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WATER QUALITY EXECUTIVE SUMMARY

Completion of the nonstructural and operational components of the Yazoo Backwater Recommended Plan will provide substantial water quality benefits to the Yazoo Backwater Project Area. Reforestation of up to 55,600 acres of cleared land within the 1- and 2-year flood plain will prevent sediment and other pollutants from entering project area water bodies and will increase the removal of these materials from floodwaters. Reforestation would remove 55,600 acres of agricultural land from production and reduce sediment, pesticide, and nutrient yield in stormwater runoff by 11, 2, and 9 percent, respectively. Scientific analysis of wetland functions shows that reforestation of cleared land will increase the wetland functional capacity for the removal of sediment, nutrients, and historic pesticides from out-of-bank floodwaters by 4, 7, and 9 percent, respectively. Combined benefits from reforestation would be a 15 percent decrease in sediment loading, a 6 percent decrease in legacy pesticide loading, and a 16 percent decrease in nutrient loading. Modifying the operation of the Steele Bayou structure to increase water surface elevation by 3 feet during low-flow periods will provide additional fisheries habitat. Increased surface area, depth, and volume would improve phytoplankton primary productivity and could provide a dissolved oxygen (DO) reservoir to buffer against sediment oxygen demand. The U.S. Army Corps of Engineers, Vicksburg District, monitoring data show that DO concentrations are typically lowest in early summer in May and June, not during the high temperature/low-flow period between July and October that has been identified as critical for DO. During the summer, phytoplankton primary productivity is an important source of DO to project area water bodies. Water quality modeling studies conducted by Mississippi State University predict that late summer DO concentrations should not be affected by the proposed changes in operation of the Steele Bayou structure.

YAZOO BACKWATER AREA REFORMULATION

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YAZOO BACKWATER AREA REFORMULATION

APPENDIX 16
WATER QUALITY

INTRODUCTION

1. This appendix presents the water quality evaluation for the Final Supplemental Environmental Impact Statement (SEIS) for the Yazoo Backwater Project (YBWP). This appendix is a revision of the draft document, Appendix 16 of Supplement No. 1 to the 1982 Yazoo Area Pump Project Final Environmental Impact Statement (U.S. Army Corps of Engineers (USACE), 2000). This revised water quality evaluation updates the draft water, sediment, and tissue quality analyses using additional data collected between 2000 and 2005. This revision also includes an analysis of project impacts on impaired waters, including those with total maximum daily loads (TMDL). While the databases used in the analyses have been updated, the conclusions have not changed since the 2000 draft document.

2. The proposed YBWP plan includes a combination of structural measures, nonstructural measures, and combination plans to reduce flooding and enhance the environmental conditions within the study area. Under the recommended plan, the primary structural feature includes the construction of a pump station near the mouth of Steele Bayou. This structure would provide for the reduction in interior flooding during those times in which gravity outflow through the existing Steele Bayou Structure is not possible. The nonstructural features include the purchase of perpetual conservation easements from willing sellers and reforestation of up to 55,600 acres within the study area at or below elevation 87.0 feet, National Geodetic Vertical Datum (NGVD), at the Steele Bayou Structure (the 1-year flood plain). The purpose of this appendix is to present the water quality conditions currently existing within the YBWP Area and discuss the impacts of the recommended plan.

3. The YBWP Area is located in west-central Mississippi within the Mississippi Delta. The YBWP Area encompasses the area bounded by the west Auxiliary Channel and west Yazoo River levees on the east and the left descending bank Mississippi River mainline levee on the west. The project area includes the drainage areas of Steele Bayou, Deer Creek, the Little Sunflower River, and the Big Sunflower River up to approximately the latitude of Belzoni, Mississippi. The Yazoo Backwater study area is defined as the 100-year Yazoo Backwater flood plain.

CURRENT WATER AND SEDIMENT QUALITY WITHIN THE YBWP AREA

4. This section will use data collected by USACE, Mississippi Department of Environmental Quality (MDEQ), Natural Resources Conservation Service (NRCS), and U.S. Geological Survey (USGS) to describe the current water, sediment, and fish tissue quality found within the YBWP Area. Waters in the YBWP Area have been shown to be impacted by agricultural practices prevalent in the Mississippi Delta for the past century. As a consequence, most streams in the project area have been determined to be impaired in some manner for their aquatic life support designated use. Surface waters are high in turbidity and have seasonally high concentrations of nitrates and phosphorus. Nutrients and suspended solids are highest in reaches with agricultural runoff. Natural levees adjacent to streams such as the Big Sunflower River, Silver Creek, and Deer Creek, were some of the first land placed into cotton production. Many of these fields received applications of organochlorine pesticides such as DDT from the 1940s through the 1970s. As a consequence, legacy organochlorine pesticides persist in agricultural soils, sediment, and fish tissue, while historic forest lands have the lowest concentrations in their soil.

5. Prior to 1990, very little water quality data were available for the YBWP Area. During 1990 and 1991, the U.S. Army Engineer Research and Development Center (ERDC) (formerly the U.S. Army Engineer Waterways Experiment Station) (Ashby, et al., 1991) and USGS (Slack and Grantham, 1991) collected water and/or sediment samples from 14 stations within the Steele Bayou Basin of the YBWP Area. Between 1992 and 2000, the U.S. Army Corps of Engineers, Vicksburg District (USACE, 1996, 2000), collected water and/or sediment samples from 32 stations within the Big Sunflower River Basin. Samples were collected from the Big Sunflower and Little Sunflower Rivers, Dowling Bayou, and from four area lakes--Howlett Bayou, Lost Lake, Fish Lake, and Plaquemine Bayou. The Vicksburg District also collected samples from two locations on Deer Creek in 2004. The USGS collected additional water quality samples from Steele Bayou and the Big Sunflower River between 1995 and 1998 and from Deer Creek in 2002. The USGS also collected water samples for mercury and methyl mercury in the Delta National Forest (DNF) in 2003, 2004, and 2005. The Vicksburg District collected *in situ* water quality, nutrient, and suspended solids data from the Big Sunflower River and Steele Bayou Basins in 2004 and 2005. To complement the water and sediment data collected within the YBWP Area, ERDC collected fish tissue for pesticide analysis from the Big Sunflower River and Steele Bayou Basins in 1993, 1994, 2000, 2001, and 2005. During this period, other agencies were also collecting fish tissue from the Mississippi Delta for pesticide analysis. The USGS collected fish tissue for pesticide analysis in 1995, 1996, and 1998. The MDEQ collected fish tissue samples between 1991 and 2003. And NRCS collected fish tissue samples in 1993, 1995, 1997, and 1998. The pesticide results from these data sets were added to the Vicksburg District's fish tissue pesticide database and are included in the fish tissue pesticides trend analysis in this appendix.

6. The water quality sampling stations within the YBWP Area are located on Plates 16-1 and 16-2 and are identified in Table 16-1. For this analysis, the water and sediment samples are grouped by the basins in which the sampling sites are located. The first group includes the Steele Bayou Basin from its mouth to the vicinity of the Highway 12 bridges over Black Bayou, Granicus Bayou, and Granny Baker Bayou. The second group includes the Big Sunflower River from its mouth to the upper limit of the backwater area near Big Sunflower River, River Mile (RM) 65 and includes Dowling Bayou, Little Sunflower River, the Connecting Channel, and the lower portion of Bogue Phalia. The third group includes four Backwater lakes (Howlet Bayou, Lost Lake, Fish Lake, and Plaquemine Bayou) whose main water source is seasonal backwater flooding. Water levels in some of these lakes are maintained by weirs creating systems that are rarely flushed. The fourth group includes Deer Creek from its mouth to the upper limits of the backwater area near Estill.

7. Water and sediment samples collected by the Vicksburg District were analyzed by the ERDC Environmental Chemistry Laboratory located in Vicksburg, Mississippi, and by Argus Analytical, Inc., located in Jackson, Mississippi, using Standard Methods for the Examination of Water and Wastewater and Environmental Protection Agency (EPA) methods in effect at the time of analysis. Generally, organochlorine pesticides and metals samples were analyzed according to EPA Test Methods for Evaluating Solid Wastes Physical/Chemical Methods (SW-846 Methods). Other inorganics were analyzed according to methods in EPA/600/R-93/100, Methods for the Determination of Inorganic Substances in Environmental Samples. *In situ* data were collected with YSI multiparameter Data Sondes calibrated according to manufacturer's guidelines the day before sampling. The following Quality Assurance samples were collected and analyzed: field duplicates and field blanks, where appropriate. Laboratory Quality Assurance samples analyzed include matrix spikes, matrix duplicates, laboratory control samples, and method blanks.

SURFACE WATER QUALITY

<u>Surface Water Physicochemical and Nutrient Data</u>

8. A summary of the physicochemical and nutrient water quality data collected between 1990 and 2005 for the Steele Bayou Basin, Big Sunflower River Basin, lower Deer Creek Basin, and the four Backwater lakes is contained in Table 16-2. Water quality samples and *in situ* data were collected by ERDC in 1990 and 1991, by the Vicksburg District between 1993 and 2005, and by USGS between 1990 and 2002. Data for the Big Sunflower River Basin were colleted by USGS between 1992 and 2002 and by the Vicksburg District between 1992 and 2005. Data for Deer Creek were collected by NRCS in 1995, USGS in 2002, and the Vicksburg District in 2004.

TABLE 16-1
WATER QUALITY SAMPLING LOCATIONS

Station	Sampling Location
USACE STATIONS	
SB-1	Steele Bayou at Highway 14
SB-2	Steele Bayou at Hopedale
SB-3	Steele Bayou at Hampton
SB-4	Steele Bayou at Eifling
SB-5	Black Bayou near Percy
SL-1	Swan Lake Slough
SL-2	Long Dump
SL-3	Silver Lake
SL-4	No. 9 Dredge Ditch
SL-5	Black Bayou at wildlife refuge
BB-1	Black Bayou at Highway 12
GB-1	Granicus Bayou at Highway 12
MC-1	Pryor Impoundment
MC-1.5	Granny Baker Bayou near James
LS	Little Sunflower River at RM 3, 6, 7, 9, 9-6, 11, 12, 13, 14, 17, 17-5, 18-0, 18-3, 22, and 27
SM-1	Six Mile Cutoff at RM 1
BS	Big Sunflower River at RM 6, 7, 12, 18, 19, 20, 23, 26, 30, 33, 35, 39, 45, 50, 55, 60, and 65
BS-H16	Big Sunflower River at Highway 16 (Holly Bluff)
FL-1	Fish Lake
LL-1	Lost Lake
HB-1, 2	Howlett Bayou at Sites 1 and 2
DB-0	Dowling Bayou near its mouth
DB	Dowling Bayou at RM 2, 5, and 7
PB	Plaquemine Bayou, Sites 1, 2, 3, 4, 5, and 6
BS-H14	Big Sunflower River at Highway 14 (near Anguilla)
BS-H12	Big Sunflower River at Highway 12 (Little Callao)
BP	Bogue Phalia at RM 0, 3, 6, 9, 12, and 18
BP-C	Bogue Phalia Cutoff at RM 0 and 11
CC	Connecting Channel at RM 0, .5, 1.5, 3, and 5
DC-1	Deer Creek at Panther Burn
DC-2	Deer Creek near Anguilla
USGS STATIONS a/	
7288624	Big Sunflower at Kinlock
7288680	Big Sunflower a Little Callao
7288700	Big Sunflower near Anguilla
7288720	Big Sunflower at Holly Bluff
331432090435300 – USGS 1	Big Sunflower below Bogue Phalia near Darlove
7288655	Bogue Phalia at Darlove
330730090431300 – USGS 2	Murphy Bayou at Murphy
7288780	Deer Creek at Cary
7288790	Deer Creek near Valley Park
323244090492300 – USGS 3	Deer Creek near Floweree
323437090502100 – USGS 4	Deer Creek near Hardee
323805090514700 – USGS 5	Deer Creek at Valley Park
323821090513900 – USGS 6	Deer Creek above Valley Park
323915090513900 – USGS 7	Deer Creek North of Valley Park
324159090555000 – USGS 8	Deer Creek near Onward
324509090554700 – USGS 9	Deer Creek at Blanton
324552090573000 – USGS 10	Deer Creek Northwest of Blanton
324728090570600 – USGS11	Deer Creek Southwest of Cary
324951090544900 – USGS 12	Deer Creek North of Cary
325034090542100 – USGS 13	Deer Creek South of Egremont
325200090533700 – USGS 14	Deer Creek near Egremont
325218090532500 – USGS 15	Deer Creek North of Egremont
325427090524500 – USGS 16	Deer Creek at Rolling Fork

TABLE 16-1 (Cont)

Station	Sampling Location
USGS STATIONS a/	
330028090511000 – USGS 17	Deer Creek at Nitta Yuma
330238090500200 – USGS 18	Deer Creek at Vickland
330414090514400 – USGS 19	Deer Creek at Panther Burn
330632090523900 – USGS 20	Deer Creek at Percy
331127090512600 – USGS 21	Deer Creek North of Hollandale
331304090521800 – USGS 22	Deer Creek at Estill
7288838	Main Canal near Wayside
7288842	Granicus Bayou near Hollandale
331122091011800 – USGS 23	Granicus Bayou near James
7288843	Black Bayou near Percy
7288820	Black Bayou near Arcola
7288825	Black Bayou near Estill
7288830	Black Bayou near Hollandale
7288844	Granny Baker Bayou near James
7288847	Steele Bayou near Glen Allen
7288860	Steele Bayou near Grace
7288870	Steele Bayou East prong near Rolling Fork
7288900	Steele Bayou near Onward
322804090533900 – USGS 24	Steele Bayou above LSFR Channel

a/ USGS, 2001, National Water Information System (NWIS Web) data available on the World Wide Web, accessed October, 2005, at URL [http://waterdata.usgs.gov/nwis/].

TABLE 16-2
WATER QUALITY DATA

Water Quality Parameter	Steele Bayou Basin				Big Sunflower River				Deer Creek				Backwater Lakes				MDEQ Criteria
	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	**2005**
Temperature (^{o} Celsius)	455	22.0	2.4	<u>34.5</u>	325	22.6	2.2	<u>33.7</u>	71	29.5	15.4	<u>33.5</u>	7	8.1	6.7	10.2	32.2 (max)
pH (Standard Units)	442	7.6	6.3	<u>9.3</u>	319	7.6	6.1	<u>9.8</u>	70	7.2	6.2	8.3	7	6.6	**5.9**	7.3	6.0-9.0
Dissolved Oxygen (mg/L)	450	7.1	**1.6**	16.6	288	6.9	**1.9**	21.4	69	5.8	**0.4**	10.3	7	7.7	5.3	10.9	4.0 (min)
Alkalinity (mg/L)					9	79.5	17.4	183									
Conductivity (μmhos/cm)	450	354	57.0	<u>1170</u>	321	261	28.0	595	70	144	69.0	270	7	114	49.0	199	1,000
Turbidity (NTU)	271	137	7.0	1320	288	197	7.0	1454	63	34.9	9.5	140	6	40.3	13.0	83.0	
Total Dissolved Solids (TDS)	265	285	80.0	<u>3358</u>	168	211	53.0	736	4	96.0	70.0	140	7	71.1	2.0	152	1,500 (max)
Total Suspended Solids (mg/L)	266	158	1.7	1300	179	113	2.0	800	4	90.2	66.0	109	7	45.1	4.0	206	
Total Solids (mg/L)	263	444	161	3966	100	353	195	1066	4	186	170	217	7	116	6.0	282	
Total Organic Carbon (mg/L)	401	6.9	2.7	35.0	170	6.4	3.4	17.1					6	6.3	4.2	9.9	
Total Phosphorus (mg/L)	415	0.40	0.03	1.8	194	0.38	0.03	1.5	4	0.28	0.16	0.42	7	0.24	0.03	0.36	
Total Kjeldahl Nitrogen (mg/L)	417	1.8	0.10	11.0	193	1.2	0.10	2.9	4	2.0	1.1	3.9	7	1.2	0.42	2.2	
Nitrate /Nitrite (mg/L)	367	0.56	0.01	2.7	156	0.73	0.04	3.9	0			<0.02	4	0.03	0.02	0.05	
Ammonia (mg/L)	247	0.22	0.01	<u>2.5</u>	83	0.20	0.02	1.3									**<u>a</u>/**

NOTES: Det = number of samples with data > Method Detection Limit.
Non-detects were not included in the analysis.
Values in **Bold** exceed a lower limit criterion.
Values <u>Underlined</u> exceed an upper limit criterion.

<u>a</u>/ Ammonia criteria are based upon temperature, pH, and salinity (EPA-822-R-99-014).

Data for the Backwater lakes were collected by the Vicksburg District in January 1995 and July 2000. Table 16-2 includes the *in situ* data, turbidity, and the physicochemical parameters of total Kjeldahl nitrogen (TKN), total phosphorus (TP), nitrate/nitrite nitrogen, ammonia nitrogen, total solids, total dissolved solids (TDS), total suspended solids (TSS), and total organic carbon (TOC). Nondetects were not included in the analysis. Table 16-2 also contains the current MDEQ Mississippi water quality criteria for comparison (MDEQ, 2002a). Table values reported in bold exceed a lower limit criterion. Table values reported underlined exceed an upper limit criterion. Parameters without data entries had no samples analyzed in that basin.

9. The State uses the Mississippi Consolidated Assessment and Listing Methodology (CALM) and the State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters (MDEQ, 2002a) to determine whether a water body is meeting its designated uses. The CALM (MDEQ, 2004a) uses the percentage of samples that meet a set water quality standard in a set timeframe as one of the criteria to determine whether a water body is attaining its designated use. Generally, 90 percent of the samples must not exceed the standard for that parameter to be classified as attaining in the water body. Specific criteria can be found in the CALM document (MDEQ, 2004a). Although the data summarized in Table 16-2 were not evaluated to determine if they meet the requirements to be used for CALM determinations, percentages of exceedances for the water quality parameters discussed in this section are included in the discussion for perspective.

10. Water temperature was measured 858 times within the project area. As expected, water temperature varied with time of year. Water temperature ranged from 2.2 to 34.5 degrees Celsius (C) with the highest temperatures measured between June and September. Of the 858 measurements, 32 measurements from Steele Bayou, Big Sunflower River, and Deer Creek exceeded MDEQ criterion of 32.2 degrees C. Overall, only 3.7 percent of the 858 water temperature measurements were outside MDEQ criterion during the 15 years evaluated. None of the mean water temperatures from the four basins exceeded the criterion.

11. There were 838 pH measurements ranging between 5.9 and 9.8 Standard Units (SU). Steele Bayou and the Big Sunflower River Basin exceeded MDEQ 9.0 SU maximum criterion a total of five times. Fish Lake exceeded the minimum criterion with a pH of 5.9 SU in 1995. Less than 1 percent of the 838 pH measurements were outside MDEQ criterion. None of the mean pH measurements for the four basins were outside the criteria.

12. Of the 814 dissolved oxygen (DO) measurements, 194 (23.8 percent) were less than MDEQ daily average of 5.0 milligrams per liter (mg/L). Ninety-seven (11.9 percent) were less than MDEQ instantaneous minimum of 4.0 mg/L. Forty-eight of the 97 were less than 3.0 mg/L. DO concentrations ranged between 0.4 and 21.4 mg/L. None of the mean DO measurements were below the 5.0 mg/L daily average.

13. Specific conductance (848 measurements) ranged between 28.0 μmhos/cm and 1,170 μmhos/cm. The 1,170 μmhos/cm measurement exceeds MDEQ maximum criterion of 1,000 μmhos/cm and was taken in the Steele Bayou Basin in 1990. All of the measurements greater than 600 μmhos/cm were taken in the Upper Steele Bayou Basin in the early 1990s. These values probably represent the influence of rice irrigation runoff. None of the specific conductance mean concentrations exceeded the 1,000 μmhos/cm criterion.

14. The TDS ranged between 2.0 and 3,358 mg/L (444 measurements). Two measurements taken in Black Bayou in the summer of 1998 exceeded the MDEQ maximum TDS criterion of 1,500 mg/L (3,358 mg/L TDS taken in June and 3,018 mg/L taken in September). None of the TDS mean concentrations were greater than the 1,500 mg/L criterion.

15. Concentrations of solids in project area surface waters were measured through *in situ* turbidity monitoring and collection of discrete samples for TSS and total solids. Instantaneous turbidity was measured 628 times. Measurements ranged between 7.0 and 1,454 nephelometric turbidity units (NTU). Total suspended solids (measured 456 times) ranged between 1.7 and 1,300 mg/L, while total solids (measured 374 times) ranged between 6.0 and 3,966 mg/L. For the 15 years of data available, mean TSS and total solids concentrations were generally higher in the Steele Bayou Basin than in the Big Sunflower River Basin, with highest concentrations in the late winter and spring. Current data show that solids concentrations in the Steele Bayou Basin have decreased since completion of the Upper Steele Bayou project such that average concentrations are slightly lower than those in the Big Sunflower River Basin. Deer Creek and the Backwater lakes had less than 10 samples each.

16. Mean TOC concentrations were 6.9 mg/L for the Steele Bayou Basin, 6.4 mg/L for the Big Sunflower River Basin, and 6.3 mg/L for the Backwater lakes. There were no TOC data collected for Deer Creek.

17. Since the Yazoo Backwater Area is located within an active agricultural area, high nutrient levels within the streams would be expected due to rainfall runoff from cultivated fields. Since 1990, 621 TKN samples were collected with concentrations ranging from 0.10 to 11.0 mg/L. Highest concentrations were measured in the Upper Steele Bayou Basin in the early 1990s. Samples with high TKN concentrations were collected in the vicinity of catfish ponds and may represent discharge from these ponds. Nitrate/nitrite nitrogen concentrations ranged from 0.01 to 3.9 mg/L. Ammonia is the only nutrient with current water quality criteria. The criteria are based upon temperature, pH, and fish species and age of fish present in the water body (EPA, 1999). Five (1.4 percent) of the 361 ammonia measurements collected in the past 15 years exceeded their respective pH-based criteria. All ammonia exceedances were from the Steele Bayou Basin in the early 1990s and represent 1.85 percent of the ammonia measurements taken in the basin. None of the mean ammonia measurements exceeded the calculated criteria.

18. For TP, there were 620 measurements above the method detection limit (MDL). Concentrations ranged from 0.03 to 1.8 mg/L. Mean concentrations for the Steele Bayou and Big Sunflower River Basins were approximately the same, 0.40 and 0.38 mg/L, respectively. Mean concentrations for Deer Creek and the Backwater lakes were also approximately the same, 0.28 and 0.24 mg/L, respectively.

19. In 1995, Mueller and others reported an analysis of nutrients in ground water and surface water from data compiled from small undeveloped basins in 20 study units of the National Water Quality Assessment (NAWQA) Program. The authors found that, for the study units evaluated, concentrations of nitrate less than 0.7 mg/L could be considered a general baseline for indicating the absence of anthropogenic effects. Mueller and others (1995) also found a correlation between undeveloped sites and TP concentrations. For the study units evaluated, TP concentrations less than 0.1 mg/L could be used as a baseline to indicate the absence of anthropogenic effects upstream of a sampling site. Using these two guidelines on the YBWP Area data, 150 of 612 nitrate samples (25 percent) exceeded the 0.7 mg/L baseline; while 605 of the 634 TP measurements (95 percent) exceeded the 0.1 mg/L TP baseline. These data appear to suggest that anthropogenic nitrate is less of an issue in the YBWP Area than is TP. Coupe (1998) noted similar findings in his analysis of the Yazoo River data collected in the Mississippi Embayment (MISE) NAWQA Program. He noted that in the Mississippi River at Vicksburg nitrate makes up about 68 percent of the total nitrogen concentration. In the Yazoo River, nitrate was only about 27 percent of the total nitrogen concentration. He attributed the low nitrate levels to "the warm, humid climate of the Southeast that promotes biological activity leading to denitrification or uptake and incorporation of nitrate to organic forms of nitrogen," the dominant form in the project area waters. Total phosphorous, on the other hand, is associated with fine soil particles and undergoes no such biological transformation. While the total nitrogen loading may be higher, these data indicate that water bodies in the YBWP Area process nitrates before they are discharged into the Yazoo and Mississippi Rivers.

Estimated Nutrient Yields

20. The USGS also estimated nitrogen and phosphorus yields from Bogue Phalia and the Yazoo River using data collected as part of the MISE NAWQA Program (Coupe, 2002). Bogue Phalia had the highest nitrogen and phosphorus yields of the agricultural watersheds sampled in the MISE. In 1996, Bogue Phalia had a nitrogen and phosphorus yield of 2.08 and 0.465 tons per square mile (tons/mi^2), respectively, compared to 1.49 and 0.283 tons/mi^2 in the Yazoo River. In 1997, a wet year, the amounts increased to 4.39 tons/mi^2 nitrogen and 0.930 tons/mi^2 phosphorus in Bogue Phalia, while the corresponding amounts for the Yazoo River were 2.67 tons/mi^2 nitrogen and 0.597 tons/mi^2 phosphorus. These high yields were attributed, in part,

to agricultural runoff, the varied use of Best Management Practices (BMP) within the watershed, to soil type/geology. Overall, USGS determined that no sample collected from Bogue Phalia or the Yazoo River exceeded the guidelines for nitrate or ammonia in effect at the time of report preparation, but most exceeded EPA's 1986 goal of 0.1 mg/L of phosphorus for the prevention of plant nuisances in streams (Coupe, 1998).

Surface Water Legacy
Organochlorine Pesticides Data

21. The water samples collected from the YBWP Area were analyzed for 19 priority pollutant pesticides identified in Table 16-3. The Vicksburg District collected water pesticide samples from Big Sunflower River Basin in 1993 and 1995 and from the Steele Bayou Basin in 1996 and 1999. The USGS also collected water pesticides samples from three locations in the upper Steele Bayou Basin in 1992 and from three locations along Deer Creek in 2002.

22. Table 16-3 lists the mean, minimum, and maximum concentrations and the number of samples with detectable pesticides concentrations. The 2005 MDEQ freshwater criteria are included for comparison. Mean concentrations reported in bold exceed MDEQ chronic criteria. Mean concentrations reported underlined in bold exceed MDEQ acute criteria. If samples from a basin were analyzed for a pesticide but none were detected, the MDL is reported in the "Max" column for that basin. The Backwater lakes and Deer Creek samples had no data greater than the individual MDLs. Only 11 pesticides had concentrations greater than the MDL, and these were generally reported in trace (subparts per billion) amounts. The most commonly detected pesticides were ppDDE, ppDDT, heptachlor, and dieldrin.

23. Examining the data in Table 16-3, some of the data for ppDDT, heptachlor, and dieldrin exceeded their chronic freshwater criteria. Some of the MDLs for ppDDT, heptachlor, endrin, endosulfan, chlordane, and toxaphene exceeded their chronic freshwater criteria. The MDL for toxaphene in the Big Sunflower River and Backwater lake samples exceeded both the chronic and acute criteria. Mean concentrations for the most commonly detected pesticides were: ppDDE, 0.026 micrograms per liter (µg/L); ppDDT, 0.025 µg/L; heptachlor, 0.014 µg/L; and dieldrin, 0.016 µg/L. For the data available, mean concentrations for ppDDT and heptachlor were greater than their respective chronic freshwater criteria.

Surface Water Current-Use Pesticides

24. Although the Vicksburg District does not routinely analyze surface water sample for current-use pesticides or their metabolites, NRCS (U.S. Department of Agriculture (USDA), 1998) and USGS have both reported results of surface water pesticide studies conducted within the Mississippi Delta in the mid-1990s. Positive identification of pesticides in these samples was

TABLE 16-3
PESTICIDES IN WATER SAMPLES

Chlorinated Pesticide µg/L	Steele Bayou Basin				Big Sunflower River				Deer Creek				Backwater Lakes				MDEQ Criteria	
	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	Acute	Chronic
Aldrin	0			<0.025	0			<0.04					0			<0.04	3.0	
A-BHC	0			<0.025	0			<0.03					0			<0.03		
B-BHC	3	0.016	0.012	0.020	0			<0.06					0			<0.06		
G-BHC	0			<0.025	0			<0.04	0			<0.004	0			<0.04	0.95	0.08
D-BHC	0			<0.025	2	0.145	0.140	0.150					0			<0.09		
ppDDD	5	0.015	0.010	0.020	2	0.185	0.180	0.190					0			<0.11		
ppDDE	7	0.018	0.011	0.028	24	0.034	0.006	0.270	0			<0.003	0			<0.04		
ppDDT	2	**0.026**	**0.023**	**0.030**	21	**0.024**	0.001	**0.034**					0			**<0.12**	1.1	0.001
Heptachlor	0			**<0.025**	22	**0.014**	**0.006**	**0.083**					0			**<0.03**	0.52	0.0038
Dieldrin	0			<0.05	22	0.016	0.005	**0.057**	0			<0.005	0			<0.02	0.24	0.056
A-Endosulfan	0			<0.025	0			**<0.14**					0			**<0.14**	0.22	0.056
B-Endosulfan	0			<0.05	2	0.010	0.005	0.016					0			<0.04		
Endosulfan Sulfate	0			<0.05	2	0.150	0.150	0.150					0			<0.66		
Endrin	3	0.013	0.011	0.015	1	0.006	0.006	0.006					0			**<0.06**	0.086	0.036
Endrin Aldehyde	0			<0.05	2	0.028	0.026	0.029					0			<0.23		
Heptachlor Epoxide	0			<0.025	0			<0.83					0			<0.83		
Methoxychlor	0			<0.25	0			<1.8					0			<1.8		
Chlordane	0			**<0.25**	0			**<0.14**					0			**<0.14**	2.4	0.0043
Toxaphene	0			**<0.25**	0			**<2.4**					0			**<2.4**	0.73	0.0002

Notes: Det = number of samples with data > Method Detection Limit
Non-detects were not included in the analysis.
<Value in Max column = all data were < Method Detection Limit
Values in **Bold** exceed chronic criterion.
Values **Underlined in Bold** exceed acute criterion.

primarily of herbicides used in cotton, corn, soybean, and rice production with atrazine, cyanazine, simazine, fluometuron, metolachlor, molinate, thiobencarb, and norflurazon being the most frequently detected. The most heavily used insecticide, methyl parathion, was also detected in Bogue Phalia in the mid-1990s. Pesticide concentrations showed distinct seasonal patterns that corresponded to the type of crops grown in the watershed and the use of pesticides on those crops (Kleiss, et al., 2000). Overall, the highest pesticide concentrations occurred in the summer months, peaking in June and July (Coupe, 2000).

25. The Mississippi Delta Management Systems Evaluation Areas (MDMSEA) Program provided an opportunity to evaluate the environmental fate of a number of current-use pesticides associated with agricultural storm runoff and various BMPs. Shaw and others (2001) concluded that soils collected by grass buffer strips have the potential to rapidly degrade fluometuron. The authors noted the importance of organic matter provided by filter strips. In two separate studies, Zablotowicz and others (2001) characterized the biological activities that contribute to removal of pesticides in forested riparian wetlands and lake water. Cooper and others (2004) examined the benefits of utilizing vegetative drainage ditches to process a pyrethroid insecticide in runoff from agricultural fields. They noted marked decreases with distance in insecticide concentrations in water, soil, and vegetation. The authors also noted that landowners often clear ditches of vegetation to facilitate drainage without understanding the important role plants can play in the uptake and processing of pesticides.

26. Most current-use pesticides have shorter half-lives than the legacy organochlorine pesticides and are more susceptible to photolysis or microbial degradation. Many are moderately soluble in water. As a result, the current-use pesticides do not persist in the environment. Experience from the USGS MISE study shows that pesticides with water solubilities greater than 5 mg/L are readily carried by surface runoff and occur in surface water (USGS, 1998) rather than becoming strongly sorbed to soil and sediment where they can be retained in the environment for long periods of time. The current-use pesticides breakdown more quickly after application or upon entering the water system. They become diluted and move out of the system and do not persist in bottom sediments as do the legacy organochlorine pesticides. Water solubilities for the herbicides listed above range from 5 to 880 mg/L. In general, the herbicides detected are only moderately sorbed to soil and move into surface water through leaching or on soil particles. In water, they tend to be resistant to photolysis and hydrolysis at the neutral pH that exists in the Big Sunflower project area. Atrazine and cyanazine are restricted-use pesticides (RUP) because of their potential for ground-water contamination. Simazine, fluometuron, metolachlor, molinate, and norflurazon are General-Use Pesticides (GUP). These herbicides are slightly to practically nontoxic to fish and are reported to have a low level of bioaccumulation (Kamrin, 1997). Methyl parathion (the insecticide) is an RUP that is highly toxic to insects, small mammals, and birds and is moderately toxic to fish and to animals that eat fish (Kamrin, 1997).

It is moderately sorbed to most soils, with reported field half-lives of 1 to 30 days and is slightly soluble in water, but degrades rapidly. Since 1995, glyphosate has become an increasingly important herbicide in the Mississippi Delta. Glyphosate is the major ingredient in Roundup, a broad-spectrum, nonselective systemic herbicide used for control of annual and perennial plants, including grasses, sedges, broad-leaved weeds, and woody plants. It is used extensively in agriculture and in the home garden. Most of the cotton, soybean, and corn planted in the lower delta are engineered to be Roundup-ready. This trend has led to a significant reduction in types and quantities of herbicide usage (Dr. Robert Williams, Mississippi State University, personal communication). Glyphosate is a GUP that is described as slightly toxic to wild birds, practically nontoxic to fish, but may be slightly toxic to aquatic invertebrates (Kamrin, 1997). Glyphosate is strongly adsorbed to most soil, even those with lower organic and clay content. The estimated average half-life in soil is 47 days. Field and laboratory studies show that it does not leach appreciably and has low potential for runoff. One estimate indicated that less than 2 percent of the applied chemical is lost to runoff. In water, glyphosate is strongly sorbed to suspended organic and mineral particles and is broken down by microbes. Its half-life in pond water ranges from 12 days to 10 weeks.

Surface Water Metals Data

27. Many of the metals analyzed in surface water samples from the YBWP Area are abundant in the earth's crust and are found in trace amounts in surface waters due to natural weathering of rock and soil or upwelling of ground water. Anthropogenic sources can be from agricultural practices or from industrial discharge. Because some of these metals are toxic to aquatic life at elevated concentrations, EPA provides national criteria for acceptable levels of certain metals in water under Section 304(a) of the Clean Water Act. Each state is required to adopt criteria for their waters that are at least as stringent as EPA criteria. The most recent State of Mississippi freshwater acute (FWA) and freshwater chronic criteria (FWC) were published in 2002 (MDEQ, 2002a). These criteria are for dissolved metals (i.e., those metals not removed from the water sample by filtration through a 0.45 μ membrane filter). Previous versions in effect when data collection began were for total recoverable metals (i.e., those metals made available from a sample of whole water through an acid digestion process). The MDEQ criteria, along with the YBWP Area metals data, are provided in Table 16-4. The impact of some trace metals is dependent upon the hardness of the water. These metals include cadmium, chromium, copper, lead, nickel, silver, and zinc. Data for the major streams within the YBWP Area show that hardness varied from less than 50 to over 200 mg/L. Since harder water would reduce a metal's toxic effect, a hardness of 50 mg/L was selected as a conservative estimate to calculate the hardness dependent criteria. In Table 16-4, values reported in bold type exceed the MDEQ FWC. Values reported underlined in bold exceed the MDEQ FWA. In this analysis, only the dissolved metals data were compared to the dissolved FWA and FWC. Statistics for the total recoverable metals data are reported, but were not compared to the dissolved metals criteria because comparison of metals from whole water samples would give a false impression of metals concentrations available to aquatic organisms based upon the current dissolved criteria.

TABLE 16-4
METALS IN WATER SAMPLES

Metals (µg/L)	Steele Bayou Basin Dissolved Metals				Big Sunflower River Total Metals				Deer Creek Dissolved Metals				Backwater Lakes Total Metals				MDEQ Criteria Dissolved	
	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	FWA	FWC
Arsenic	6	3.33	2.00	4.00	17	5.99	5.00	8.4	6	31.5	3.00	72.0	13	3.81	2.00	6.10	340	150
Cadmium	3	**<u>2.00</u>**	**1.00**	**<u>3.00</u>**	24	0.225	0.100	0.600	0			<0.5	7	0.776	0.370	2.13	1.74	0.62
Chromium	0			<5	27	4.05	1.00	13.0	0			<1.0	11	4.38	1.00	11.0	339	53
Copper	0			**<u><10</u>**	29	8.48	1.00	24.0	0			<2.0	13	7.13	3.00	19.6	7.0	5.0
Iron	6	108	22.0	410	25	1263	902	1720	6	39.5	3.00	197						
Lead	0			**<10**	17	3.59	1.00	6.00	0			**<2.0**	11	3.03	1.00	6.10	30	1.18
Manganese	6	25.3	4.00	56.0	25	69.6	38.0	137	6	69.5	3.00	136						
Nickel	0			<10	11	16.1	1.10	65.0	3	2.00	2.00	2.00	16	4.73	1.00	12.2	260	29
Zinc	5	12.4	5.00	31.0	7	14.6	5.00	31.0	0			<2.0	12	1081	12.0	4020	65	65
Selenium					1	5.00	5.00	5.00					0			<2	11.8	4.6
Mercury	1	**0.400**	**0.400**	**0.400**	0			<0.2	0			**<0.1**	10	0.510	0.007	4.30	2.1	0.012
Barium					25	78.9	63.0	99.0										
Cobalt					0			<10										
Silver	2	1.00	1.00	1.00	0			<1	0			<1.0	0			<1	1.05	-

Notes: Det = number of samples with data > Method Detection Limit
Non-detects were not included in the analysis
FWA = State of Mississippi Freshwater Acute criteria
FWC = State of Mississippi Freshwater Chronic criteria
Values in **Bold** exceed the MDEQ chronic criteria
Values **<u>Underlined in Bold</u>** exceed the MDEQ acute criteria

28. Metals data evaluated for the Big Sunflower River Basin and the Backwater lakes were collected by the Vicksburg District in 1993, 1995, and 2000. These data are for total recoverable metals and will not be compared to the current 2002 MDEQ dissolved metals criteria. The USGS collected dissolved metals data in 1992 and 2002 from the Steele Bayou Basin and Deer Creek, respectively. The USGS also collected total mercury and methyl mercury samples from the Little Sunflower River (Big Sunflower Basin) and from Cypress Bayou (Backwater lake) in 2003 and 2004. These data will be discussed in greater detail in the section on methyl mercury.

29. The YBWP does not have any features that would disturb area streambanks or streambeds. Construction at the pump station site and completion and periodic maintenance dredging of the inlet and outlet channels are the only project components that might cause short-term, localized increases in metal concentrations. Use of BMPs specific to stormwater runoff and sediment and dust control during construction should minimize these impacts. For these reasons, the project will not directly impact water metals concentrations. Reduced erosion resulting from reforestation of flood-prone agricultural land could affect the amount of soil entering area streams and could indirectly reduce the influx of sediment metals associated with that soil.

30. Arsenic was detected in 12 of the 13 surface water samples analyzed. None of the data reported exceeded MDEQ FWA or FWC criteria.

31. Cadmium was detected in 3 of the 13 samples evaluated. Cadmium concentrations ranged from nondetect to a maximum of 3.00 µg/L. The average concentration from Steele Bayou was 2.00 µg/L, which exceeded both the FWC and FWA. None of the Deer Creek samples had detectable concentrations of cadmium.

32. Chromium was not detected in any of the dissolved metals samples.

33. Copper was not detected in any of the dissolved metals samples. However, the MDL for the Steele Bayou samples was greater than the FWC and FWA criteria.

34. Lead was not detected in any of the dissolved metals samples. The MDL for the Steele Bayou lead samples was greater than the FWC criterion.

35. Nickel was detected at 3.00 µg/L in three of the Deer Creek samples, but did not exceed any criteria.

36. Zinc was detected in five of the Steele Bayou samples, but did not exceed any criteria.

37. None of the dissolved metals samples were analyzed for selenium.

38. Only two of the Steele Bayou samples had detectable concentrations of dissolved silver. The mean concentration of 1.00 µg/L did not exceed the 1.05 µg/L FWA criterion.

39. Mercury was only detected in one sample from Steele Bayou. The 0.400 μg/L concentration exceeded the FWC. The detection limit of 0.1 μg/L for the Deer Creek samples also exceeded the FWC for dissolved mercury. Examining the low-level mercury surface water data from samples collected by USGS using clean sampling techniques in March 2005, dissolved mercury concentrations in the Little Sunflower River and a DNF backwater lake were less than the FWC criterion of 0.012 μg/L (Table 16-30). The concentration of dissolved mercury in the Little Sunflower River was 0.00267 μg/L while the concentration of dissolved mercury in Cypress Bayou was 0.00171 μg/L.

40. In general, the dissolved heavy metals cadmium and mercury exceeded their freshwater aquatic life criteria at least some of the time. Some of the detection limits used for dissolved lead, copper, and mercury were higher than at least one criterion and could not be used to rule out exceedances. Data representing total recoverable metals from the Big Sunflower River and the Backwater lakes were not compared to dissolved criteria in the preceding analysis. In 1970, Kopp and Kroner summarized 5 years of data collected on trace metals concentrations in rivers and lakes of the United States between 1962 and 1967 and reported the average and maximum concentrations for many of the same metals analyzed from the YBWP Area. A portion of their results is presented here in order to put the YBWP Area surface water metals data into perspective. The authors found that the average concentration for cadmium was 9.5 μg/L. For copper, the 1970 average concentration was 15 μg/L with a maximum of 112 μg/L. Lead had a 1970 average of 32 μg/L with a maximum concentration of 140 μg/L. Zinc had a 1970 average concentration of 64 μg/L with a maximum concentration of 1180 μg/L. No results were given for mercury. Only the total recoverable zinc samples collected in the Backwater lakes in 1995 exceeded the average and maximum concentrations reported in 1970. In comparison, the average concentration for zinc collected in 2000 was much lower, 23 μg/L. These data suggest that the quality of surface water with respect to metals concentrations has improved. The trend towards higher metals concentrations found in the 1995 Backwater lake samples could be attributed to high sediment metals concentrations typical of the native backswamp clay soil or to the fact that the water in these lakes does not flush. Instead it concentrates each year of backwater flooding after the floods recede. This sequestration of elements and compounds is a wetland function of these Backwater lakes that is not expected to change as a result of the YBWP.

SEDIMENT QUALITY

41. The Vicksburg District has an extensive sediment database for the Yazoo Backwater Area of the Mississippi Delta. Most of the sediment samples were analyzed for 19 legacy pesticides, but some included analysis for 10 priority pollutant metals and four nonpriority pollutant metals. A few of the sediment samples were only analyzed for DDT and its metabolites. The sediment database representing the YBWP Area evaluated in this report contains a total of 149 pesticides analyses and 101 metals analyses. These samples represent surface sediment concentrations only because the YBWP does not have any extensive dredging or channel cleanout features that would require analysis of sediment cores. A quality assurance summary of the sediment data collected by the Vicksburg District is presented as an attachment to this document (Attachment 1).

Sediment Quality Guidelines

42. Although sediment quality plays a critical role in the overall health of an aquatic system, there are no nationally accepted criteria for most contaminants. Various criteria have been applied on a regional basis or by states, but none have been applied on a national scale. The EPA issued sediment criteria for endrin, dieldrin, and three polycyclic aromatic hydrocarbons (PAH) in the early 1990s, but none have been issued since. As of 2007, the State of Mississippi has not issued any specific sediment quality standards.

