 2003).

To compensate for impacts associated with the proposed channel work, a suite of mitigation techniques are proposed that are practicable, applicable, and suitable to replace (or enhance) ecosystem functions currently offered by project area ditches. Mitigation techniques include:

- Constructing nine transverse dikes in the lower 3.7 miles of St. Johns Bayou to create a low flow sinuous channel.
- Constructing a bank stability structure (*i.e.,* weir) at the confluence of St. Johns Bayou and Setback Levee Ditch to provide stability as well as provide structure.
- Constructing a bank stability structure at the confluence of Setback Levee Ditch and St. James Ditch.
- Creating stream bank slopes that are designed to prevent erosion and maximize fish and wildlife habitat.
    - Langler and Smith (2001) found that habitat restoration using graded banks significantly increased the abundance and diversity of fish populations through increased structural complexity (vegetation for spawning substratum) and offered areas of increased temperature (which can increase growth rate through enhanced food assimilation rate, and possibly, indirect effects by increased supply of food).
- Establishing buffer strips consisting of both woody vegetation on one bank and warm season grasses on the opposite bank along reaches of ditches that were previously farmed to top bank as well as replanting vegetation in areas cleared by construction efforts. All efforts would be made to establish the woody vegetation on the ditch bank that would provide the maximum amount of shade to the ditch.
    - Although USACE would ensure buffer strips are established on both banks, credit would only be taken for woody vegetation, therefore, grass buffers would be planted and maintained as an environmental design feature.
- Placing spoil material from all future maintenance activities outside of the mitigation rights-of-way.

Following acquisition of site-specific mitigation tracks, a Standard Operating Procedure (SOP) manual will be created detailing mitigation areas that are to be preserved/maintained by the project sponsor despite future maintenance requirements.

In-Stream Work

In many rivers, natural patterns of sediment transport, erosion, and deposition re-create morphological features such as riffles and pools following channel modification (Pretty et al. 2003). Due to the agricultural setting of the project area ditches and their required maintenance (vegetation and sediment removal), natural restoration would not occur. Instead, artificial structures at known locations that can be avoided by routine maintenance are proposed to gain mitigation credit through the MSMM.

St. Johns Bayou Basin

Following USACE and MSMM guidelines, data sheets were completed to determine mitigation credits resulting from in-stream work, restoration or enhancement and relocation worksheet (Appendix P, Part 3). The following assumptions were used:

- St. Johns Bayou (Net Benefit 1 and 2), Setback Levee Ditch (Net Benefit 3), and St. James Ditch (Net Benefit 4) were classified as perennial stream type. The perennial stream type designation was applied due to the fact that these ditches have flowing water year-round during a typical year.
- St. Johns Bayou, Setback Levee Ditch, and St. James Ditch were classified as tertiary for priority area. The tertiary designation was assigned due to these ditches not meeting criteria to establish them as primary or secondary.
- St. Johns Bayou, Setback Levee Ditch, and St. James Ditch were considered functionally impaired as at least one of the following required criteria has been met:
    - The ditch was previously channelized.
    - The ditch has little or no riparian buffer on one or both sides.
    - The ditch has extensive human-induced sedimentation.
- In stream work in St. Johns Bayou was assigned a net benefit of 2, classified as a "good" stream channel restoration/enhancement. The nine transverse dikes proposed meet the designated criteria for restoring in-stream channel features using methodology appropriate to stream type. Additionally, steep upper slopes will be re-shaped and both the stream bed (via nine transverse dikes) and banks (via sloping) will be stabilized.
- In stream work in Setback Levee Ditch (Net Benefit 3) and St. James Bayou (Net Benefit 4) were assigned a net benefit of 1, classified as a "moderate" stream channel restoration/enhancement. Actions proposed in both ditches (the placement of riprap and confluence areas as well as creating stream bank slopes that are designed to prevent erosion and maximize fish and wildlife habitat) meet the designated criteria of restoring streambank stability in moderately eroded areas, as well as stabilizing the stream channel in place. All ditches were assigned a Level II monitoring program, as both plant survival and channel stability will be monitored in accordance with the MSMM.
- All ditches were assigned a Schedule 2 mitigation construction timing, as a majority of the mitigation would be completed concurrent with impacts.

Mitigation credits resulting from in-stream work would generate 384,099.9 stream credits.

<u>New Madrid Floodway</u>

No in-steam work is proposed within the New Madrid Floodway.

Riparian Buffer Creation

Riparian areas are critical components of stream ecosystems that provide important ecological functions, and directly influence the functions of streams, especially in terms of habitat quality and water quality. As greater than 80 percent of the project area is devoted to agricultural production (which consists of applying copious amounts of fertilizer and pesticides to maximize yields), riparian buffer establishment along ditches adjacent to agricultural fields may very well provide the greatest ecosystem service to an area so highly manipulated for anthropogenic purposes.