43. In the absence of any criteria, the Vicksburg District has used benchmarks derived from data collected in the National Status and Trends Program to put sediment concentrations into perspective. In March 1990, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Ocean Service, Office of Oceanography, and Marine Assessment published Technical Memorandum (NOS OMA 52), "Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program," (NOAA, 1990). These benchmarks were revised in 1995 by Long and others. Both reports evaluated the available bioassay data for many contaminants and derived two statistically calculated benchmarks. These benchmarks are referred to as Effects Range-Low (ERL) and Effects Range-Median (ERM). The ERL is the 10th percentile of the accumulated environmental effects data and represents a low-level benchmark. The ERM represents the 50th percentile of the range of contaminant levels that produce environmental effects. These two benchmarks divide the range of effects into three categories. Sediments with contaminant

concentrations less than the ERL represent a minimum effects range in which adverse biological effects would rarely be seen. Sediments with contaminant concentrations greater than the ERL, but less than the ERM, represent a possible effects range in which effects would occasionally occur. Finally, sediments with contaminant concentrations greater than the ERM represent a probable effects range in which effects would frequently occur. It must be noted that these benchmarks were calculated from bioeffect assays performed on marine organisms and are not applied to freshwater systems. The authors also recommend that these numerical guidelines be used as informal screening tools in environmental assessments. They were not intended to preclude toxicity tests or other measures of biological effects.

44. In 2002, EPA published a guidance manual to support the assessment of contaminated sediments in freshwater ecosystems (EPA, 2002). This document presents consensus-based freshwater sediment quality guidelines that can be used to compare probable toxic effects from some organics and metals in sediments due to their interaction with the water column and aquatic biota. Two important concentrations were identified: the threshold effect concentration (TEC) and the probable effect concentration (PEC). The TEC represents concentrations of a chemical in sediment below which adverse biological effects are unlikely to occur and is comparable to the NOAA ERL. The PEC represents concentrations of a chemical in sediment above which harmful effects are likely to be observed. The PEC is comparable to the NOAA ERM above which harmful effects are expected to frequently occur. Concentrations between the TEC and PEC represent a range in which the link between concentration and adverse biological effects is less certain. The TEC and PEC are included in the Vicksburg District's sediment quality evaluation. The ∑DDT PEC guideline is particularly significant because the mix of DDD, DDE, and DDT (∑DDT) is the form in which the DDT compounds exist in the sediment environment.

Sediment Organochlorine Pesticides Data

45. Table 16-5a summarizes the results of organochlorine pesticides analyses for sediment samples collected within the project area. Table 16-5b summarizes the number of sediment samples that exceeded EPA TEC or PEC criteria for each basin. Thirty-four Steele Bayou Basin sediment samples were collected in 1995, 1996, and 1999. Ninety-seven sediment samples from the Big Sunflower River Basin were collected in 1993, 1995, and 1999 through 2002. Seven Deer Creek sediment samples were collected in 1995, 1997, and 2004; and 11 Backwater lake sediment samples were collected in 1995, 2000, and 2001. The data in Table 16-5a represent the analysis of results greater than the MDL. If samples from a basin were analyzed for organochlorine pesticides but none were detected, the MDL concentration was placed in the "Max" column for that basin and pesticide. The table also contains the EPA TEC and PEC biological effect criteria for comparison. Table values in bold type exceed the EPA TEC. Values underlined in bold exceed the EPA TEC and PEC.

TABLE 16-5a
PESTICIDES IN SEDIMENT SAMPLES

CHLORINATED PESTICIDE **µg/kg**	STEELE BAYOU BASIN				**Big Sunflower River**				**Deer Creek**				**Backwater Lakes**				**Criteria**	
	Det	**Mean**	**Min**	**Max**	DET	**Mean**	**Min**	**Max**	DET	**Mean**	**Min**	**Max**	DET	**Mean**	**Min**	**Max**	**EPA TEC**	**EPA PEC**
Aldrin	11	4.78	1.40	7.50	2	0.805	0.410	1.20	0			<1.71	0			<1.25		
A-BHC	7	4.68	0.830	12.0	8	2.03	1.70	2.64	0			<1.71	1	1.84	1.84	1.84		
B-BHC	10	2.77	1.50	3.60	20	8.74	0.470	110	0			<1.71	1	7.53	7.53	7.53		
G-BHC	14	1.61	0.620	**2.50**	16	**3.79**	1.90	**8.00**	0			<1.71	1	1.53	1.53	1.53	2.37	4.99
D-BHC	13	3.40	1.30	5.42	23	6.48	1.17	27.9	0			<1.71	1	0.840	0.840	0.840		
ppDDD	30	**35.5**	2.24	**110**	92	**24.8**	0.610	**85.9**	7	**64.3**	0.010	**155**	7	**16.4**	4.50	**45.0**	4.88	28.0
ppDDE	31	**79.9**	0.850	**254**	95	**50.2**	0.410	**227**	7	**182**	0.010	**482**	11	**45.4**	1.58	**130**	3.16	31.3
ppDDT	26	**13.4**	2.00	**70.0**	84	**11.5**	0.001	**65.0**	5	**38.0**	0.030	**121**	5	**7.73**	0.930	**13.8**	4.16	62.9
∑DDT	31	**125**	0.850	**391**	96	**83.4**	0.950	**305**	7	**274**	0.020	**758**	11	**59.3**	2.51	**175**	5.28	572
Heptachlor	10	1.50	0.600	2.26	34	2.36	0.520	9.50	0			<1.71	0			<1.25		
Dieldrin	15	**23.7**	**2.40**	**230**	28	**10.7**	0.350	**150**	1	**24.1**	**24.1**	**24.1**	1	**4.80**	**4.80**	**4.80**	1.90	61.8
A-Endosulfan	9	2.55	0.320	5.30	4	4.40	2.00	7.10	0			<1.71	0			<1.25		
B-Endosulfan	10	4.11	2.30	6.90	6	3.25	1.10	5.13	0			<3.42	1	3.70	3.70	3.70		
Endosulfan Sulfate	9	2.61	1.80	3.70	10	21.2	1.99	67.0	0			<3.42	0			<2.50		
Endrin	16	**3.94**	1.40	**6.20**	19	**6.09**	0.470	**24.0**	0			**<3.42**	2	**4.40**	**3.70**	**5.10**	2.22	207
Endrin Aldehyde	6	11.9	2.80	19.0	6	5.16	0.560	11.0	0			<3.42	1	3.00	3.00	3.00		
Heptachlor Epoxide	10	1.64	0.250	2.40	13	2.30	0.760	**4.50**	0			<1.71	0			<1.25	2.47	16.0
Methoxychlor	8	11.3	2.50	21.0	1	7.76	4.76	7.76	0			<1.71	0			<12.5		
Chlordane	0			**<5.0**	0			**<5.0**	0			**<34.2**	0			**<12.5**	3.24	17.6
Toxaphene	0			<12.5	0			<25.0	0			38.0	0			<12.5		

NOTES: Det = number of samples with data > Method Detection Limit
Non-detects were not included in the analysis
< Value in "Max" column = all data were < Method Detection Limit
Values in **Bold** exceed TEC (threshold effect concentration)
Values **Underlined in Bold** exceed TEC and PEC (probable effect concentration)

TABLE 16-5b
NUMBER OF PESTICIDES DETECTIONS IN SEDIMENT SAMPLES

Chlorinated Pesticide	Steele Bayou Basin				Big Sunflower River				Deer Creek				Backwater Lakes				Criteria	
	No. Det	Total No.	> TEC	> PEC	No. Det	Total No.	> TEC	> PEC	No. Det	Total No.	> TEC	> PEC	No. Det	Total No.	> TEC	> PEC	EPA TEC	EPA PEC
Aldrin	11	34	-	-	2	97	-	-	0	7	-	-	0	11	-	-		
A-BHC	7	34	-	-	8	97	-	-	0	7	-	-	1	11	-	-		
B-BHC	10	34	-	-	20	97	-	-	0	7	-	-	1	11	-	-		
G-BHC	14	34	1	0	16	97	12	4	0	7	0	0	1	11	0	0	2.37	4.99
D-BHC	13	34	-	-	23	97	-	-	0	7	-	-	1	11	-	-		
ppDDD	30	34	24	12	92	97	82	36	7	7	3	3	7	11	6	1	4.88	28.0
ppDDE	31	34	28	19	95	97	84	60	7	7	3	3	11	11	10	5	3.16	31.3
ppDDT	26	34	26	16	84	97	47	1	5	7	3	1	5	11	3	0	4.16	62.9
∑DDT	31	34	28	0	96	97	88	0	7	7	3	2	11	11	10	0	5.28	572
Heptachlor	10	34	-	-	34	97	-	-	0	7	-	-	0	11	-	-		
Dieldrin	15	34	15	1	28	97	22	1	1	7	1	0	1	11	1	0	1.90	61.8
A-Endosulfan	9	34	-	-	4	97	-	-	0	7	-	-	0	11	-	-		
B-Endosulfan	10	34	-	-	6	97	-	-	0	7	-	-	1	11	-	-		
Endosulfan Sulfate	9	34	-	-	10	97	-	-	0	7	-	-	0	11	-	-		
Endrin	16	34	14	0	19	97	14	0	0	7	0	0	2	11	2	0	2.22	207
Endrin Aldehyde	6	34	-	-	6	97	-	-	0	7	-	-	1	11	-	-		
Heptachlor Epoxide	10	34	0	0	13	97	5	0	0	7	0	0	0	11	0	0	2.47	16.0
Methoxychlor	8	34	-	-	1	97	-	-	0	7	-	-	0	11	-	-		
Chlordane	0	34	0	0	0	97	0	0	0	7	0	0	0	11	0	0	3.24	17.6
Toxaphene	0	34	-	-	0	97	-	-	0	7			0	11	-	-		

NOTES: No. Det = number of samples with data > Method Detection Limit

46. Because of their chemical nature, organochlorine pesticides are more closely associated with sediment than with water. This is apparent in the higher number of detections and higher concentrations in the sediment samples as compared to the water samples. Seventeen of the 19 organochlorine pesticides were detected in the Steele Bayou Basin. Seventeen organochlorine pesticides were detected in the Big Sunflower River Basin. Four organochlorine pesticides were detected in Deer Creek, and 11 were detected in the Backwater lakes. The most frequently detected pesticides were ppDDD, ppDDE, ppDDT, and the total of the three, ∑DDT. These pesticides were found in more than 80 percent of the samples. Dieldrin, endrin, heptachlor, B-BHC, D-BHC, and G-BHC were found in 20 to 30 percent of the samples analyzed.

47. Eight organochlorine pesticides plus ∑DDT have EPA TEC and PEC guidelines. For G-BHC, 13 samples exceeded the TEC concentration of 2.37 micrograms per kilogram (μg/kg). One was collected in the Steele Bayou Basin and twelve were collected in the Big Sunflower River Basin. Four samples collected in the Big Sunflower River Basin exceeded the EPA PEC of 4.99 μg/kg. None of the samples collected in Deer Creek or the Backwater lakes exceeded the TEC. Only the Big Sunflower River had its mean G-BHC concentration above the TEC. For G-BHC, 58 percent of the samples collected had concentrations below the TEC, and 87 percent had concentrations below the PEC.

48. There were 136 samples collected in the YBWP Area with detectable concentrations of ppDDD, 115 of them exceeded the TEC and 52 exceeded the PEC. Twenty-four samples from the Steele Bayou Basin exceeded the TEC, and 12 exceeded the PEC. Eighty-two of the Big Sunflower River Basin samples exceeded the ppDDD TEC. Thirty-six exceeded the PEC. For Deer Creek, three each exceeded the TEC and PEC. Six of the seven Backwater lake samples exceeded the TEC, and one exceeded the PEC. Mean concentrations for the Big Sunflower River and Backwater lake exceeded the TEC. Mean concentrations for Steele Bayou and Deer Creek Exceeded the PEC. Overall, 15 percent of the ppDDD samples had concentrations below the TEC of 4.88 μg/kg, and 62 percent had concentrations below the PEC of 28.0 μg/kg.

49. There were 144 samples with detectable concentrations of ppDDE; 125 exceeded the TEC, and 87 exceeded the PEC. Basin by basin, 28 samples from the Steele Bayou Basin exceeded the TEC, and 19 exceeded the PEC. Eighty-four Big Sunflower River Basin samples exceeded the TEC, and 60 exceeded the PEC. For Deer Creek, three each exceeded the TEC and PEC. Ten Backwater lake samples exceeded the TEC, while five exceeded the PEC. Mean concentrations for all four basins exceeded the ppDDE PEC. Overall, 13 percent of the ppDDE samples were below the TEC concentration of 3.16 μg/kg, and 40 percent were below the PEC concentration of 31.3 μg/kg.

50. For ppDDT, 69 of the 120 total samples with detectable concentrations of ppDDT exceeded the TEC of 4.16 μg/kg; while only three exceeded the PEC of 62.9 μg/kg. Sixteen Steele Bayou Basin samples exceeded the TEC, and 1 exceeded the PEC. Forty-seven Big Sunflower River

Basin samples exceeded the TEC, and 1 exceeded the PEC. Three Deer Creek samples exceeded the TEC, and one exceeded the PEC. Three Backwater lake samples exceeded the TEC; none exceeded the PEC. Mean concentrations for all four basins exceeded the ppDDT TEC. None exceeded the PEC. Overall, 42 percent of the ppDDT samples had concentrations below the TEC, and 97 percent had concentrations below the PEC.

51. While ppDDE is the most frequently detected DDT compound, it is often found with measurable concentrations of ppDDD and ppDDT. Any biological effects associated with these compounds are associated with the mix (∑DDT) and not the individual compounds. This is acknowledged through the development of NOAA and EPA criteria for total or ∑DDT. In the YBWP Area, 145 samples had detectable concentrations of ∑DDT. Of those, 129 exceeded the TEC concentration of 5.28 μg/kg, but only 2 exceeded the PEC of 572 μg/kg. Figure 16-1 is a graphic of the distribution of ∑DDT in the Yazoo Backwater surface sediment samples. The box plots represent the 25th and 75th percentiles. Whiskers represent the 10th and 90th percentiles, while circles are data outside the 10th and 90th percentiles. The mean concentration (represented by dashed lines inside the box) for all four basins exceeded the TEC, but not the PEC. Twenty-eight of the 31 Steele Bayou Basin samples exceeded the ∑DDT TEC. None exceeded the ∑DDT PEC. Eighty-eight of the 96 Big Sunflower River Basin samples exceeded the TEC; none exceeded the PEC. Deer Creek had the highest ∑DDT concentrations. Three of the seven samples exceeded the TEC; two of those exceeded the PEC. Ten of the 11 Backwater lake samples exceeded the TEC; none exceeded the PEC. Overall, only 11 percent of the samples with detectable ∑DDT had concentrations below the TEC. However, 98 percent of the same samples had concentrations below the PEC. Translated, this means that, based on bioassays using freshwater sediment and organisms, only 2 percent of the sediment samples collected in the YBWP Area were in the concentration range in which harmful effects are likely to be observed.

52. Dieldrin is the next organochlorine pesticide with EPA sediment quality guidelines. Forty-five of the 149 samples had detectable concentrations of dieldrin. Of these, 39 had concentrations higher than the TEC of 1.90 μg/kg, and 2 had concentrations higher than the PEC of 61.8 μg/kg. Mean concentrations for all four basins exceeded the dieldrin TEC, but not the PEC. All 15 of the Steele Bayou Basin samples had concentrations above the TEC. Only one was higher than the PEC. For the Big Sunflower River Basin, 22 of the 28 samples above the MDL had concentrations above the TEC. Only one was higher than the PEC. One sample each from Deer Creek and the Backwater lakes was greater than the TEC, but not the PEC. Overall, 13 percent of the samples with detectable concentrations of dieldrin were less than the TEC concentration. Ninety-six percent of the dieldrin samples had concentrations below the PEC.

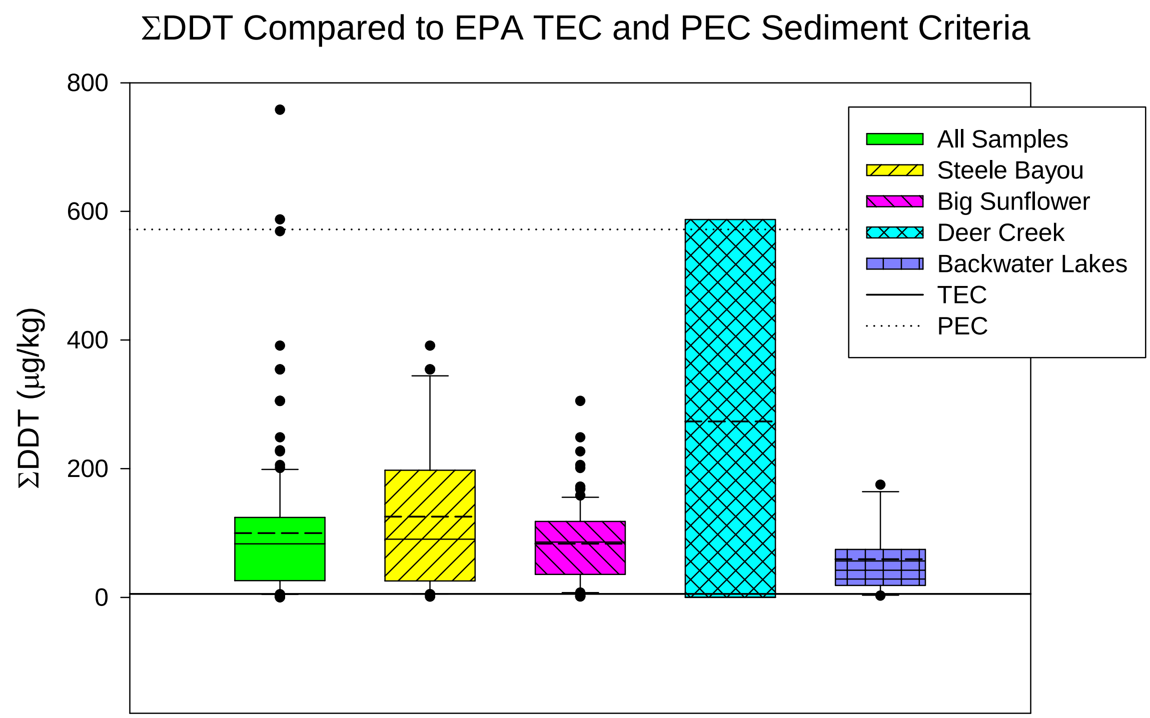


Figure 16-1. ∑ DDT concentrations compared to EPA TEC and PEC Sediment Criteria. Mean concentrations are represented by dashed lines inside each box. Box plots represent the 25th and 75th percentiles. Whiskers represent the 10th and 90th percentiles. Circles are data outside the 10th and 90th percentiles. Deer Creek did not have enough data to plot outliers.

53. Thirty-seven of the 149 Yazoo Backwater samples had concentrations of endrin above the MDL. Thirty of those had concentrations above the TEC of 2.22 µg/kg. None exceeded the PEC of 207 µg/kg. Basin by basin, 14 of the 16 Steele Bayou Basin samples exceeded the TEC, 14 of the 19 Big Sunflower River Basin samples exceeded the TEC, no Deer Creek sample exceeded the TEC, and both of the Backwater lakes samples exceeded the TEC. Mean concentrations for Steele Bayou, Big Sunflower River, and the Backwater lakes were greater than the endrin TEC. The MDL for the Deer Creek samples was greater than the TEC. Overall, 19 percent of the samples with detectable concentrations of endrin were below the TEC. All of the samples were below the PEC.

54. Heptachlor epoxide was only detected in the Steele Bayou and Big Sunflower River Basin samples with 23 detections. Five samples from the Big Sunflower River Basin exceeded the TEC of 2.47 µg/kg. None exceeded the PEC concentration of 16.0 µg/kg. None of the means exceeded the TEC. Overall, 78 percent of the heptachlor epoxide samples were less than the TEC. All were less than the PEC.

55. Chlordane is the last organochlorine pesticide with EPA sediment quality guidelines. None of the MDLs for any of the samples collected were low enough to evaluate the data against the TEC concentration of 3.24 µg/kg. Only the MDLs for the Deer Creek samples exceeded the chlordane PEC of 17.6 µg/kg.

56. Toxaphene is an organochlorine pesticide associated with sediment and fish tissue impairment within the Mississippi Delta. Because of weathering and analytical interferences and because toxaphene is a multipeak compound, it is difficult to analyze in sediments. As a result, the detection limit is often higher than the trace amounts of toxaphene found in stream sediment. This was the case for the sediment samples analyzed for the YBWP. Toxaphene was not detected in any of the sediment samples. There are no EPA sediment quality criteria for toxaphene.

57. The sediment quality of each basin can be evaluated by comparing the data for each pesticide detected against the existing sediment quality guidelines and then looking at the percentage of samples that meet those guidelines. For the Steele Bayou Basin, 27 percent of the sediment samples analyzed had concentrations below their respective TECs. This means that 27 percent of the samples were at concentrations where no adverse biological effects are likely to occur. Eighty-one percent of the samples analyzed were less than the PEC, the concentration above which harmful effects are likely to be observed. For the Big Sunflower River Basin, 20 percent of the samples analyzed were less than the TEC, and 77 percent were less than the PEC. For Deer Creek with seven samples analyzed, 52 percent were less than the TEC, and 67 percent were less than the PEC. For the Backwater lakes with 11 samples total, 16 percent were less than the TEC, and 84 percent were less than the PEC. Overall, 78 percent of the 681 YBWP Area sediment samples had pesticide concentrations less than the PEC. Twenty-three percent of these had pesticide concentrations less than the TEC and should not cause harmful biological effects. These data show that a majority of the YBWP Area sediments

evaluated did not have organochlorine pesticides at concentrations that could be associated with frequent biological effects in aquatic organisms. Sediment samples with pesticides concentrations greater than their PEC criteria were generally collected in smaller streams with depositional sediment that would benefit from some form of channel cleanout. Toxicological assays, discussed in the section "Sediment Toxicity Bioassay," were conducted using sediment from these areas to determine project-specific toxicity impacts to aquatic organisms. The sediments tested did not cause adverse responses in the test organisms.

Sediment Metals Data

58. Table 16-6 summarizes the results of metals analysis for sediment samples collected within the YBWP Area. Sediment samples representing the Steele Bayou Basin were collected in 1995, 1996, and 1999. The Big Sunflower River Basin was sampled for sediment metals in 1993, 1995, and 1998. Samples were collected from Deer Creek in 2004 and from the Backwater lakes in 1995 and 2000. Table 16-6 contains summary statistics for the metals with concentrations greater than MDL. As did the water quality analyses, the sediment analysis examines concentrations of metals within the Steele Bayou Basin (42 samples), the Big Sunflower River Basin (39 samples), lower Deer Creek (6 samples), and the Backwater lakes (14 samples). If samples from a basin were analyzed for a metal, but none were detected, the MDL concentration was placed in the "Max" column for that metal. Table 16-6 also contains USGS concentrations reported for metals in soils in the eastern United States (Shacklette and Boerngen, 1984) and EPA TEC and PEC guidelines. The flagging system used with Table 16-5a for EPA guidelines was also used in Table 16-6.

59. All of the 101 sediment samples had detectable concentrations of arsenic. This is not surprising since there is a history of arsenic-based pesticides and herbicides use in the Mississippi Delta (Pettry and Switzer, 2001). Concentrations ranged from 0.598 to 73.6 mg/kg. Seventeen samples from the Steele Bayou Basin exceeded the TEC of 7.79 mg/kg, but none exceeded the PEC. Twenty-three samples from the Big Sunflower River Basin exceeded the TEC; seven exceeded the PEC of 33 mg/kg. Four samples from Deer Creek exceeded the TEC; none exceeded the PEC. None of the 14 samples from the Backwater lakes exceeded either the TEC or PEC. Only one sample from the Big Sunflower Basin exceeded the concentration range reported by USGS for arsenic in the earth's crust. Overall, 56 percent of the arsenic samples were less than the TEC, and 93 percent were less than the PEC. Only the means for the Big Sunflower River and Deer Creek exceeded the TEC.

60. All of the 101 sediment samples had detectable concentrations of cadmium. Concentrations ranged from 0.059 to 1.40 mg/kg. Five samples from the Steele Bayou Basin, one sample from the Big Sunflower River Basin, and one from the Backwater lakes exceeded the TEC of 0.99 mg/kg. None of the samples exceeded the cadmium PEC of 4.98 mg/kg. For cadmium, 93 percent of the samples were less than the TEC, and 100 percent were less than the PEC. No mean exceeded the sediment criteria.

TABLE 16-6
METALS IN SEDIMENT SAMPLES

Metals (mg/kg)	Steele Bayou Basin				Big Sunflower River				Deer Creek				Backwater Lakes				Criteria		
	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	Det	Mean	Min	Max	USGS[1] Earth's Crust	EPA TEC	EPA PEC
Arsenic	42	8.88	3.58	**15.1**	39	**19.0**	3.20	**73.6**	6	**11.8**	8.86	**14.9**	14	4.58	0.598	7.38	0.1-73	9.79	33.0
Cadmium	42	0.530	0.139	**1.40**	39	0.436	0.059	**1.11**	6	0.617	0.452	0.744	14	0.554	0.070	**1.08**		0.99	4.98
Chromium	42	30.8	14.7	**47.6**	39	22.2	3.50	40.1	6	30.0	20.8	36.4	14	23.7	3.39	**54.9**	1-1000	43.4	111
Copper	42	24.8	14.5	**35.8**	39	19.2	1.40	**36.5**	6	28.7	13.7	**68.4**	14	26.5	2.80	**50.4**	1-700	31.6	149
Lead	42	23.4	12.3	**56.4**	37	17.3	4.10	34.7	6	26.0	18.8	**38.4**	14	21.0	2.90	**36.5**	10-300	35.8	128
Mercury	41	0.083	0.021	**0.337**	15	0.159	0.063	**0.375**	0			**<0.2**	14	**0.680**	0.066	**4.89**	0.01-3.4	0.18	1.06
Nickel	42	**27.3**	18.3	**33.6**	39	**22.9**	6.30	**39.1**	6	**25.1**	18.8	**30.3**	14	**26.0**	2.80	**51.0**	5-700	22.7	48.6
Selenium	42	0.968	0.200	1.60	23	0.611	0.240	0.998	6	0.453	0.362	0.524	11	0.854	0.410	1.73	0.1-3.9		
Zinc	42	85.4	44.4	116	39	86.9	1.09	**250**	6	113	86.9	**137**	14	**132**	10.7	**302**	5-2900	121	459
Barium					25	180	20.4	395									10-1500		
Cobalt					25	39.9	2.60	255									0.3-70		
Iron (g/kg)					25	21.8	3.62	37.8									0.1->100		
Manganese					25	494	5.52	1820									2-7000		
Silver	34	0.289	0.100	0.797	0			<0.1	6	0.228	0.228	0.250	4	0.275	0.200	0.399			

NOTES: Det = number of samples with data > Method Detection Limit
Non-detects were not included in the analysis
< Value in Max column = all data were < Method Detection Limit
Values in **Bold** exceed TEC (threshold effect concentration)
Values **Underlined in Bold** exceed TEC and PEC (probable effect concentration)
[1]Concentrations in Soils of the Eastern U.S. (Shacklette and Boerngen, 1984)

61. All of the 101 sediment samples had detectable concentrations of chromium. Concentrations ranged from 3.39 to 54.9 mg/kg. One sample each from the Steele Bayou Basin and the Backwater lakes had concentrations that exceeded the TEC of 43.4 mg/kg. None of the samples exceeded the PEC. None of the samples were outside the range observed for the earth's crust. For Chromium, 98 percent of the samples were less than the TEC, and 100 percent were less than the PEC. No mean exceeded the sediment chromium criteria.

62. All of the 101 sediment samples had detectable concentrations of copper. Concentrations ranged from 1.40 to 68.4 mg/kg. Four samples from the Steele Bayou Basin, three samples from the Big Sunflower River Basin, one sample from Deer Creek, and four samples from the Backwater lakes exceeded the TEC of 31.6 mg/kg. None of the samples exceeded the PEC. None of the samples were outside the range observed for the earth's crust. Eighty-eight percent of the copper samples from the YBWP Area had concentrations less than the TEC, and 100 percent had concentrations less than the PEC. No mean exceeded the sediment copper criteria.

63. Ninety-nine of the Yazoo Backwater samples had detectable concentrations of lead. Concentrations ranged from 2.90 to 56.4 mg/kg. One sample each from the Steele Bayou Basin, Deer Creek, and the Backwater lakes exceeded the TEC of 35.8 mg/kg. For the rest of the samples, lead was at concentrations below which adverse biological effects are likely to occur. None of the samples exceeded the PEC, and concentrations were well within the earth's crust range. Overall, 97 percent of the lead samples were less than the TEC, and 100 percent were less than the PEC. No mean exceeded the sediment lead criteria.

64. Seventy samples had concentrations of mercury above the MDL. Concentrations ranged from 0.021 to 4.89 mg/kg. Sixteen of these samples had concentrations above the TEC of 0.18 mg/kg. Five of the exceedances for the TEC were from the Steele Bayou Basin, four were from the Big Sunflower River Basin, and seven were from the Backwater lakes. None of the Deer Creek samples were greater than the MDL of 0.2 mg/kg. However, this concentration exceeded the TEC. Two samples from the Backwater lakes exceeded the PEC for mercury. One of these was outside the earth's crust range. Including the six nondetect Deer Creek samples, 69 percent of the mercury samples had concentrations less than the TEC, while 97 percent had concentrations below the PEC. Only the mean for the Backwater lakes exceeded the mercury TEC.

65. All 101 of the sediment samples had detectable concentrations of nickel. Concentrations ranged between 2.80 and 51.0 mg/kg. Seventy-eight samples exceeded the TEC of 22.7 mg/kg. Only one sample from the Backwater lakes exceeded the PEC of 48.6 mg/kg. Samples exceeding the TEC were Steele Bayou Basin - 39; Big Sunflower River Basin - 24; Deer Creek - 4; and Backwater lakes - 11. Means for all four basins exceeded the nickel TEC, but not the PEC. All of the samples had concentrations well within the range typical for the earth's crust. Although only 23 percent of the nickel samples had concentrations less than the TEC, 99 percent were less than the PEC.

66. Selenium was detected in 82 samples. Concentrations ranged from 0.200 to 1.73 mg/kg. While there are no guidelines for selenium, none of the samples exceeded the range typical for the earth's crust.

67. All 101 of the sediment samples had detectable concentrations of zinc. Concentrations ranged between 1.09 to 302 mg/kg. Twenty samples had concentrations greater than the TEC of 121 mg/kg. None of the Steele Bayou Basin samples exceeded the TEC. Eight of the Big Sunflower River Basin samples, three of the Deer Creek samples, and nine of the Backwater lake samples exceeded the TEC. None of the zinc data exceed the PEC. However, the Backwater lake mean exceeded the TEC. None of the zinc concentrations were outside the typical range given for the earth's crust. Eighty percent of the zinc samples were less than the TEC, and 100 percent were less than the PEC.

68. Only 25 sediment samples collected from the Big Sunflower River Basin were analyzed for barium, cobalt, iron, and manganese. There are no sediment guidelines for these metals. Of the four, only cobalt had samples with concentrations outside the typical range given for the earth's crust.

69. Forty-four samples had detectable concentrations of silver. Concentrations ranged between 0.100 and 0.797 mg/kg. There are no guidelines for comparison.

70. In 1997 and 1998, MDEQ Office of Geology took part in a cooperative project with USGS to develop the Mississippi portion of the National Geochemical Survey. One of the goals of the project was to determine baseline, naturally occurring values for chemical elements within the State, based on stream sediment and soil samples. Summary statistics from the resulting data set are presented for six metals in Table 16-7 (Thompson, et. al., 2002). Maximum observed concentrations for arsenic, selenium, copper, and lead in the YBWP Area were within the baseline range observed in the Mississippi Geochemical Survey. Maximum concentrations for mercury and zinc were not.

TABLE 16-7
STATISTICAL GEOCHEMICAL VALUES FROM
STREAM SEDIMENT AND SOIL SAMPLES IN MISSISSIPPI[1]

mg/kg	Sediment			Soil		
	Min	Median	Max	Min	Median	Max
As	< 0.6	2.3	137	1.7	8.6	27.9
Se	< 0.2	< 0.2	2.5	< 0.2	0.4	4.1
Hg	< 0.02	< 0.02	0.08	< 0.02	0.03	0.20
Cu	< 2	3	517	< 2	10	62
Pb	< 4	13	101	< 4	17	50
Zn	< 2	14	220	6	49.5	222

[1](Thompson, et al., 2002)

71. Overall, for the samples that have EPA guidelines and whose metals concentrations were greater than their respective detection limits, 79 percent of the samples from the Steele Bayou Basin had concentrations below the TEC, the concentration below which no adverse biological effects are likely to occur. For the Big Sunflower River Basin, 78 percent of the samples were less than the TEC. Deer Creek and the Backwater lakes had fewer samples available for analysis. Sixty percent of the Deer Creek samples were less than the TEC, while 70 percent of the Backwater lake samples were less than the TEC. All of the Steele Bayou Basin and Deer Creek samples were less than the PEC, the concentration above which adverse biological effects are likely to be observed. Ninety-seven percent of the Big Sunflower River Basin and Backwater lakes samples were less than the PEC. Overall, 98 percent of the sediment metals samples were found to be below the PEC. Seventy-six percent of these samples had concentrations less than the TEC and should not cause harmful biological effects. These data suggest that sediment metals concentrations in the YBWP Area are not in the range that would cause frequent harmful biological effects. The YBWP should not increase sediment metals concentrations. Other than completion and periodic maintenance dredging of the inlet and outlet channels at the pump station site, the project will not disturb study area streambanks or streambeds. The reforestation feature will reduce erosion on flood-prone agricultural land and could reduce the amount of soil associated metals entering study area streams.

SUMMARY OF EXISTING WATER AND SEDIMENT EVALUATIONS

72. The water and sediment quality evaluations were based on water and sediment samples collected over a 15-year period by USGS, NRCS, MDEQ, ERDC, and the Vicksburg District. The data indicate that rivers and streams within the YBWP Area occasionally exceed their MDEQ and EPA recommended criteria for some important parameters. For example, DO and water temperature were occasionally outside the recommended ranges during the late summer months, and concentrations of ammonia occasionally exceeded recommended EPA criteria at certain locations. Suspended sediment and nutrient concentrations were found at levels indicating agricultural influences. Four priority pollutant metals had concentrations that occasionally exceeded their MDEQ freshwater criteria, but 98 percent of the metals sediment samples were below the concentration that would classify them as likely causes of harmful biological effects to aquatic organisms based on comparisons to EPA PEC criteria. While DDT and a few other organochlorine pesticides are in high enough concentrations in the sediment to be found in trace amounts in the water column, 78 percent of the sediment samples had organochlorine pesticide concentrations that were too low to be classified as likely causes of harmful biological effects to aquatic organisms. The USGS reported that current-use pesticides are the type of pesticide detected most often in surface water.

73. The EPA recommends a tiered sampling program for evaluating sediments (EPA, 1998). Initially, water and sediment samples are collected and analyzed for pollutant groups such as metals and pesticides. If concentrations are high, EPA recommends fish tissue sampling. Since some of the water and sediment samples collected within the YBWP Area contained

concentrations of these compounds in a range that do not preclude them from causing adverse biological effects to aquatic organisms, the Vicksburg District initiated a fish tissue sampling program in the Big Sunflower River and Steele Bayou Basins. The Vicksburg District also conducted other studies to better understand and predict project impacts to late summer DO concentrations, sediment pesticide toxicity, and nutrient and soil runoff. These topics will be discussed in greater detail in subsequent sections.

SEDIMENT TOXICITY BIOASSAY

74. In order to more clearly understand the impact of sediment DDT concentrations to aquatic organisms, the Vicksburg District had research scientists at ERDC conduct sediment bioassays from the Big Sunflower River Basin. Test sediment was collected from high deposition areas with the greatest probability of having elevated pesticides concentrations. Initially, the assays were performed on sediment collected from the Little Sunflower River – Reach 2 in March 2001 (reported in Wade, et al., 2002). Additional bioassays were conducted on sediment from Big Sunflower River and Bogue Phalia Reaches 2, 6, 7, and 8 in January 2002 (Lotufo, et al., 2002). The control sediment for all assays was collected from Brown's Lake in Vicksburg, Mississippi, in spring 2001. The test sediment for each reach was a composite of cores collected across transects of the river at several locations within that reach.

75. The purpose of this section is to describe and document the sediment bioaccumulation and toxicity studies performed on the Big Sunflower Basin sediment samples. The results of the assays are useful to predict the potential for bioaccumulation and toxicity of DDX (DDD, DDE, or DTT) to freshwater organisms in the project area. All tests were performed using EPA recommended procedures utilizing freshwater organisms. The test methodology followed recommendations from the EPA (2000a) guidance document, "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates" (EPA/600/R-99/064). Tissue samples collected at the end of the bioaccumulation test were analyzed for nonpolar organic contaminants. The DDX tissue contaminant levels were used to calculate Biota-Sediment Accumulation Factors (BSAFs) for each DDX component and for ∑DDT. Assay results were used to predict the potential for bioaccumulation and toxicity of DDX to freshwater organisms in the Big Sunflower Basin. *Lumbriculus variegatus* (*L. variegatus*) was used in the 28-day bioaccumulation assays, and *Hyalella azteca* (*H. azteca*) was used in the 10-day toxicity assays. Reference toxicant tests were set up concurrent to each test to evaluate the health of the test organism and suitability of the test conditions.

76. The EPA (2000a) *L. variegates* 28-day bioaccumulation test for sediments (Test Method 100.3) was used to investigate organochlorine bioaccumulation. Each bioaccumulation study was conducted using three replicates from each sediment collection site. Tests were conducted under flow-through conditions in box aquaria. Test and control sediments were added to aquaria to achieve a final sediment thickness of 2.5 centimeters (cm). At the start of the

bioaccumulation test, organisms equaling 1 gram of wet tissue were added to each chamber. DO and temperature were monitored daily. Water chemistry was monitored at the beginning and the end of the test period. After 28 days, test sediments were sieved to recover the worms. Surviving worms were then dried, weighed, and frozen for chemical and lipid analysis. Body residue analysis was used to calculate BSAFs for nonpolar organic contaminants present in animal tissue and sediment. Sediment and tissue DDX concentrations were analyzed by the ERDC Environmental Chemistry Branch using EPA SW-846 methods.

77. The TOC, grain size distribution, and concentrations of DDX for the test and control sediments are reported in Table 16-8. Note that the concentrations for Little Sunflower River Reach 2 sediments collected approximately 1 year apart are almost identical. The mean concentrations of DDX in *L. variegatus* exposed to the test sediments are reported in Table 16-9. The mean BSAFs calculated for ∑DDT (Table 16-10) range from 1.98 for Little Sunflower Reach 2 sediments to 0.55 for Big Sunflower Reach 6 sediments. The BSAF values for Bogue Phalia Reaches 7 and 8 were 0.90 and 0.67, respectively. For comparison, BSAFs determined in other studies using spiked sediments are presented in Table 16-11. Previously calculated BSAF values for freshwater amphipods ranged from 0.07 to 2.13 for DDT. In the Big Sunflower River Basin the DDT BSAF values ranged from 0.13 to 0.78. The DDD BSAF values ranged from 0.29 to 1.09 and the DDE BSAF values ranged from 0.37 to 2.64. The total BSAF calculated for ∑DDT, the cumulative effect BSAF, ranged from 0.55 to 1.98.

78. The second bioassay performed using these Big Sunflower River sediments was the *H. azteca* 10-day survival and growth test (EPA 2000a Test Method 100.1). This test was used to investigate the toxicity associated with project sediments. As were the bioaccumulation tests, the toxicity tests were also conducted in two stages: the Little Sunflower Reach 2 sediments in 2001 and the Reach 2, 6, 7, and 8 sediments in 2002. These tests were also conducted utilizing a flow-through system. Tests were conducted in 300-mL glass beakers containing 4.5-cm of homogenized sediment and ten 10-day-old amphipods. Two liters of test water were delivered to the beakers every 12 hours. Animals were fed daily. Water chemistry was monitored at the beginning and end of the experiment. Temperature and DO were monitored daily. At the end of the 10-day test, sediments were sieved to recover the organisms, and survival was documented. Initial and final animal images analyses were used to assess growth of the animals.

TABLE 16-8
SEDIMENT CHARACTERISTICS FROM BIG SUNFLOWER
COMPOSITE SAMPLES BY REACH AND BROWN'S LAKE (Control)

Reach - Water Body	**DDT (µg/kg)**	**DDD (µg/kg)**	**DDE (µg/kg)**	**∑DDT (µg/kg)**	**TOC (%)**	**Fines (%)**	**Sand (%)**
2 [1] - Little Sunflower River	16.3	36.5	81.1	133.8	1.1	98.0	2.0
Control [1] - Brown's Lake	< 2.92	<2.92	<2.92	<2.92	0.65	98.2	1.8
2 [2] - Little Sunflower River	16.1	33.1	81.0	130.2	1.530	97.8	2.2
6 [2] – Big Sunflower River	12.4	12.4	18.5	43.3	0.242	18	82
7 [2] - Bogue Phalia	15.6	12.3	24.3	52.2	0.771	71	29
8 [2] - Bogue Phalia	14.5	23.1	39.1	76.7	0.37	62.8	37.2
Control [2] **-** Brown's Lake	<3.0	<3.0	<3.0		0.65	99.3	0.7

[1] Little Sunflower River Reach 2 sediment collected 2001 (Wade, et al., 2002)
[2] Big Sunflower Basin sediments (Reaches 2, 6, 7, 8) collected 2002 (Lotufo, et al., 2002)

TABLE 16-9
CONCENTRATIONS OF DDT, DDD, DDE AND ΣDDT
IN *L. VARIEGATUS* TISSUE SAMPLES

Reach - Water Body	**DDT (µg/kg)**	**DDD (µg/kg)**	**DDE (µg/kg)**	**∑DDT (µg/kg)**
2 [1] - Little Sunflower River	9.6	100.8	578.0	668.4
Control [1] - Brown's Lake	< 5.03	< 5.03	11.1	21.2
2 [2] - Little Sunflower River	20.1	84.8	502.5	607.4
6 [2] - Big Sunflower River	33.0	71.3	361.3	465.6
7 [2] - Bogue Phalia	75.1	32.1	184.3	291.6
8 [2] - Bogue Phalia	59.7	106.3	392.3	558.3

[1] Little Sunflower River Reach 2 sediment collected 2001 (Wade, et al., 2002)
[2] Big Sunflower Basin sediments (Reaches 2, 6, 7, 8) collected 2002 (Lotufo, et al., 2002)

TABLE 16-10
MEAN BASF VALUES CALCULATED
FOR DDT, DDD, DDE, AND ∑DDT FOR *L. VARIEGATUS* EXPOSED
TO SEDIMENTS COLLECTED FROM THE BIG SUNFLOWER BASIN

Reach - Water Body	**DDT**	**DDD**	**DDE**	**∑DDT**
2 [1] - Little Sunflower River	0.22	1.05	2.72	1.96
2 [2] - Little Sunflower River	0.53	1.09	2.64	1.98
6 [2] - Big Sunflower River	0.13	0.29	1.00	0.55
7 [2] - Bogue Phalia	0.78	0.43	1.23	0.90
8 [2] - Bogue Phalia	0.42	0.92	0.37	0.67

[1] Little Sunflower River Reach 2 sediment collected 2001 (Wade, et al., 2002)
[2] Big Sunflower Basin sediment (Reaches 2, 6, 7, 8) collected 2002 (Lotufo, et al., 2002)

TABLE 16-11
BSAF VALUES FOR DDT AND DDE FOR AQUATIC INVERTEBRATES

Species	**Sediment Contamination**	**Compound**	**BSAF**	**Reference ***
Estuarine amphipod *Leptocheirus plumulosus*	Spiked	DDT	2.88	Lotufo et al. 2001b
Freshwater amphipod *Hyalella azteca*	Spiked	DDT	0.76 - 2.13	Lotufo et al. 2001a
Freshwater amphipod *Diporeia* spp.	Spiked	DDT	0.07 - 0.56	Lotufo et al. 2001a
Marine amphipod *Rephoxinius abronius*	Field-collected	DDT	0.09	Meador et al. 1997
Marine bivalve *Macoma nasuta*	Field-collected	DDT	0.05	Boese et al., 1997
Marine bivalve *Macoma nasuta*	Field-collected	DDT	0.14	Rubinstein 1994
Marine polychaete *Hetermastus filiformis*	Spiked	DDT	0.4 - 0.8	Mulsow and Landrum 1995
Marine polychaete *Armandia brevis*[c]	Field-collected	DDT	0.2	Meador et al., 1997
Marine polychaete *Nereis virens*	Field-collected	DDT	0.14	Rubinstein 1994
Marine bivalve *Macoma nasuta*	Field-collected	DDE	0.65 - 2.8	Ferraro et al. 1990
Marine bivalve *Macoma nasuta*	Field-collected	DDE	0.07	Rubinstein 1994
Marine polychaete *Nereis virens*	Field-collected	DDE	0.48	Rubinstein 1994
Table 19. (Wade, et al., 2002) * Detailed references located in Wade, et al., 2002				

79. The mean percent survival and length of *H. azteca* exposed to these sediments are shown in Table 16-12. For the 2001 Reach 2 assays, mean survival in the 10-day assay for test organisms was 86 percent and the mean survival for control organisms was 95 percent. Mean survival for the 2002 assays were as follows: Reach 2 – 90.0 percent; Reach 6 – 97.5 percent; Reach 7 – 93.8 percent; Reach 8 – 94.3 percent; and 2002 Control – 91.3 percent. Mean survival in both control groups was higher than the test acceptability requirement of 80 percent (EPA, 2000a), indicating that the testing conditions were adequate for the test species. There were no significant differences in survival between the test and control sediments (p=0.183 for the 2001 assays and p=0.388 for the 2002 assays). Organism length at the end of the exposure period was used as an indicator of growth. Mean length of the organisms exposed to 2001 Little Sunflower Reach 2 and Brown's Lake sediments were 2.24 and 2.17 millimeters, respectively. No significant differences in length were observed (p=0.598). Mean length of the organisms exposed to the 2002 sediments ranged from 2.75 to 2.99 with a mean length in the control sediments of 2.64. Again, no statistically significant differences in length were observed (p=0.222).

TABLE 16-12
MEAN PERCENT SURVIVAL AND LENGTH OF
HYALELLA AZTECA EXPOSED TO SEDIMENTS COLLECTED
FROM DIFFERENT REACHES IN THE BIG SUNFLOWER BASIN

Treatment	Percent Survival (Std Dev)	Length in mm (Std Dev)
Reach 2	86.0 (17)	2.24 (0.26)
Control	95.0 (5)	2.17 (0.22)
Reach 2	90.0 (9.3)	2.95 (0.49)
Reach 6	97.5 (4.6)	2.75 (0.27)
Reach 7	93.8 (5.2)	2.99 (0.33)
Reach 8	94.3 (7.9)	2.86 (0.34)
Control	91.3 (9.9)	2.64 (0.35)

80. Lethal tissue residue concentrations associated with 50 percent mortality (LR_{50}) in several benthic invertebrates have been determined in various studies. The LR_{50} concentrations calculated from sediment exposure to DDT are presented in Table 16-13, while the LR_{50} values calculated from water exposure are listed in Table 16-14. The final observed DDX tissue values from organisms exposed to Big Sunflower River Basin sediments (Table 16-9) were considerably lower than the published LR_{50} values.

TABLE 16-13
LR_{50} VALUES FOR ΣDDT IN BENTHIC
INVERTEBRATES DERIVED FROM SEDIMENT EXPOSURES

Species	LR_{50} (µg/kg wet wt)	Reference*
Marine polychaete *Neanthes arenaceodentata*	>141,600	Lotufo, et al., 2000b
Estuarine copepod *Schizopera knabeni*	>425,000	Lotufo (unpublished)
Freshwater oligochaete *Tubifex tubifex*	>754,000	Lotufo (unpublished)
Marine amphipod *Leptocheirus plumulosus*	2,690	Lotufo, et al., 2001b
Freshwater amphipod *Diporeia* spp.	5,947	Lotufo, et al., 2001a
Freshwater amphipod *Hyalella azteca*	2,620	Lotufo, et al., 2001a
Table 20. (Wade, et al., 2002) * Detailed references located in Wade, et al., 2002		

TABLE 16-14
LR_{50} VALUES FOR DDT, DDD, AND DDE IN BENTHIC INVERTEBRATES
DERIVED FROM WATER EXPOSURES (LOTUFO et al. 2000a).

Species	Compound	LR_{50} (µg/kg wet wt)
Hyalella azteca	DDT	710
	DDD	15,000
	DDE	123,700
Diporeia spp.	DDT	15,600
	DDD	84,200
	DDE	477,000
Table 21. (Wade, et al., 2002)		

81. Lotufo and others (2001a) used spiked sediment to determine the LC_{50} sediment concentration for ∑DDT in *H. azteca*. The 10-day LC_{50} for ∑DDT was 1,097 µg/kg (885 to 1,133 µg/kg; 95-percent confidence interval) or 182,833 µg organic carbon (147,500 – 188,833 µg/kg organic carbon; 95 percent confidence interval). The spiked sediment 10-day LC_{50} of 1,097 µg/kg ∑DDT is higher than the highest observed concentration in the YBWP Area sediments tested (Table 16-5a). The value is almost twice as high as the EPA PEC of 572 µg/kg for total DDT (∑DDT), which is also primarily based on co-occurrence assays in freshwater organisms.

82. The results of these bioassays clearly show that the sediments from the Big Sunflower River Basin of the YBWP Area are not toxic to aquatic organisms. The bioaccumulation assays show that DDT and its metabolites do accumulate in organisms exposed to YBWP sediments containing DDT, but that the accumulated levels are well below published ∑DDT LR_{50} levels.

FISH TISSUE QUALITY

83. Fish tissue quality tends to reflect sediment and water quality. Contaminant levels in fish are important because of the potential impacts to fish, wildlife, and humans. High contaminant levels can result in acute or chronic responses in fish. Also, contaminant levels provide a gage for consideration by human consumers. Because of the impact to humans, EPA recommends a tiered sampling program for contaminants (EPA and USACE, 1998). Initially, water and sediment samples are collected and analyzed for pollutants such as metals and pesticides. If concentrations are high, EPA recommends fish tissue sampling. Since the water and sediment samples collected within the YBWP Area contained elevated levels of some contaminants, the Vicksburg District initiated a fish tissue sampling program in the Big Sunflower River and Steele Bayou Basins in 1993. Research scientists at ERDC collected and analyzed fish tissue samples for the Vicksburg District in 1993, 1994, 2000, 2001, and 2005. The resulting database contains 200 fish specimens. The database includes black, small mouth, and bigmouth buffalo; blue, channel and flathead catfish; shortnose gar; paddlefish; white crappie; largemouth bass; and common carp. The 1993 and 1994 fish specimens were analyzed for both metals and organochlorine pesticides. The 2000, 2001, and 2005 specimens were analyzed for organochlorine pesticides. The October 2005 specimens were also analyzed for mercury. Table 16-15 lists descriptive information for the Vicksburg District fish database including species, sampling location, data collected, and length of each fish.

84. The primary concern with sediment pesticide levels found within the Mississippi Delta is the potential for bioaccumulation in the aquatic food chain. The effects of pesticides upon fish and other aquatic organisms have been intensely studied and documented. Pesticide levels, especially ∑DDT, in fish collected from the Delta have been monitored for years. Cotton and Herring reported one of the first studies in 1970. Total DDT (∑DDT) fish tissue levels in that study ranged from 0.5 to 29.0 mg/kg. A subsequent study in 1974 found DDT fish tissue levels ranging from 0.05 to 9.1 mg/kg. Fish tissue levels exceeding the Food and Drug Administration (FDA) action levels in three Delta lakes (Wolf, Mossy, and Washington) forced their closing to commercial fishing in 1973. Mossy Lake and Lake Washington were reopened in 1977 after their fish tissue levels dropped below the FDA maximum allowable levels. Wolf Lake remained closed until 1982. Most recently, in June 2001, MDEQ issued fish consumption advisories for DDT and toxaphene for all water bodies east of the Mississippi River levee and west of the bluff hills (Table 16-16). The Advisory recommends limiting the amount of fish consumed based on types of fish. The Advisory states “persons eat no more than two meals per month of buffalo, gar, carp, and large catfish greater than 22 inches in length caught in Delta waters.” The State issues advisories based on the mean concentration from analysis of composite samples of fish tissue collected over a 2-year period. Advisories are usually listed for specific species and lengths of fish.

TABLE 16-15
PERTINENT DATA FOR FISH COLLECTED BY ERDC

Sample ID	Waterbody	Site	Sampled Date	Species	Sample Type	Length (mm)
38584	Big Sunflower	Nr Choctaw B	19 Oct 93	Bigmouth Buffalo	Flesh	530
38585	Big Sunflower	Nr Choctaw B	19 Oct 93	Bigmouth Buffalo	Flesh	518
38586	Big Sunflower	Nr Choctaw B	19 Oct 93	Bigmouth Buffalo	Flesh	403
38587	Big Sunflower	Nr Choctaw B	19 Oct 93	Bigmouth Buffalo	Flesh	524
38588	Big Sunflower	Nr Choctaw B	19 Oct 93	Bigmouth Buffalo	Flesh	427
38589	Big Sunflower	HB Cutoff	19 Oct 93	Blue Catfish	Flesh	435
38590	Big Sunflower	HB Cutoff	19 Oct 93	Blue Catfish	Flesh	426
38591	Big Sunflower	HB Cutoff	19 Oct 93	Blue Catfish	Flesh	512
38592	Big Sunflower	HB Cutoff	19 Oct 93	Blue Catfish	Flesh	430
38593	Big Sunflower	Nr Choctaw B	19 Oct 93	Blue Catfish	Flesh	625
38594	Big Sunflower	HB Cutoff	19 Oct 93	Shortnose Gar	Flesh	505
38595	Big Sunflower	HB Cutoff	19 Oct 93	Shortnose Gar	Flesh	630
38596	Big Sunflower	HB Cutoff	19 Oct 93	Shortnose Gar	Flesh	502
38597	Big Sunflower	Nr Choctaw B	19 Oct 93	Shortnose Gar	Flesh	605
38598	Big Sunflower	Nr Choctaw B	19 Oct 93	Shortnose Gar	Flesh	603
38599	Big Sunflower	HB Cutoff	19 Oct 93	Smallmouth Buffalo	Flesh	460
38600	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	465
38601	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	451
38602	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	571
38603	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	400
38604	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	396
38605	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	491
38606	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	340
38607	Big Sunflower	Nr Choctaw B	19 Oct 93	Smallmouth Buffalo	Flesh	380
51238	Big Sunflower	SW Hwy 49	10 Sep 94	Bigmouth Buffalo	Flesh	570
51223	Big Sunflower	Kinlock	14 Sep 94	Flathead Catfish	Flesh	669
51224	Big Sunflower	NE Hwy 49	16 Sep 94	Flathead Catfish	Flesh	641
51236	Big Sunflower	NE Hwy 49	16 Sep 94	Smallmouth Buffalo	Flesh	408
51237	Big Sunflower	NE Hwy 49	16 Sep 94	Smallmouth Buffalo	Flesh	400
51241	Big Sunflower	Kinlock	18 Sep 94	Bigmouth Buffalo	Flesh	629
51229	Big Sunflower	NE Hwy 49	18 Sep 94	Shortnose Gar	Flesh	840
51230	Big Sunflower	NE Hwy 49	18 Sep 94	Shortnose Gar	Flesh	800
51231	Big Sunflower	Kinlock	18 Sep 94	Shortnose Gar	Flesh	640
51233	Big Sunflower	Kinlock	18 Sep 94	Smallmouth Buffalo	Flesh	460
51234	Big Sunflower	Kinlock	18 Sep 94	Smallmouth Buffalo	Flesh	458
51225	Big Sunflower	SW Hwy 49	19 Sep 94	Flathead Catfish	Flesh	703
51226	Big Sunflower	Gravel Pit	19 Sep 94	Flathead Catfish	Flesh	720
51227	Big Sunflower	Gravel Pit	19 Sep 94	Flathead Catfish	Flesh	700
51239	Big Sunflower	Gravel Pit	12 Oct 94	Bigmouth Buffalo	Flesh	591

TABLE 16-15 (Cont)

Sample ID	Waterbody	Site	Sampled Date	Species	Sample Type	Length (mm)
51240	Big Sunflower	Gravel Pit	12 Oct 94	Bigmouth Buffalo	Flesh	601
51242	Big Sunflower	Gravel Pit	12 Oct 94	Bigmouth Buffalo	Flesh	579
51231	Big Sunflower	Gravel Pit	12 Oct 94	Shortnose Gar	Flesh	760
51232	Big Sunflower	Gravel Pit	12 Oct 94	Shortnose Gar	Flesh	698
51218	Big Sunflower	Gravel Pit	2 Nov 94	Paddlefish	Flesh	1410
51219	Big Sunflower	Gravel Pit	2 Nov 94	Paddlefish	Flesh	1240
51220	Big Sunflower	Gravel Pit	2 Nov 94	Paddlefish	Flesh	1276
51221	Big Sunflower	Gravel Pit	2 Nov 94	Paddlefish	Flesh	1287
51222	Big Sunflower	Gravel Pit	2 Nov 94	Paddlefish	Flesh	2360
51235	Big Sunflower	Gravel Pit	2 Nov 94	Smallmouth Buffalo	Flesh	510
100957	Big Sunflower	Nr Choctaw B	16 Oct 01	Smallmouth Buffalo	Flesh	486
100961	Big Sunflower	Nr Choctaw B	16 Oct 01	Bigmouth Buffalo	Flesh	517
100962	Big Sunflower	Nr Choctaw B	16 Oct 01	Bigmouth Buffalo	Flesh	548
100963	Big Sunflower	Nr Choctaw B	16 Oct 01	Bigmouth Buffalo	Flesh	546
100973	Big Sunflower	Nr Choctaw B	16 Oct 01	Bigmouth Buffalo	Flesh	493
100974	Big Sunflower	Nr Choctaw B	16 Oct 01	Bigmouth Buffalo	Whole	493
100969	Big Sunflower	Nr Choctaw B	16 Oct 01	Black Buffalo	Flesh	670
100970	Big Sunflower	Nr Choctaw B	16 Oct 01	Black Buffalo	Flesh	670
100979	Big Sunflower	Nr Choctaw B	16 Oct 01	Black Buffalo	Flesh	471
100980	Big Sunflower	Nr Choctaw B	16 Oct 01	Black Buffalo	Whole	471
100964	Big Sunflower	Nr Choctaw B	16 Oct 01	Blue Catfish	Flesh	521
100965	Big Sunflower	Nr Choctaw B	16 Oct 01	Blue Catfish	Flesh	440
100966	Big Sunflower	Nr Choctaw B	16 Oct 01	Blue Catfish	Flesh	504
100967	Big Sunflower	Nr Choctaw B	16 Oct 01	Blue Catfish	Flesh	561
100977	Big Sunflower	Nr Choctaw B	16 Oct 01	Blue Catfish	Flesh	511
100978	Big Sunflower	Nr Choctaw B	16 Oct 01	Blue Catfish	Whole	511
100955	Big Sunflower	Nr Choctaw B	16 Oct 01	Flathead Catfish	Flesh	700
100956	Big Sunflower	Nr Choctaw B	16 Oct 01	Flathead Catfish	Flesh	658
100975	Big Sunflower	Nr Choctaw B	16 Oct 01	Flathead Catfish	Flesh	621
100976	Big Sunflower	Nr Choctaw B	16 Oct 01	Flathead Catfish	Flesh	621
100968	Big Sunflower	Nr Choctaw B	16 Oct 01	Paddlefish	Flesh	1073
100971	Big Sunflower	Nr Choctaw B	16 Oct 01	Paddlefish	Flesh	1392
100972	Big Sunflower	Nr Choctaw B	16 Oct 01	Paddlefish	Whole	1392
100958	Big Sunflower	Nr Choctaw B	16 Oct 01	Smallmouth Buffalo	Flesh	532
100959	Big Sunflower	Nr Choctaw B	16 Oct 01	Smallmouth Buffalo	Flesh	516
100960	Big Sunflower	Nr Choctaw B	16 Oct 01	Smallmouth Buffalo	Flesh	517
100981	Big Sunflower	Nr Choctaw B	16 Oct 01	Smallmouth Buffalo	Flesh	496
100982	Big Sunflower	Nr Choctaw B	16 Oct 01	Smallmouth Buffalo	Whole	496
92451	Black Bayou	Leroy Percy	27 Oct 00	Buffalo	Flesh	320
92454	Black Bayou	LP Upstream	27 Oct 00	Buffalo	Flesh	400

TABLE 16-15 (Cont)

Sample ID	Waterbody	Site	Sampled Date	Species	Sample Type	Length (mm)
92452	Black Bayou	Leroy Percy	27 Oct 00	Channel Catfish	Flesh	510
92453	Black Bayou	LP Upstream	27 Oct 00	Largemouth Bass	Flesh	280
92449	Main Canal	Weir E	3 Nov 00	Buffalo	Flesh	360
92448	Main Canal	Weir E	3 Nov 00	Channel Catfish	Flesh	430
92450	Main Canal	Weir E	3 Nov 00	White Crappie	Flesh	320
93956	Black Bayou	Leroy Percy	23 Feb 01	Bigmouth Buffalo	Flesh	560
93957	Black Bayou	Leroy Percy	23 Feb 01	Bigmouth Buffalo	Flesh	481
93958	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	342
93959	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	494
93960	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	363
93961	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	511
93962	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	320
93963	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	452
93964	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	362
93965	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	340
93966	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	315
93967	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	392
93968	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	303
93969	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	406
93970	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	331
93971	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	433
93972	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	492
93973	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	363
93974	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	450
93975	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	490
93976	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	363
93977	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	420
93978	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	326
93979	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	400
93980	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	298
93981	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	358
93982	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	298
93983	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	333
93984	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	406
93985	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	365
93986	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	385
93987	Black Bayou	Leroy Percy	23 Feb 01	Buffalo	Flesh	333
93955	Black Bayou	Leroy Percy	23 Feb 01	Channel Catfish	Flesh	485
95616	Black Bayou	LP Below Weir	18 Apr 01	Channel Catfish	Flesh	370
95617	Black Bayou	Leroy Percy	18 Apr 01	Channel Catfish	Flesh	369

TABLE 16-15 (Cont)

Sample ID	Waterbody	Site	Sampled Date	Species	Sample Type	Length (mm)
95618	Black Bayou	Leroy Percy	18 Apr 01	Channel Catfish	Flesh	378
95619	Black Bayou	Leroy Percy	18 Apr 01	Channel Catfish	Flesh	610
95620	Black Bayou	Leroy Percy	18 Apr 01	Channel Catfish	Flesh	390
95621	Black Bayou	Leroy Percy	18 Apr 01	Channel Catfish	Flesh	331
95622	Black Bayou	Leroy Percy	18 Apr 01	Channel Catfish	Flesh	485
95623	Black Bayou	LP Below Percy	18 Apr 01	Channel Catfish	Flesh	375
95624	Black Bayou	Weir E	18 Apr 01	Channel Catfish	Flesh	341
95625	Main Canal	Weir E	18 Apr 01	Channel Catfish	Flesh	422
95626	Main Canal	Weir E	18 Apr 01	Channel Catfish	Flesh	390
95627	Main Canal	Weir E	18 Apr 01	Channel Catfish	Flesh	440
95628	Main Canal	Weir E	18 Apr 01	Channel Catfish	Flesh	466
95629	Main Canal	Weir E	18 Apr 01	Channel Catfish	Flesh	390
95630	Main Canal	Weir E	18 Apr 01	Channel Catfish	Flesh	439
95610	Black Bayou	Leroy Percy	18 Apr 01	White Crappie	Flesh	214
95611	Black Bayou	Leroy Percy	18 Apr 01	White Crappie	Flesh	246
95612	Black Bayou	Leroy Percy	18 Apr 01	White Crappie	Flesh	263
95613	Black Bayou	Leroy Percy	18 Apr 01	White Crappie	Flesh	309
95614	Black Bayou	Leroy Percy	18 Apr 01	White Crappie	Flesh	315
96615	Black Bayou	Leroy Percy	18 Apr 01	White Crappie	Flesh	311
96511	Steele Bayou	At Muddy Bayou	23 May 01	Bigmouth Buffalo	Flesh	476
96512	Steele Bayou	At Muddy Bayou	23 May 01	Bigmouth Buffalo	Flesh	410
96506	Steele Bayou	At Muddy Bayou	23 May 01	Black Buffalo	Flesh	505
96519	Steele Bayou	At Muddy Bayou	23 May 01	Blue Catfish	Flesh	442
96520	Steele Bayou	At Muddy Bayou	23 May 01	Blue Catfish	Flesh	428
96521	Steele Bayou	At Muddy Bayou	23 May 01	Blue Catfish	Flesh	410
96522	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	332
96523	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	323
96524	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	390
96525	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	433
96526	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	508
96527	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	421
96528	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	478
96529	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	343
96530	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	382
96531	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	451
96532	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	400
96533	Steele Bayou	At Muddy Bayou	23 May 01	Channel Catfish	Flesh	342
96513	Steele Bayou	At Muddy Bayou	23 May 01	Common Carp	Flesh	458
96514	Steele Bayou	At Muddy Bayou	23 May 01	Common Carp	Flesh	473
96515	Steele Bayou	At Muddy Bayou	23 May 01	Common Carp	Flesh	442
96516	Steele Bayou	At Muddy Bayou	23 May 01	Common Carp	Flesh	330
96517	Steele Bayou	At Muddy Bayou	23 May 01	Common Carp	Flesh	420
96518	Steele Bayou	At Muddy Bayou	23 May 01	Common Carp	Flesh	472
96508	Steele Bayou	At Muddy Bayou	23 May 01	Smallmouth Buffalo	Flesh	407
96509	Steele Bayou	At Muddy Bayou	23 May 01	Smallmouth Buffalo	Flesh	520

TABLE 16-15 (Cont)

Sample ID	Waterbody	Site	Sampled Date	Species	Sample Type	Length (mm)
96510	Steele Bayou	At Muddy Bayou	23 May 01	Smallmouth Buffalo	Flesh	468
96507	Steele Bayou	At Muddy Bayou	23 May 01	White Bass	Flesh	388
125556	Black Bayou	Leroy Percy	03 Mar 05	Bigmouth Buffalo	Flesh	531
125224	Black Bayou	Leroy Percy	03 Mar 05	Channel Catfish	Flesh	514
125225	Black Bayou	Leroy Percy	03 Mar 05	White Crappie	Flesh	350
125226	Black Bayou	Leroy Percy	03 Mar 05	Blue Catfish	Flesh	720
125227	Black Bayou	Leroy Percy	03 Mar 05	Channel Catfish	Flesh	600
125228	Black Bayou	Leroy Percy	03 Mar 05	Smallmouth Buffalo	Flesh	382
125229	Black Bayou	Leroy Percy	03 Mar 05	Bigmouth Buffalo	Flesh	444
125230	Black Bayou	DS Weir HWY 12	03 Mar 05	Common Carp	Flesh	430
125231	Black Bayou	DS Weir HWY 12	03 Mar 05	Smallmouth Buffalo	Flesh	395
125232	Black Bayou	DS Weir HWY 12	03 Mar 05	Smallmouth Buffalo	Flesh	445
125233	Main Canal	DS Weir E	03 Mar 05	Black Crappie	Flesh	225
125234	Main Canal	DS Weir E	03 Mar 05	Largemouth Bass	Flesh	364
125235	Main Canal	DS Weir E	03 Mar 05	Channel Catfish	Flesh	536
125236	Main Canal	DS Weir E	03 Mar 05	Channel Catfish	Flesh	463
125237	Steele Bayou	HWY 1	03 Mar 05	Smallmouth Buffalo	Flesh	476
125238	Steele Bayou	HWY 1	03 Mar 05	Smallmouth Buffalo	Flesh	405
125239	Steele Bayou	HWY 1	03 Mar 05	Common Carp	Flesh	504
125240	Steele Bayou	HWY 1	03 Mar 05	Blue Catfish	Flesh	712
125241	Main Canal	US Weir E	03 Mar 05	Smallmouth Buffalo	Flesh	515
125242	Main Canal	US Weir E	03 Mar 05	White Crappie	Flesh	251
125243	Main Canal	US Weir E	03 Mar 05	Largemouth Bass	Flesh	320
125244	Main Canal	US Weir E	03 Mar 05	Common Carp	Flesh	466
125245	Main Canal	US Weir E	03 Mar 05	Bigmouth Buffalo	Flesh	430
125246	Main Canal	US Weir E	03 Mar 05	Smallmouth Buffalo	Flesh	505
125247	Main Canal	HWY 438 at WS	03 Mar 05	Common Carp	Flesh	600
125248	Main Canal	HWY 438 at WS	03 Mar 05	Channel Catfish	Flesh	512
125249	Black Bayou	US Weir HWY 12	03 Mar 05	Smallmouth Buffalo	Flesh	352
125269	Steele Bayou	US Structure 25m	08 Mar 05	Smallmouth Buffalo	Flesh	267
125270	Steele Bayou	US Structure 25m	08 Mar 05	Spotted Gar	Flesh	615
125271	Steele Bayou	US Structure 25m	08 Mar 05	Spotted Gar	Flesh	600
125272	Steele Bayou	US Structure 25m	08 Mar 05	Common Carp	Flesh	552
125273	Steele Bayou	US Structure 25m	08 Mar 05	Common Carp	Flesh	608
125274	Steele Bayou	US Structure 25m	08 Mar 05	Paddlefish	Flesh	882
125275	Steele Bayou	At Structure	08 Mar 05	Blue Catfish	Flesh	572
129080	Main Canal	Weir E	07 Oct 05	Smallmouth Buffalo	Flesh	455
129081	Main Canal	Weir E	07 Oct 05	Smallmouth Buffalo	Flesh	449
129082	Main Canal	Weir E	07 Oct 05	Smallmouth Buffalo	Flesh	390
129083	Main Canal	Weir E	07 Oct 05	Spotted Gar	Flesh	615
129084	Main Canal	Weir E	07 Oct 05	Smallmouth Buffalo	Flesh	449
129085	Main Canal	Weir E	07 Oct 05	Smallmouth Buffalo	Flesh	404
129086	Black Bayou	HWY 12	07 Oct 05	Common Carp	Flesh	417
129087	Black Bayou	HWY 12	07 Oct 05	Smallmouth Buffalo	Flesh	463
129088	Black Bayou	HWY 12	07 Oct 05	Smallmouth Buffalo	Flesh	478

TABLE 16-15 (Cont)

Sample ID	Waterbody	Site	Sampled Date	Species	Sample Type	Length (mm)
129089	Black Bayou	HWY 12	07 Oct 05	Smallmouth Buffalo	Flesh	423
129090	Black Bayou	HWY 12	07 Oct 05	Smallmouth Buffalo	Flesh	400
129091	Black Bayou	HWY 12	07 Oct 05	Smallmouth Buffalo	Flesh	429
129092	Black Bayou	HWY 12	07 Oct 05	Common Carp	Flesh	405
129093	Black Bayou	HWY 12	07 Oct 05	Common Carp	Flesh	486
129094	Black Bayou	HWY 12	07 Oct 05	Common Carp	Flesh	470
129095	Black Bayou	HWY 12	07 Oct 05	Common Carp	Flesh	378
129096	Muddy Bayou	At Structure	07 Oct 05	Smallmouth Buffalo	Flesh	378
129097	Muddy Bayou	At Structure	07 Oct 05	Smallmouth Buffalo	Flesh	418
129098	Muddy Bayou	At Structure	07 Oct 05	Smallmouth Buffalo	Flesh	415
129099	Muddy Bayou	At Structure	07 Oct 05	Smallmouth Buffalo	Flesh	450
129100	Muddy Bayou	At Structure	07 Oct 05	Common Carp	Flesh	553
129101	Muddy Bayou	At Structure	07 Oct 05	Channel Catfish	Flesh	545
129102	Muddy Bayou	At Structure	07 Oct 05	Channel Catfish	Flesh	497
129103	Muddy Bayou	At Structure	07 Oct 05	Spotted Gar	Flesh	697
129104	Muddy Bayou	At Structure	07 Oct 05	Spotted Gar	Flesh	680
129105	Muddy Bayou	At Structure	07 Oct 05	Spotted Gar	Flesh	650
129106	Muddy Bayou	At Structure	07 Oct 05	Spotted Gar	Flesh	678
129107	Steele Bayou	HWY 14	07 Oct 05	Common Carp	Flesh	443
129108	Steele Bayou	HWY 14	07 Oct 05	Smallmouth Buffalo	Flesh	426
129109	Steele Bayou	HWY 14	07 Oct 05	Smallmouth Buffalo	Flesh	465
129110	Steele Bayou	HWY 14	07 Oct 05	Smallmouth Buffalo	Flesh	440
129111	Steele Bayou	HWY 14	07 Oct 05	Spotted Gar	Flesh	604
129112	Steele Bayou	HWY 14	07 Oct 05	Flathead Catfish	Flesh	726
129113	Steele Bayou	HWY 14	07 Oct 05	Blue Catfish	Flesh	720
129114	Steele Bayou	HWY 14	07 Oct 05	Blue Catfish	Flesh	444

TABLE 16-16
MISSISSIPPI FISH ADVISORY CRITERIA
FOR DDT, TOXAPHENE, AND MERCURY

Consumption Advice	Fish Concentration of DDT (mg/kg)	Fish Concentration of Toxaphene (mg/kg)	Fish Concentration of Mercury (mg/kg)
No limit	< 1.0	< 0.4	<1.0
Two meals per month	1.0 to 5.9	0.4 to 1.9	1.0 to 1.4
No consumption	≥ 6.0	≥ 2.0	≥ 1.5
MDEQ, 2001			

85. Mercury is the only metal with a fish consumption advisory in Mississippi. None of the affected water bodies are within the Mississippi Delta, however. Under the advisory, consumption by pregnant women and young children is restricted to 2 fish per month when tissue concentrations exceed 1.0 mg/kg. Fish should not be eaten when tissue concentration exceeds 1.5 mg/kg (Table 16-16).

86. In 2001, EPA recommended a methyl mercury water quality criterion for the protection of human heath (EPA, 2001). The criterion, based on advances in the understanding of toxicology, bioaccumulation, and exposure, set the concentration of methyl mercury in fish tissue at 0.3 mg/kg. The criterion was issued as guidance, and states retained the right to adopt water quality standards within their boundaries. In 2006, EPA issued draft guidance to assist states in implementing the 2001 methyl mercury fish tissue criterion (EPA, 2006a).

87. The EPA has developed fish tissue screening values (SV) for certain contaminants based on risk-based methods to protect the health of fish and shellfish consumers (EPA, 2000b). The SV for ∑DDT is 0.117 mg/kg. This SV is based on the risk of one person in 100,000 contracting cancer from a lifetime of exposure. Exposure includes ingestion. Also, FDA has developed an action limit of 5.0 mg/kg for DDT and its metabolites. The FDA action limit was created to protect humans who consume fish from high levels of pesticides. This action limit is not meant to imply that fish with tissue levels less than the action limit are necessarily safe.

FISH TISSUE PESTICIDES

88. Table 16-17 lists the organochlorine pesticides with detectable concentrations found within the tissue of the fish collected by ERDC from the Big Sunflower River and Steele Bayou Basins between 1993 and 2005. The table lists the mean, minimum, and maximum concentrations for seven major fish groups. In general, average concentrations were higher in buffalo, shortnose gar, and paddlefish. Overall, chlordane was the only pesticide not detected. The pesticides DDD, DDE, and DDT were detected in more than 95 percent of the fish tissue samples (the DDE

TABLE 16-17
DETECTABLE FISH TISSUE PESTICIDE CONCENTRATIONS

Pesticide	Pesticide Concentration (μg/kg)						
	Blue Catfish	Buffalo	Channel Catfish	Flathead Catfish	Shortnose Gar	Paddlefish	White Crappie
Aldrin							
Mean	4.13	4.36	0.94			5.96	
Minimum		3.16					
Maximum		6.71					
Det / Obs	1/19	3/109	1/37	0/10	0/10	1/10	0/9
A-BHC							
Mean	8.14	10.4	4.08			1.52	
Minimum	6.96	6.48	3.17				
Maximum	9.40	16.1	5.55				
Det / Obs	4/19	3/109	6/37	0/10	0/10	1/10	0/9
B-BHC							
Mean	4.40	15.0	1.46	3.98		1.71	0.68
Minimum	0.85	0.80	0.92				
Maximum	7.94	82.0	1.90				
Det / Obs	2/19	6/109	3/37	1/10	0/10	1/10	1/9
G-BHC							
Mean	2.74	4.38	2.64	6.22	1.65		1.34
Minimum	0.91	1.10	1.70		1.10		
Maximum	5.97	6.42	3.27		2.20		
Det / Obs	4/19	8/109	6/37	1/10	2/10	0/10	1/9
D-BHC							
Mean	13.0	40.8	14.7	10.4			
Minimum	12.5	2.49	8.56				
Maximum	13.5	418	29.1				
Det / Obs	2/19	15/109	8/37	1/10	0/10	0/10	0/9
ppDDD							
Mean	134	195	100	199	1155	486	9.64
Minimum	2.61	0.50	1.68	3.06	291	16.2	0.52
Maximum	788	2910	356	580	3130	1390	53.8
Det / Obs	19/19	108/109	37/37	10/10	10/10	10/10	9/9
ppDDE							
Mean	422	715	375	689	2874	1063	30.1
Minimum	10.5	3.19	14.1	12.0	790	46.8	4.12
Maximum	1649	7830	1386	1705	7350	2280	144
Det / Obs	19/19	109/109	37/37	10/10	10/10	10/10	9/9
ppDDT							
Mean	45.6	127	51.4	69.2	389	122	4.28
Minimum	0.64	0.32	0.59	0.91	54.0	2.42	0.42
Maximum	205	1650	194	210	990.0	300	16.9
Det / Obs	19/19	107/109	37/37	10/10	10/10	10/10	9/9
∑DDT							
Mean	603	1033	527	957	4418	1671	44.0
Minimum	13.8	3.19	16.3	16.0	1410	67.4	5.06
Maximum	2534	12370	1751	2166	11130	3960	215
Det/Obs	19/19	109/109	37/37	10/10	10/10	10/10	9/9
Heptachlor							
Mean	10.3	3.86	2.39		4.35		
Minimum		0.42	0.84		4.10		
Maximum		9.20	3.78		4.60		
Det / Obs	1/19	15/109	6/37	0/10	2/10	0/10	0/9
Dieldrin							
Mean	14.9	27.9	7.30	24.8	30.40	43.2	
Minimum	3.57	4.33	2.08	6.79	18.00	3.58	
Maximum	28.5	140	24.90	36.6	50.00	92.0	
Det / Obs	6/19	23/109	10/37	4/10	5/10	10/10	0/9
EndosulfanI							
Mean		67.5	2.89				
Minimum		22.0	1.35				
Maximum		113	4.42				
Det / Obs	0/19	2/109	2/37	0/10	0/10	0/10	0/9

TABLE 16-17 (Cont)

Pesticide	Pesticide Concentration (μg/kg)						
	Blue Catfish	Buffalo	Channel Catfish	Flathead Catfish	Shortnose Gar	Paddlefish	White Crappie
EndosulfanII							
Mean	15.12	12.7	15.4	19.4	9.15		4.54
Minimum	2.87	0.99	3.61	0.76	5.30		
Maximum	22.2	42.0	64.4	41.5	13.0		
Det / Obs	3/19	35/109	17/37	3/10	2/10	0/10	1/9
EndosulfanSulfate							
Mean	1.7	4.54		12.6		0.73	0.65
Minimum		4.37					0.56
Maximum		4.70					0.72
Det / Obs	1/19	2/109	0/37	1/10	0/10	1/10	3/9
Endrin							
Mean		60.9					
Minimum		0.78					
Maximum		180					
Det / Obs	0/19	3/109	0/37	0/10	0/10	0/10	0/9
Endrin Aldehyde							
Mean	14.4	58.8		26.7	24.3	58.7	
Minimum	2.2	1.50		3.48	7.00	8.79	
Maximum	36.0	250.0		50.0	43.0	116	
Det / Obs	6/19	21/109	0/37	2/10	5/10	3/10	0/9
Heptachlor Epoxide							
Mean	3.99	8.60	6.91	0.68	1.24	34.0	1.43
Minimum	1.30	1.30	1.60		0.48		1.19
Maximum	9.27	13.7	32.8		2.00		1.70
Det / Obs	3/19	3/109	8/37	1/10	2/10	1/10	3/9
Methoxychlor							
Mean	31.2		19.1				5.47
Minimum							4.97
Maximum							5.96
Det / Obs	1/19	0/109	1/37	0/10	0/10	0/10	2/9
Toxaphene							
Mean	406	729	404	752	1980	2272	
Minimum	108	107	161	320	570	720	
Maximum	611	3800	845	1620	2920	4900	
Det / Obs	3/19	13/109	12/37	5/10	5/10	5/10	0/9

NOTE: Mean = mean of detectable concentrations
Minimum = minimum detectable concentration
Maximum = maximum detectable concentration
Det / Obs = number of fish with detectable concentrations / total number of sampled fish

values for the 1993 fish tissue were estimated values). Concentrations for ppDDE ranged from 3.19 to 7,830 µg/kg in buffalo, with the highest average concentration of 2,874 µg/kg found in a shortnose gar. Heptachlor epoxide, heptachlor, endrin aldehyde, G-BHC, and D-BHC were detected in 10 to 20 percent of the fish samples. Toxaphene was found in 25 percent of the samples, with concentrations ranging between 107 and 4,900 µg/kg with the highest concentrations found in a paddlefish. Dieldrin and endosulfan II were found in approximately 30 percent of the fish samples. The other organochlorine pesticides were found in less than 10 percent of the samples.

89. According to the Mississippi Fish Advisory Task Force criteria (Table 16-16), there are no consumption restrictions for fish with DDT concentrations less than 1.0 mg/kg. Fish with DDT concentrations between 1.0 and 5.9 mg/kg can be eaten at the rate of two meals per month. Fish with DDT concentrations greater than 6.0 mg/kg should not be eaten. The criteria for toxaphene are less than 0.4 mg/kg, 0.4 to 1.9 mg/kg, and greater than 2.0 mg/kg. The average and maximum concentrations for ∑DDT measured in fish collected in the YBWP Area since 1993 were 1.07 and 12.4 mg/kg. Seventy-three percent of the fish collected by ERDC had ∑DDT concentrations less than the 1.0 mg/kg consumption restriction for DDT. Only six (1 percent) of the fish had concentrations that exceeded 6.0 mg/kg. The average and maximum concentrations for toxaphene measured in the same fish were 0.83 and 4.90 mg/kg, respectively. Eighty-nine percent of these fish were less than the 0.4 mg/kg limit. Only six fish exceeded the 2.0 mg/kg nonconsumption limit. Clearly, the pooled data for fish collected in the YBWP Area show that the safe consumption concentrations for the organochlorine pesticides ∑DDT and toxaphene were occasionally exceeded.

90. Figures 16-2 and 16-3 are plots of ∑DDT detected in fish collected by ERDC between 2001 and 2005. In Figure 16-2, the Big Sunflower River had 28 fish collected in 2001. Ten fish (36 percent) had ∑DDT concentrations greater than the 1.0 mg/kg fish consumption lower advisory limit. In Figure 16-3, Steele Bayou had 151 fish collected in 2001 and 2005. The fish are grouped by year. Nineteen (23 percent) of the 82 fish collected in 2001 exceeded the 1.0 mg/kg fish consumption limit, while only 2 (3 percent) of the 69 fish collected in 2005 exceeded the limit. The average and maximum ∑DDT concentration for fish collected since 2001 was 0.53 and 5.8 µg/kg, respectively. None of these recent fish collected from the YBWP Area exceeded the upper advisory limit.

FISH TISSUE METALS

91. As mentioned earlier, fish tissue quality reflects sediment and water quality. Table 16-18 shows the mean, minimum, and maximum fish tissue priority pollutant metal concentrations observed in fish collected in the YBWP Area in 1993, 1994, and October 2005 (mercury only). Although some of the observed metals levels in the sediment samples were high, these concentrations have not led to high metals concentration in fish tissue. This is due to the fact

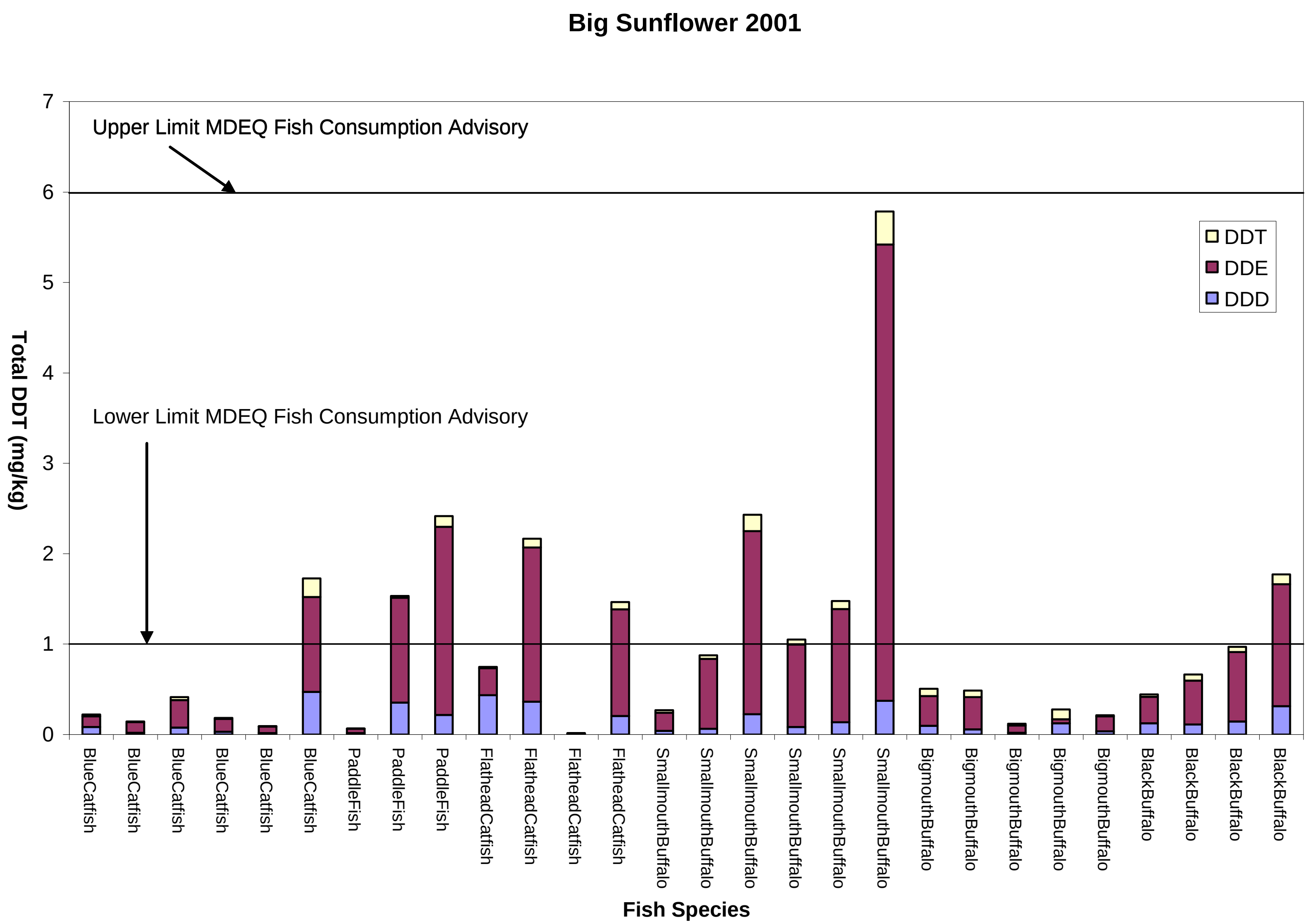


Figure 16-2. Big Sunflower Total DDT in fish tissue – 2001.