Because of the agricultural nature of the project area ditches, many reaches have no riparian vegetation present, serving as a means to access the ditch for inspection and maintenance purposes as well as maximizing all land available to the farmer. Due to this fact, establishment of woody vegetation along both banks is not practical. Consultation with members on the Mitigation Banking Review Team (IRT) and an Independent External Peer Review (IEPR) panel has suggested that woody vegetation be established on one bank and warm season grasses on the opposite bank, which would serve as the construction/maintenance side. Although grass buffers do not provide shade to the level of woody vegetation, in agricultural regions, grassy areas may be more effective in reducing bank erosion and trapping suspended sediments than wooded areas (Lyons 2000). In fact, Castle et al. (1994) reported that grass buffer strips as narrow as 15 feet trapped approximately 90 percent of NH_4-N, NO_3-N and PO_4-P, and that trapping efficiencies increased to between 96 percent and 99.9 percent when the buffer width was increased to 30 feet. Wolf (2009) also noted that switchgrass provides excellent erosion control when used as filter strips, grass hedges, or cover such as river levee banks. In addition, Moore et al. (2000) stated that agricultural ditches in the Mississippi Alluvial Delta have been recognized as comparable substitutes for edge-of-field wetlands and can provide areas for mitigation of non-point source pollution.

However, as previously stated, due to interagency team (IAT) concerns of the grass buffer being used as access to periodically to maintain agricultural ditches in the project area, the grass buffer will be implemented as an environmental design feature and no mitigation credit will be taken through the MSMM.

St. Johns Bayou Basin

Following USACE and MSMM guidelines, data sheets were completed to determine mitigation credits in the St. Johns Bayou Basin resulting from riparian buffer creation, enhancement, restoration, and preservation worksheet (Appendix P, Part 3). The following assumptions were used:

- St. Johns Bayou (Net Benefit 1 and 2), Setback Levee Ditch (Net Benefit 3), and St. James Ditch (Net Benefit 4) were classified as perennial stream type. The perennial stream type designation was applied due to the fact that these ditches have flowing water year-round during a typical year. St. Johns Bayou, Setback Levee Ditch, and St. James Ditch were classified as tertiary for priority area. The tertiary designation was assigned due to these ditches not meeting criteria to establish them as primary or secondary. St. Johns Bayou, Setback Levee Ditch, and St. James Ditch would be provided a woody riparian buffer of 25 feet on one bank. Therefore a net benefit of 0.4 was applied.
    - Note: The grass vegetative buffer would be planted on the opposite bank at 40 feet wide as an environmental design feature, and no mitigation credit would be taken.
- St. Johns Bayou, Setback Levee Ditch, and St. James Ditch were assigned a Level II monitoring program, as both plant survival and channel stability will be monitored in accordance with the MSMM. St. Johns Bayou, Setback Levee Ditch, and St. James Ditch were assigned a site protection credit of 0.2, which is defined as USACE approved site protection recorded with third party guarantee, or transfer of title to a conservancy.
- St. Johns Bayou, Setback Levee Ditch, and St. James Ditch were assigned a Schedule 2 mitigation construction as a majority of the mitigation would be completed concurrent with impacts.
- Riparian buffers along St. Johns Bayou were assigned a temporal lag of 10 to 20 years (-0.2).
    - Woody vegetation is currently present along select reaches of St. Johns Bayou.
- Riparian buffers along Setback Levee Ditch and St. James Ditch were assigned a temporal lag of 0 to 5 years.
    - These stretches of ditch currently have little to no areas of riparian vegetation present.

Mitigation credits resulting from riparian buffer creation along ditches in the St. Johns Bayou Basin would generate 173,330.3 stream credits.

After an impact resulting in the need to mitigate for 699,685.6 stream credits, the in-stream work generated 384,099.9 stream credits and the riparian buffer creation generated 173,330.3 credits; a total of 142,255.4 stream credits remain unaccounted for.

As noted in the Compensatory Mitigation Plan Requirements for Permittee Responsible Mitigation Projects, mitigation sites containing streams and other open waters should include riparian areas as part of the overall compensatory mitigation project. In such cases, compensatory mitigation credits should also be awarded to riparian areas in accordance with the State of Missouri Stream Mitigation Method. As noted in previous sections of the draft EIS, borrow pits would be created as part of the authorized project and riparian buffers could be established along the banks to compensate for any remaining stream mitigation credits.

To calculate the mitigation credits that would be provided by 387 acres of borrow pits (Net Benefit 5) in the St. Johns Bayou Basin the following assumptions were made to ensure a conservative estimate:

- The 387 acres of borrow pits were assumed to be from one collective area. Therefore, when actual borrow pits are created, the riparian buffer would not be any shorter, in terms of linear feet, than one which would have come from a single borrow site.
- The riparian buffer was assumed to be straight with no sinuosity. Although, ecologically designed borrow pits would be constructed (consisting of sinuous shoreline to achieve maximum ecological benefits), using a homogenous shoreline ensures a conservative estimate.
- A perennial stream type was assigned as borrow pits would contain water year-round.
- A priority area of tertiary was assigned as a conservative estimate.
- A net benefit was calculated for 25 feet of woody riparian buffer on only one side, although the riparian buffer would encompass the borrow pit.
- A Level II monitoring contingency was assigned. Plant survival and Photo Reference/Sample Site would be included in the mitigation component. Please note that to make a conservative estimate, it was assumed that only one side would be monitored, although the riparian buffer would encompass the borrow pit.
- A value of 0.2 was assigned for site protection, as this would be a USACE approved site protection recorded with third party grantee, or transfer of title to a conservancy.
- A Schedule 2 mitigation construction timing would be utilized, as a majority of mitigation would be completed concurrent with impacts.
- A temporal lag of 10 – 20 years was assigned as woody vegetation would be expected to become established during this time frame.