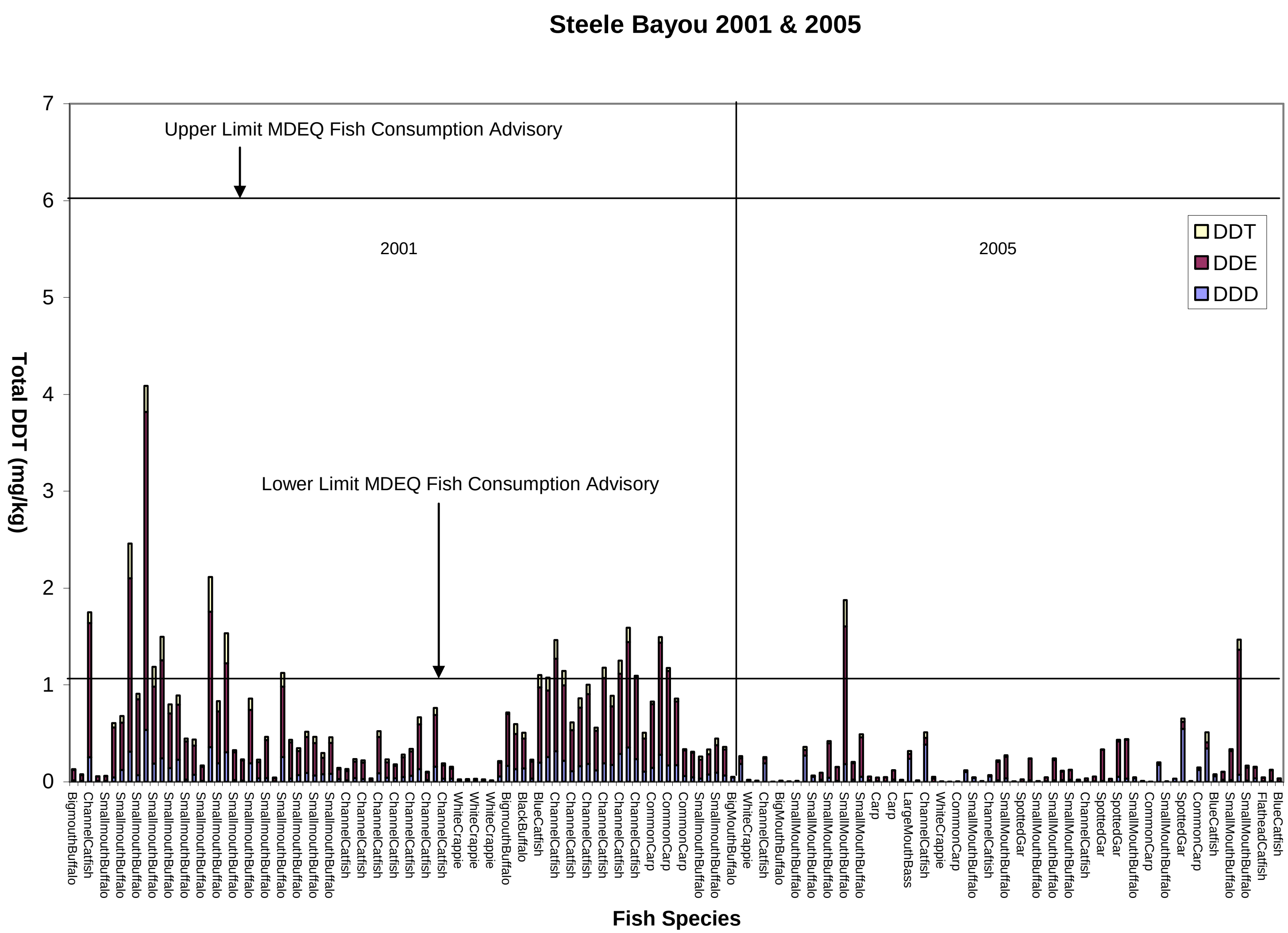


Figure 16-3. Steele Bayou Basin fish tissue Total DDT - 2001 and 2005.

TABLE 16-18
PRIORITY POLLUTANT METAL CONCENTRATIONS IN FISH TISSUE

	Metal (mg/kg)										
Fish	**AS**	**CD**	**CR**	**CU**	**PB**	**HG**	**NI**	**SE**	**ZN**	**FE**	**MN**
All Fish											
Mean	0.301	0.138	0.348	0.419	0.153	0.331	0.556	0.422	25.32	18.8	0.695
Minimum	0.031	0.02	0.1	0.1	0.1	0.023	0.1	0.18	4.4	3.15	0.1
Maximum	0.64	1.0	1.32	1.93	0.4	1.56	2.84	0.98	159.	106.	2.58
Det/Obs	9/49	37/49	8/49	40/49	11/49	86/86	30/49	46/49	49/49	46/49	32/49
Paddlefish											
Mean	0.344	0.290		0.394		0.091	0.138	0.404	25.52	7.796	0.115
Minimum	0.031	0.025		0.31		0.06	0.11	0.31	18.6	4.6	0.1
Maximum	0.64	0.44		0.64		0.173	0.16	0.56	40.6	16.3	0.13
Det/Obs	5/5	3/5	0/5	5/5	0/5	5/5	4/5	5/5	5/5	5/5	4/5
Flathead Catfish											
Mean		0.055	0.1	0.37		0.76	0.27	0.288	37.7	4.75	0.205
Minimum		0.026		0.33		0.332	0.12	0.21	19.9	3.15	0.11
Maximum		0.098		0.41		1.56	0.57	0.36	46.2	5.62	0.3
Det/Obs	0/5	5/5	1/5	5/5	0/5	6/6	5/5	4/5	5/5	4/5	2/5
Blue Catfish											
Mean		0.074	0.45	0.87		0.213	1.36	0.21	17.92	25.98	1.076
Minimum		0.029		0.29		0.060	0.1	0.18	7.09	12.2	0.585
Maximum		0.153		1.93		0.419	2.84	0.23	50.1	64.6	2.58
Det/Obs	0/5	5/5	1/5	4/5	0/5	7/7	4/5	3/5	5/5	5/5	5/5
Shortnose Gar											
Mean	0.253	0.202	0.488	0.419	0.215	0.495	0.441	0.294	25.69	40.68	0.861
Minimum	0.21	0.039	0.13	0.1	0.1	0.337	0.1	0.22	4.54	5.27	0.1
Maximum	0.3	0.929	1.32	0.67	0.4	0.858	0.97	0.45	86.3	106.	1.98
Det/Obs	3/10	7/10	4/10	9/10	4/10	10/10	7/10	10/10	10/10	10/10	10/10
Small Mouth Buffalo											
Mean		0.081	0.16	0.346	0.123	0.314	0.618	0.634	28.76	14.50	0.652
Minimum		0.02		0.1	0.1	0.091	0.1	0.26	4.4	6.84	0.15
Maximum		0.29		0.78	0.18	1.14	1.67	0.98	159.	34.5	1.36
Det/Obs	0/14	12/14	1/14	10/14	4/14	32/32	6/14	14/14	14/14	14/14	9/14
Big Mouth Buffalo											
Mean	0.23	0.24	0.12	0.316	0.11	0.489	0.635	0.38	17.55	8.7	0.75
Minimum		0.03		0.1	0.1	0.266	0.35	0.23	4.77	4.18	0.5
Maximum		1.0		0.45	0.13	0.918	1.39	0.61	32.5	17.5	1.
Det/Obs	1/10	5/10	1/10	7/10	3/10	10/10	4/10	10/10	10/10	8/10	2/10
FWS National Contaminant Study											
Mean	0.16	0.04		0.86	0.19	0.11		0.46	25.6		
Minimum	0.04	0.01		0.29	0.10	0.01		0.09	7.69		
Maximum	2.08	0.41		38.8	6.73	1.10		3.65	168		
EPA Safe Value for Human Consumption	3.0	10.0				0.3		50.0			
State of Mississippi Levels of Concern	1.0	1.0	1.0	5.0	1.0			1.0			

NOTE: Mean = mean of detectable concentrations
Minimum = minimum detectable concentration
Maximum = maximum detectable concentration
Det/Obs = number of fish with detectable concentrations/total number of sampled fish

that most metals in the sediments are not readily bioavailable. Thus, the sediment concentrations of metals are not a good indicator of fish tissue quality. For example, arsenic was detected in 94 percent of the sediment samples evaluated, but was only detected in nine (18 percent) of the fish samples. On the other hand, mercury was detected in 70 percent of the sediment samples and 100 percent of the fish samples. In fish tissue, mercury concentrations ranged from 0.02 to 1.56 mg/kg with a mean of 0.33 mg/kg. Three of the fish contained mercury levels that exceeded the restricted consumption level of 1,000 µg/kg used by the state. Other metals were also detected in the fish samples. Chromium was detected in eight of the 49 fish, lead in 11, nickel in 30, manganese in 32, cadmium in 37, copper in 40, iron and selenium in 46, and zinc in all 49. The fish tissue samples were also analyzed for barium and cobalt, but neither of these two metals was detected.

92. The State of Mississippi has established “levels of concern” for six trace metals. These levels of concern are not regulatory levels, and there are no known health risks associated with them. They are simply levels that were selected for use in screening the data and for regional comparison of data. The levels of concern are 1.0 mg/kg each for arsenic, lead, selenium, cadmium, and chromium and 5.0 mg/kg for copper. None of the fish tissue samples collected from the YBWP Area had concentrations that equaled or exceeded the state levels of concern for arsenic, copper, lead, or selenium. Cadmium and chromium each had one sample at or above the 1.0 mg/kg level of concern. Both fish were collected in the Big Sunflower River. The buffalo was collected in 1993. The gar was collected in 1994. No fish have been tested for metals other than mercury since 1994.

93. According to the Mississippi Fish Advisory Task Force criteria (Table 16-16), there are no consumption restrictions for fish with mercury concentrations less than 1.0 mg/kg. Fish with mercury concentrations between 1.0 and 1.4 mg/kg can be eaten at the rate of two meals per month. Fish with mercury concentrations greater than 1.5 mg/kg should not be eaten. The mean and maximum concentrations for mercury measured in fish collected by ERDC in the YBWP Area were 0.33 and 1.56 mg/kg, respectively. The mean and maximum mercury concentrations for the 2005 fish were 0.21 and 1.1 mg/kg, respectively. Two of the fish with tissue concentrations greater than 1.0 mg/kg were collected in the Big Sunflower River Basin in 1994. Only one of these had a tissue concentration greater than 1.5 mg/kg, the no consumption limit for mercury. The third fish was collected in Steele Bayou in 2005.

TRENDS IN ∑DDT CONCENTRATIONS

94. DDT has been used in the Mississippi Delta since the 1940s and was used heavily in the late 1960s and early 1970s until its ban in 1972. Organochlorine pesticides like DDT are hydrophobic and are more likely to be found in sediment or in fatty portions of fish than in water. Clarke and McFarland (1991) developed a procedure using sediment pesticides concentrations to assess the bioaccumulation potential of DDT in fish tissue. Using these methods, it can be predicted that if sediment concentrations decrease, so will concentrations in fish. In fact, the U.S. Fish and Wildlife Service (FWS) National Contaminant Biomonitoring Program showed a marked decline in the national average DDT levels in freshwater fish collected between 1970 and 1984 subsequent to the ban of DDT (EPA, 2003).

95. More recently, studies by the Vicksburg District have demonstrated that the removal of sediment containing DDT has led to a reduction in the concentration in fish tissue. The Upper Steele Bayou Project, which began in 1992 (USACE, 1992), consisted of channel cleanout and enlargement and use of structural BMP to control soil runoff. In addition to USACE efforts, local farmers in the watershed have incorporated BMPs into their farming practices to control drainage and runoff. Summary statistics comparing pre- and postproject sediment pesticides concentrations for two streams in the Upper Steele Bayou are presented as box and whisker plots in Figure 16-4. Box plots show the 25th, median (solid line), mean (dotted line), and 75th percentiles. Whiskers show the 10th and 90th percentiles. Outlying data are represented by circles. These data show that both the mean concentration and the range of data were higher in the preproject sediments in both streams. A t-test comparison of the ∑DDT sediment concentrations for Black Bayou and Main Canal show that the differences between the pre- and postproject means are significant (Black Bayou, $P = 0.027$; Main Canal, $P = 0.006$).

96. This decrease in sediment pesticides concentration was also reflected in fish tissue concentrations. Figure 16-5 compares the ∑DDT concentrations in catfish and buffalo species collected from the Steele Bayou Basin pre- and postproject. Fish collected postproject in 2000, 2001, and 2005 show a 90 percent decrease in ∑DDT concentrations compared to fish collected by other agencies before 1990. A one-way analysis of variance (ANOVA) for unbalanced data and Duncan's Multiple Range test (Statistical Analysis System Software (SAS)) showed that the differences between pre- and postproject data for both catfish and buffalo were significant ($Pr>F = <0.0001$). These data show that removal of pesticides from the aquatic environment will reduce pesticide fish tissue concentrations. Comparing the postproject Steele Bayou data to MDEQ fish advisory criteria in Table 16-16, the mean and maximum fish concentrations were 0.43 and 4.1 mg/kg ∑DDT and 0.30 and 0.84 mg/kg toxaphene. According to these data, none of the fish had concentrations that would place them in the "no consumption" category.

SUMMARY OF CURRENT CONDITIONS WITHIN THE YBWP AREA

97. The data collected from the YBWP Area show that rivers and streams are impacted by agricultural activities. This is reflected in the number of impaired waters found within the project area. Concentrations of many parameters such as DO, nutrients, and suspended solids vary with season. Concentrations of nitrate and TP were found at levels indicating anthropogenic influences. Although YBWP Area sediments are still impacted by legacy organochlorine pesticides that were applied to project area fields more than 30 years ago, current-use pesticides for cotton, corn, soybeans, and rice are found most often in the surface waters. Both water and sediment samples have many parameters that occasionally exceed their MDEQ and EPA recommended criteria. For example, DO and water temperatures were often outside the recommended ranges during the late summer months, and concentrations of ammonia

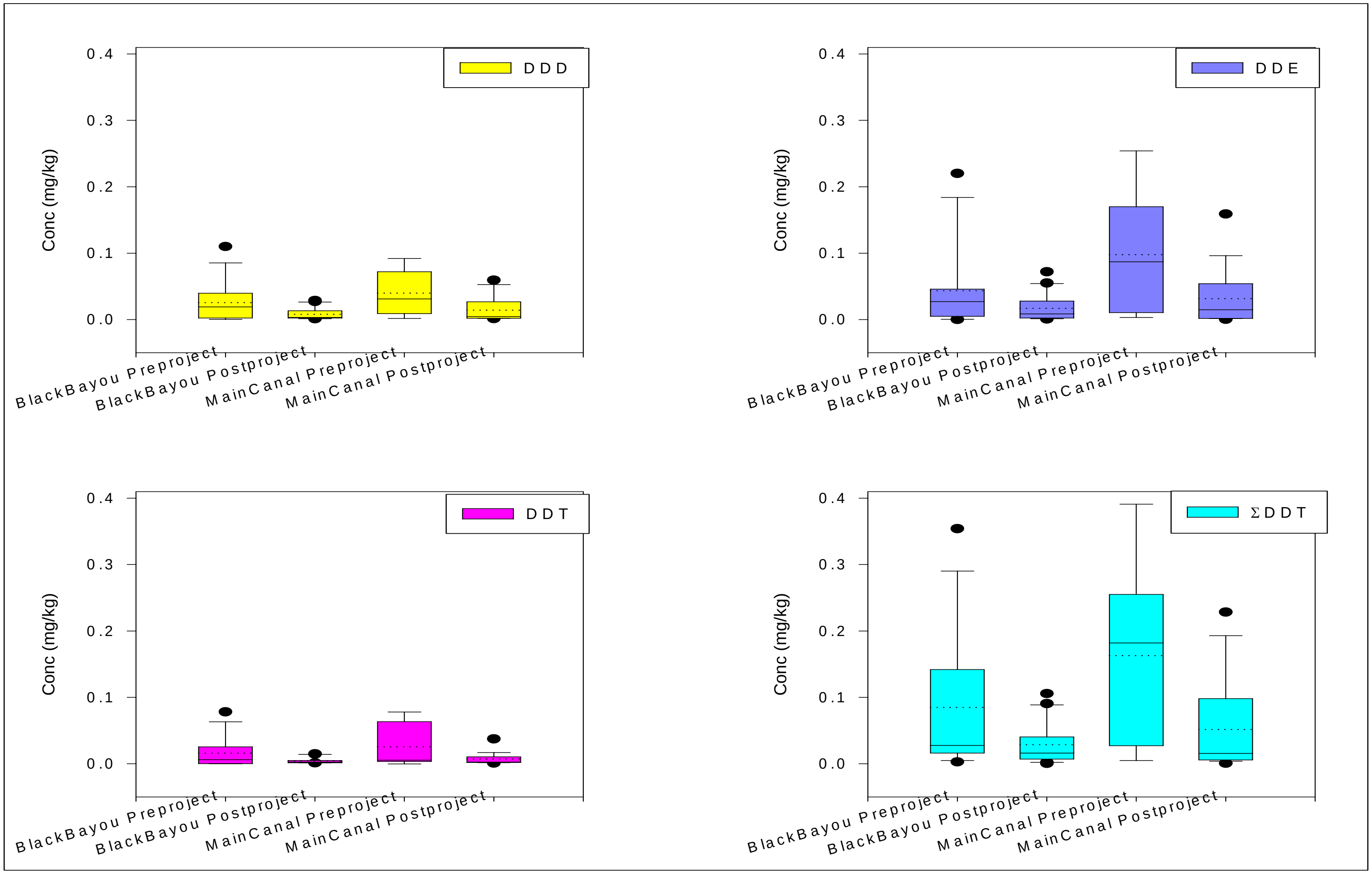


Figure 16-4. Comparison of pre- and post-project DDT sediment concentrations from upper Steele Bayou. Mean concentrations are represented by the dotted lines. Box plots represent the 25th and 75th percentiles. Whiskers represent the 10th and 90th percentiles. Circles are data outside the 10th and 90th percentiles.

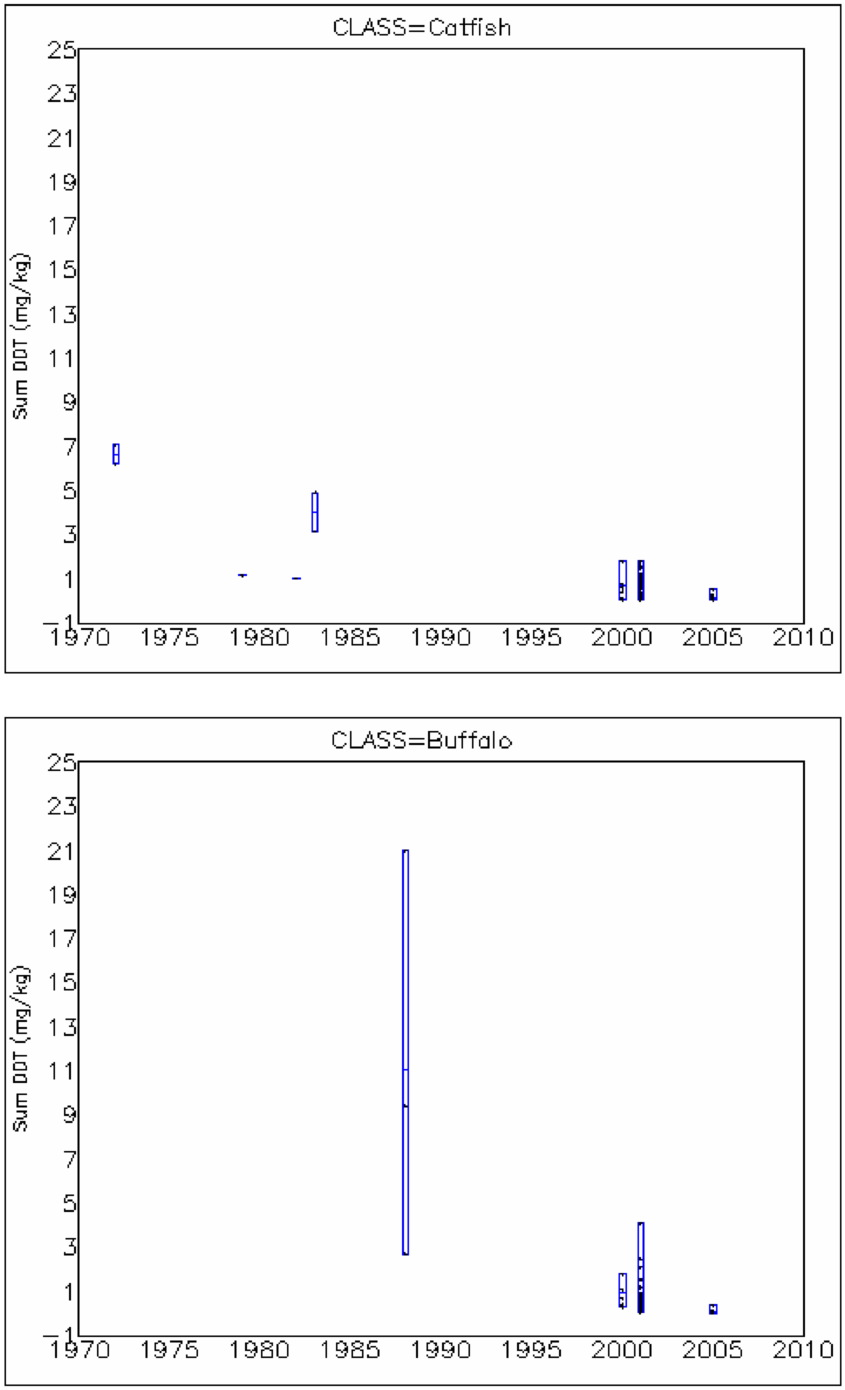


Figure 16-5. Catfish and buffalo collected in Steele Bayou pre- and post-project show a decrease in Total DDT (∑DDT) concentrations after channel cleanout.

occasionally exceeded recommended EPA criteria. Highest concentrations for conductivity, TKN and ammonia were measured in upper Steele Bayou in the early 1990s from areas with rice and catfish pond discharges. Four priority pollutant metals had concentrations that occasionally exceeded their MDEQ freshwater criteria, but 98 percent of the metals sediment samples were below the concentration that would classify them as likely causes of harmful biological effects to aquatic organisms. DDT and a few other organochlorine pesticides are in high enough concentrations in the sediment to be found in trace amounts in the water column; concentrations in 78 percent of the sediment samples, however, were too low to be classified as likely causes of harmful biological effects to aquatic organisms based on comparisons to their respective PECs.

98. Biotoxicity studies using Big Sunflower River Basin sediments show that these sediments were not toxic to the freshwater aquatic organisms tested. Bioaccumulation studies also showed that the final observed DDX concentrations in the test organisms were considerably lower than the corresponding lethal residue concentration that would cause 50 percent mortality in the test organisms (LR_{50}). The concentration of ∑DDT that would cause 50 percent mortality was higher than the highest ∑DDT concentration in the test sediments and in the samples collected from the YBWP Area.

99. The Mississippi Delta is currently under a fish consumption advisory for DDT and toxaphene in large fish of certain species. Pesticide data from fish tissue collected in the Steele Bayou Basin suggest that the average fish tissue ∑DDT concentrations may be decreasing. Overall for the YBWP Area, 73 percent of the fish had ∑DDT concentrations less than 1.0 mg/kg and could be eaten without restriction. Only 1 percent of the fish exceeded the 6.0 mg/kg no consumption limit. For toxaphene, 89 percent were less than the 0.4 mg/kg limit and could be eaten without restriction. Only 3 percent were greater than the 2.0 mg/kg no consumption limit.

PROJECT ALTERNATIVES

100. A complete description of the project alternatives is given in Volume 1 - Main Report of the Yazoo Backwater Area Reformulation Report SEIS. The alternatives are summarized briefly here for discussion purposes. The impact on each alternative will be addressed in the discussion of project impact on impaired waters, including those with TMDL.

a. Plan 1. No action.

b. Plan 2 – Nonstructural Plan. No pump with perpetual conservation easements and reforestation on up to 124,400 acres of agricultural lands obtained from willing sellers. Plan 2 also includes acquisition of perpetual flowage easements on up to 197,600 acres of agricultural land between 91.0 and 100.3 feet, NGVD, and modified operation of the Steele Bayou structure to maintain water levels between 70.0 and 73.0 feet, NGVD, during low-water periods.

c. Plan 2A – Nonstructural Plan. No pump with perpetual conservation easements and reforestation on up to 81,400 acres of agricultural lands obtained from willing sellers. Buildings in the 100-year flood plain would be flood proofed. An income assurance program would be established for cropland above 88.5 feet, NGVD.

d. Plan 2B – Nonstructural Plan with Structural Component. No pump with perpetual conservation easements and reforestation on up to 26,400 acres of agricultural land obtained from willing sellers. Fourteen ring levees would be constructed to provide 100-year flood protection to 88 percent of existing structures. This plan includes pumps to evacuate precipitation from inside the ring levees and replacement of septic tanks with wastewater treatment facilities for each structure within the ring levees.

e. Plan 2C – Nonstructural Plan. No pump with perpetual conservation easements and reforestation on up to 114,400 acres of agricultural land obtained from willing sellers. An income assurance program would be established for all remaining cropland in the 100-year flood plain. All structures within the 100-year flood plain would be relocated.

f. Plan 3. A 14,000-cubic-foot-per-second (cfs) pump station with a pump operation elevation of 80.0 feet, NGVD (1 March – 31 October), at the Steele Bayou structure and 85.0 feet, NGVD (1 November – 28 February), at the Steele Bayou structure; acquisition and reforestation of open land for compensatory mitigation; and modified operation of the Steele Bayou structure to maintain water levels between 70.0 and 73.0 feet, NGVD, during low-water periods.

g. Plan 4. A 14,000-cfs pump station with a year-round pump operation elevation of 85.0 feet, NGVD, at the Steele Bayou structure; perpetual conservation easements and reforestation/conservation measures on up to 37,200 acres of agricultural land obtained from willing sellers; and modified operation of the Steele Bayou structure to maintain water levels between 70.0 and 73.0 feet, NGVD, during low-water periods.

h. Plan 5 (the recommended plan). A 14,000-cfs pump station with a year-round pump operation elevation of 87.0 feet, NGVD, at the Steele Bayou structure; perpetual conservation easements and reforestation/conservation measures on up to 55,600 acres of agricultural land obtained from willing sellers; and modified operation of the Steele Bayou structure to maintain water levels between 70.0 and 73.0 feet, NGVD, during low water periods.

i. Plan 6. A 14,000-cfs pump station with a year-round pump operation elevation of 88.5 feet, NGVD, at the Steele Bayou structure; perpetual conservation easements and reforestation/conservation measures on up to 81,400 acres of agricultural land obtained from willing sellers; operation of the Steele Bayou structure to maintain water levels between 70.0 and 73.0 feet, NGVD, during low-water periods; and reintroduced flows from the Mississippi River up to a maximum elevation of 87.0 feet, NGVD, at the Steele Bayou structure.

j. Plan 7. A 14,000-cfs pump station with a year-round pump operation elevation of 91.0 feet, NGVD, at the Steele Bayou structure; perpetual conservation easements and reforestation/conservation measures on up to 124,400 acres of agricultural land obtained from willing sellers; perpetual conservation easements on 81,800 acres of existing forests below the 91.0-foot, NGVD, elevation; operation of the Steele Bayou structure to maintain water levels between 70.0 and 73.0 feet, NGVD, during low-water periods; and reintroduced flows from the Mississippi River up to a maximum elevation of 87.0 feet, NGVD, at the Steele Bayou structure.

101. For each of the project alternatives with a reforestation feature, up to 10 percent of the agricultural lands targeted for reforestation could be set aside by landowners for alternative conservation practices such as food plots for wildlife or moist soil management areas such as seasonally flooded impoundments. The Vicksburg District will provide landowners with materials to construct water control structures (slotted board riser) on up to 5 percent of these targeted lands. For Plan 5 with up to 55,600 acres targeted reforestation, up to 5,560 acres could be set aside for alternative conservation management practices. Of these 5,560 acres, the Vicksburg District would provide landowners with construction materials to manage up to 2,780 acres as moist soil areas.

PROJECT IMPACTS

102. The final array of project alternatives was summarized in the previous section. Impacts to water quality for the recommended plan (Plan 5) may result from direct impacts from construction at the pump site, direct hydrologic impacts from operating the pump (structural), direct and indirect impacts from the nonstructural reforestation component, and indirect impacts from the operational component (increasing the water surface elevation behind the Steele Bayou structure each year).

103. Construction for the Yazoo Backwater Area Reformulation Project will focus at the site selected for the pump station. When in operation, the pumping station will discharge floodwaters from the YBWP Area into the lower Yazoo River near the Steele Bayou Structure. The recommended plan will reduce the extent of backwater flooding by lowering the elevation of the 100-year flood by approximately 5 feet at the Steele Bayou Structure, but will not affect the most frequently flooded wetlands (1-year frequency). The recommended plan also includes a modification of the operation of the Steele Bayou Structure to increase minimum summer water elevations each year by up to 3 feet. Increasing summer water depth will increase streambank wetted surface area several miles upstream of the Steele Bayou structure. Increased water surface area along streambanks will expand foraging and rearing opportunities for many species of fish. The littoral area will become more structurally diverse, and streams will have greater connectivity with the riparian zone (personal communication, August 3, 2006, Dr. Jack Killgore, ERDC, Vicksburg, Mississippi).

104. When operational, the Yazoo Backwater pumps will transfer floodwaters from the ponding areas inside the backwater levees to the Yazoo River during those periods when the Steele Bayou structure has been closed to prevent the Mississippi River backwater from entering the lower delta. After construction, the lower Yazoo River will be the receiving water for backwater floodwaters just as it is preproject. In operation, the same volume of water will be delivered to the Yazoo River, only the timing of floodwater discharge will be changed. According to EPA, natural stream drainages are not considered point source discharges (EPA, 2005a). Controversy arises over water transfers between two separate basins (interbasin transfer) and over addition of pollutants during or because of the transfer process. The Yazoo Backwater project cannot be considered interbasin transfer nor will the pumping process add pollutants to existing flood waters ponded behind the Steele Bayou structure. For these reasons, the Yazoo Backwater Project will not require a National Pollutant Discharge Elimination System (NPDES) point source permit for floodwater discharge.

105. The Vicksburg District does not expect any other operations at the completed pump station site to require NPDES permits. Wastewater will be treated onsite. The fuel storage area will comply with EPA 40 §CFR 112 and have a Spill Protection and Countermeasure Plan (SPCC) and the required containment. During operation, the pump engines and speed reducers will be cooled by four cooling water pumps. Under full load, three cooling water pumps will be required. The fourth pump serves as a backup. Cooling water will be taken from the floodwater and discharged into the Yazoo Backwater pump discharge. It is expected that the maximum increase in water temperature at the discharge point will be 0.05 degree F. The average and maximum water temperatures measured in the lower Steele Bayou pool between January and June are 66 and 86 degrees F. The Vicksburg District does not believe that a 0.05 degree F increase in water temperature will cause an increase in ambient water temperatures within the outlet channel or at its confluence with the Yazoo River.

IMPACTS FROM CONSTRUCTION

106. The construction site for the proposed Yazoo Backwater pumping plant lies to the west of the Steele Bayou structure and covers approximately 215.2 acres excluding the existing levee, cofferdam, and Highway 465. The area includes 98.1 acres of wetland pasture, 20.4 acres of scrub-shrub wetlands, 39.2 acres of open water, and 57.5 acres of nonwetlands. The inlet and outlet channels were constructed in 1987, but were never connected to Steele Bayou or the Yazoo River. These two channels, 34.5 acres of open water, will be temporarily drained (unwatered) to complete construction. Once completed, the inlet channel will provide 30.8 acres of permanent open water behind the Yazoo Backwater pump station. The outlet channel will provide up to 19.2 acres of additional open water that fluctuate with the water level of the Yazoo River. Project construction will permanently convert approximately 5.6 acres of open water at

the construction site to other uses. This includes up to 0.9 acre of Cypress Lake, located adjacent to Highway 465. The remaining 4.7 acres of open water are in low areas left during construction of the cofferdam in 1987. These shallow ponds are seasonal and are sustained by precipitation. The project will also convert approximately 38 acres of forested wetlands to other uses. All impacts of clearing the site in 1986 have been included in the mitigation analysis (Appendix 1). Impacts of conversion of the 5.6 acres of water and 38 acres of forested wetlands are accounted for in the appropriate environmental analyses.

107. Possible impacts to water quality from construction at the pump station site could result from unwatering and completion of the inlet and outlet channels and from dewatering and soil disturbance during construction. Unwatering (draining) the inlet and outlet channels during construction could potentially introduce turbid water into Steele Bayou and the Yazoo River, particularly when water levels in the two channels approach the channel bottom surface elevations. Increases in turbidity would depend upon the time of year and the ambient concentrations in each of the receiving water bodies. Increases in turbidity would be temporary and would return to ambient conditions once unwatering is complete. Postproject, these two channels will be the only locations that will have periodic dredging to maintain channel depth. The greatest potential for increased turbidity would occur when the channels are connected and during periodic channel maintenance; however, these impacts would be localized and short term. Because these channels were never connected to Steele Bayou or the Yazoo River, the probability of existing sediment having appreciable concentrations of pesticides or metals is low. Concentrations in future sediment dredged from the channels could be higher, however, as sediments from areas adjacent to agricultural fields move downstream and settle in the channels. During periodic maintenance, dredged material will be deposited onsite in borrow/disposal areas and will be removed from the aquatic system. Dewatering was discussed in the Engineering Appendix (Appendix 6). During construction, the pump station site will be dewatered to a depth 5 feet below the deepest excavation depth. A well field will be designed to achieve this purpose. Ground water will be discharged into Steele Bayou or the Yazoo River. There is also the potential for increases in turbidity and suspended solids due to stormwater runoff at the construction site. For this project, most of the cleared lands will be isolated from neighboring water bodies by dikes and existing levees. The impacts will be further minimized by the application of BMPs for nonpoint source pollution prevention at the construction site. These nonpoint source control measures include silt screens, buffer zones, and containment dikes. A Stormwater Prevention Plan will be developed for each construction item as required under the State of Mississippi's Storm Water Construction General Permit. This plan will outline the steps that will be utilized to reduce nonpoint source runoff from the construction site and thereby minimize the direct impacts to water quality. Any impacts to water quality at the construction site will be short term, lasting until construction is complete and disturbed areas are revegetated.

IMPACTS FROM REDUCED FLOOD ELEVATIONS

108. The hydrological analysis of backwater floods between 1943 and 1997 (Figure 16-6a) shows the number of days pumped each year had the Yazoo Backwater recommended plan been operational. For the period of record (POR), the pumps would have operated 42 of the 55 years

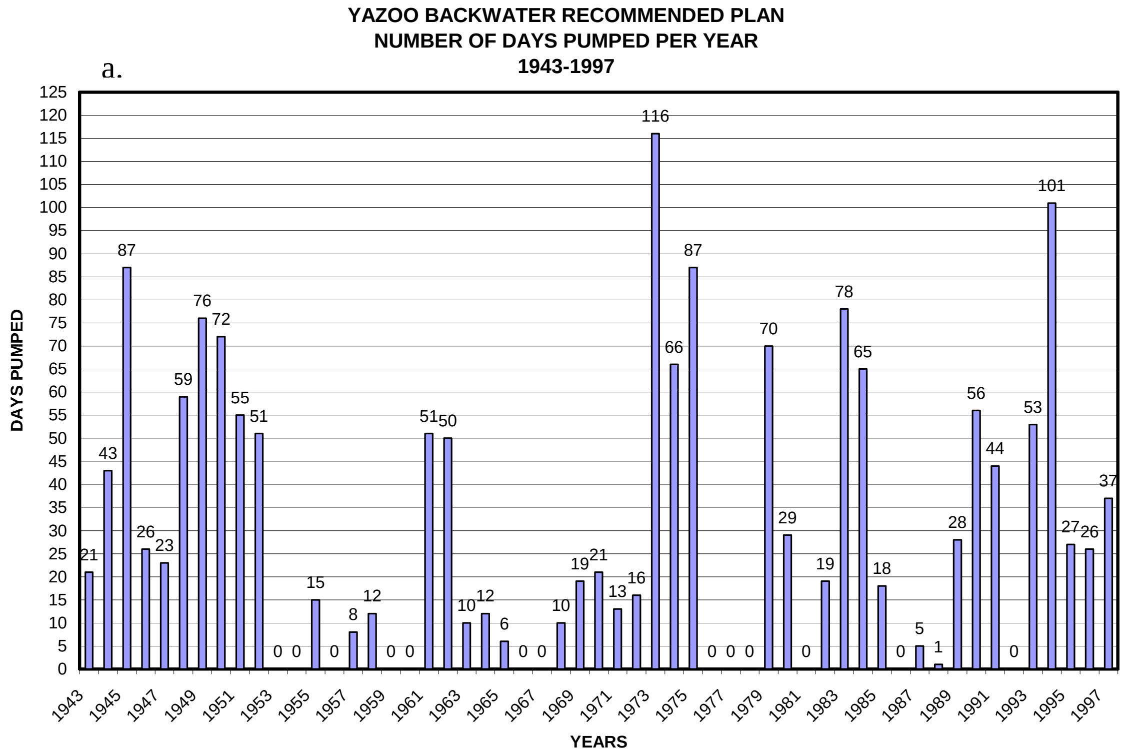
or 76.4 percent of the POR. Several years had more than one period of flooding per year with water surface elevations higher than the average pump-on elevation of 87.5 feet, NGVD, at the Steele Bayou structure. Based on the POR evaluation, the average pump-off elevation would have been 88.4 feet, NGVD. Figure 16-6b shows the frequency of pump operation by month based on the POR. Eighty-two percent of POR pump operation would have been between February and May.

109. Reducing flood elevations in the Yazoo Backwater study area could reduce the value of wetland functions associated with water quality. Reducing flood elevations could also affect ground-water recharge, alter the rate at which suspended sediment and pollutants are removed from study area waters, and cause changes in the way land is used within the study area. The following sections will discuss each of these possible impacts.

<u>Loss of Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area</u>

110. Assessment of the Yazoo Backwater wetland functions is discussed in detail in Appendix 10, the Wetlands Appendix to the Yazoo Backwater Reformulation SEIS, and in Smith and Lin (2007), a hydrogeomorphic (HGM) assessment of wetland functions specific to the YBWP. An HGM assessment is a representation of functions performed by a wetland ecosystem. The assessment is made by defining the relationship between characteristics and processes of the wetland and translating them into functional assessment values. The HGM assessment for the YBWP utilized eight functions to determine project impacts to the wetlands (Smith and Klimas, 2002; and Smith and Lin, 2007). Three of these functions can be directly associated with water quality--the Export of Organic Carbon and the Physical and Biological Removal of Elements and Compounds (E/C). The Export of Organic Carbon function is defined as the capacity of a wetland to export dissolved and particulate organic carbon, which is vitally important as food and energy resources for downstream aquatic systems. Removal of E/C is defined as the ability of the wetland to permanently remove or temporarily immobilize nutrients, metals, and other elements and compounds that are imported to the wetland via flooding. The Physical Removal of the E/C Function addresses those elements and compounds that are primarily removed by the physical process of settling. This includes phosphorus and other elements and compounds adsorbed to soil particles such as metals and legacy pesticides. The Biological Removal of the E/C Function addresses compounds such as nitrogen and pesticides that can be removed by biological processes such as microbial degradation or uptake by plants.

111. The HGM assessment utilizes the concept of wetland functional capacity units (FCU) to measure changes in wetland functionality. The FCU is the product of the functional capacity index (FCI) and the number of acres impacted. Smith and Lin (2007) calculated the total FCU that would result from changing the extent and duration of backwater flooding for each of the project alternatives. These data are presented in Table 16-19. Additionally, the individual FCU



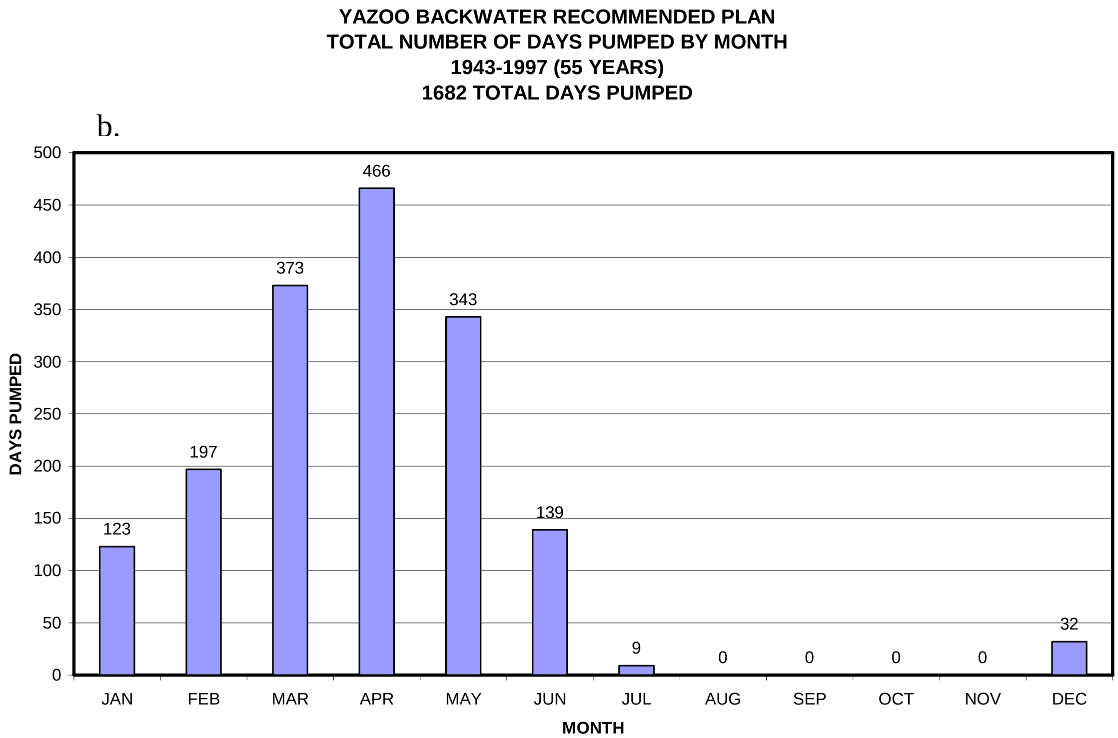


Figure 16-6. Yazoo Backwater Recommended Plan Frequency of Period-of-Record Pump Operation.

were calculated for each of the three water quality functions discussed in the previous paragraphs. These data are also presented in Table 16-19. The FCU data show that the nonstructural alternative, Plan 2B, and all of the structural alternatives would diminish wetland functional capacity within the Yazoo Backwater study area to some extent. An analysis of the water quality wetland functions shows that most of the losses in total wetland function were attributed to losses of the three water quality wetland functions. The discussion on reforestation will show that these wetland FCU losses are offset by reforestation of frequently flooded agricultural land.

TABLE 16-19
ESTIMATES OF ANNUAL CHANGES IN WETLAND
WATER QUALITY FCU DUE TO CHANGES IN HYDROLOGY a/

Project Alternative	Total FCU[b/]	Water Quality FCU			
		Total Water Quality FCU	Export of Organic Carbon FCU	Physical Removal of E/C FCU	Biological Removal of E/C FCU
Plan 2	0	0	0	0	0
Plan 2A	0	0	0	0	0
Plan 2B	-50,869	-48,268	-16,075	-16,118	-16,075
Plan 2C	0	0	0	0	0
Plan 3	-43,990	-41,706	-14,177	-13,352	-14,177
Plan 4	-28,132	-26,710	-8,971	-8,768	-8,971
Plan 5	-14,188	-13,513	-4,442	-4,629	4,442
Plan 6	-9,300	-8,860	-2,911	-3,038	-2,911
Plan 7	-3,949	-3,777	-1,207	-1,363	-1,207

a/ HGM analysis assumed all targeted acreage would be reforested.
b/ From Table 80 (Smith and Lin., 2007).

Ground-Water – Surface-Water Interactions

112. The Mississippi River Valley alluvium beneath the Delta consists of Quaternary-aged beds of sand, gravel, and clay consistent with alluvial deposits. The water-bearing sand and gravel strata in the alluvium comprise the Mississippi River Valley Alluvial Aquifer (USACE, 1993). Wells tapping this aquifer typically are drilled to depths ranging between 80 and 120 feet. Overlying the saturated zone of the aquifer is a clay cap that averages approximately 20 feet thick across the Delta. This cap serves as a confining layer for the shallow aquifer and has helped protect it from agricultural chemicals widely used in the area. Recharge for the aquifer is not completely understood. Some recharge occurs when the Mississippi River and certain Delta streams reach high stages. However, this flow regime may naturally reverse during the drier summer and fall months. On the eastern boundary, the water-bearing units underlying the

western edge of the Bluff Hills are a major recharge source for the aquifer (Arthur, 2001). The Mississippi River is incised into the aquifer and forms its western boundary. Because the Mississippi River seasonally recharges and drains the aquifer depending on river stage, it is not a major recharge source. Locally, the unregulated, incised streams within the Delta are important recharge sources, especially near the heavy withdrawal areas in the central part of the Delta (Arthur, 2001).

113. Extensive use of ground water for irrigation and aquaculture has caused the water level to steadily decline in some areas. These declines have resulted in dramatic decreases in the base flow contribution to some Delta streams (MDEQ, 1998). Because of these declines in ground-water level, concern has been expressed about project impacts to the water quality and quantity of the Mississippi River Valley Alluvial Aquifer. The concern is whether decreasing flood stages during high water periods might influence ground-water levels in the Mississippi River Alluvial Aquifer by affecting soil permeabilities. A secondary concern is whether agricultural chemicals carried in the floodwaters might be migrating into the aquifer. This section will discuss project area geology and its affect on percolation rates. It will also summarize the findings of the state's agricultural chemical ground-water monitoring studies.

114. The YBWP area covers a significant portion of the lower Yazoo River Basin within the Delta. Numerous reports have been written describing the general geology and ground water conditions (Frisk, 1944; Smith, 1979; Lamonds and Kernodle, 1984; USACE, 1993; Saucier, 1994; O'Hara, 1996; Arthur, 2001; and Cooper et al., 2003). The Mississippi River Valley alluvium, deposited by the meandering ancestral Mississippi River, consists predominantly of sand, silt, clay and gravel that have been reworked into distinctive top-stratum landforms that have been mapped in considerable detail (Smith, 1979 and Saucier, 1994). These landform types are characterized as abandoned course, abandoned channel, point bar, backswamp, and natural levee deposition and are described briefly below (Smith and Klimas, 2002).

115. Point bar deposits generally consist of relatively coarse-grained materials such as silts and sands that were deposited on the inside bend of a migrating stream. Point bar topography consists of alternating low ridges and swales that may be filled with fine-grained deposition.

116. Abandoned courses are channel segments left behind when a stream diverts flow to a new meander belt. Within the Yazoo Backwater, portions of many smaller streams now flow within abandoned courses of the Mississippi River. If the course is abandoned gradually, the remnant streams can remain continuous with the original point bar deposits rather than fill in with fine-grained clays.

117. Abandoned channels are the result of cutoffs where a stream abandons a channel segment either because flood flows have scoured out a point bar swale and created a new main channel, or because migrating bendways intersect and channel flow diverts through the intersection. Abandon channels can fill in to form depressions or the upper and lower ends can fill in to form an oxbow lake. Remnant channel connections between the lake and the river at high stages allow fine-grained sediments to gradually fill in the abandoned channel until the river meanders away.

118. Natural levees form where overbank flows result in the deposition of relatively coarse sediments adjacent to the stream channel. The material is deposited in a continuous sheet that thins with distance from the stream. The result can be a relatively high ridge along the bank and a gradual back slope that becomes progressively more fine-grained with distance from the channel.

119. Backswamps are flat, poorly-drained areas bounded by uplands and other features such as natural levees. Surface deposits are fine-grained sediments that were slowly deposited in slack-water conditions. Under unmodified conditions, backswamps characteristically have substrates of clay and are incompletely drained by small streams. They may include large areas that never fully drain and remain ponded well into the growing season.

120. Whether or not a stream or geographic location within the YBWP has connectivity with the subsurface alluvial aquifer and can move water and pollutants into ground water depends upon the top-stratum landform - its permeability and thickness. Point bar and locally abandoned course deposits (if enough sand is present) are more permeable than the finer grained abandoned channel and backswamp deposits. In fact, the finer grained deposits usually serve as barriers to ground water movement (USACE, 1993).

121. O'Hara (1996) evaluated the various regions of the state for local ground water susceptibility to contamination. Soil permeability was one of the factors used to estimate the relative ease with which pollutants might reach the saturated zone. According to O'Hara, most of the Yazoo Backwater Area has a soil permeability of less than 0.1 inch per hour. Soil permeability was higher, between 0.1 and 0.5 inch per hour, along the Big Sunflower River and Deer Creek channels.

122. Smith's geological investigation of the Yazoo Basin (1979) shows the various strata and relative depth based on core transects. Most of the Big Sunflower River channel in the project area is in abandoned course or abandoned channel deposits. Sediment core data show that most of the Big Sunflower River channel consists of fine-grained silt and clay deposits. The exceptions are just south of Holly Bluff and upstream of Anguilla where the cores had high percentages of sand because they cut through point bar deposits. North of Anguilla and up to Bogue Phalia, point bar deposits are the predominant top-stratum landform. West of the Big Sunflower River at Anguilla and south to Valley Park, the top-stratum is primarily backswamp. Holly Bluff Cutoff, the Little Sunflower River, and a good portion of Steele Bayou cut through backswamp. Deer Creek, which the water surface elevation models show as not being affected by pre- or postproject 2-year frequency floods, is either in abandoned channel or point bar deposits in this region and is bordered by natural levees. Steele Bayou lies in abandoned channel deposits that meander in and out of backswamp and point bar deposits. Just east and north of Holly Bluff, point bar deposits interspersed with abandoned channel and abandoned course predominate. In most of the lower part of the project area, the fine-grained abandoned channel and backwater deposits make the soil relatively impermeable. In the upper project area around the Big Sunflower River, point bar deposits provide more permeability; although the maximum is still estimated to be less than 0.1 inch per hour away from the influence of the Big Sunflower River.

123. Lamonds and Kernodle (1984) published a study evaluating the potential changes to the Mississippi River Valley Alluvial Aquifer from a navigation project proposed for the Yazoo River. The study evaluated the ground-water levels collected between 1978 and 1981 from a number of ground-water observation well transects within the Yazoo Navigation project area. All but two of the observation well transects were outside the Yazoo Backwater study area. Line 4, along the lower Whittington Auxiliary Channel (i.e., Connecting Channel) near Floweree, and Line 16, east of Valley Park, are within the southern most tip of the YBWP area. Line 4 extended from a flood control levee eastward across the Deer Creek meander and the Connecting Channel to the Yazoo River. During the study period, water level measurements made during flood stage seemed to indicate water moved from streams into the shallow aquifer. The 1984 study was conducted during a period when the lower Yazoo Backwater study area had a different hydrologic regime and may not describe current conditions. Lower Deer Creek, south of Valley Park, is segmented by roads with inadequate culverts and no longer has connectivity or a continuous source of flow. Years of inadequate flushing of the Deer Creek channel have resulted in a thick layer of fine grained sediment. In addition, extensive use of surface and ground water for irrigation over the past 20 years has lowered the water table. Comparing the extent of the YBWP pre- and postproject 2-year frequency floods, the lower Yazoo Backwater study area described in the 1984 study will receive less flooding postproject. As a result, ground-water recharge in this region could be reduced. The water surface elevation models also show that Deer Creek, which is bounded by natural levees, is not inundated by the pre- or postproject 2-year frequency floods, such that its influence on aquifer recharge may have diminished. In the lower Yazoo Backwater study area, local aquifer recharge is more influenced by the nearby Mississippi and Yazoo Rivers (permeability approximately 2.0 inches per hour or greater) and the Big Sunflower River and Connecting Channel (permeability approximately 0.5 to 1.0 inch per hour).

124. O'Hara used permeability, land slope, and land use data to evaluate the potential for ground-water contamination by means of surface infiltration. To do this, he assumed that ground water was susceptible to contamination only in those areas where the aquifers were unconfined. Most of the project area was determined to have a low to moderate susceptibility to contamination from surface pollutants. The exception is a wedge shaped area in the Lake George region running from the Big Sunflower River to the Whittington Auxiliary Channel. This area was determined to have a very high susceptibility to ground-water contamination via infiltration from the surface. West of the Whittington Auxiliary Channel, most of this region is confined within levees and has been reforested. Only the tip of the wedge, about 1,000 acres, is still subject to backwater flooding from the Big Sunflower River.

125. Cooper, et al. (2003), evaluated the susceptibility of ground water to contamination by legacy and current-use pesticides in three oxbow lake watersheds in the Mississippi Delta. Beasley Lake is an abandoned channel near the Big Sunflower River that cuts through approximately 20 feet of point bar deposits. Deep Hollow Lake is an abandoned course of the Yazoo River that also cuts through approximately 20 feet of point bar. A third lake, Thigman Lake, also an abandoned course of the Yazoo River. Of the 622 well samples collected during

the 3-year study, only 5 samples from the Beasley Lake watershed had detectable current-use pesticides. No legacy pesticides were detected. The authors noted that field applied compounds seldom moved into shallow ground water because pesticides leached into the soil profile were likely degraded in the biologically active upper soil horizons. Based on the available information, pesticides contamination to the Mississippi Alluvial Aquifer should be minimal.

126. The MDEQ Office of Pollution Control has monitored ground water in the state for agricultural and other chemicals since 1989 under the Agricultural Chemical Ground-Water Monitoring (AgChem) Program (MDEQ, 2003k). Through December 31, 2003, a total of 1,085 wells have been sampled throughout the state. Of these, 614 were drinking water wells from every county in the state. The drinking water wells were analyzed for pesticides and metabolites, volatile organic compounds, minerals, solids, nutrients, and metals. A total of 471 irrigation and fish culture wells have been sampled in 17 counties in the Mississippi Delta. These wells were analyzed for pesticides, chloride, and nitrate. Generally, the results indicate that the overall quality of Mississippi's ground-water supply is relatively unaffected by agricultural activities. Ninety-six percent of the wells had no detectable concentrations of agricultural chemicals. Many of the wells with detectable concentrations of pesticides were found to be affected by localized contamination at the well site. Resampling at these sites has shown that pesticides concentrations have gradually declined to less than the drinking water maximum contaminant limits (MCL). Of the 30 inorganic constituents, total nitrates are most closely associated with agricultural practices. Only 0.8 percent of the samples exceeded the MCL for total nitrates. Resampling has shown that all but four of the wells are presently within allowable limits. Other chemicals not normally associated with agriculture such as pentachlorophenol and methylene chloride (a common laboratory solvent) were detected in trace amounts in a high percentage of wells. Concentrations, however, were reported to generally be considerably lower than the safe levels established by EPA for drinking water. Since the initiation of the ground-water monitoring program, the state has initiated several pollution control programs to preserve the quality of Mississippi's ground water (MDEQ, 2004b).

127. In summary, the Yazoo Backwater study area is characterized by backswamp deposits and by fine-grained deposits in abandoned channels and abandoned courses. Soil permeabilities in these deposits range from less than 0.1 to 0.5 inch per hour, with the highest permeabilities in the Big Sunflower River and Deer Creek channels. In contrast, permeabilities along the Mississippi River and the lower Yazoo River are 2.0 inches per hour or more. This suggests that the riverbeds and streambeds have the greatest potential for localized recharge of the alluvial aquifer; however, the more permeable point bar deposit landforms are also important sources of local recharge during wet periods. The YBWP will not alter project area geology or affect soil or sediment permeability. There could be some minimal decreases in aquifer recharge in areas with reduced flooding where the predominant landforms are point bar or abandoned channel. Because of the predominance of landforms with low soil/sediment permeabilities in most of the project area, however, changes to hydrology due to the structural feature should have only a minimal, localized effect on the Mississippi River Valley Alluvial Aquifer.

128. The data evaluated also show that there is a low probability the aquifer will be contaminated by surface pollutants such as legacy or current-use pesticides. Legacy pesticides are bound to clays and organic matter and will not move easily through the clay barriers. Current-use pesticides are easily degraded by microbial activity. Studies show they are usually

degraded before they pass through the upper soil horizons. The results of the MDEQ AgChem ground-water monitoring program support these findings. Fewer than 4 percent of the wells sampled since 1989 showed detectable concentrations of pesticides. Based on the available data, ground-water contamination of the Mississippi River Valley Alluvial Aquifer should remain minimal.

Impacts on Efficiency of
Suspended Sediment Removal

129. The retention of suspended sediments and associated pollutants are wetland functions affecting water quality. Studies conducted by the Vicksburg District and presented in this section show that suspended sediment retention is affected by flood duration. The Yazoo Backwater Study evaluated alternative plans that vary in regard to the water surface elevation that would initiate pumping and the reforestation/conservation measures on agricultural lands below the pump-on elevation. Alternatives with lower pump-on elevations would have a greater effect on flood duration. The magnitude of the impacts to water quality will vary among plans, but can include increased filtration of floodwaters through riverine backwater forested wetlands or decreased filtration because flood duration is reduced. While operation of the backwater pump station will not change the amount of floodwaters moving out of the Yazoo Backwater Area, it could change the timing of a flood event and the amount of sediment removed from the floodwaters. This section will present data from studies monitoring TSS removal during backwater floods.

130. The DNF along the Little Sunflower River represents typical wetlands in the lower Yazoo Backwater study area. It consists of seasonally flooded bottom-land hardwoods in a flow-through system where water enters from the north and exits to the south. Soil samples collected in DNF only show trace amounts of ∑DDT while sediment samples from the adjacent Little Sunflower River contain some of the highest concentrations of ∑DDT in the YBWP Area. A typical profile of ∑DDT concentrations along the Little Sunflower River in DNF shows a gradient from high concentrations in the center channel to concentrations at or below the method detection limit on top bank in the forest. The Little Sunflower River sustains good flow during high water when the Steele Bayou Structure is open, but can become stagnant when the river stage at Holly Bluff drops below 72 feet, NGVD. During low-flow stages when the Steele Bayou Structure is operated to maintain a minimum pool, the retention time of water in the Little Sunflower River increases allowing sediments and associated pollutants to settle. The fact that the Little Sunflower River sediments are accumulating ∑DDT, but the adjacent forest soils are not, suggests that the fined-grained sediments are not being deposited in the forested lands surrounding the Little Sunflower River. Either the flood duration is insufficient or these sediments are filtered out of the floodwater before they reach the forest sampling sites.

131. To better understand the filtering capacity of forested wetlands, the Vicksburg District began a suspended solids monitoring program in the DNF and nearby reforested Wetland Reserve Program (WRP) lands during flood events. Since pollutants such as DDT and some nutrients are strongly associated with fine-grained sediments, removal of TSS should indicate a

proportional removal of these pollutants as well. During 2001-2003, the Vicksburg District conducted studies during three flood events to help quantify impacts to sedimentation due to changes in flood duration. Although there was some fluctuation in both the TSS and turbidity measurements at individual sites over the duration of each study, overall, each site displayed significant decreases in both TSS and turbidity.

132. In March 2001, the Little Sunflower River was out-of-bank (greater than 85.0 feet, NGVD, at the Little Sunflower structure land side (LS)) for 23 days. Total suspended solids and turbidity samples were collected over a span of 15 days. Samples were collected at four sites on cleared agricultural lands enrolled in the WRP and at five sites in DNF near the Little Sunflower River. Samples were collected approximately every 4 days. The results of this study are presented in Table 16-20. At the WRP (ag) sites, the mean TSS dropped from 109 mg/L to 32.5 mg/L in 15 days. The mean turbidity dropped from 229.3 to 74.7 NTU. This is approximately a 70 percent decline in suspended solids in 15 days. The forested data were divided into two groups. Three sites adjacent to Dummy Line Road (forest sites) with direct access to floodwaters through flooded ditches had turbidity and TSS concentrations similar to those observed at the cleared WRP sites. Inundation at the other two "deep" forest sites was the result of floodwater encroachment through the forest undergrowth. The two deep forest sites never had concentrations for either parameter above 25, which may be the reason the deep forest sites generally have lower ∑DDT concentrations. For samples collected adjacent to Dummy Line Road, TSS fell from a mean of 166 to 78.7 mg/L and turbidity fell from a mean of 237.7 to 139.4 NTU, indicating a decline of 53 and 41 percent, respectively. Generally, the sites retained from 41 to 70 percent of the suspended sediment in the 15-day sampling event. The means of these data are presented graphically and in relation to the flood duration on Figures 16-7 and 16-8. Clearly, sites having less obstruction in the path of the rising floodwater had higher overall concentrations of TSS and turbidity over the course of the study.

133. The second flood event was in April 2002. The Little Sunflower River was out-of-bank for 25 days. Similar TSS and turbidity data were collected over a period of 17 days with samples collected approximately every 4 days. In this study, samples were collected from one station of the Little Sunflower River, four sites within the cleared agricultural WRP land, six forest sites adjacent to Dummy Line Road, and four deep forest sites. The results of this study are presented in Table 16-21 and in Figures 16-9 and 16-10. At the cleared WRP sites, mean TSS and turbidity decreased 72 and 78 percent, respectively. Mean TSS and turbidity at the forest sites adjacent to Dummy Line Road decreased 54 and 61 percent, respectively. At the deep forest sites, mean TSS and turbidity decreased 59 and 71 percent, respectively. Notably, at the one river site, TSS decreased 72 percent and turbidity decreased 84 percent over the course of the 17 days sampled during the 2002 flood event. As in the 2001 study, the deep forest sites had the lowest TSS and turbidity measurements.

TABLE 16-20
RESULTS OF 2001 SEDIMENTATION STUDY

Site No.	Land Use	Location	5 Mar 01	7 Mar 01	12 Mar 01	16 Mar 01	21 Mar 01
Total Suspended Solids (mg/L)							
3	Ag	Near Ramp	104	198	96	116	48
1	Ag	Second	92	164	102	108	12
7	Ag	Third	162	30	90	122	34
8	Ag	Last-Opposite Side	78		78	90	36
	Ag	Mean	109	131	91.5	109	32.5
5	Forest	Boat Ramp	202	160	88	78	114
6	Forest	Dummy Line	204	122	46	110	94
4	Forest	Dummy Line	92	64	26	44	28
	DL-Forest	Mean	166	115.3	53.3	77.3	78.7
2	Forest	Deep	20	2	20	6	4
9	Forest	Deep	20	2	6	14	14
	Deep Forest	Mean	20	2	13	10	9
Turbidity (NTU)							
3	Ag	Near Ramp	294.0	298.0	176.0	184.0	103.0
1	Ag	Second	299.0	290.0	195.0	172.0	42.6
7	Ag	Third	225.0	110.0	167.0	179.0	76.6
8	Ag	Last-Opposite Side	99.1	123.0	149.0	89.1	76.4
	Ag	Mean	229.3	205.3	171.8	156.0	74.7
5	Forest	Boat Ramp	298.0	233.0	167.0	146.0	186.0
6	Forest	Dummy Line	307.0	237.0	179.0	186.0	153.0
4	Forest	Dummy Line	108.0	126.0	72.1	80.0	79.2
	DL-Forest	Mean	237.7	198.7	139.4	137.3	139.4
2	Forest	Deep	14.8	14.6	15.9	3.5	24.2
9	Forest	Deep	22.0	17.2	11.3	7.6	23.3
	Deep Forest	Mean	18.4	15.9	13.6	5.6	23.8

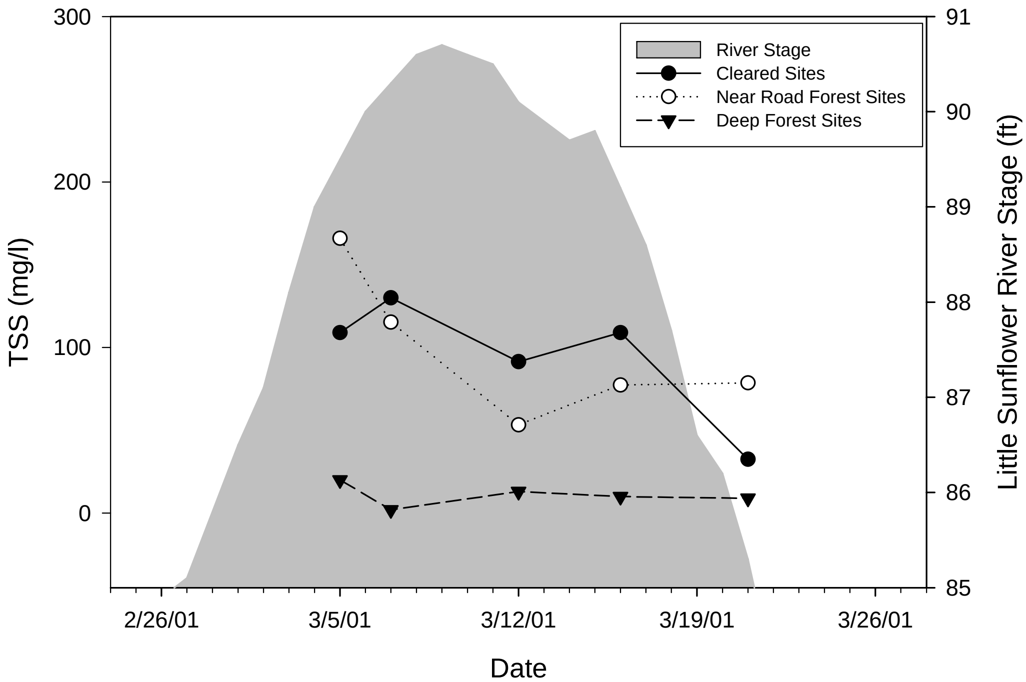


Figure 16-7. Total suspended solids measured during backwater flooding in the Little Sunflower River, March 2001.

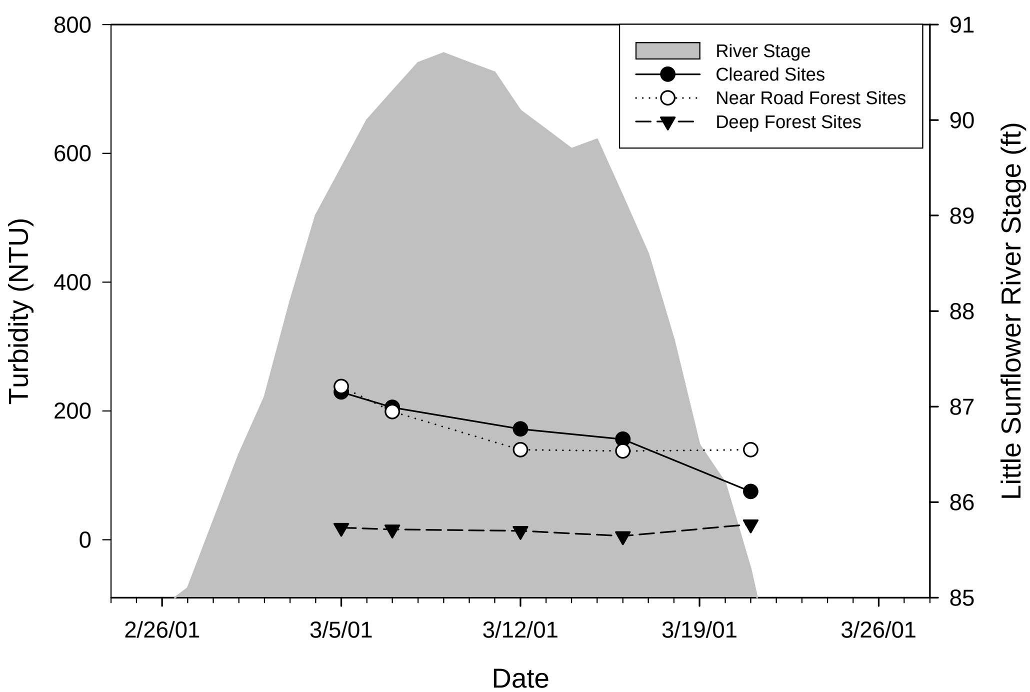


Figure 16-8. Turbidity measured during backwater flooding in the Little Sunflower River, March 2001.

TABLE 16-21
RESULTS OF 2002 SEDIMENTATION STUDY

Site No.	Land Use	5 Apr 02	9 Apr 02	12 Apr 02	16 Apr 02	19 Apr 02	22 Apr 02
Total Suspended Solids (mg/L)							
7	Ag	209	310	100	140	50	30
8a	Ag	160	165	125	80	50	55
9a	Ag	90	160	115	90	25	60
9b	Ag	105	70	65	25	35	35
Ag Mean		161.2	176.2	101.2	83.8	40	45
2a	Forest	80	240	180	70	85	60
2b	Forest	125	140	110	25	65	65
3	Forest	80	85	85	20	30	50
4a	Forest	60	50	45	25	25	25
4b	Forest	85	85	80	35	25	25
8b	Forest	125	90	120	15	5	30
Forest Mean		92.5	115	103.3	31.7	39.2	42.5
1	River	200	180	160	120	85	55
5a	Deep forest	20	105	15	5	10	15
5b	Deep forest	50	60	20	10	25	25
6a	Deep forest	60	80	25	10	10	20
6b	Deep forest	65	35				
Deep Forest Mean		48.8	70	20	8.3	15	20
Turbidity (NTU)							
7	Ag	646	474	218	205	138	50
8a	Ag	249	329	204	136	123	111
9a	Ag	221	237	210	177	75	46
9b	Ag	221	173	202	91	72	85
Ag Mean		334.2	303.2	208.5	152.2	102	73
2a	Forest	192	132	86	181	196	131
2b	Forest	285	135	92	71	155	150
3	Forest	118	129	87	55	102	72
4a	Forest	92	74	64	82	28	11
4b	Forest	209	176	134	80	30	15
8b	Forest	196	190	253	99	71	41
Forest Mean		182	139.3	119.3	94.6	97	70
1	River	748	266	130	256	212	121
5a	Deep forest	110	38	25	11	20	19
5b	Deep forest	64	24	24	12	14	19
6a	Deep forest	5	34	17	23	24	16
6b	Deep forest	66	32				
Deep Forest Mean		61.2	32	22	15.3	19.3	18

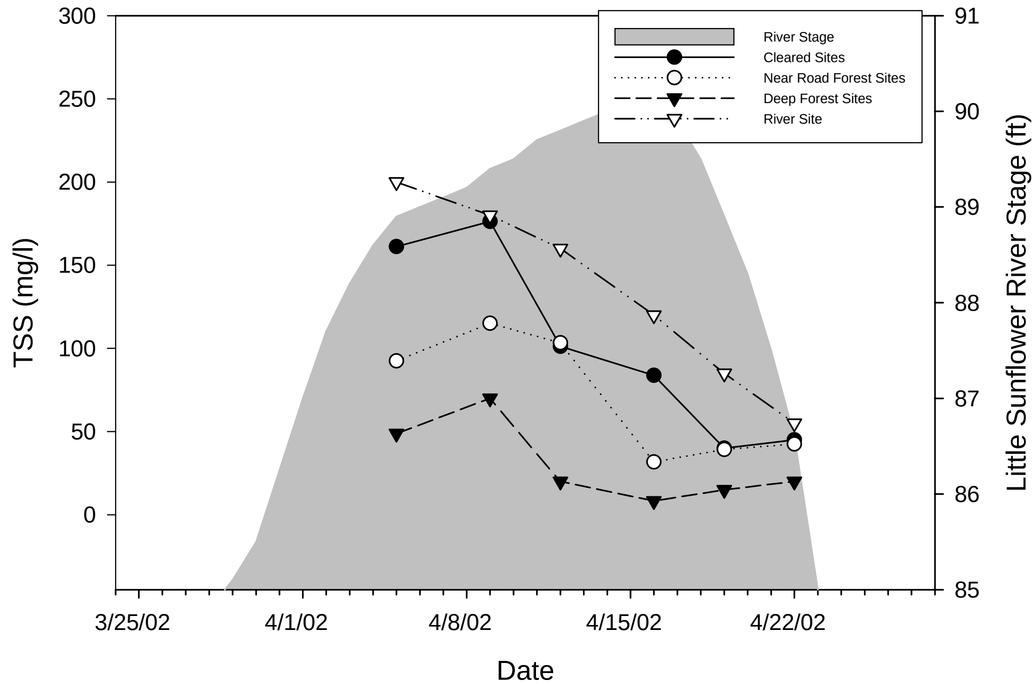


Figure 16-9. Total suspended solids measured during backwater flooding in the Little Sunflower River, April 2002.

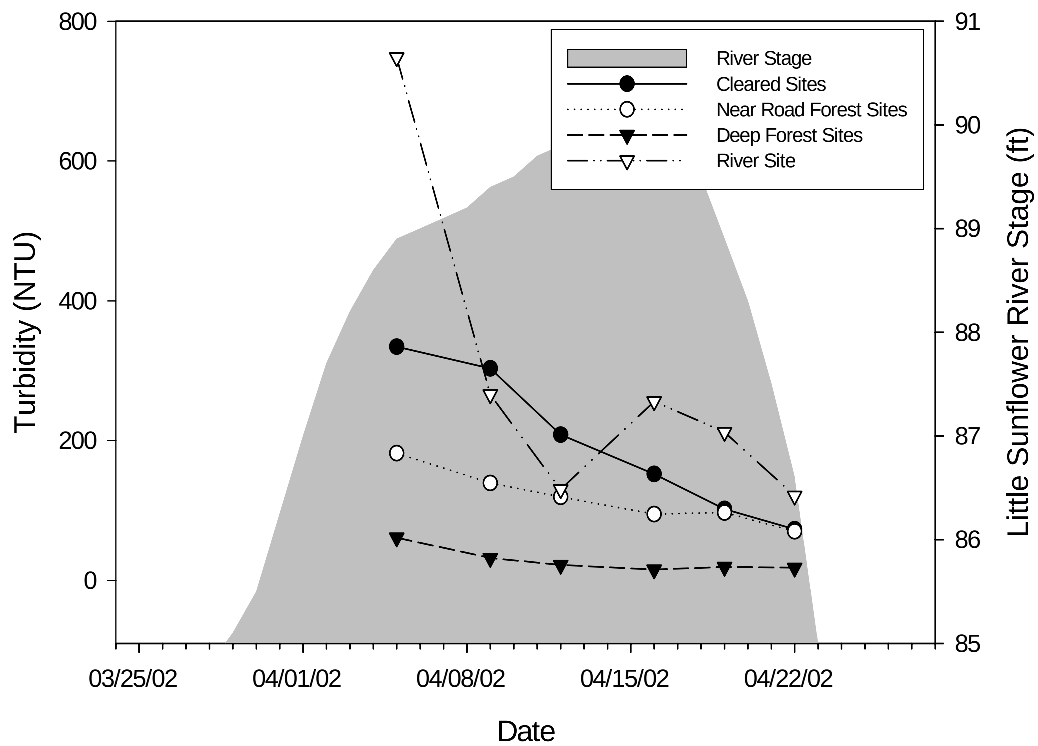


Figure 16-10. Turbidity measured during backwater flooding in the Little Sunflower River, April 2002.

134. The third flood event was in February and March 2003 and lasted 20 days. These samples, collected over a period of 21 days, more fully captured the entire out-of-bank event. The first samples were collected as the Little Sunflower River just exceeded 85.0 feet, NGVD. The last samples were collected after the river receded below 85.0 feet, NGVD. Samples were collected from the Little Sunflower River, five cleared agricultural sites in the WRP, four forest sites adjacent to Dummy Line Road, and nine deep forest sites. The agricultural sites and several of the deep forest sites did not have sufficient water to sample during the first and last days of sampling. The results of this study are presented in Table 16-22 and Figures 16-11 and 16-12. The data from the Little Sunflower River were similar to the previous year. Total suspended solids and turbidity concentrations decreased by 83 and 75 percent, respectively. The forested sites along Dummy Line Road that have a more direct connection to the river had decreases of 72 percent for TSS and 56 percent for turbidity. Data for the WRP sites and the deep forest sites had notable changes from previous years. The WRP sites have evolved from cleared agricultural fields into areas with established trees, grass, and brush. The data suggest that rising floodwaters from False River are being stripped of some of their sediment load before they reach the sampling sites along Dummy Line Road. The decrease in TSS and turbidity at the WRP sites over the course of the 2003 flood was 54 percent and 59 percent, respectively. Just before the 2003 flood, workers in DNF altered the hydrology at some of the sampling sites by installing culverts to divert water into different areas. As a result, the deep forest samples collected did not represent the same type of flood event of the previous 2 years and the decrease in suspended solids was significantly less.

135. Based on an elevation of 85.0 feet, NGVD, at the Little Sunflower River structure, the average flood during the DNF monitoring study was 23 days. For the three monitoring studies discussed here, the average period with floodwaters available for collection at the sampling locations was 17 days. During the 3 years evaluated, there was a 72 percent average reduction in TSS in the Little Sunflower River, a 65 percent average reduction in TSS at the reforested WRP sites, and an average 60 percent TSS reduction in the forest sites. Overall, 60 percent or more of TSS was removed from backwater floodwaters that were out-of-bank between 14 and 20 days.

136. The Wetland Appendix utilizes flood duration in the growing season as a hydrologic standard for wetland delineation. The Wetland Appendix divides the Yazoo Backwater study area into four bands based on their annual duration of flooding during the growing season. The four bands are >5 to 7.5 percent, >7.5 to 10.0 percent, >10.0 to 12.5 percent and >12.5 percent. A flood lasting 14 days, for example, would have a duration of 5 percent, and a flood lasting 20 days would have a duration of 7.5 percent. The average 17-day flood observed at the DNF sample sites between 2001 and 2003 falls within the 5 to 7.5 percent duration band. The DNF studies showed that a minimum of 60 percent of the TSS found in out-of bank floodwaters was removed through physical settling processes in 17 days (the 5 to 7.5 percent duration band). If one assumes that increases in duration should increase TSS removal, then longer durations of flooding should remove at least 60 percent of the TSS. Sediment removal efficiencies should increase proportionately with longer durations. Table 16-23 compares the number of base forested wetland acres to the forested wetland acres remaining after hydraulic impacts for each of

TABLE 16-22
RESULTS OF 2003 SEDIMENTATION STUDY

Site No.	Land Use	26 Feb 03	28 Feb 03	4 Mar 03	7 Mar 03	11 Mar 03	14 Mar 03	18 Mar 03
Total Suspended Solids (mg/L)								
13	Ag		125	110	75	90	30	
14a	Ag		155	35	85	115	55	
14b	Ag		95	50	25	75	45	
15a	Ag		70	70	50	85	55	
15b	Ag			55	70	100	70	
Ag Mean			111	64	61	93	51	
2a	Forest	75	245	155	150	105	110	
2b	Forest	90	245	135	115	105	80	
3	Forest	60	440	115	75	95	45	45
4	Forest	75	90	100	130	40	45	
Forest Mean		75	255	126	118	86	70	45
1	River	240	220	185	150	120	95	40
5	Deep Forest	6	4	25	135	45	35	25
6a	Deep Forest	25	55	16	45	35	35	
6b	Deep Forest	0	0	80	40	25	40	
7b	Deep Forest		45	25	30	15	35	
9b	Deep Forest			30	25	20	20	
10a	Deep Forest			45	70	45	30	
10b	Deep Forest			20	15	55	20	
11a	Deep Forest			65	40	5	15	
11b	Deep Forest					45		10
Deep Forest Mean		10	34	38	50	32	29	18
Turbidity (NTU)								
13	Ag		395	205	180	143	83	
14a	Ag		282	97	121	162	126	
14b	Ag		146	83	101	104	65	
15a	Ag		76	118	129	141	91	
15b	Ag			126	193	164	100	
Ag Mean			225	126	145	143	93	
2a	Forest	99	430	291	231	203	153	
2b	Forest	179	391	231	189	163	134	
3	Forest	128	141	202	132	190	137	78
4	Forest	109	177	163	158	116	75	
Forest Mean		129	285	222	178	168	125	78
1	River	594	438	301	269	191	159	146
5	Deep Forest	18	17	19	24	36	42	15
6a	Deep Forest	22	21	53	73	56	51	
6b	Deep Forest	14	9	13	43	24	38	
7b	Deep Forest		16	11	11	3	9	
9b	Deep Forest			21	26	18	15	
10a	Deep Forest			48	48	57	44	
10b	Deep Forest			68	27	56	42	
11a	Deep Forest		75	63	70	77	37	
11b	Deep Forest		69			82		9
Deep Forest Mean		18	35	37	40	45	35	12

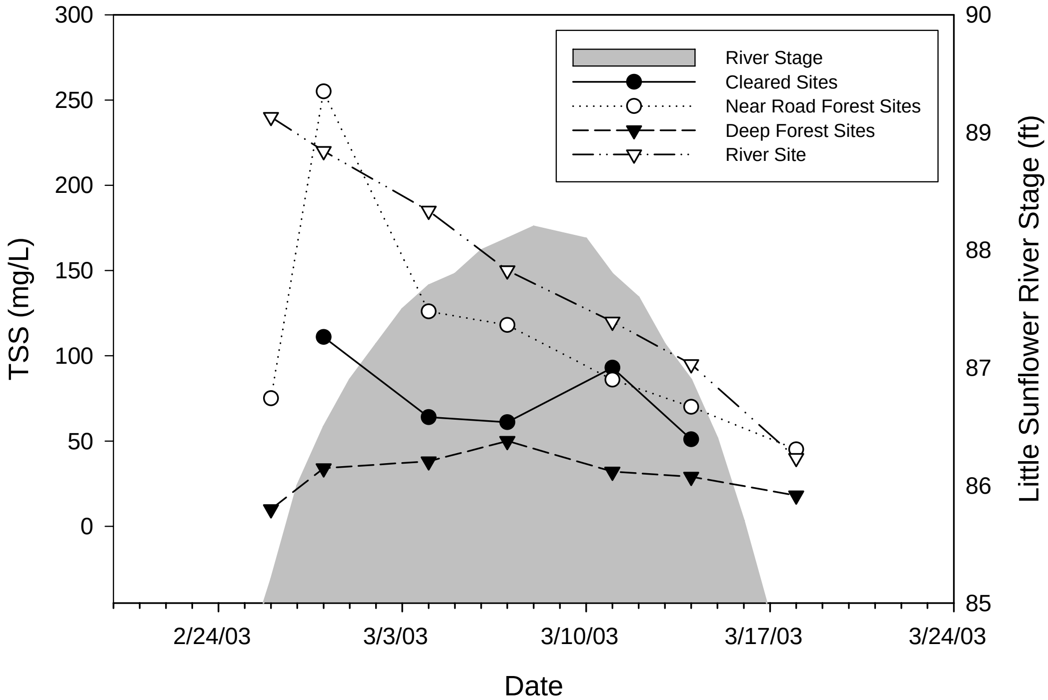


Figure 16-11. Total suspended solids measured during backwater flooding in the Little Sunflower River, February / March 2003.

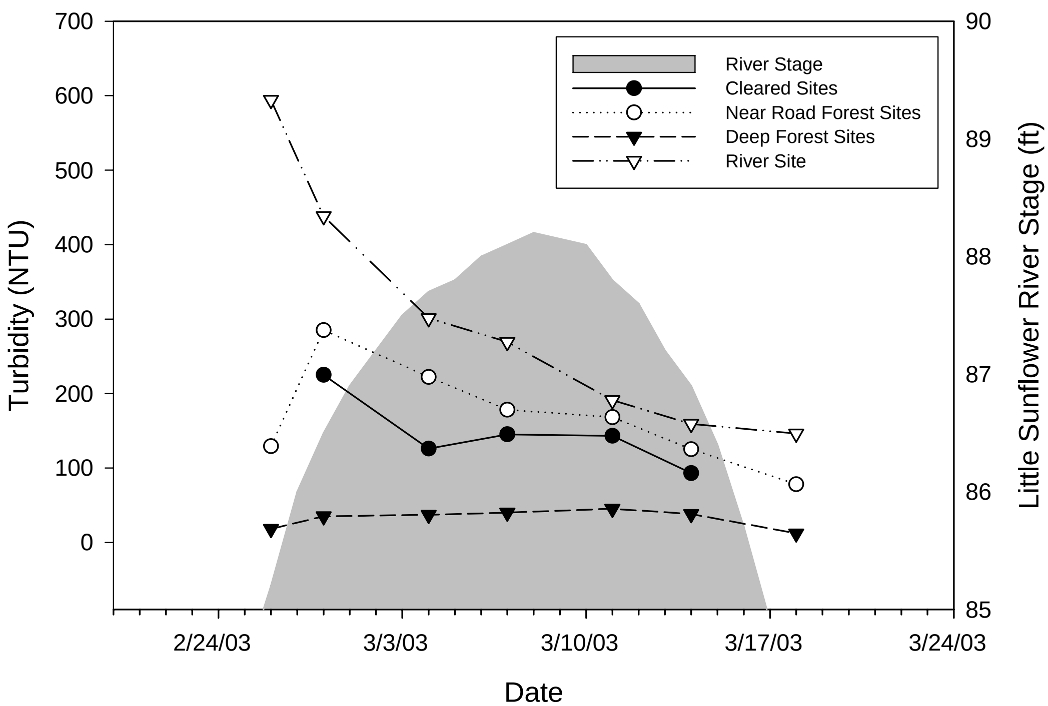


Figure 16-12. Turbidity measured during backwater flooding in the Little Sunflower River, February / March 2003.

the structural alternatives are taken into account. The table does not include increases attributed to the proposed reforestation component for each of the alternatives. Table 16-23 shows that under the recommended plan, 88 percent of existing forested wetland acres will be retained to continue providing the HGM wetland function, Physical Removal of Elements and Compounds at current rates. Addition of the proposed 55,600 acres will provide a net increase in sediment removal that will be discussed in the section on "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area."

TABLE 16-23
FORESTED WETLAND ACRES FOR THE BASE
AND STRUCTURAL ALTERNATIVES PRIOR TO REFORESTATION a/

Days	14 – 20	20 – 27	27 – 34	> 34	Total	% of Base
Duration	5 – 7.5 %	7.5 – 10 %	10 – 12.5 %	> 12 %		
	Acres					%
Base	20,501	35,070	21,330	46,322	123,223	-
Plan 3	22,503	13,241	9,209	31,025	75,978	62
Plan 4	26,602	16,180	17,547	35,496	95,825	78
Plan 5	20,151	27,011	20,179	41,224	108,564	88
Plan 6	19,556	28,818	16,782	47,257	112,414	91
Plan 7	20,388	31,782	15,436	50,771	118,378	96

a/ Data are forested acres only from 2005 land use.

Land Use - Agricultural Intensification

137. Agricultural intensification is a change in cropping patterns which allows farmers the potential to change from a less profitable crop to a more profitable crop or an increase in the acreage planted. In the YBWP Area, land clearing peaked in the 1980s. Since that time, many initiatives have encouraged landowners to reverse that trend. The Food Security Act of 1985 discourages the clearing of bottom-land hardwoods for agricultural purposes. Prior to this legislation, clearing of wooded tracts was a common practice influenced to a great extent by agricultural commodity prices. Also, the permit application requirements of Section 404 of the Clean Water Act have served an additional deterrent to land clearing. Much of the remaining 242,000 acres of bottom-land hardwoods in the study area are in public ownership; however, significant amounts remain in private ownership. Some of these bottom-land hardwoods are classified as wetlands and are protected by provisions of the Food Security Act of 1985. Approximately 70,000 acres of bottom-land hardwoods are not protected by the Food Security Act, but the owners value these lands for wildlife and timber production. While there are increasing pressures on agriculture, significant shifts in land use are unlikely unless there are major changes in agricultural policy.