A 25-foot buffer around a 387-acre borrow pit would result in 14,658.7 linear feet of buffer. When applied to the MSMM using the previously described assumptions, 18,323.4 riparian restoration credits would be generated. Applying those credits to the remaining mitigation debit, 123,932 debits remain unaccounted for.

To mitigate for the remaining debits, a 25 foot riparian buffer consisting of woody vegetation on one bank and warm season grasses on the opposite bank could be established on an area ditch for 18.8 miles (Net Benefit 6).

To determine the mitigation credits that would be provided by a 18.8-mile, 25-foot wide riparian buffer along a hypothetical ditch in the St. Johns Bayou Basin the following assumptions were made to ensure a conservative estimate:

- The proposed mitigation reach (Net Benefit 6) was assumed to be intermittent, having flowing water only during certain times of the year.
- The proposed mitigation reach was classified as tertiary for priority area.

- The proposed mitigation reach would be provided a woody riparian buffer of 25 feet on one bank. Therefore a net benefit of 0.4 was applied.
    - Note: The grassy vegetative buffer would be planted on the opposite bank at 25-feet wide as an environmental design feature, although no mitigation credit would be given.
- The proposed mitigation reach was assigned a Level II monitoring program, as both plant survival and channel stability will be monitored in accordance with the MSMM.
- The proposed mitigation reach was assigned a site protection credit of 0.2, which is defined as USACE approved site protection recorded with third party grantee, or transfer of title to a conservancy.
- The proposed mitigation reach was assigned a Schedule 2 mitigation construction as a majority of the mitigation would be completed concurrent with impacts.
- Riparian buffers along the proposed mitigation reach were assigned a temporal lag of 0 to 5 years.
    - Target stretches of ditch would currently have little to no areas of riparian vegetation present.

A 25-foot buffer (woody vegetation on one bank) along 18.8 miles of an intermittent ditch would result in 99,250 linear feet of buffer. When applied to the MSMM using the previously described assumptions, 124,062.5 riparian restoration credits would be generated. Applying those credits to the remaining mitigation debit results in full mitigation for impacts to ditches in the St. Johns Bayou Basin, according to the MSMM.

New Madrid Floodway

Following USACE and MSMM guidelines, data sheets were completed to determine mitigation credits in the New Madrid Floodway resulting from riparian buffer creation, enhancement, restoration, and preservation worksheet (Appendix P, Part 3).

As in the St. Johns Bayou Basin, to mitigate for the 1,087.2 stream debits in the New Madrid Floodway, a 25-foot riparian buffer consisting of woody vegetation could be established around the 60 acres of proposed borrow pits.

To calculate the mitigation credits that would be provided by 60 acres of borrow pits (Net Benefit 1) in the New Madrid Floodway the following assumptions were made to ensure a conservative estimate:

- The 60 acres of borrow pits were assumed to be from one collective area. Therefore, when actual borrow pits are created, the riparian buffer would not be any shorter, in terms of linear feet, than one which would have come from a single borrow site.
- The riparian buffer was assumed to be straight with no sinuosity. Although, ecologically designed borrow pits would be constructed (consisting of sinuous shoreline to achieve maximum ecological benefits), using a homogenous shoreline ensures a conservative estimate.

- A perennial stream type was assigned as borrow pits would contain water year-round.
- A priority area of tertiary was assigned as a conservative estimate.
- A net benefit was calculated for 25 feet of woody riparian buffer on only one side, although the riparian buffer would encompass the borrow pit.
- A Level II monitoring contingency was assigned. Plant survival and Photo Reference/Sample Site would be included in the mitigation component. Please note that to make a conservative estimate, it was assumed that only one side would be monitored, although the riparian buffer would encompass the borrow pit.
- A value of 0.2 was assigned for site protection, as this would be a USACE approved site protection recorded with third party grantee, or transfer of title to a conservancy.
- A Schedule 2 mitigation construction timing would be utilized, as a majority of mitigation would be completed concurrent with impacts.
- A temporal lag of 10 – 20 years was assigned as woody vegetation would be expected to become established during this time frame.

A 25-foot buffer around a 60 acre borrow pit would result in 5,799.1 linear feet of buffer. When applied to the MSMM using the previously described assumptions, 7,248.9 riparian restoration credits would be generated. Applying those credits to the mitigation debit, a surplus of 6,185.2 mitigation credits are generated.