138. The Division of Agriculture, Forestry and Veterinary Medicine at Mississippi State University (MSU, 2005) prepared a report on current Agricultural Data for the Yazoo Backwater Area of Mississippi for the Vicksburg District. This report discusses current practices and considerations for soybean, cotton, and corn production in the YBWP Area. Application rates of chemicals for growing cotton, soybeans, and corn by planting dates and certain farming practices are included in the report.

139. Farmers in the flood prone regions of the Mississippi Delta make decisions on cropping based upon economic factors, environmental conditions, soil types, and soil moisture (flooding). Soybeans in the lower Mississippi Delta are normally planted on clayey soils that are often in the lowest lying areas. These areas are the first to flood from inundating rainfall or from backwater that occurs during high-water events when the region cannot drain. Cotton, on the other hand, is typically grown on well-drained sandy soil formed as natural levees along stream meanders. There are optimum windows for planting to ensure a successful yield for each of these crops. Typically, agricultural land impacted by floodwater is planted later in the season after the floodwaters recede, with the result of lower yields.

140. Total land in agricultural production is expected to remain relatively constant (refer to Mitigation Appendix). Once the Yazoo Backwater pump station is in operation, it is unlikely, based on current normalized agricultural prices, that there would be any increases in the acreage planted or permanent conversions to alternate crops. Current crop rotation patterns, however, are expected to continue (i.e., rice and soybeans). The major change will likely be earlier planting of soybeans in areas better protected from flooding. This, however, is not considered agricultural intensification since these same lands are currently in soybean production. Early planting of soybeans would reduce the amount of fungicide required to control Asian Soybean Rust and could reduce irrigation requirements. Because soybeans are not routinely fertilized, there should be no increases in nutrient runoff from early soybeans. Farming practices in the Delta (MSU, 2005) show that phosphorus is typically applied in the fall, and nitrogen is typically applied in March through May. These dates coincide with seasonal increases in surface water nutrient concentrations observed in project area streams. This pattern should not change; but surface water concentrations could be reduced with implementation of the nonstructural reforestation feature. Reforested low-lying cropland would be become stabilized with reduced sediment yield. It would gradually develop wetland functions that would remove some of the sediments and nutrients passing through it.

141. Since 1995, the trend in the Mississippi Delta has been toward the use of genetically engineered seed such as Roundup Ready corn and soybean seed and Roundup Ready Bt cotton seed. This transition to genetically engineered seed enables farmers to move away from conventional tillage and utilize conservation tillage and no-till planting practices, which should further reduce erosion during the spring rainy season. Reduced erosion reduces the amount of suspended sediment entering adjacent streams and could reduce the concentration of legacy pesticides entering the aquatic environment. The transition to genetically engineered seed has also resulted in a significant shift in the quantities and types of chemicals needed for successful

crop production (personal communication, March 8, 2006, Dr. Robert Williams, MSU, Starkville, Mississippi). According to EPA pesticide market estimates (Aspelin, 1997; Aspelin and Grube, 1999; Donaldson, et. al., 2002; and Kiely, et. al., 2004), total agricultural pesticide use in the United States remained fairly constant between 1982 and 2001; however, the annual volume of insecticides and fungicides used may have decreased. The use of Bt cotton seed has significantly reduced the amount of insecticides used in cotton production. No-till planting practices and the use of genetically engineered seed could increase the use of current-use herbicides such as glyphosate, however. Glyphosate, discussed in the section on "Current-Use Pesticides," is a broad spectrum systemic herbicide that is generally not mobile in soil. It is estimated that only 2 percent of the applied chemical is lost to runoff (Kamrin, 1997).

IMPACTS FROM INCREASED WATER DEPTH BEHIND THE STEELE BAYOU STRUCTURE

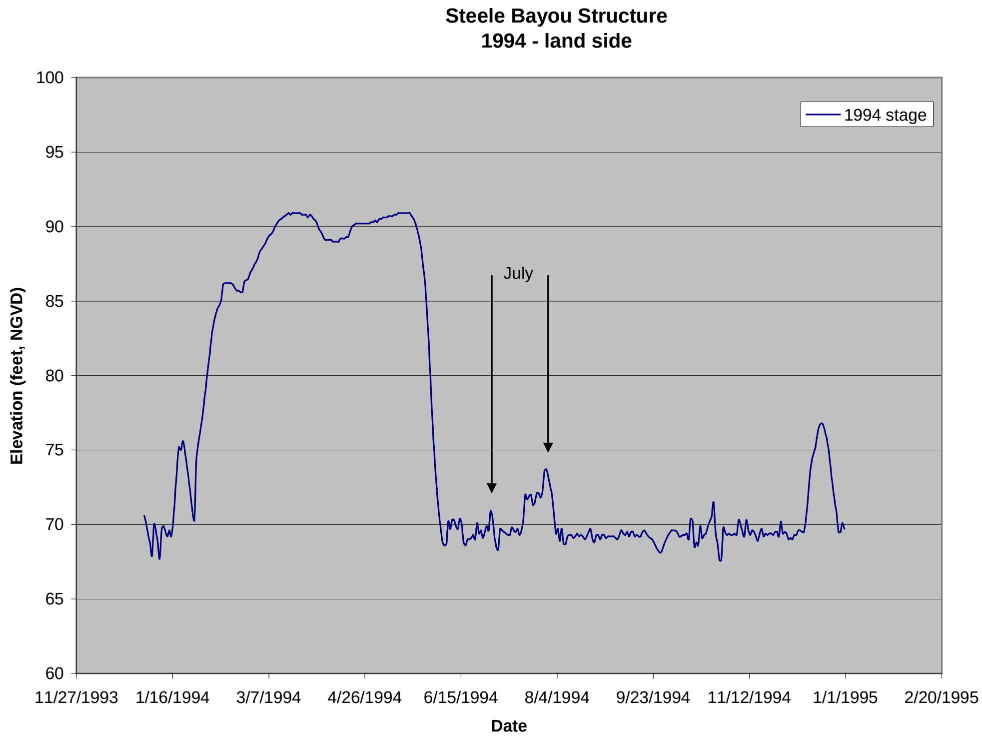
142. During periods of low flow in the Yazoo River, the Vicksburg District restricts flow through the Steele Bayou structure in order to maintain water depth and improve aquatic habitat in the streams and rivers of the lower Yazoo Backwater Area. Without this action, portions of the lower Big Sunflower and Little Sunflower Rivers could experience dry periods each year. An analysis of the POR at the structure shows that the water elevation in the Yazoo River has been lower than 68.0 feet, NGVD, 48 percent of the time and has been lower than 60 feet, the bottom elevation of the Connecting Channel, 24 percent of the time. Since 1969, the Steele Bayou structure has been operated to maintain a minimum water elevation of 68.5 feet, NGVD, throughout the year. During the summer, the Steele Bayou structure is operated to maintain the water elevation between 68.5 and 70.0 feet, NGVD, and a minimum flow of approximately 100 cfs. The recommended plan includes a feature that would increase the minimum water depth at the Steele Bayou structure an additional 3 feet each year during low-water periods typical of the summer and fall. This would have the effect of increasing water depth up the Steele Bayou and Sunflower River channels and would add additional, regulated depth to smaller side tributaries of these water bodies. Water depth would increase to approximately 13 feet through the Connecting Channel up to the Little Sunflower River structure. Water depths would be increased up the Little Sunflower River and Big Sunflower River to approximately RM 60 and would increase in Steele Bayou to approximately RM 30.

143. While an increase in water depth provides additional aquatic habitat, it does not necessarily ensure that DO concentrations will be greater than 5.0 mg/L throughout the water column. In fact, isolated measurements of DO less than 4.0 mg/L, the instantaneous DO criterion for Mississippi waters, are often observed in these systems during the summer. DO is produced through surface water interactions with the atmosphere (reaeration) or as a by-product of photosynthesis, either from macrophytes in shallower water or from free-floating phytoplankton in the water column. DO is utilized by these same plants during the night

(respiration) and by fish and other aquatic life. DO is also utilized in microbial degradation of organic matter in the water and sediment. When the requirement for DO exceeds the amount available during the course of a 24-hour day, the DO supply becomes depleted and an oxygen sag occurs. In highly eutrophic waters with heavy organic loading, high DO concentrations may be present during the afternoon hours only to have the DO depleted by the early morning hours before dawn. Since this type of daily DO swing, although a natural phenomenon, places stress on many desirable fish species, there is a concern that increasing the water depth will indirectly create or exacerbate a region in the deeper water where DO concentrations are at a minimum because sources of DO either from phytoplankton photosynthesis or from reaeration are limited. At the latitude of the YBWP, still waters can develop sufficient differences in temperature to stratify and block the transfer of DO into deep water. Stratified from the surface, this layer can have a greater demand for DO (microbial degradation of settled organic matter) than can be met.

144. In their aquatics analysis for the YBWP, Killgore and Hoover (2007) report that they observed stratification and a fishkill behind the Steele Bayou structure in July 1994 when collecting fish samples for the project. The authors state that “stratification was most prevalent behind the closed structure due to stagnant conditions and high water temperatures.” A review of the MDEQ, 1998, Section 305(b) water quality report, revealed that a fishkill at the Steele Bayou structure on July 8, 1996, was also attributed to low DO. This was the only reported incident at the Steele Bayou structure that was investigated by MDEQ between 1990 and 1998. The Vicksburg District did not find additional fishkill information for the years since 1998, but realizes that fishkills are infrequent, but natural occurrences in the Mississippi Delta. In both cases, the Backwater Area experienced spring flooding (Figure 16-13). In July 1994, the landside water elevation was continuously above 85.0 feet, NGVD, between February 10 and May 28 and did not lower to 70.0 feet, NGVD, until June 4 when the gates began regulating water between 68.5 and 70.0 feet, NGVD. In July 1996, the water surface elevation was above 85.0 feet, NGVD, for most of June. The Steele Bayou structure was still discharging floodwater (elevation 73.7 feet, NGVD) on July 8, 1996, when the fishkill was reported. A review of NOAA precipitation and climatological data for June and July 1996 showed this was a relatively cool, wet summer (NOAA, 1996a and 1996b). In June 1996, the average precipitation between Vicksburg, Rolling Fork, and Yazoo City was 2.2 inches and average temperatures were below 90 degrees F. Similarly, the June and July 1994 NOAA data for Rolling Fork show average maximum air temperatures in the low 90s and higher than normal precipitation (NOAA, 1994a and 1994b).

145. Field data presented in this section show that the lower backwater area relies on photosynthesis for much of its dissolved oxygen supply in the summer. However, the data suggest that the lowest DO concentrations are found early in the summer between May and June, not in the late summer between July and October during low-flow, high-temperature periods when low DO conditions have the greatest potential for adverse effects to the aquatic environment (the critical period). It is also likely that phytoplankton populations are not well established or cannot be maintained at the Steele Bayou Structure during flood discharge.



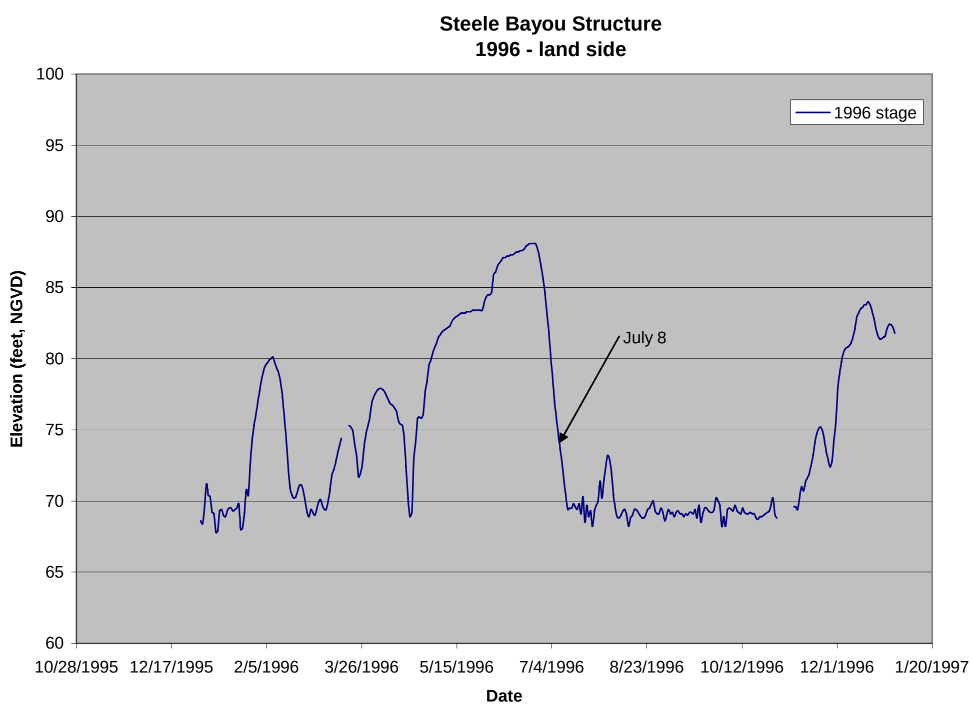


Figure 16-13. Water surface elevation behind Steele Bayou Structure prior to observed fish kills.

Increased cloud cover would have reduced population recovery and photosynthesis rates. Given the flooding and climatological conditions, increased rainfall and floodwater discharge could have introduced additional organic carbon load creating an imbalance between photosynthesis and respiration rates. The result would be DO stress on susceptible fish species. It is likely that this type of climate induced oxygen depletion is responsible for many of the fishkills attributed to low DO in the Delta. The YBWP will not have an impact on these events.

146. The Vicksburg District's monitoring data show that a type of unstable diurnal stratification can occur in the summer as surface waters are heated by the sun's radiation. The data also show that these temperatures modulate during the night, possibly mixing the oxygen-saturated surface water with the deeper water. However, it is possible that the Steele Bayou pool stratifies during backwater floods when the gates are closed for extended periods. Completion of the YBWP and operation of the pump station would create flow in the lower pool during extended backwater floods and could help reduce the likelihood of stratification during these periods. The two fishkills documented in the previous paragraphs suggest DO stress can occur after backwater floods that extend into early summer because organic loading is high and phytoplankton populations are not well established. The following sections will discuss the current DO data available for the lower Steele Bayou and Sunflower system and address the indirect impacts modification of summer water depth behind the Steele Bayou structure may have on DO concentrations.

Stratification Potential

147. Freshwater impoundments have the potential to stratify vertically forming areas with cooler temperatures and low DO in deeper water. Shallow run-of-the-river impoundments such as the Steele Bayou Structure pool often only weakly stratify due to flow and wind mixing. There are a number of methods to determine the stratification potential of an impoundment such as the one formed by the Steele Bayou–Big Sunflower summer pool. Stratification potential has been described as a function of heat exchange, lake depth, bathymetry, flows and wind mixing (Martin and McCutcheon, 1999). Ford and Johnson (1986) indicate that an impoundment tends to stratify when its mean depth exceeds 10 meters (m) and its mean annual residence time exceeds 20 days. For the impoundment formed upstream of the Steele Bayou Structure including the Connecting Channel and Six Mile Cutoff, the new mean depth will be 3.9 m while the mean residence time based on mean flows of 100 cfs is 33 days.

148. Additionally, the modified densiometric Froude number by Norton, et al. (1968), provides an indication of stratification potential using the following equation (Martin and McCutcheon, 1999).

$$Fd = \sqrt{\frac{1}{ge}\frac{LQ}{DmV}}$$

Where:

g = gravitation acceleration (m s^{-2})
e = a dimensionless density gradient (10^{-6} m^{-1})
L = length (m)
Q = average flow (m^3 s^{-1})
Dm = mean depth (m)
V = volume (m^3)

149. Supporting data used to calculate the modified densiometric Froude numbers are given in Table 16-24. When Fd >> 1/π, the impoundment is well mixed. When Fd << 1/π, the impoundment is expected to be strongly stratified. When Fd ~ 1/π, the impoundment is expected to be weakly or intermittently stratified. Using a mean flow of 100 cfs, the lower Big Sunflower pool up to Holly Bluff should be well mixed under both the current 70.0 feet, NGVD, and the proposed 73.0 feet, NGVD, maximum operating conditions (Table 16-24). Under existing operating conditions the Sunflower pool could become stratified when mean flows approach 35 cfs. For the proposed 73.0 feet, NGVD, maximum, the Sunflower pool could become stratified around 60 cfs. For the Steele Bayou side, the pool could stratify at a mean flow of 15 cfs for the current operating conditions and at a mean flow of 25 cfs for the proposed operating conditions. This analysis, however, does not address duration of reduced flow before stratification occurs. These data show that during summer low-flow conditions, the Steele Bayou pool could become intermittently stratified. However, under normal summer operating conditions, the potential is low. Any stratification that occurs should only last 1 or 2 days and should not be a problem.

Field Data

150. The Vicksburg District conducted six sampling trips between June and September 2005 to measure DO and water temperature concentrations in the lower YBWP Area (Plate 16-3). The September sampling was collected after Hurricane Katrina. It is unclear if the resulting data are representative of typical September conditions or are an anomaly. Measurements were taken at several depths in the water column to include a measurement at mid-depth for streams less than 10 feet deep and a measurement at 5 feet for streams greater than 10 feet deep. Figure 16-14 shows the results of vertical DO and water temperature profile measurements collected at several

TABLE 16-24
ESTIMATE OF STRATIFICATION POTENTIAL UPSTREAM
OF THE STEELE BAYOU STRUCTURE UNDER EXISTING
AND PROPOSED SUMMER OPERATING CONDITIONS

<table>
<tr><td></td><td colspan="3">Current Summer Maximum 70.0 ft, NGVD</td><td colspan="3">Proposed Summer Maximum 73.0 ft, NGVD</td></tr>
<tr><td></td><td>Steele Bayou Structure to LSF Structure</td><td>LSF Structure to Holly Bluff</td><td>Steele Bayou</td><td>Steele Bayou Structure to LSF Structure</td><td>LSF Structure to Holly Bluff</td><td>Steele Bayou</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Cross sectional area (ft^2)</td><td>2300</td><td>2000</td><td>1000</td><td>3107</td><td>2600</td><td>1300</td></tr>
<tr><td>Length (mi)</td><td>16</td><td>19.6</td><td>31</td><td>16</td><td>19.6</td><td>33.5</td></tr>
<tr><td>Estimated Depth (ft)</td><td>10</td><td>10</td><td>10</td><td>13</td><td>13</td><td>13</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td></td><td colspan="2">Steele Bayou Structure to Holly Bluff</td><td>Steele Bayou</td><td colspan="2">Steele Bayou Structure to Holly Bluff</td><td>Steele Bayou</td></tr>
<tr><td>Flow (cfs)</td><td colspan="2">100</td><td>100</td><td colspan="2">100</td><td>100</td></tr>
<tr><td>Fd</td><td colspan="2">0.987879</td><td>2.4213</td><td colspan="2">0.57367</td><td>1.325802</td></tr>
<tr><td>Condition</td><td colspan="2">Well Mixed</td><td>Well Mixed</td><td colspan="2">Well Mixed</td><td>Well Mixed</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>Flow (cfs)</td><td colspan="2">32.2</td><td>13.4</td><td colspan="2">55.8</td><td>24</td></tr>
<tr><td>Fd</td><td colspan="2">0.318479</td><td>0.324892</td><td colspan="2">0.320058</td><td>0.318342</td></tr>
<tr><td>Condition (lower limit)</td><td colspan="2">Intermittently Stratified</td><td>Intermittently Stratified</td><td colspan="2">Intermittently Stratified</td><td>Intermittently Stratified</td></tr>
<tr><td colspan="7">Fd >> 1/π, well mixed
Fd ≈ 1/π, intermittently stratified
Fd << 1/π, strongly stratified</td></tr>
</table>

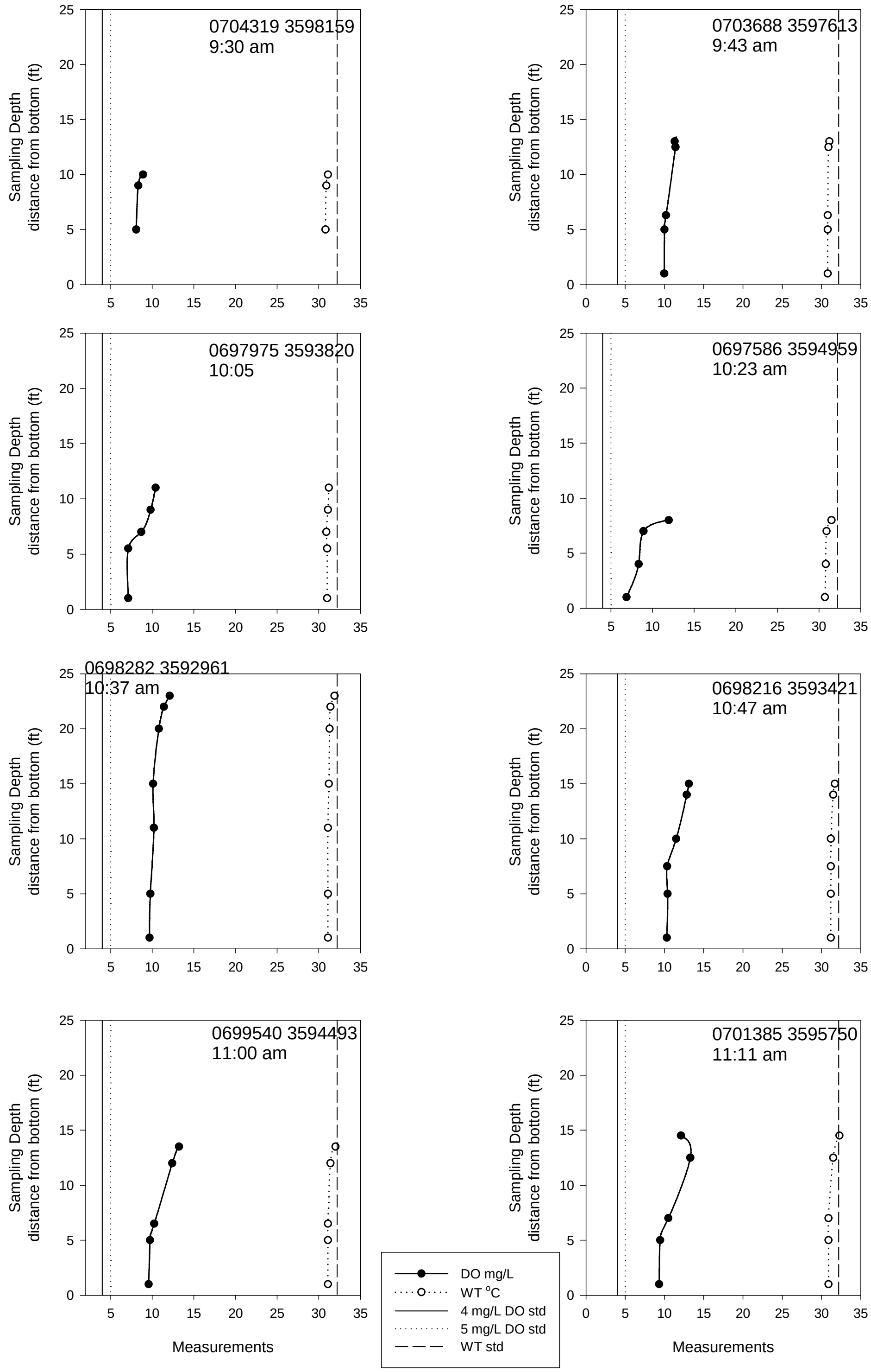


Figure 16-14. Dissolved oxygen and water temperature profiles measured on 22 July 2005 at various locations along the Connecting Channel and lower Steele Bayou above the Steele Bayou Structure.

locations in the lower Connecting Channel and Steele Bayou just above the Steele Bayou structure on the morning of July 22, 2005. Water temperatures are indicated by white circles and DO concentrations by black circles. State DO and water temperature criteria are indicated by vertical lines. While these *in situ* data represent measurements taken at a single point in time, they show that the channel was not thermally stratified and that morning DO concentrations were well above 5 mg/L (the MDEQ daily average criterion) at all depths.

151. Figures 16-15 and 16-16 show the results of vertical DO profiles collected monthly from stations farther upstream in the Yazoo Backwater study area. Figure 16-15 shows the summer profiles from two stations that are generally under low flow conditions during this period. The Little Sunflower River station at Dummy Line Road (DLR) was sampled in the morning and afternoon to measure the changes in DO due to phytoplankton productivity. Afternoon profiles at this station showed a classic pattern of diurnal stratification caused by solar heating. Morning water temperatures were homogeneous with depth, while afternoon temperatures were higher by 2 to 4 degrees C. DO concentrations showed similar increases in the afternoon measurements. Morning mid-depth DO concentrations in early June were less than 5 mg/L. In July and August, however, morning DO concentrations were well above 5 mg/L at all depths. Afternoon DO concentrations in July and August were substantially higher than the morning concentrations. In July, the afternoon concentration exceeded 20 mg/L. In September, the morning mid-depth concentration was still above 5 mg/L, but the concentration near the bottom was approximately 2 mg/L. By afternoon, the mid-depth concentration had dropped to 4.52 mg/L. Since this sampling was after Hurricane Katrina, it is unclear if this is typical of September oxygen profiles at this site. The Steele Bayou at Grace station (Figure 16-15) is upstream of the influence of the increased Steele Bayou Structure summer pool. It is included because it represents DO concentrations affected by phytoplankton upstream of a weir. Like the Little Sunflower River station, this station appeared to have high phytoplankton productivity. Most of the data were collected in the early afternoon, but it is likely that a comparison between morning and afternoon data would resemble the Little Sunflower River profiles. This station was sampled six times between June and September. None of the mid-depth DO measurements were less than the 5.0 mg/L daily average criterion. However, measurements taken near the bottom were less than 4.0 mg/L in June and August. High DO concentrations observed in June suggest that the phytoplankton population was more established at Grace than at the Little Sunflower River site.

152. Figure 16-16 shows summer DO profiles in the Big Sunflower River, a flowing stream. The Holly Bluff Cutoff station is approximately 300 yards downstream of the Holly Bluff Cutoff weir. This station represents DO concentrations affected by weir reaeration. It is the only station with no DO measurements below 5 mg/L. The Six Mile Cutoff station represents a flowing river with wind and wave reaeration. While the surface was slightly choppy, it generally had homogeneous flow with depth for the four sampling events. Beyond 5 feet, the June measurements were less than 5 mg/L; however, the July through September measurements were not. In general, the June measurements showed the lowest DO concentrations for all four sites, while the July measurements were the highest. Figure 16-17 shows the results from a predawn

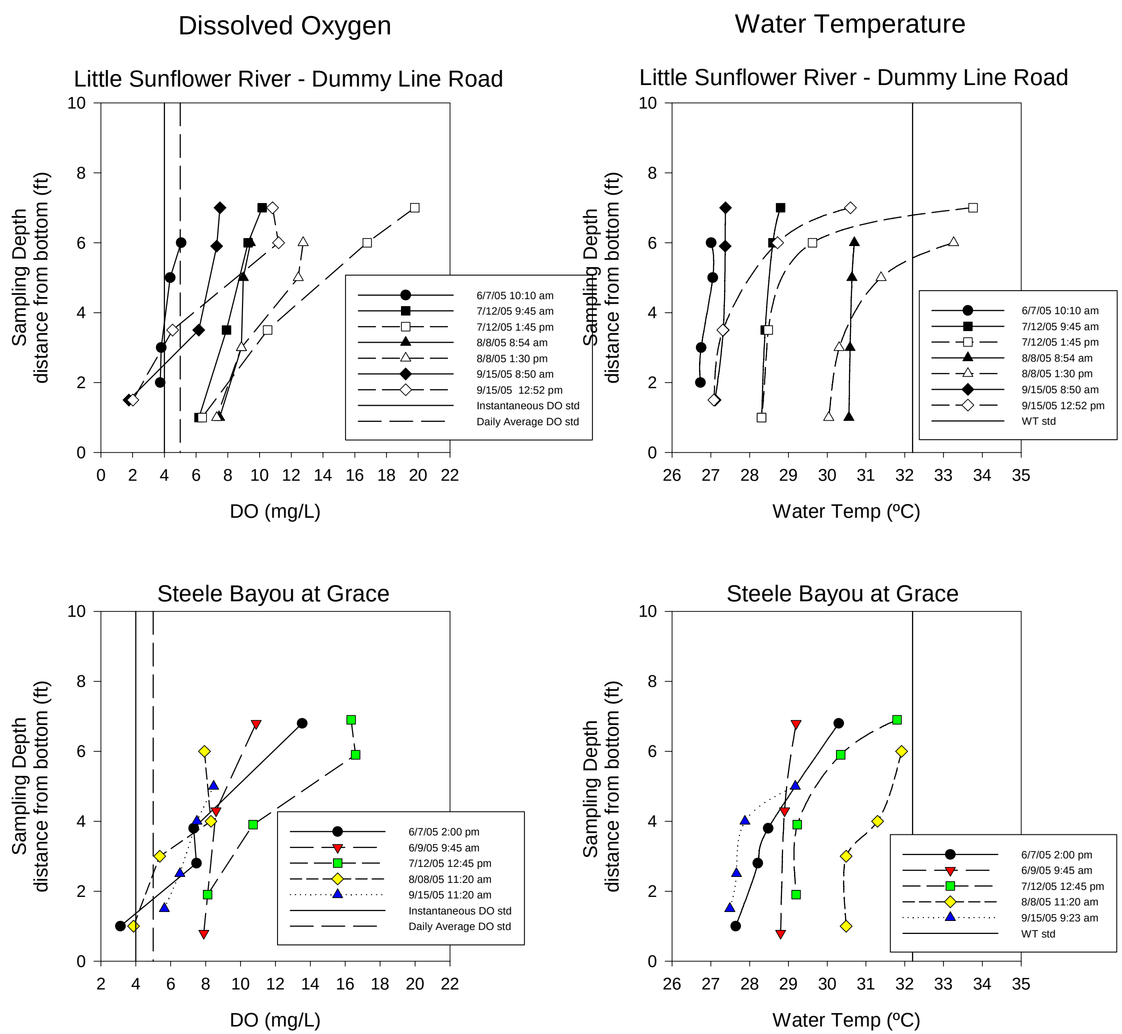


Figure 16-15. Summer DO and water temperature profiles from pooled streams in the Yazoo Backwater Project Area.

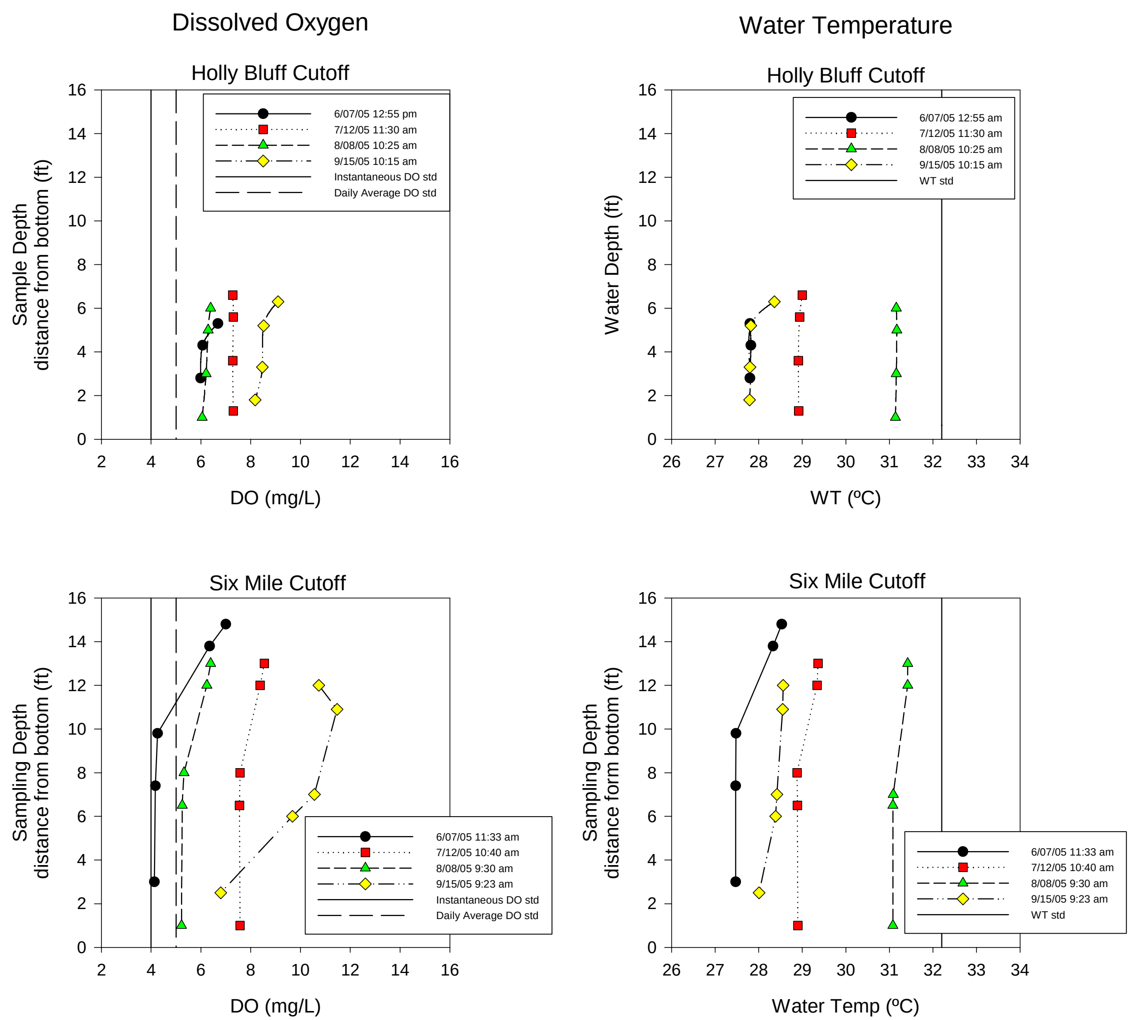


Figure 16-16. Summer DO and water temperature profiles in flowing streams in the Yazoo Backwater Project Area.

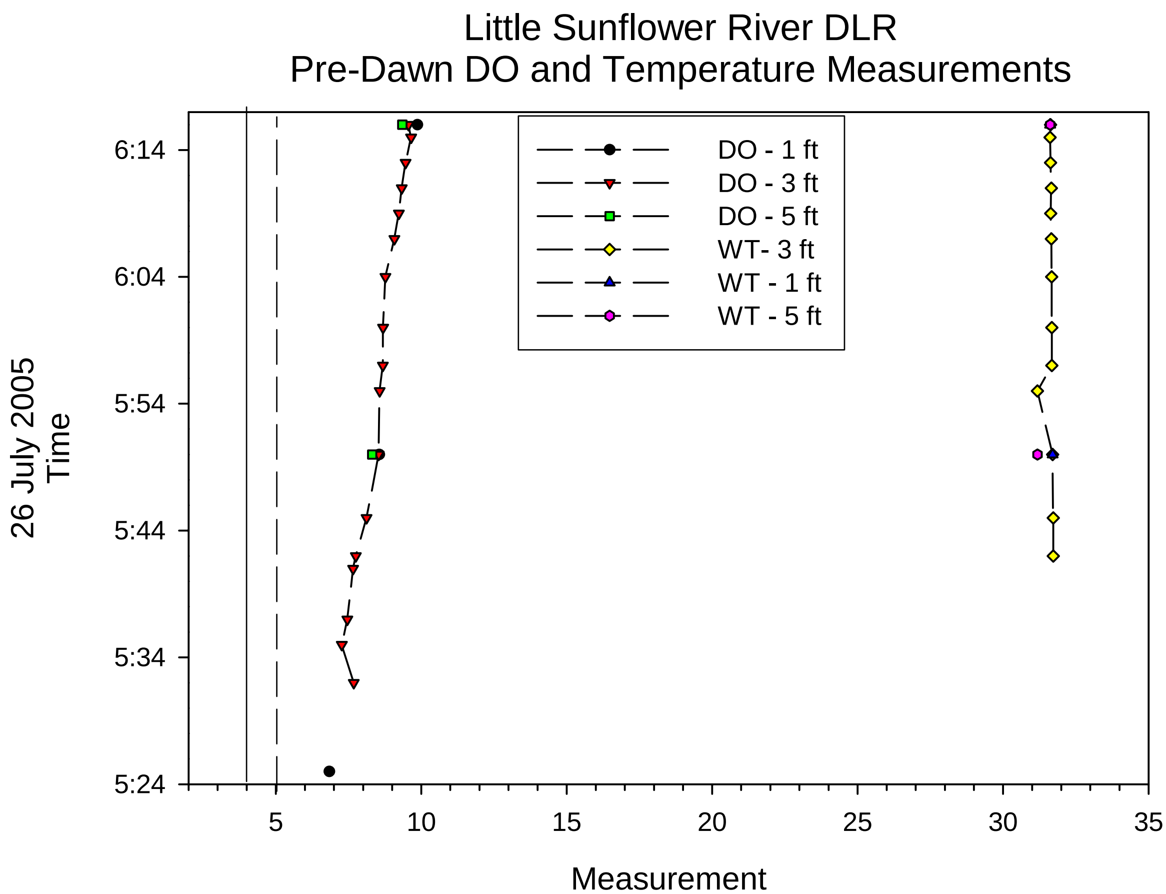


Figure 16-17. Early morning DO (mg/L) and water temperature (Celsius) measurements in the Little Sunflower River at Dummy Line Road on 26 July 2005.

sampling trip to the Little Sunflower River on July 26, 2005. *In situ* DO measurements collected between 5:25 and 6:17 a.m. show that the water column was well mixed and that the DO produced the previous day was not fully utilized during the night. The predawn DO concentration at 5:25 a.m. was 6.84 mg/L. Concentrations gradually increased to 9.35 mg/L by 6:17 a.m. As was observed in the monthly profiles at this station, the morning water temperatures were homogenous with depth.

153. The *in situ* data from the YBWP Area suggest that Steele Bayou and the Big Sunflower River systems have completely different *in situ* stream characteristics. Steele Bayou appears to carry a lower sediment load during periods of agricultural activity and rainfall runoff. This results in a less turbid stream that has an active phytoplankton population during spring and early summer. Mid-day DO concentrations have been measured at greater than 10 mg/L at the surface. At 1 m, however, the DO concentration dropped to less than 3 mg/L at the same location, indicating that the photic zone was relatively shallow. The Big Sunflower River system, on the other hand, is a higher energy system during storm events. It carries more water and has much higher sediment loads. As a result, the system does not appear to have a well established phytoplankton population in the spring. Reaeration appears to be driven by water velocity during high flows and wind and wave action during initial pooling. Mid-day surface DO concentrations have been repeatedly measured at less than 4.0 mg/L. During middle to late summer, however, as the water clears and turbidity levels decrease, portions of the Big Sunflower River become ideal habitat for phytoplankton. On clear sunny days, mid-day DO concentrations near the surface can exceed saturation, with concentrations increasing until early evening. Corresponding surface water temperatures can be 2 to 4 degrees higher than temperatures at mid-depth. Because of the low turbidity, the photic zone extends beyond 1 m. Given the right conditions, increased photosynthesis combined with wind mixing can produce a higher mean concentration of DO in the water column during late summer. There is some evidence, however, that rain events during this period can flush the system, reducing the DO concentration for a few days before the phytoplankton population rebuilds. Extended periods of rain and cloud cover coinciding with high organic loading could result in oxygen depletion and localized fishkills, as was observed by ERDC and MDEQ above the Steele Bayou structure in 1994 and 1996.

154. One disadvantage of increased phytoplankton populations, especially in still water such as is found behind weirs or in the Little Sunflower River during the summer, is the wide swing in DO concentrations that could occur from large populations of phytoplankton. Diel variations in DO characteristically result in highest concentrations in the afternoon and lowest concentrations in the early morning before sunrise. Algal blooms and algal die-offs also impact the amount of DO available in an affected water body. Phytoplankton populations increase as long as the supply of organic carbon and nutrients are available to support them. If the population reaches a critical mass and the components needed for continued growth become depleted, a phytoplankton die-off can occur. When this happens, DO production is suspended and the

reservoir of organic matter and nutrients held within the phytoplankton biomass is temporarily released until it can be reutilized by the aquatic community. These types of algal die-offs place a DO stress on fish and other aquatic life. DO production ceases as the demand for DO increases with the addition of microbial decay of dead algal cells. While there are no data to demonstrate conclusively whether algal blooms and die-offs are common in these water bodies, there are data on nitrogen and phosphorus concentrations in the Little Sunflower and Big Sunflower Rivers (Figure 16-18). These data show that, because of reduced external input and increased macrophyte and phytoplankton uptake, ammonia, nitrate, and TP concentrations are lowest in the period between July and October, the critical period for the organic enrichment/low DO and nutrient impairments. Nutrient concentrations during the period evaluated remained adequate to support continued algal growth, however.

<u>Effect On Weirs</u>

155. Increasing the maximum summer water surface elevation to 73.0 feet, NGVD, should not have a negative impact on the normal cycle of seasonal events and biological factors that influence DO concentrations in the lower Yazoo Backwater study area. One exception, however, could be reaches downstream of low head weirs. These weirs currently form pooled areas for aquatic habitat and function to reaerate water flowing over the weirs. In Figure 16-16, the DO profiles measured at Holly Bluff Cutoff reflect reaeration immediately downstream of the Holly Bluff Cutoff weir. The greater the drop from the weir to the stream below, the greater the reaeration and mixing potential. If the increased pool elevation reduces the height of the drop, then DO in the water column downstream of these weirs could be reduced. In Steele Bayou, the first weir is located near RM 35. Given a weir height of 78.0 feet, NGVD, with an increase in water elevation of 73.0 feet, NGVD, there will still be a 5-foot drop. The first weir in the Big Sunflower River is on the lower Holly Bluff Cutoff. Here, the weir elevation is 73.0 feet, NGVD. Currently, the drop averages about 2 to 2.5 feet during the summer. Depending upon the river slope, raising the surface elevation to 73.0 feet, NGVD, at the Steele Bayou structure could place this weir underwater at the beginning of the summer impoundment season. Plans 6 and 7, which raise the maximum elevation at Steele Bayou to 87.0 feet, NGVD, could also impact Lock and Dam No. 1 at Little Calleo, downstream of Highway 12.

156. During summer low-flow periods, the water surface elevation regulated by the Steele Bayou structure should drop due to continued minimum discharge and should allow for reaeration below the weir during these periods. During the low-flow months, the Steele Bayou gates are not closed for extended periods to maintain the maximum water surface elevation. As seen in Figure 16-13, during the low-flow summer period, the water surface elevation oscillates as the gates are opened and closed to maintain water levels within the operational range of

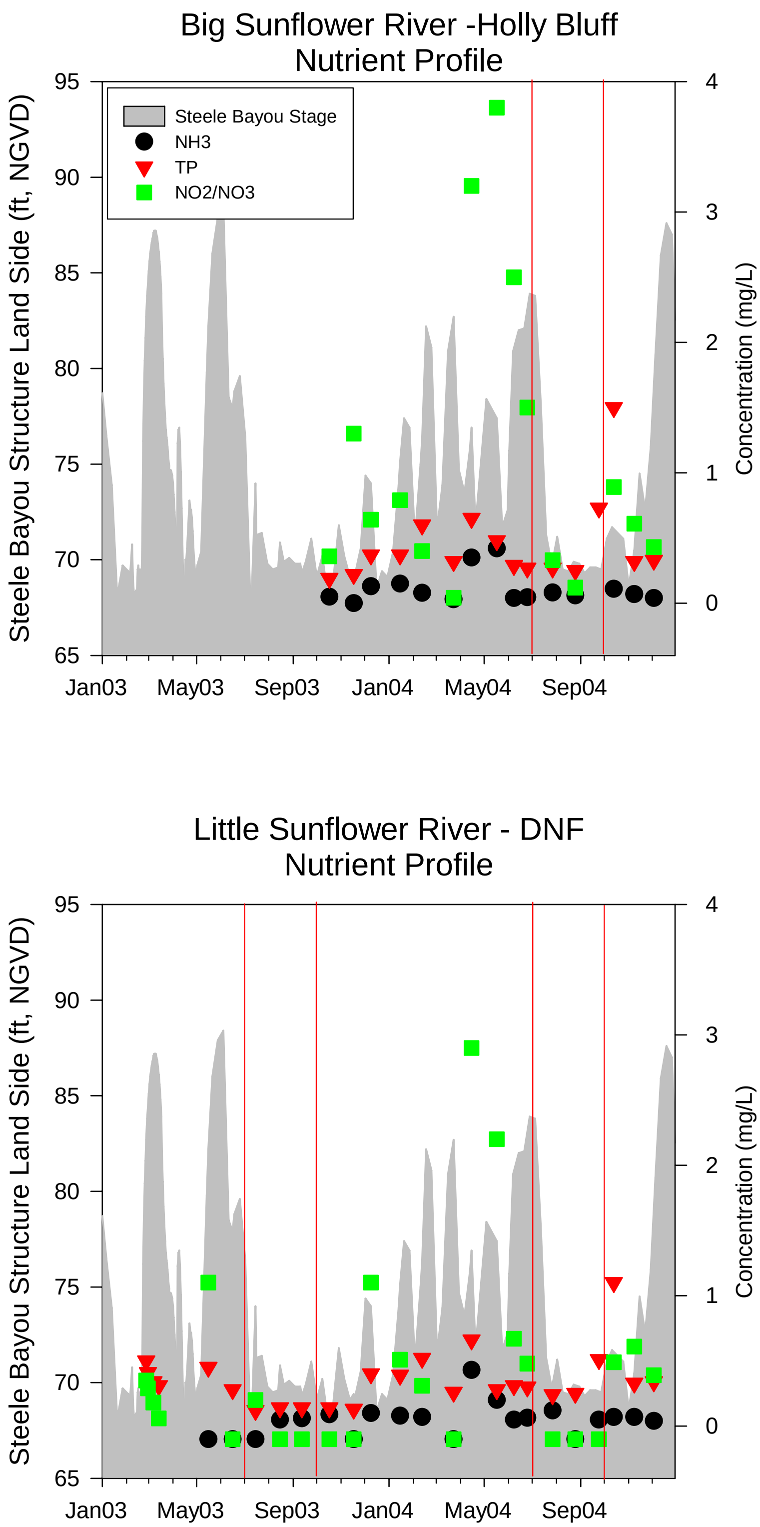


Figure 16-18. Nitrogen and phosphorus data collected from the backwater project area (data reported as < MDL are shown as negative concentrations). Observed nutrient concentrations are lowest during the critical season between July and October.

68.5 to 70.0 feet, NGVD. Managing the Steele Bayou structure in this way allows the system to have a minimum discharge during low-water periods and prevents extended periods of stagnation and stratification. The organic enrichment/low DO TMDL for the Big Sunflower River reach, MSBIGSUNRM4, between Bogue Phalia and the Little Sunflower River structure (Yazoo River) indicates that two control structures, Lock and Dam No. 1 and the Holly Bluff Cutoff weir, may result in DO impairment immediately upstream of these two structures. Water quality model simulations used in development of the TMDL predict that there should be adequate DO downstream of the Holly Bluff Cutoff weir during the summer low-flow period. Postproject impacts downstream of the weir will be discussed in the next section.

Water Quality Model

157. The Vicksburg District asked Dr. James L. Martin at MSU - Bagley College of Engineering to modify the EPA water quality model (Water Quality Analysis Simulation Program (WASP)) developed for the MDEQ TMDL of the Big Sunflower River. The modification extended the model to the Steele Bayou structure and analyzed low-flow conditions with and without the 3 feet of additional water depth proposed under Plan 5. Modeled parameters were updated with project-specific water quality data collected within the study area between 2004 and 2005. The WASP model also analyzed the cumulative effects of completing the Big Sunflower Maintenance Project with and without increases in summer water levels behind the Steele Bayou structure. Results of the model analysis suggest that there is no clear relationship between the proposed increases in pool elevation and variations in DO concentrations. In the model output, DO contributions from phytoplankton primary productivity maintained average water column concentrations above the MDEQ DO standard of 5.0 mg/L for all model reaches. This includes loss of reaeration downstream of the Holly Bluff Cutoff weir during periods when the water surface elevation was 73.0 feet, NGVD (Appendix 16, Attachment 2). The model results suggest that the operational feature to increase the minimum water surface elevation will not have a detrimental impact on DO concentrations in the lower study area. Therefore, the Corps does not expect the proposed changes to operation of the Steele Bayou structure to affect late summer DO concentrations in the Steele Bayou pool. The MSU WASP model report is included as Attachment 2 to this appendix.

Effect on Aquatic Habitat

158. The data suggest that, in both flowing and nonflowing systems, DO concentrations vary with season, flow, weather conditions, time of day, and with depth. It is reasonable to expect that there will be periods when both systems have DO concentrations below the MDEQ average daily minimum of 5.0 mg/L for aquatic life. This may be especially true near the bottom of

streams where the sediment DO requirements are highest. Because the lower Backwater Area is so dependent on phytoplankton productivity, extended periods of heavy cloud cover or heavy rainfall can impact productivity and lower DO concentrations. The data available do show that late summer DO concentrations are fairly uniform in flowing streams and that there is adequate DO to support aquatic life at mid-depth in pooled or nonflowing streams. Additionally, in streams where conditions support high phytoplankton productivity, the system appears to be able to sustain adequate concentrations of DO through the night. While the system may intermittently stratify, this is more likely to occur under unusual climatological circumstances such as extended periods of drought or heavy cloud cover.

159. Fish surveys indicate that the Yazoo Backwater Area is inhabited by fish species tolerant of higher temperatures, low DO, and turbid conditions. Species include catfish, gar, shad, and buffalo. Recent fish surveys in Steele Bayou show that species less tolerant of low DO and turbid conditions have begun to repopulate the bayou as water quality improves. These include black bass and darters. Increasing water depth in the Yazoo Backwater Area is not expected to have a significant impact on the current water column DO concentrations or the current fish assemblage in the majority of the YBWP Area. Increasing the water depth would have the effect of increasing the wetted surface along the channel banks to provide increased foraging and rearing opportunities for many species of wetland and riverine fishes (personal communication, August 3, 2006, Dr. Jack Killgore, ERDC, Vicksburg, Mississippi). Increased volume, depth, and surface area would improve phytoplankton primary productivity and could provide a DO reservoir to buffer against sediment oxygen demand. Increased depth would also provide some relief from the wide swings in afternoon thermal heating that occurs in the summer.

160. The Vicksburg District will monitor DO concentrations in the Steele Bayou pool. If implementation of the summer water level management feature is determined to adversely impact DO concentrations, water level management can be returned to preproject conditions.

IMPACTS FROM REFORESTATION

161. The following analysis of water quality impacts from reforestation was done without knowledge of the exact location of the reforestation other than that the cleared lands in the 1-year flood plain would be targeted. For impaired and TMDL waters, the precise location of the reforestation could be important. To reduce impairment, the reforestation needs to be at the source of the impairment for erosion control or downstream or down-gradient of the impairment in order to fully utilize wetland function as described by HGM wetland functional model. Maps identifying cleared land remaining in the Yazoo Backwater study area show that the majority of cleared land in the 1-year flood plain is located in the ponding areas above the Steele Bayou and the Little Sunflower River structures. Floodwaters ponding in these two areas would receive

maximum benefits from increases in wetland functional value. In addition, the agricultural land surrounding the 1- and 2-year flood frequency cleared lands are up-gradient such that runoff from higher elevation agricultural land often passes through 2- and 1-year land before entering streams. This type of filtering through progressive layers of reforested wetlands maximizes YBWP reforestation benefits to water quality.

162. Eight of the plans (Plans 2, 2A, 2B, 2C, and 4 through 7) evaluated for the YBWP propose reforestation of 26,400 to 124,400 acres of currently-farmed land within the Yazoo Backwater study area. Reforestation of this magnitude will result in a 15 to 65 percent increase in the total number of forested wetland acres within the study area. This impact is almost the direct opposite of clearing at the construction site since lands would be revegetated rather than cleared. In addition to the proposed YBWP reforestation, the USDA Federal Conservation Reserve Program (CRP) and the WRP reforestation programs also provide water quality benefits. These programs convert agricultural lands to forested lands; however, these programs are at or near current program limits in the two counties that make up the majority of the study area. The 2005 land use classification utilized for the wetland analysis classified these USDA lands as cleared noncrop and early-aged forest. Benefits from these USDA reforested acres will be similar to benefits from the proposed YBWP reforestation. Initial planting stabilizes the soil and reduces erosion while forested wetland functional value will improve study area water quality as the forests mature.

163. The nonstructural reforestation component of the recommended plan serves two purposes. The first 15,029 acres that are reforested will ensure that there is no loss in aquatic resource functional value from past and future construction at the pump station site or from changes in hydrology due to operation of the pump station. Reforestation of the 15,029 acres will also ensure net gains in resource value for the other three resources: terrestrial, waterfowl, and wetlands. Reforestation of the remaining acres will provide additional environmental resource benefits. Impacts from reforestation will be long term. Reforestation of cleared lands along streams can have the positive impact of reducing sediment and pollutant yields into the streams and increasing the wetland filtering capacity of seasonal floodwaters. Increasing the number of flooded forest acres could also have the negative impact of increasing methyl mercury production within the Yazoo Backwater study area.

<u>Reduction and Improved
Quality of Stormwater Runoff</u>

164. Conversion from agriculture to forest improves the water quality of receiving water bodies by reducing the amount of sediment, nutrients (fertilizers), and pesticides associated with nonpoint source runoff from agricultural fields. As cropland becomes reforested, these materials no longer reach adjacent streams and gain entry to the aquatic system.

165. A number of methods have been developed to estimate soil runoff from a variety of soil types and land use scenarios. These include the Revised Universal Soil Loss Equation (RUSLE) and the Soil Conservation Service (SCS) runoff curve number method. The RUSLE estimates the soil loss and sediment yield resulting from upland erosion (Julien, 1995). It does not estimate gully or stream-channel erosion. Average annual soil loss can be estimated from applying factors that represent rainfall/runoff erosivity, soil erodibility, slope length and steepness, land cover, and conservation practices. In the Yazoo Backwater study area, a transition from agricultural cropland to forest should only affect the cover-management and conservation practice factors. Changing the land cover from agricultural cropland to forest land or implementing conservation practices should reduce soil erosion and sediment yield, thereby improving water quality.

166. The SCS runoff curve number method, on the other hand, estimates peak rainfall runoff after accounting for soil infiltration. In the Yazoo Backwater study area, rainfall runoff carries sediment, nutrients, and agricultural chemicals. Curve numbers have been developed for various land covers and hydrologic soil groups (USDA NRCS, 1986). Within a particular hydrologic soil group, the runoff curve numbers vary with land cover. Row crops have less runoff than bare soil. Contoured fields have less runoff than straight rowed fields. And wooded lands have less runoff than cropped land or bare fallow land. Both methods show that the proposed changes to land use or cover will decrease runoff with the expected result of reducing quantities and concentrations of suspended sediment and associated nutrients and pesticides in area streams.

167. Yuan and others (2002) used a simulation tool, the Annualized Agricultural Non-Point Source pollutant loading model (AnnAGGNPS 2.1) to evaluate watershed responses to agricultural management practices. The research team used the model to assess the impact of several BMP combinations on sediment yield from a typical Mississippi Delta agricultural watershed, the Deep Hollow Lake Watershed studied in the MDMSEA. The model was used to simulate different tillage systems for cotton and soybeans and make comparisons on sediment yield based on tillage system and BMP evaluated. In addition, the model also compared sediment yield from pasture and forested land to that from conventionally tilled fields. Results showed a 98 percent reduction in sediment yield when a conventionally tilled field was restored to all pasture and a 100 percent reduction in sediment yield when the field was restored to all forest.

168. The USGS quantified the relationship between land use and nutrient and sediment yield to streams in the 1990-91 USGS National Water Summary, (Smith, et al., 1993). Based on data collected between 1980 and 1989, agricultural land planted in corn and soybeans had a nitrate yield of 0.932 tons per square mile per year, a TP yield of 0.163 tons per square mile per year, and a suspended sediment yield of 100 tons per square mile per year. In contrast, during that same period, forest lands yielded 0.255 tons per square mile per year of nitrate, 0.063 tons per square mile per year of TP, and 31 tons per square mile per year of suspended sediment. Based on these data, conversion from agricultural land to forest would result in a 60 to 70 percent reduction in nutrient and suspended sediment yield into adjacent streams. These differences in yield result from factors such as fertilizer composition and application rates, tillage practices,

climate, and soil characteristics that have an influence on both nutrient and suspended sediment availability or on runoff. Although current agricultural practices such as no-till planting and land leveling may have narrowed the gap between the 1993 land use results, the data still show that there will be considerable reduction in nutrient and suspended sediment yield into streams through the reforestation of agricultural land.

169. At the request of the Vicksburg District, USGS is evaluating the benefits of reforestation of agricultural lands within the YBWP Area. This study encompasses more acres than were available for the MDMSEA study. The study will document potential decreases in suspended sediment and nutrient concentrations in runoff from recently forested agricultural fields in the YBWP Area. The study will compare runoff concentrations from reforested lands to runoff concentrations from cropped lands to determine actual percent reductions that could be used to determine project-specific reforestation benefits. At this time, the study is ongoing and no results are available.

170. Estimated reductions in sediment, pesticide, and nutrient yield from stormwater runoff. It is possible to make rough estimates of the benefits to the Yazoo Backwater study area from reforestation in terms of reductions in sediment, pesticide, and nutrient yield in advance of data from the USGS study discussed in the previous paragraph. The sediment TMDL for the Big Sunflower River and Steele Bayou (MDEQ, 2003b, and MDEQ, 2003c) ranges between 0.6 and 1.6 metric tons/km^2-day at the effective discharge (the discharge that typifies sediment transport). This corresponds to sediment yields between 0.3 and 10.5 metric tons/km^2-day (MDEQ, 2003c) or between 110 and 3,832 metric tons/km^2-year. Using the conservative lower number, 110 metric tons/km^2-year multiplied by the number of acres in the 2-year flood plain that are removed from agricultural production yields the amount of sediment retained each year by reforestation. For the recommended plan, reforestation of 55,600 acres (225 km^2) would reduce sediment yield by 24,750 metric tons per year. Table 16-25 shows an estimate of the reduction in sediment yield based upon the 2005 land use for each of the YBWP alternate plans. The mass of suspended sediment exported from the YBWP Area was calculated based on data obtained from Moody and Meade (1992) and Runner and others (2002) and is presented in Table 16-32. The estimated base sediment discharge for the YBWP, 221,747 metric tons per year, was used to calculate a percent reduction for the study area. For the recommended plan, reforestation of agricultural land within the 2-year flood plain would reduce annual sediment yield by 11 percent.

TABLE 16-25
REFORESTATION - ESTIMATED REDUCTIONS
IN SEDIMENT, NUTRIENT, AND PESTICIDE YIELDS

Plan	Sediment	Sediment	Phosphorus	Pesticides	Total Nitrogen	Total Nitrogen
	Metric Tons/Yr	% Reduction	% Reduction	% Reduction	Metric Tons/Yr	% Reduction
YBWP Base	221,747	-	-	-	3,614	-
Plan 2	42,602	19%	19%	3%	423	12%
Plan 2A	36,236	16%	16%	2%	360	10%
Plan 2B	9,170	4%	4%	1%	91	3%
Plan 2C	42,602	19%	19%	3%	423	12%
Plan 3 a/	23,755	11%	11%	2%	236	7%
Plan 4	16,560	7%	7%	1%	165	5%
Plan 5	24,750	11%	11%	2%	246	7%
Plan 6	36,690	16%	16%	2%	360	10%
Plan 7	42,602	19%	19%	3%	423	12%

a/ Includes mitigation acres.

171. Agricultural chemicals such as phosphorus and the legacy pesticides, DDT and toxaphene, are sorbed onto soil and sediment, such that reducing sediment yield from reforested agriculture land would also remove a corresponding amount of each of these materials from the aquatic system. Soils in the study area have adequate levels of phosphorus, such that most crops do not require additional phosphorus applications. Therefore, reductions in phosphorus yield from reforested agricultural land were considered equivalent to reductions in sediment yield. For the recommended plan, there would also be an 11 percent reduction in the amount of phosphorus leaving the field on soil particles each year. Legacy pesticides, on the other hand, were generally applied on cotton land, which is at higher elevations than the 1-year flood plain. Estimates for reductions in legacy pesticide yield were based upon the percentage of cotton land in the 2-year flood plain (2005 land use). Reductions in legacy pesticide yield were estimated to be 14 percent of the corresponding sediment yield for each alternative. For the recommended plan, Table 16-25 shows that reforestation would reduce the sorbed pesticide yield by 2 percent. It must be noted, however, that there would also be benefits from the elimination of applications of other agricultural chemicals such as the current-use pesticides that are not discussed here.

172. Reductions in nitrogen yield for the proposed reforestation for each alternative were also estimated (Table 16-25). Nitrogen is not associated with sediment export. Nitrogen is soluble in water and usually exits the point of application in its dissolved form. Reductions in nitrogen export from reforestation were calculated using nitrogen export coefficients for cotton, corn, and

soybeans (Ashby, et al., 2000; and Beaulac, M.N. and Reckhow, K.H., 1982). The products of the individual coefficients and the number of acres of each crop were summed and divided by the total number of crop acres in the 2-year flood plain to obtain an average nitrogen export coefficient (1.09 metric tons/km^2-year). The amount of agricultural land in the 2-year flood plain proposed for reforestation for each alternative was multiplied by the nitrogen export coefficient (1.09 metric tons/km^2-year) to obtain the average annual mass of nitrogen removed from the aquatic system by taking agricultural land out of production. The YBWP base load for total nitrogen was estimated to be 3,614 metric tons/ km^2-year. Load calculations were based upon USGS (Runner, et al., 2002; and Goolsby, et al., 1999) estimates of total nitrogen loading in the Yazoo River and Mississippi River and on the average total nitrogen concentration (2.2 mg/L) observed in the YBWP Area by the Vicksburg District. For the recommended plan, reforestation would reduce total nitrogen in runoff by 7 percent. Results of the preceding stormwater runoff analysis were used to address project impacts to impaired waters, including those with TMDL.

173. The yield estimates described in the previous paragraphs assumed stormwater runoff benefits from all of the acres targeted for reforestation. While the recommended plan could potentially affect flood durations on up to 66,945 acres of existing wetlands to some extent, the Vicksburg District does not believe that the flood protection provided by the YBWP will alter current land use such that additional acres of existing forest land will be cleared (Mitigation Appendix, Appendix 1). Postproject, forested acres will remain forested, and agricultural acres should remain in agriculture or be converted to forests. Postproject, existing agricultural land that is not reforested will continue to export sediment and other agricultural chemicals into study area water bodies at current rates. For these reasons, the stormwater runoff analysis did not include increases in stormwater runoff yield for sediment, nutrients, or pesticides, but assumed these yields to be part of the project base conditions.

174. Actual reductions in stormwater runoff yield will be location specific. However, most of the agricultural lands in the 1- and 2-year flood plains lie in the lower and upper ponding areas above the Steele Bayou and Little Sunflower River structures. Floodwaters ponding in these two areas would receive maximum benefits from reforestation because they flood the most frequently. Cleared land above the 1- and 2-year flood frequency is upgradient, such that runoff from higher elevation agricultural land often passes through 2- and 1-year land before entering streams. This type of filtering through progressive layers of reforested wetlands maximizes the YBWP reforestation benefits to water quality.

175. There is another direct benefit from reforestation. These low-lying lands tend to be sediment sinks that remove suspended sediments, nutrients, and pesticides from the floodwaters that pass through them. This type of sequestration and transformation of particles, elements, and compounds is recognized as important wetland functions that directly impact water quality (Smith and Klimas, 2002; Ashby, 2002; and Smith and Lin, 2007). The amount of reduction is difficult to quantitate, however. Quantitative reductions in total nitrogen and phosphorus in the

Yazoo Backwater Area due to reductions in the amount of fertilizer applied are likely to be minimal. Low-lying agricultural lands in the basin are planted primarily in soybeans, which generally are not treated with fertilizer because, as legumes, they obtain nitrogen though symbiotic nitrogen fixation processes. The reduction in suspended sediment could be considerable, but will depend on the actual extent and period of inundation of the newly forested lands. Forested wetland removal of suspended sediments and nutrients will be discussed in greater detail in the section entitled "Wetland Functions Related to Removal of Sediments, Nutrients and Pesticides within the Yazoo Backwater Study Area."

Increased Filtering Capacity
of TSS from Floodwater

176. Changes in duration or land cover can alter the filtering capacity of areas inundated by backwater floods. In the section on “Impacts on Efficiency of Suspended Sediment Removal,” it was shown that for the three monitoring studies in the DNF, there was a 72 percent average reduction in TSS in the Little Sunflower River, a 65 percent average reduction in TSS at the reforested WRP sites, and an average 60 percent TSS reduction in the forest sites in a 17-day sampling period. The same data can be used to demonstrate the amount of suspended sediment removed as floodwater traveled from the Little Sunflower River to the sampling sites in the WRP fields along Dummy Line Road. Figure 16-19 graphs mean TSS concentrations during the 2002 and 2003 backwater flood events along the Little Sunflower River. Floodwaters enter the fields from the north via False River and travel southward through fields recently planted in hardwood trees before reaching the sampling stations along Dummy Line Road. Data from the Little Sunflower River are shown for comparison. There appears to be a marked difference between the amounts of TSS in the leading edge of the floodwaters moving through the fields relative to the TSS concentration in the Little Sunflower River during the two events. In 2002, the trees were small and barely indistinguishable from the surrounding grass. By 2003, the trees were well above the surrounding vegetation, which consisted of thick tall grass, vines, and brush. The data show that less TSS reached the sampling stations in 2003 than in 2002 although concentrations in the river were very similar.

177. The data suggest that backwater floods moving through reforested fields benefit from the filtering of suspended sediment and the materials attached to them. This filtering capacity may vary with the progression of forest development, the distance the out-of-bank waters travel, and with the length of time the floodwaters remain out-of-bank.

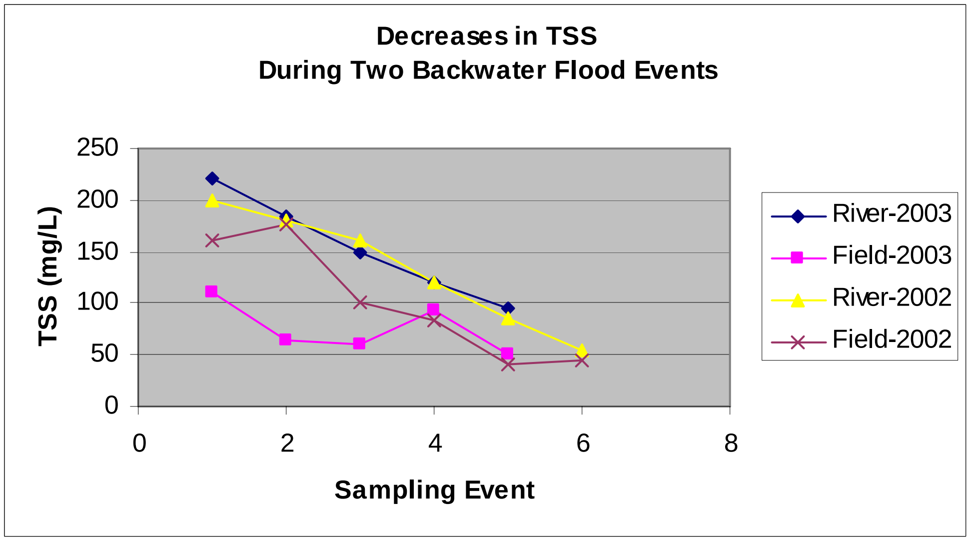


Figure 16-19. Comparison of TSS removed from backwater flood waters by overgrown vegetation in 2002 and 2003. The average TSS concentration in waters reaching sampling sites on Dummy Line Road appears to have decreased as trees and brush fill in the former agricultural fields and increase filtering capacity.

178. Plan 1, the "No Action" plan, will not have any impacts to water quality. Plans 2, 2A, 2B, and 2 C are nonstructural plans. By virtue of no pump station and greater areas of reforestation, these plans offer the longest duration of flooding and will maximize the retention of sediment, nutrients, and pesticides on flooded lands. Plans 3 through 7 all have a 14,000-cfs pump station, but differ in the amount of reforestation and the on/off elevation for pump station operation. In general, the larger areas of reforestation should provide greater benefits to water quality. Higher pump-on elevations will increase the duration of floodwater ponding and increase sediment retention. These types of increases or decreases in sediment and associated pollutant levels are difficult to quantify. However, one approach is to utilize the same wetland functional capacity assessment used in the Yazoo Backwater Wetland Analysis. A discussion of wetland functions affecting water quality is presented in the next section.

Wetland Functions Related to Removal
of Sediments, Nutrients, and Pesticides
Within the Yazoo Backwater Study Area

179. The concept of water quality wetland functions was introduced in the discussion of impacts of reduced flood elevations. In the HGM wetland analyses of the YBWP Area, Smith and Lin (2007) utilized eight functions to determine project impacts to wetlands. Three of these functions, Export of Organic Carbon and the Physical and Biological Removal of E/C, can be directly associated with water quality.

180. As was described, the HGM assessment utilizes the concept of wetland FCUs to measure changes in wetland functionality. The FCU is the product of FCI and the number of acres impacted. In their 2007 assessment, Smith and Lin calculated the average annual change for each of the eight functions, in 10 year increments, over the 50-year period expected for forest maturity, and utilized an average of that period to measure benefits of reforestation (Table 16-26). This assessment was completed without prior knowledge of the location or flood durations of targeted lands other than the lands would be located primarily in the 1- and 2-year flood plain. In Table 16-26, the average FCU per acre is equivalent to the FCI, which is used as an indicator for the level of quality or efficiency that a particular function exhibits in a wetland. An FCI can range in value from 0 to 1.0. A lower number indicates that the wetland is not functioning at a high capacity compared to the ability of reference wetlands to perform the same function. For the YBWP, the average annual change in FCI at the end of 50 years was determined to be 3.74 for the combined eight Yazoo Backwater wetland functions. The combination for the three wetland water quality functions for Organic Carbon and Removal of E/C is 0.61 or 16 percent of the total FCI. In the first year after reforestation, FCI for Export of Organic Carbon and Biological Removal of E/C was low, 0.03. The model predicted an increase in FCI for both functions every 10 years as the forest matured reaching 0.33 at year 40, a projected tenfold increase in each FCI. The FCI for Physical Removal of E/C increases from 0.00 to 0.33 by year 50, suggesting that the model adjusts for changes in ground cover as forests develop and mature. The recommended plan would increase forested wetland acres by approximately 30 percent, thereby increasing the study area's capacity to physically remove E/C.

TABLE 16-26
AVERAGE ANNUAL CHANGE IN FCU PER ACRE (FCI)
OVER PERIOD OF WETLAND ANALYSIS

FUNCTION	FCU/Acre Restoration Year 1	FCU/Acre Restoration Year 10	FCU/Acre Restoration Year 20	FCU/Acre Restoration Year 30	FCU/Acre Restoration Year 40	FCU/Acre Restoration Year 50	Average Annual a/ Change in FCU/Acre
Detain Floodwater	0.00	0.44	0.59	0.80	0.94	0.97	0.62
Detain Precipitation	0.25	0.38	0.50	0.69	0.88	1.00	0.61
Cycle Nutrients	0.19	0.56	0.60	0.95	1.00	1.00	0.72
Export Organic Carbon	0.03	0.16	0.19	0.31	0.33	0.33	0.23
Physical Removal of E/C	0.00	0.04	0.08	0.17	0.25	0.33	0.15
Biological Removal of E/C	0.03	0.16	0.19	0.31	0.33	0.33	0.23
Maintain Plant Communities	0.00	0.53	0.68	0.82	0.91	0.98	0.65
Provide Wildlife Habitat	0.00	0.00	059	0.80	0.87	0.90	0.53
Total	0.49	2.27	3.42	4.87	5.51	5.86	3.74

a/ Average Annual = (Sum of Year 1 through 50) / 6
Taken from Table 79 (Smith and Lin, 2007)

181. Smith and Lin (2007), also calculated the annual changes expected in FCU for two scenarios: "B1" - the YBWP alone, and "B2" - the cumulative impacts of the combined Yazoo Backwater and the Big Sunflower River Maintenance Projects. The model evaluated total project FCU for each scenario and alternative based upon 100 percent reforestation of the targeted acres. Elements included in the model were: construction impacts on wetlands due to the placement of pump station and other infrastructure under all the proposed alternative plans; hydrologic impacts on wetlands due to the alteration of the extent and duration of backwater flooding in portions of the lower Yazoo Basin; project changes in wetland acres due to nonstructural reforestation; and project changes in wetland acres due to other than nonstructural reforestation to achieve no-net-loss. Tables 16-27 and 16-28 are adapted from the information presented in Tables 80 and 81 of Smith and Lin (2007), for the changes in annual FCU for the Yazoo Backwater alternatives. The tables also estimate the change in FCU for the wetland water

TABLE 16-27
ESTIMATE OF ANNUAL CHANGES IN VARIOUS FCU FOR THE YAZOO BACKWATER PROJECT

	Annual Change in FCU Due to Construction Impacts	Annual Change in FCU Due to Hydrologic Impacts	Acres of Non-Structural Reforestation (Projected)	Annual (Average) Change in FCU Per Acre	Annual (Average) Change in FCU for Non-Structural Reforestation	Acres of Other Than Non-Structural Reforestation to Achieve No-Net-Loss	Annual Change in FCU Per Acre	Annual change in FCU for Other Than Non-Structural Reforestation	Total Annual Change in FCU
SUMMARY OF ANNUAL CHANGE IN FCU FOR B1 SCENARIO (adapted from Table 80., Smith and Lin, 2006)									
Plan 2	0	0	124400	3.74	44768	0	3.74	0	464,768
Plan 2A	0	0	81400	3.74	304116	0	3.74	0	304,116
Plan 2B	0	-50869	26400	3.74	98632	0	3.74	0	47,763
Plan 2C	0	0	114400	3.74	427407	0	3.74	0	427,407
Plan 3	-240	-43990	0	3.74	0	20860	3.74	77935	33,705
Plan 4	-240	-28132	37200	3.74	138982	0	3.74	0	110,610
Plan 5	-240	-14188	55600	3.74	207726	0	3.74	0	193,298
Plan 6	-240	-9300	81400	3.74	304116	0	3.74	0	294,576
Plan 7	-240	-3949	124400	3.74	464768	0	3.74	0	460,579
ESTIMATE OF ANNUAL CHANGE IN EXPORT OF ORGANIC CARBON FCU FOR B1 SCENARIO									
Plan 2	0	0	124400	0.23	28612	0	0.23	0	28,612
Plan 2A	0	0	81400	0.23	18722	0	0.23	0	18,722
Plan 2B	0	-16075	26400	0.23	6072	0	0.23	0	-10,003
Plan 2C	0	0	114400	0.23	26312	0	0.23	0	26,312
Plan 3	-21	-14177	0	0.23	0	20860	0.23	4798	-9,400
Plan 4	-21	-10537	37200	0.23	8556	0	0.23	0	-2,002
Plan 5	-21	-4442	55600	0.23	12788	0	0.23	0	8,325
Plan 6	-21	-2911	81400	0.23	18722	0	0.23	0	15,790
Plan 7	-21	-1207	124400	0.23	28612	0	0.23	0	27,384
ESTIMATE OF ANNUAL CHANGE IN PHYSICAL REMOVAL OF ELEMENTS / COMPOUNDS FCU FOR B1 SCENARIO									
Plan 2	0	0	124400	0.15	18660	0	0.15	0	18,660
Plan 2A	0	0	81400	0.15	12210	0	0.15	0	12,210
Plan 2B	0	-16118	26400	0.15	3960	0	0.15	0	-12,158
Plan 2C	0	0	114400	0.15	17160	0	0.15	0	17,160
Plan 3	-25	-13352	0	0.15	0	20860	0.15	3129	-10,248
Plan 4	-25	-9130	37200	0.15	5580	0	0.15	0	-3,575
Plan 5	-25	-4629	55600	0.15	8340	0	0.15	0	3,686
Plan 6	-25	-3038	81400	0.15	12210	0	0.15	0	9,147
Plan 7	-25	-1363	124400	0.15	18660	0	0.15	0	17,242
ESTIMATE OF ANNUAL CHANGE IN BIOLOGICAL REMOVAL OF ELEMENTS / COMPOUNDS FCU FOR B1 SCENARIO									
Plan 2	0	0	124400	0.23	28612	0	0.23	0	28,612
Plan 2A	0	0	81400	0.23	18722	0	0.23	0	18,722
Plan 2B	0	-16075	26400	0.23	6072	0	0.23	0	-10,003
Plan 2C	0	0	114400	0.23	26312	0	0.23	0	26,312
Plan 3	-21	-14177	0	0.23	0	20860	0.23	4798	-9,400
Plan 4	-21	-10537	37200	0.23	8556	0	0.23	0	-2,002
Plan 5	-21	-4442	55600	0.23	12788	0	0.23	0	8,325
Plan 6	-21	-2911	81400	0.23	18722	0	0.23	0	15,790
Plan 7	-21	-1207	124400	0.23	28612	0	0.23	0	27,384

TABLE 16-28
ESTIMATE OF ANNUAL CHANGES IN FCU FOR COMBINED YAZOO BACKWATER AND BIG SUNFLOWER RIVER PROJECTS

	Annual Change in FCU Due to Construction Impacts	Annual Change in FCU Due to Hydrologic Impacts	Acres of Non-Structural Reforestation (Projected)	Annual (Average) Change in FCU Per Acre	Annual (Average) Change in FCU for Non-Structural Reforestation	Acres of Other Than Non-Structural Reforestation to Achieve No-Net-Loss	Annual Change in FCU Per Acre	Annual change in FCU for Other Than Non-Structural Reforestation	Total Annual Change in FCU
SUMMARY OF ANNUAL CHANGE IN FCU FOR B2 SCENARIO (adapted from Table 81., Smith and Lin, 2006)									
Plan 2	0	0	124400	3.74	464768	0	3.74	0	464,768
Plan 2A	0	0	81400	3.74	304116	0	3.74	0	304,116
Plan 2B	0	-49697	26400	3.74	98632	0	3.74	0	48,936
Plan 2C	0	0	114400	3.74	427407	0	3.74	0	427,407
Plan 3	-240	-45229	0	3.74	0	21367	3.74	79829	34,359
Plan 4	-240	-35337	37200	3.74	138982	0	3.74	0	103,405
Plan 5	-240	-17627	55600	3.74	207726	0	3.74	0	189,858
Plan 6	-240	-9998	81400	3.74	304116	0	3.74	0	293,878
Plan 7	-240	-3874	124400	3.74	464768	0	3.74	0	460,654
ESTIMATE OF ANNUAL CHANGE IN EXPORT OF ORGANIC CARBON FCU FOR B2 SCENARIO									
Plan 2	0	0	124400	0.23	28612	0	0.23	0	28,612
Plan 2A	0	0	81400	0.23	18722	0	0.23	0	18,722
Plan 2B	0	-15713	26400	0.23	6072	0	0.23	0	-9,641
Plan 2C	0	0	114400	0.23	26312	0	0.23	0	26,312
Plan 3	-21	-14590	0	0.23	0	21367	0.23	4914	-9,697
Plan 4	-21	-11375	37200	0.23	8556	0	0.23	0	-2,840
Plan 5	-21	-5585	55600	0.23	12788	0	0.23	0	7,182
Plan 6	-21	-3137	81400	0.23	18722	0	0.23	0	15,564
Plan 7	-21	-1184	124400	0.23	28612	0	0.23	0	27,407
ESTIMATE OF ANNUAL CHANGE IN PHYSICAL REMOVAL OF ELEMENTS / COMPOUNDS FCU FOR B2 SCENARIO									
Plan 2	0	0	124400	0.15	18660	0	0.15	0	18,660
Plan 2A	0	0	81400	0.15	12210	0	0.15	0	12,210
Plan 2B	0	-15722	26400	0.15	3960	0	0.15	0	-11,762
Plan 2C	0	0	114400	0.15	17160	0	0.15	0	17,160
Plan 3	-25	-13688	0	0.15	0	21367	0.15	3205	-10,508
Plan 4	-25	-10751	37200	0.15	5580	0	0.15	0	-5,196
Plan 5	-25	-5589	55600	0.15	8340	0	0.15	0	2,726
Plan 6	-25	-3246	81400	0.15	12210	0	0.15	0	8,939
Plan 7	-25	-1339	124400	0.15	18660	0	0.15	0	17,296
ESTIMATE OF ANNUAL CHANGE IN BIOLOGICAL REMOVAL OF ELEMENTS / COMPOUNDS FCU FOR B2 SCENARIO									
Plan 2	0	0	124400	0.23	28612	0	0.23	0	28,612
Plan 2A	0	0	81400	0.23	18722	0	0.23	0	18,722
Plan 2B	0	-15713	26400	0.23	6072	0	0.23	0	-9,641
Plan 2C	0	0	114400	0.23	26312	0	0.23	0	26,312
Plan 3	-21	-14590	0	0.23	0	21367	0.23	4914	-9,697
Plan 4	-21	-11375	37200	0.23	8556	0	0.23	0	-2,840
Plan 5	-21	-5585	55600	0.23	12788	0	0.23	0	7,182
Plan 6	-21	-3137	81400	0.23	18722	0	0.23	0	15,564
Plan 7	-21	-1184	124400	0.23	28612	0	0.23	0	27,407

quality functions, Export Organic Carbon, Physical Removal of E/C, and Biological Removal of E/C. FCU data for the construction and hydrologic impacts for the function specific evaluations were found in the supporting spreadsheet accompanying the Smith and others 2007 report. FCU for the nonstructural and other than nonstructural mitigation components were calculated by multiplying the acres by the appropriate average annual change in FCU per acre from Table 16-26. Table 16-27 presents data results for the B1 scenario, and Table 16-28 presents data results for the B2 scenario. These data provide a relative comparison of expected changes in the wetland water quality functions for each of the proposed alternatives. Although the HGM model includes the USDA CRP and WRP reforested acres in the base/existing functional analysis, they were not evaluated as mature forests. Instead, they were input into the model as cleared noncrop and early-aged forest acres just as they appeared in the 2005 land use classification.

182. Compared to the base wetland functional value, all of the alternative plans would produce a net increase in total wetland FCU. This net increase includes any compensatory mitigation requirements to achieve a no-net-loss. Estimating the annual change in each of the three individual water quality wetland functions, all of the alternatives except Plans 2B, 3, and 4 would also produce net increases. Plans 2B, 3, and 4 would have net losses in wetland functional value with regard to water quality. For Plan 2B, the B1 scenario would have the greater loss, while the B2 scenario would have the greater loss for Plans 3 and 4. The recommended alternative, Plan 5, has a net gain in FCU for all wetland functions evaluated, with the B1 scenario for each function having the greater gain.

183. The wetland assessment utilizes the changes in total FCU to quantitate impacts to study area wetlands. Similarly, changes in FCU for the individual wetland water quality functions discussed above can be used as a tool to quantitate project impacts to water quality for each of four listed impairments: sediment, pesticides, nutrients, or organic enrichment. Table 16-26 shows that each of the three water quality wetland functions is projected to improve during the 50 years after reforestation. Increased forested wetland acres will improve the retention of suspended sediments and the elements and compounds, such as pesticides and phosphorus that are attached to them. Increased forested wetland acres will also increase biological processing of nitrogen and other degradable materials. Comparing the FCU for each project alternative (Tables 16-27 and 16-28) to the YBWP base FCU provides a means of measuring the expected improvement. An increase over base for an impairment means that the alternative would have the result of improving water quality for that impairment during flooding. The percent change in FCU for each of the project alternatives and scenarios is summarized in Table 16-29. During flooding the recommended plan would increase sediment removal by 4 percent, increase pesticide removal by 4 percent, increase nutrient removal by 7 percent, and increase the export of dissolved organic carbon by 9 percent. Results of the HGM analysis were combined with results from the stormwater runoff analysis to address project impacts to TMDL and impaired water bodies.

TABLE 16-29
PERCENT CHANGE IN WATER QUALITY FCU
FOR THE B1 AND B2 SCENARIOS FOR LISTED WATER BODY
IMPAIRMENTS IN THE YAZOO BACKWATER PROJECT AREA

Plan	Listed Impairment							
	Sediment		Pesticides		Nutrients		Organic Enrichment	
	B1	B2	B1	B2	B1	B2	B1	B2
Plan 2	+ 22	+ 22	+ 22	+ 22	+ 27	+ 27	+ 31	+ 31
Plan 2A	+ 14	+ 14	+ 14	+ 14	+ 17	+ 17	+ 20	+ 20
Plan 2B	- 14	- 14	- 14	- 14	- 12	- 12	- 11	- 11
Plan 2C	+ 20	+ 20	+ 20	+ 20	+ 24	+ 24	+ 29	+ 29
Plan 3	- 12	- 12	- 12	- 12	- 11	- 11	- 10	- 11
Plan 4	- 4	- 6	- 4	- 6	- 2	- 5	- 0.5	- 3
Plan 5	+ 4	+ 3	+ 4	+ 3	+ 7	+ 6	+ 9	+ 8
Plan 6	+ 11	+ 10	+ 11	+ 10	+ 14	+ 14	+ 17	+ 17
Plan 7	+ 20	+ 20	+ 20	+ 20	+ 25	+ 25	+ 30	+ 30

NOTE: B1 Changes due Yazoo Backwater Project alone.
B2 Cumulative changes for Yazoo Backwater Project and the Big Sunflower Maintenance Project.

184. Utilization of the HGM approach to evaluate changes in individual wetland functions is not without precedence. The NRCS utilized individual HGM functional capacity indices (FCI) to compare changes in the functional condition among wetlands of the same subclass including bottom-land hardwood wetlands of the Mississippi Delta (USDA NRCS, 2002). Scientists at ERDC are also using HGM methodology to monitor changes to wetland functional capacity on other existing reforested mitigation lands in the Mississippi Delta for the Vicksburg District. As used in the YBWP water quality analysis, the individual FCU provides a relative comparison of changes in the water quality wetland functions for each of the proposed alternatives.

185. The Vicksburg District will continue to monitor water quality during backwater flooding in the Little Sunflower River and the DNF. Results of these monitoring studies will be used to further document and understand preproject water quality conditions. Once the pump station is operational, impacts will be monitored through continued sampling.

Methyl Mercury

186. Mercury contamination is an environmental concern in the United States. Nearly all fish and shellfish contain traces of mercury. However, some fish contain higher levels of mercury than others. Mercury is cited as a cause of fish consumption advisories in more than 42 states and is responsible for approximately 80 percent of such advisories in the country. Mercury has also become an issue in the Gulf of Mexico where EPA and FDA advise susceptible sectors of the population to limit or avoid consumption of certain species of fish (FDA, 2004). Mercury has historically been used in its metallic and inorganic forms in a wide variety of industrial uses. Combustion of mercury containing fuels or waste is the source of most of the anthropogenic mercury entering the environment today (EPA, 2006a). Some of the mercury emitted into the atmosphere can be transported over very long distances where it can be deposited onto land or

directly into waterways or the ocean (NSTC, 2004). In Mississippi, MDEQ believes that atmospheric deposition is the source of mercury impairment in some of the Yazoo Basin's headwaters (MDEQ, 2004c). Mercury emissions deposited on land can be washed into streams and rivers during rainfall events. Based on aerial deposition, the mercury contribution from any subbasin or watershed should be proportional to its size. In the YBWP Area, the streams and rivers empty into the Yazoo River, then into the Mississippi River and the Gulf of Mexico. The Mississippi River is estimated to contribute more than 10 metric tons of total mercury per year into the Gulf of Mexico (Garbarino, et al., 1995; and NSTC, 2004). With approximately 1 percent of the drainage basin, the YBWP Area contributes a small portion of that load. The YBWP will not change the amount of total mercury load leaving the project area, as the pump station will change only the time that water leaves the project area, not the amount of water.

187. Inorganic mercury is generally not a health concern because it is poorly absorbed by the digestive tract. In contrast, methyl mercury is an organic form of mercury that is toxic to the nervous system (Brigham, et al., 2003). It is generally accepted that 95 percent of all mercury in fish tissue is methyl mercury. Methyl mercury is passed through the food chain and eventually passed to man primarily through the consumption of fish.

188. A possible impact of wetland reforestation within the Yazoo Backwater study area is the potential for increased methyl mercury production. This is because the large amounts of detritus (decomposing organic material) on a forest floor are believed to provide the organic precursors for the methyl group in methyl mercury. While existing forests have been shown to produce methyl mercury during backwater flooding, croplands that contain limited detritus under current conditions would provide substantially more detritus when converted into forests with trees, underbrush, and leaf litter. The amount of methyl mercury produced is dependent on the amount of precursors available and the period of inundation. If inundated for extended periods of time, these newly created forests could increase the production of methyl mercury above current levels. Although the YBWP would have some effect on the extent and duration of flooding, the net result would be an increase in the number of forested wetlands by 26,400 to 124,400 acres, depending upon the plan. The following analysis will show that the reduced flood durations associated with the pump-on elevation for Plan 5, the recommended plan, would only increase the opportunity for methyl mercury production by approximately 3 percent over 50 years. The nonstructural plans, on the other hand, could increase the potential for methyl mercury production by as much as 31 percent.

189. <u>Factors Controlling Methyl Mercury Production</u>.

a. Although the factors controlling methyl mercury production are not fully understood, studies by Canadian researchers have shown that inundation of forests surrounding newly formed reservoirs has resulted in increases in methyl mercury concentrations in water and fish tissue (St. Louis, 1994; and Jackson, 1991). Other researchers have shown that methyl mercury production can begin after 7 to 10 days of inundation (Wright and Hamilton, 1982). Many researchers believe that naturally occurring sulfate-reducing bacteria are the primary agents of the environmental production of methyl mercury. Sulfate reducing bacteria are anaerobes that oxidize a limited range of organic substrates. They use sulfate as a terminal electron receptor for their respiration and produce sulfide.

b. While the concentration of inorganic mercury is important for methyl mercury production, it is not the only factor nor is it necessarily the controlling factor. Other factors identified as important include the chemical form of mercury, temperature, the availability of organic substrate for sulfate-reducing bacteria, mercury demethylation activity, *in situ* reduction–oxidation conditions, and pH. There is also evidence that additions of high concentrations of ferrous iron may reduce net methyl mercury production. (Mehrotra and Sedlak, 2005). In addition to these factors, researchers in the Everglades have found that sulfide concentrations can control methyl mercury production by affecting the species of mercury available to the sulfate-reducing bacteria (Benoit et al., 2003). In aquatic environments, especially flowing water, many of these parameters vary temporally and spatially. Any of these factors can potentially limit the concentration of methyl mercury in aquatic systems. Researchers in the Everglades also found that the highest levels of methylation and methyl mercury in water and fish were associated with sediments showing intermediate levels of sulfate and sulfate reduction. In their "National Pilot Study of Mercury Contamination of Aquatic Ecosystems," Brumbaugh and others (2001) found positive correlations between percentages of wetlands in a watershed and concentrations of dissolved organic matter to mercury in fish tissue. They also found that methyl mercury in water was a better predictor of fish tissue mercury concentrations than was methyl mercury in sediment.

190. Current Methyl Mercury in the DNF, Mississippi.

a. The Vicksburg District has collected methyl mercury samples from two regions within the District's boundary. With the assistance of USGS, the Vicksburg District has collected total mercury and methyl mercury samples from the Ouachita River in Arkansas and Louisiana since 1998, including Felsenthal National Wildlife Refuge (NWR). Samples from 10 locations within the DNF in Mississippi were also collected in 2003, 2004, and 2005 during backwater flood events (the peak period of methyl mercury production). The seasonal variations of total mercury and methyl mercury in Felsenthal NWR and the DNF are plotted in Figures 16-20. Felsenthal NWR is operated as a greentree reservoir where the water level is raised annually for 6 months each winter at the request of FWS to benefit migrating waterfowl. Two of the 2003 DNF samples were collected in a greentree reservoir; the other four were collected in the forest along the outer perimeter of the backwater during the peak of the flood event. In 2004, two DNF samples were collected in the same greentree reservoir, one was collected in a DNF lake, and one was collected in the Little Sunflower River. Five of the 2005 DNF samples were collected in greentree reservoirs, two were collected in DNF lakes, and one was collected in the Little Sunflower River.

b. Total mercury and methyl mercury levels in the Ouachita River increased within weeks of the pool being raised in Felsenthal NWR (Figure 16-20a and b). Concentrations decrease each year as river stages are returned to normal elevations after the waterfowl migratory season. In the Yazoo Backwater study area, mercury samples were only collected during

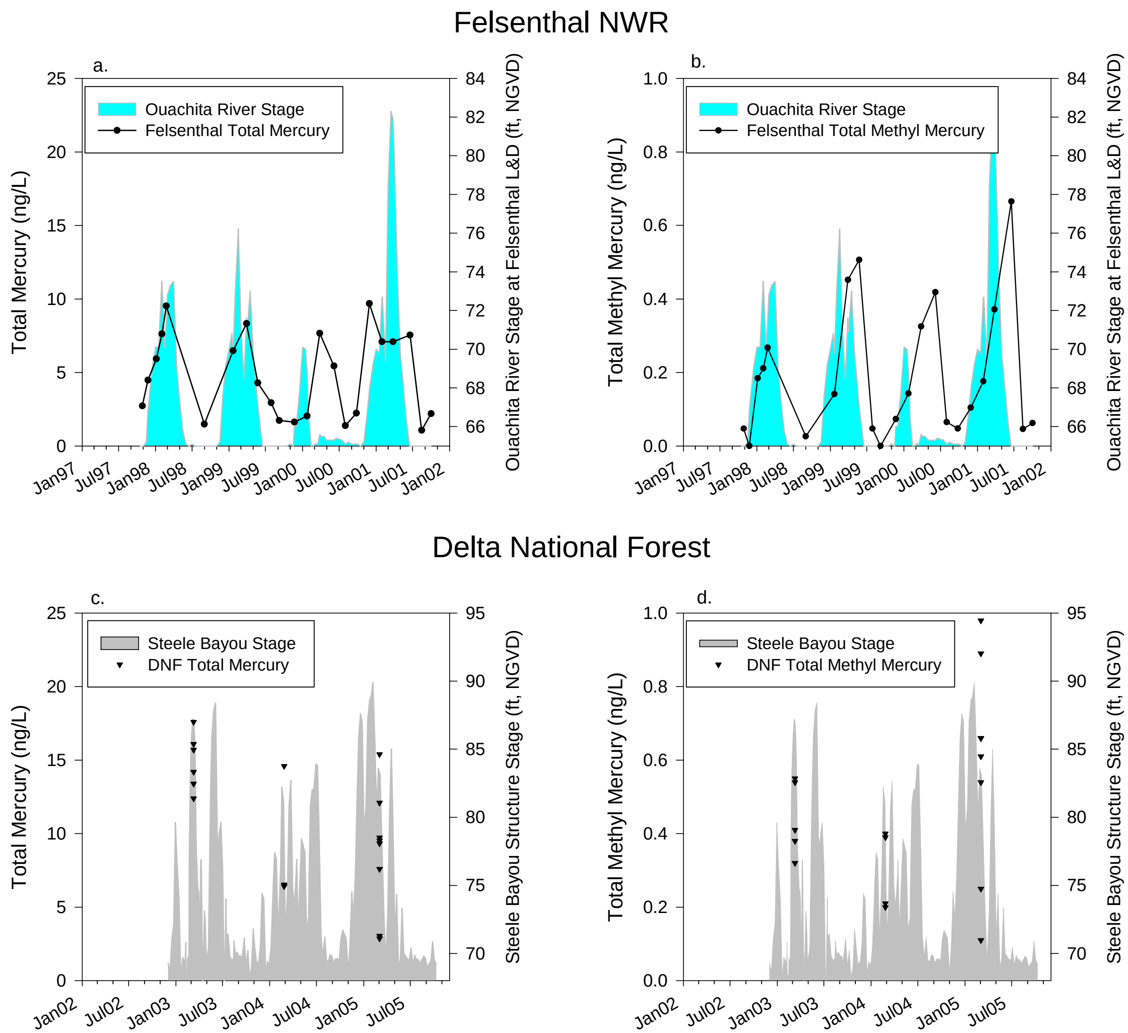


Figure 16-20. Seasonal variation in mercury concentrations: a) total mercury in Felsenthal NWR; b) total methyl mercury in Felsenthal NWR; c) total mercury in DNF; and d) total methyl mercury in DNF.

backwater floods (Figure 16-20c and d). The results of the DNF sampling are presented in Table 16-30. One of the greentree reservoirs, Long Bayou, was sampled all three years. Cypress Bayou and the Little Sunflower River were sampled for two years. Note that the concentrations varied spatially and somewhat temporally. Methyl mercury was approximately 5.5 percent of the total mercury concentration in the Long Bayou Greentree Reservoir, approximately 3 percent of the total mercury concentration in the DNF backwater floodwater, approximately 2 percent of the total mercury concentration in Cypress Bayou, and less than 1 percent of the total mercury concentration in the Little Sunflower River. Notably, the Sunflower Greentree Reservoir sampled in 2005 had the highest percentage of methyl mercury to total mercury concentration, approximately 30 percent. While the concentrations and ratios vary, they remained fairly consistent within each site.

191. Estimation of Potential Increases in Methyl Mercury Production.

a. One way to estimate the potential for increased methyl mercury production is to examine the number of acres of existing forested wetlands and the number of acres of reforested wetlands affected by each alternative plan. Assuming the precursors for methyl mercury production are present, if each acre of flooded wetland forest has the potential to produce a unit of methyl mercury per day of inundation, any increase or decrease in acres should also increase or decrease the amount of methyl mercury produced. The measure of the potential for methyl mercury production, then, becomes one methyl mercury unit for every day an acre of forest is flooded. Assuming methyl mercury production begins after 7 days of inundation as observed by Wright and Hamilton (1982), the worst-case measure of the potential for methyl mercury production then becomes one methyl mercury unit for every day an acre of forest is flooded beyond the first 7 days. This simplistic, linear model, however, will probably overestimate methyl mercury production at higher flood durations. In reality, most biochemical processes do not continue in an indefinite linear pattern. A controlling factor such as those discussed in the preceding paragraphs will kick in and slow or halt the biochemical (methylation) process, thereby limiting the amount of methyl mercury that may actually be produced as flood duration increases.

b. Table 16-31 presents the results of the methyl mercury analysis used to determine YBWP impacts to water quality. The number of flooded existing forest acres (base) and the reforested acres for Plans 2 through 7 are converted into the number of potential methyl mercury units that could be produced from implementation of each alternative. For each alternative plan, the number of preproject forested acres (including USDA WRP and CRP acres) that will continue to be flooded after the pump station is in operation is multiplied by the estimated number of days of flooding minus 7 days. For example, lands within the 7.5 to 10 percent duration band will be flooded a minimum of 20 days. Methyl mercury would then be produced for 13 days (20 days minus 7 days) on these acres. This provides a conservative, worst case estimate of the number of methyl mercury units that could be produced annually from the remaining preproject forested wetlands for each alternative. These numbers are summed to yield the maximum number of methyl mercury units produced annually from existing forests during

TABLE 16-30
CONCENTRATIONS OF TOTAL MERCURY AND TOTAL METHYL MERCURY IN DELTA NATIONAL FOREST

Date	Long Bayou Greentree Reservoir		Green Ash Greentree Reservoir		Sunflower Greentree Reservoir		Delta National Forest 1		Delta National Forest 2		Delta National Forest 3		Delta National Forest 4		Cypress Bayou		Little Six Mile Wetland		Little Sunflower River	
	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg	Hg	MeHg
ng/L																				
3/11/03	15.7	0.90					12.4	0.38	13.4	0.32	16.1	0.54	14.2	0.54						
3/11/03	17.6	0.41																		
2/26/04	6.42	0.39													14.6	0.21			21.5	0.20
2/26/04	6.52	0.40																		
3/3/05	7.60	0.54	9.33	0.66	3.05	0.89									9.53	0.25	15.4	0.66	12.1	0.11
3/3/05			9.73	0.61	2.87	0.98														
MDEQ FWA for Total Hg = 2100 ng/L MDEQ FWC for Total Hg = 12 ng/L																				

TABLE 16-31
METHYL-MERCURY UNITS a/

Alternative Plans	Days Methyl Mercury Is Produced in Existing Forests				Total Methyl Mercury Units Produced		
	7	13	20	27	Total from Existing Forests	Total from Project Reforestation (7 days inundation) b/, c/	Total from Both Sources
	Data Reported as Methyl Mercury Units						
Base	170,709	504,595	524,220	1,523,313	2,722,837	0	2,722,837
Plan 2	170,709	504,595	524,220	1,523,313	2,722,837	870,800	3,593,637
Plan 2A	170,709	504,595	524,220	1,523,313	2,722,837	569,800	3,292,637
Plan 2B	59,605	191,542	279,280	807,867	1,338,294	371,133	1,709,427
Plan 2C	170,709	504,595	524,220	1,523,313	2,722,837	800,800	3,523,637
Plan 3	245,707	200,486	257,060	1,034,829	1,738,082	373,541	2,111,623
Plan 4	203,616	243,230	437,920	1,183,437	2,068,203	260,400	2,328,603
Plan 5	161,056	386,438	457,520	1,409,670	2,414,684	389,200	2,803,884
Plan 6	157,752	417,027	378,940	1,597,590	2,551,309	569,800	3,121,109
Plan 7	169,365	454,077	358,740	1,704,159	2,686,341	870,800	3,557,141

a/ 1 Unit = methyl mercury produced from 1 acre of forested land that is flooded for 1 day based on 2005 land use.
b/ Assumes 100 percent of targeted acres for each plan are reforested.
c/ Plans 2B and 3 include compensatory mitigation.

backwater flooding (i.e., total from existing forests). In addition, for each of the alternative plans the total acres proposed for reforestation are assumed to be flooded for at least 14 days. Again, multiplying the number of reforested acres by 7 days (14 days minus 7 days) yields the number of methyl mercury units produced from the proposed reforestation. The with-project reforestation estimates for Plans 2B and 3 include each plan's compensatory mitigation acres. While it is understood that flooded croplands targeted for reforestation may be producing methyl mercury under current (base) conditions (Rogers, 1976), the methyl mercury unit analysis assumes that current cropland production is zero. Although this analysis may overestimate methyl mercury production for longer duration floods, it provides a worst-case analysis of the potential for project induced methyl mercury production

c. Only the base plan does not result in additional methyl mercury units. Plans 3 and 4 result in less total methyl mercury units than the base/existing conditions. Plan 5, the recommended plan, reduces the number of existing forest methyl mercury units produced due to shorter flood durations, but increases the number produced from reforestation. Plan 5 could have a 3 percent net increase in methyl mercury units. All of the nonstructural plans have much greater increases in methyl mercury production due to increases in duration and/or reforestation. This evaluation demonstrates that increasing the number of forested acres in areas subject to flooding has the potential to increase the amount of methyl mercury produced in the study area.

192. Potential Mercury Increases in Fish Tissue Concentration.

a. It is generally accepted that 95 percent of all mercury in fish tissue is methyl mercury. While one can assume an increase in potential methyl mercury production would lead to an increase in fish tissue concentration, it is impossible to estimate the resulting increase in fish tissue concentration from the preceding analysis. Just as the amount of methyl mercury produced depends on concentration, duration, and limiting factors, so does methyl mercury bioaccumulation in the aquatic food chain. In a wetland system such as the Yazoo Backwater where out-of-bank floodwaters only last a few weeks each year, fish tissue concentrations are probably more related to year-round ambient concentrations of methyl mercury rather than the total amount of methyl mercury produced in the system during backwater flooding. In their "National Pilot Study of Mercury Contamination of Aquatic Ecosystems" which analyzed data collected between June and October, 1998, Brumbaugh and others (2001) found that methyl mercury in water was a better predictor of fish tissue mercury concentrations than was methyl mercury in sediment. The Yazoo Backwater flood data (Table 16-30) suggest that the highest concentrations of methyl mercury (0.98 nanogram per liter (ng/L)) are found in artificially flooded forests (i.e., greentree reservoirs) where fish access is limited. Intermediate concentrations (0.54 ng/L) were found in out-of-bank floodwaters in DNF, and lowest concentrations (0.20 ng/L) were found in flowing streams (the Little Sunflower River). In comparison, the maximum winter methyl mercury concentration in Felsenthal NWR was 0.66 ng/L. Once the Yazoo Backwater floodwaters recede and forested wetlands lose connectivity to the river, methyl mercury concentrations are diluted and quickly move out of the system with the effect of moderating aquatic biota exposure in the project area. The period of longest fish exposure to methyl mercury in the Yazoo Backwater study area would be during summer months when seasonal flow is reduced. Warner and others (2005) found a weak negative correlation between concentrations of Chlorophyll A and mercury concentrations in large mouth bass in the Mobile River Basin. Other researchers (Lange, et al., 1993 and Cizdziel, et al., 2002) show that the trophic status of lakes affects methyl mercury bioaccumulation with eutrophic systems tending toward lower concentrations in predatory fish.

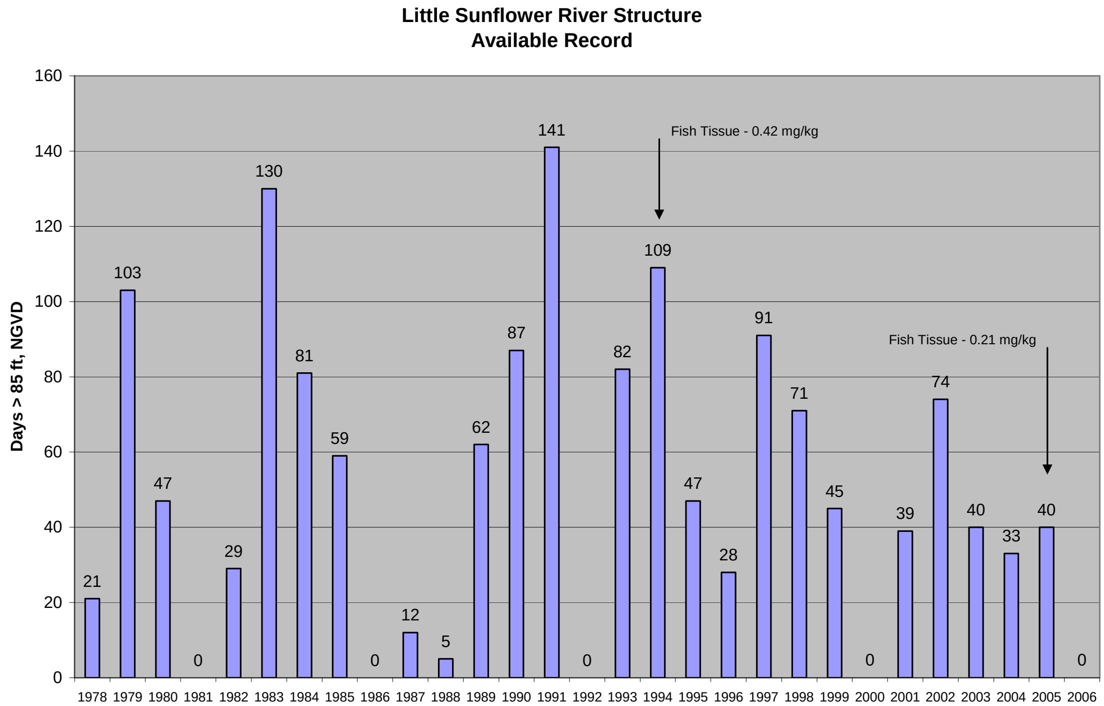
b. Algae and zooplankton have been identified as important intermediates in the trophic uptake of methyl mercury (Plourde, et al., 1997 and Westcott and Kalff, 1996). Pickhardt and others (2002) found that increases in algal biomass decreased the concentration of mercury per algal cell. This results in a lower dietary input to zooplankton grazers feeding on algae and reduced bioaccumulation in algal-rich systems. This result has important implications for the transfer of methyl mercury. Uptake of methyl mercury remaining in project area streams after backwater floods recede would be diluted (bloom dilution) by the increase in algal biomass that begins in June and July and lasts into October. The more algae cells there are, the authors found, the lower the methyl mercury concentration there is in each cell. The authors show that increasing the number of algae cells reduced the body concentration of methyl mercury in the zooplankton that feed on these algae. This, in turn, has the potential to decrease methyl mercury body concentrations in planktivorous fish that feed on the zooplankton. Fish uptake of methyl mercury is driven by concentration and exposure. These data suggest that during the period of longest exposure (i.e., summer when the Steele Bayou Structure is operated to hold water to benefit aquatic life) the concentration of methyl mercury available to the food chain would be at its most dilute. Thus, uptake of methyl mercury by omnivorous and piscivorous fish would also be reduced during this period.

c. In their draft guidance for implementing the methyl mercury water quality criterion (EPA, 2006a), EPA reports that mercury tissue data from the National Listing of Fish Advisories (NLFA) fish tissue database may have been biased high due a focus on fish species and sizes that tended to bioaccumulate more mercury. The EPA reports that NLFA data suggest that fewer watersheds actually contain fish with methyl mercury that exceed the 2001 recommended methyl mercury tissue criterion of 0.3 mg/kg than have been previously reported (EPA, 2006a). The EPA also believes that mercury fish tissue concentrations should continue to decrease in future because of the regulations now in place.

d. As shown in Table 16-18, the average mercury concentration in fish tissue collected between 1993 and 2005 (n = 86) was 0.33 mg/kg. Although the 2005 fish were collected in the Steele Bayou basin, land use maps reveal that the percentages of existing forested wetlands and lands targeted for reforestation are approximately the same in the lower Steele Bayou and Big Sunflower basins. Therefore, the 2005 fish tissue mercury average concentration should be a reasonable estimate of current fish tissue concentrations in the lower Yazoo Backwater study area. For the 2005 fish collected in Steele Bayou (n = 35), the average mercury concentration was 0.21 mg/kg. According to Brumbaugh and others (2001), the average fish tissue mercury concentration collected in their analysis of 20 basins across the country was 0.48 mg/kg (n = 159). In addition, bioaccumulation models developed for the 2001 nationwide study predicted a tissue concentration of 0.30 mg/kg in 3-year-old fish from waters with a methyl mercury concentration of 0.12 ng/L. In the Little Sunflower River, the average methyl mercury water concentration collected during two backwater flood events was 0.16 ng/L. The average fish tissue concentrations from the Yazoo Backwater study area (0.33 mg/kg nonaged) were in line with the 2001 nationwide average while the 2005 average (0.21 mg/kg nonaged) was lower. Currently, Mississippi restricts consumption when their fish survey data show that average composite concentrations have exceeded 1.0 mg/kg and recommends no consumption when concentrations have exceeded 1.5 mg/kg. Under existing conditions, Mississippi Delta waters are not under a fish consumption advisory for mercury. For the 1993-2005 data set evaluated in this report, the average tissue concentration was 33 percent of the state's lower advisory limit and 22 percent of the "no consumption" limit. Evaluating only the 2005 fish, the average concentration was 21 and 14 percent of the state's advisory limits. Under the recommended plan (Plan 5), the Yazoo Backwater study area would have the potential to produce approximately 3 percent additional methyl mercury units compared to current conditions. A 3 percent increase in future methyl mercury concentrations (0.22 mg/kg) would not be expected to elevate mean fish tissue concentrations above current state or EPA mercury criteria.

e. Methyl mercury production depends upon availability of precursors and adequate periods of inundation. While lack of historic data prevents an examination of trends in methyl mercury concentration in the Yazoo Backwater study area, fish tissue data collected in 1993 and 1994 and in 2005 suggest that average tissue concentrations may be decreasing. It is impossible to determine whether this is in fact a trend or whether this is part of a normal cycle; however, some discussion of possible reasons for this decrease is warranted.

f. Figure 16-21 presents 15 years of stage data at the Steele Bayou structure and the Little Sunflower River structure. The figure shows that four of the years prior to fish tissue collection in 1993 and 1994 had the highest number of days above elevations that cause minor flooding in the lower forested areas within the two basins (85.0 feet, NGVD, at the Little Sunflower River structure and 83.5 feet, NGVD, at the Steele Bayou structure). Mercury fish tissue concentrations in 1993 and 1994 averaged 0.42 mg/kg. Mercury fish tissue concentrations in 2005 averaged 0.21 mg/kg. The 2005 fish collection was preceded by several years with shorter flood durations. An examination of the available stage data at the Steele Bayou structure suggests some periodicity in flood duration. It is possible that methyl mercury concentrations could decrease throughout the basin during a period with several years of reduced flooding in forested areas. This theory could account for the 50 percent decrease in fish tissue mercury concentrations between 1994 and 2005 and would suggest that fish tissue concentrations could increase during periods of extended flood duration. Under Plan 5, operation of the Yazoo



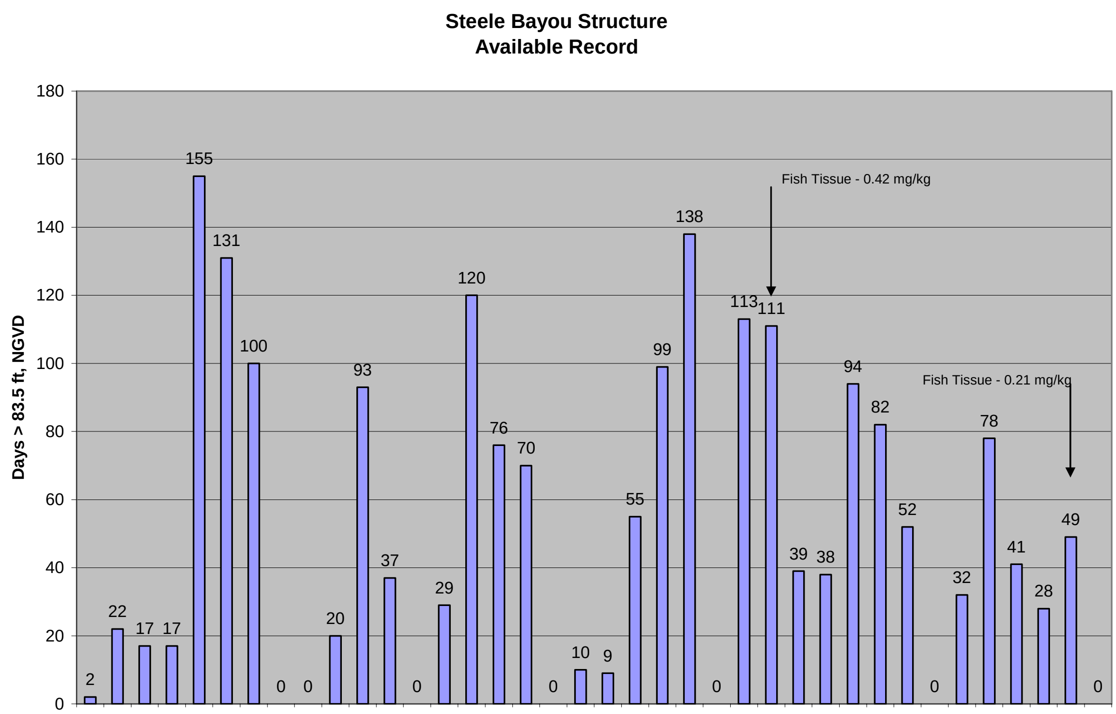


Figure 16-21. Number of days that exceeded the elevation associated with minor flooding in forested areas in the lower YBWP Area (85 ft, NGVD, for the Little Sunflower River Structure and 83.5 ft, NGVD, for the Steele Bayou Structure).

Backwater pump would shorten flood durations by taking the peak off of backwater floods during pump station operation. This should have the effect of reducing methyl mercury production and fish uptake during extended Yazoo Backwater floods regardless of reforestation efforts in the 1-year flood plain.

g. The concentration of mercury available for methylation during flooding is also an important factor affecting mercury methylation and uptake in fish tissue. As an element, mercury is neither created nor destroyed. Mercury occurs naturally in the earth's crust and cycles in the environment as part of both natural and human-induced activities. The EPA estimates that 83 percent of the mercury deposited in the United States originates from international sources, with the remaining 17 percent coming from United States and Canadian sources (EPA, 2006b). Domestic sources account for much of the mercury deposition in the eastern United States, while international sources have a greater impact in the west where relatively few domestic sources exist (EPA, 2006b). The source of much of the mercury in Felsenthal NWR may come from natural shale deposits in the Ouachita Mountains (Armstrong, et al., 1995, and FTN, 2002). The MDEQ lists atmospheric deposition as the source of mercury impairment in some of the Yazoo Basin's headwaters (MDEQ, 2004c). The United States has made significant progress in the reduction of industrial air emissions in the last 15 years and is working internationally to address risks associated with mercury uses, releases, and exposure (EPA, 2006b).

h. In 1990, more than two-thirds of the United States' anthropogenic mercury emissions came from coal-fired powerplants, municipal waste combustion, and medical waste incineration. Mercury in waste combustion emissions was addressed in the 1990s with regulations to reduce the amount of mercury in waste by limiting the use of mercury in batteries, paint, and other materials. More recent regulations to control mercury emissions from chlorine-production facilities that use mercury cells and regulate the use of industrial boilers will further reduce emissions of mercury. In 2006, the largest single source of anthropogenic mercury emissions in the country was coal-fired powerplants. The Clean Air Mercury Rule (CAMR), signed by EPA in March 2006, should permanently cap and reduce mercury emissions from coal-fired powerplants (EPA, 2005b). The EPA estimates that the United States' anthropogenic mercury emissions in the air have declined more than 45 percent since passage of the 1990 Clean Air Act amendments (EPA, 2006a). When CAMR is fully implemented, EPA expects the United States' utility mercury emissions to be reduced by nearly 70 percent (EPA, 2006a).

i. The EPA uses a Mercury Maps Geographic Information System model, a TMDL development tool, to predict proportional changes in fish tissue from changes in atmospheric mercury deposition. The model's basis is that over the long term, fish concentrations are expected to decline proportionally to declines in atmospheric loading to a water body. The Yazoo Backwater fish tissue data appear to follow this trend. After 10 years of mercury air emissions regulations, the average fish tissue concentration in fish tissue collected in 2005 was 0.21 mg/kg, 50 percent of the 1993-1994 average concentrations. After full implementation of the EPA CAMR to reduce coal-fired powerplant emissions, mercury fish tissue concentrations in the YBWP Area could be reduced even more. Under linear, steady-state conditions, an additional 70 percent reduction in the United States mercury emissions could reduce mercury fish tissue concentrations in the YBWP Area to 0.063 mg/kg, well below the current MDEQ fish consumption advisory of 1.0 mg/kg and the EPA water quality criterion of 0.3 mg/kg in fish tissue. Based on the variation in flood duration shown in Figure 16-21 and availability of mercury already in the Yazoo Backwater system, it is unlikely that this low target concentration would ever be realized. However, conditions are in place to continue the reduction in fish tissue concentrations. In fact, the 0.42 mg/kg average from 1993 and 1994 could be a maxima for fish tissue concentrations because the fish were collected within a cluster of high flood duration years before any of the air emission controls were fully implemented. Nowadays, based on current fish tissue concentrations, United States' reductions in mercury air emissions, and decreases in flood durations (YBWP Plan 5), mercury fish tissue concentrations should continue to decrease. The potential for a minor increase (3 percent) in methyl mercury production from reforestation of up to 55,600 acres of cropland over the next 50 years may be unavoidable, but reforestation in the Mississippi Delta is consistent with Federal wetland restoration programs and will provide wide ranging environmental benefits such as improved terrestrial and aquatic habitat and improved water quality.

BENEFITS OF WATER CONTROL STRUCTURES

193. Plan 5 also contains alternative conservation measures by which up to 5 percent of the 55,600 acres targeted in the nonstructural reforestation feature can be used for seasonal impoundments with water control structures. The Vicksburg District will assist landowners by providing materials to construct the water control structures. These types of structures have been shown to reduce sediment yield during the winter and spring rainy seasons by trapping water and soil runoff. In the Yazoo Backwater, inclusion of such structures should provide additional sediment control benefits to the project. Yuan and others (2002) used computer models to simulate watershed response to agricultural BMPs. The modeled data were then compared to different tillage practices to predict the amount of sediment reduction each BMP would provide relative to conventional tillage. The model predicted that a slotted board riser water control structure managed to impound winter water on conventionally tilled fields with no other BMPs would reduce sediment yield by 21 percent. Used on reduced tillage or no-till fields, the same structure would reduce sediment yield between 60 and 90 percent compared to conventionally tilled fields. The same model predicted that conversion to all pasture or all forest would reduce sediment yield by 98 and 100 percent, respectively, compared to conventional tillage. According to these data, combining water control structures that feature winter water ponding with reforestation will provide substantial sediment reduction benefits to the project.

CUMULATIVE IMPACTS TO WATER QUALITY

194. The YBWP Area was first impacted by early settlers establishing farms and communities along the top bank natural levee of the Mississippi River. As populations increased, settlements were also established along top banks of the distributary rivers such as the Yazoo River, Deer Creek, and the Big Sunflower River and tributaries. A review of early maps suggests the first areas to be cleared were top bank natural levees. Clearing moved inland as populations increased, farming practices improved, and economics dictated. Beginning with the Flood Control Act (FCA) of 1928 and continuing in successive years, the Federal Government began to provide Federal protection to the lower Mississippi River Valley, including the Yazoo Backwater Area. Federal flood protection in the form of levees, floodways, and improved channels; improvements in planting, harvesting, and pesticide control measures; and increased demand for crops such as cotton and soybeans increased the demand for cropland such that more land was eventually cleared and placed into production. Land use assessments show that clearing in the YBWP Area peaked in the 1980s. Current data from NRCS show that the agricultural program incentives begun in the 1980s have encouraged farmers to reforest cropland. In the last 20 years, approximately 61,000 acres of cropland have been reforested in the Yazoo Backwater study area through the CRP and WRP programs. Since 1985, only 1,105 acres in the Mississippi Delta have been cleared. While there are no historic data that can be used to establish initial water quality conditions within the project area, it is safe to assume that clearing and historic farming practices did have significant impacts on water quality. Siltation was a natural by-product of historic, conventional farming practices. The legacy organochlorine pesticide and fish consumption impairments are the result of DDT and toxaphene applications that were made between the 1940s and 1980s. This section of the Yazoo Backwater Water Quality Appendix will discuss cumulative impacts of the various Vicksburg District projects in the basin.

195. Vicksburg District projects that will be discussed in this cumulative analysis include completion of the different components of the YBWP. This includes completion of the Backwater levee (1978), completion of the Little Sunflower River structure (1978), completion of the lower Whittington Auxiliary Channel connecting Steele Bayou and the Big Sunflower River (1975), completion of the Steele Bayou structure (1969), completion of the Muddy Bayou Control Structure (1978), and the proposed completion of the YBWP. Other Vicksburg District projects include the Steele Bayou Flood Control Project authorized in 1944 and reformulated in 1989, construction of water control structures in lower Steele Bayou, and the proposed Big Sunflower River Maintenance Project. In addition impacts of recent efforts by local farmers, NRCS, Delta Farm, the Yazoo-Mississippi Delta Joint Water Management District (YMD), and Ducks Unlimited will be discussed.

196. The Yazoo Backwater levee system was completed in 1978. The Yazoo Backwater levee system prevented the Mississippi River floodwater from backing up into the lower Delta. Several projects, authorized under the 1941 FCA, were completed in the lower Backwater Area in the late 1960s and 1970s. These include the Little Sunflower River structure, the Steele Bayou structure, and the Connecting Channel, which connects the Big Sunflower River and Steele Bayou. Some of the subbasins within the YBWP Area were targeted for additional flood control and environmental enhancement measures. The Muddy Bayou Control Structure was completed in 1978. This structure controls the water level in Eagle Lake and prevented the more turbid, pesticide-laden Steele Bayou water from entering the lake. The Steele Bayou Flood Control Project was authorized in 1944. For Steele Bayou below the Yazoo NWR, channel work included channel enlargement, channel cleanout, construction of a channel cutoff, and construction of weirs. The Upper Steele Bayou Project was reformulated in 1993. This project addressed flooding in and around Greenville, Mississippi. In this project, channels were excavated, cleared, and snagged, and weirs and drop-pipe structures were constructed along Black Bayou and Main Canal. Currently, approximately 80 percent of the upper Steele Bayou Watershed is protected by some form of water control structure. Farmers, with the help of NRCS and Ducks Unlimited, have constructed small drop-pipe structures to contain water for irrigation, rice production, or seasonal waterfowl habitat. In addition, the Vicksburg District constructed 72 grade control structures to prevent gully erosion along the streams. Comparison of pre- and postproject water quality data shows up to a 50 percent improvement in TSS concentrations in upper Steele Bayou. The excavation feature of the project removed unconsolidated loose sediment from stream bottoms. A comparison of pre-and postproject sediment data (Figure 16-4) show decreases in DDT sediment concentrations following channel cleanout. Independent fish surveys also show that fish tissue DDT concentrations are lower following channel cleanout (Figure 16-5). These fish surveys also show that because of the removal of loose, unconsolidated sediment the aquatic environment is improving such that species such as darters and black bass juveniles have returned to Steele Bayou. The Vicksburg District recently identified up to 100 sites on lower Steele Bayou that would benefit from construction of additional water control structures. The Vicksburg District will install the larger structures. Delta Farm, with funding from an EPA 319 Grant, will assist farmers with installation of smaller structures. Cumulatively, completion of these two projects will significantly improve water, sediment, and fish tissue quality in Steele Bayou. Fishery biologists indicate that one of the remaining needs in Steele Bayou is good structure (trees) along the banks.

197. The Deer Creek Basin lies in the center of the YBWP. Deer Creek occupies an abandoned course of a much larger river and was a distributary of the Mississippi River until it was isolated by the mainline levees. Currently, Deer Creek is divided at Rolling Fork into Upper and Lower Deer Creeks. For the most part, upper Deer Creek is not affected by Yazoo Backwater floods. It is perched on a ridge of natural levees and runs from Lake Bolivar south to Rolling Fork. In the early 1900s, a local water control group diverted Deer Creek's flow into Rolling Fork Creek and then into the Little Sunflower River. With the exception of August and September, there is generally flow from Upper Deer Creek into Rolling Fork Creek. Lower Deer Creek has become

an isolated series of shallow lakes divided by filled road crossings and inadequate or failing culverts. Many of these segments have been clear-cut to increase farmable land. There is no continuous flow in Deer Creek south of Rolling Fork. Lower Deer Creek connects to the Connecting Channel; however, the general impact is modulation of the water level in that last segment rather than delivering any significant flow into the Connecting Channel. Data available from Deer Creek show that it is impacted from sediment and legacy pesticides. In addition, MDEQ developed a TMDL for fecal coliform for two areas along upper Deer Creek. There is public interest (i.e., a proposed Environmental Restoration Section 1135 project and a citizens group's activities) in restoring Upper Deer Creek by adding flows from the Mississippi River into Lake Bolivar and by performing some selective channel cleanout. At this time, there is little public interest in restoring Lower Deer Creek since no group has come forward to sponsor a similar environmental restoration project.

198. The Big Sunflower River was improved (channel cleanout) to increase floodwater discharge in the 1950s and 1960s. The Holly Bluff Cutoff was also constructed during that time. The cutoff bypassed the old bendway of the Big Sunflower River. This bypass carries high flows during the rainy season, but is designed to continue to shunt low-flow water down the old bendway. The design also allows high flows down the Little Sunflower River. During the late summer, however, there is usually not sufficient flow to divert to the Little Sunflower River. The proposed environmental restoration project to add flow to Upper Deer Creek via Lake Bolivar could provide much needed flow to the upper Little Sunflower River during the fall. The proposed Big Sunflower River Maintenance Project is intended to reestablish the 1965 flowlines and provide additional flood protection in the Darlove, Mississippi, area of Bogue Phalia. One of the alternatives being evaluated for this project includes improving floodwater discharge by step-cutting banks in selected reaches to avoid mussel beds and by dredging between 2 to 4 feet in some reaches to reestablish the 1965 flowline. Excavated material would be utilized by farmers or placed in thin layer disposal areas.

199. Most of the cumulative impacts explored during the water quality analysis were those between the YBWP and the proposed Big Sunflower River Maintenance Project. One of the primary tools used to determine the magnitude of cumulative impacts to these projects was the HGM analysis conducted by ERDC. In this analysis, three wetland functions directly related to water quality were identified. These are the export of organic carbon function, the physical removal of elements and compounds function, and the biological removal of elements and compounds function. These functions were first discussed in the section titled "Wetland Function Related to Removal of Sediment, Nutrients, and Pesticides within the Yazoo Backwater study area." In the HGM analysis, ERDC analyzed the YBWP alone (B1) and with the Big Sunflower Maintenance Project in place (B2). Results of the water quality wetland functional analysis were presented in Tables 16-27 and 16-28. In the second and third column, construction and operation of the structural feature (the pump station) would result in slight negative impacts to the wetland functional analysis. This negative impact was much less than the positive benefit of reforestation, however. All of the improvements for the recommended plan (Plan 5) were

from the nonstructural reforestation feature. The results of the analyses are summarized in Table 16-29 as percent change in wetland functional capacity compared to current base conditions. In Table 16-29, the B2 analysis is the cumulative impact for the two projects. Each of these wetland functions can be related to listed water quality impairments identified within the study area (sediment, pesticides, nutrients, and organic enrichment). Cumulative benefits resulting from reforestation, including benefits from taking agricultural land out of production, will be presented in the sections on project impacts on each of the listed water quality impairments found in the TMDL discussion. The cumulative analysis (B2) for Plan 5 shows that there would be a 3 percent increase in the wetland function that represents sediment and pesticides removal from floodwater. There would be a 6 percent cumulative increase in the wetland function that represents nutrient removal from floodwater; and an 8 percent cumulative increase in the wetland function that represents export of organic carbon into study area waters. On average, the cumulative improvement to the water quality wetland functions for Plan 5 would be 5 percent. This analysis does not include the water quality improvements that will result as the WRP and CRP reforested areas mature because these acres appeared as cleared noncrop and early-aged forest in the 2005 land use classification. Benefits from these USDA reforested acres will be similar to benefits from the proposed YBWP reforestation. Initial planting stabilizes the soil and reduces erosion while forested wetland functional value will improve water quality as the forests mature.

200. Starting in the 1970s, irrigation withdrawals began reducing aquifer recharge to Delta streams. By 1980, the aquifer water level fell below the streambed of the Big Sunflower River such that minimum base flows were reduced from 100 to 10 cfs (YMD, 2005). In the most heavily irrigated areas of the Delta, water levels have declined to as much as 45 feet below land surface. Recent ground-water recharge monitoring data show that in areas of high irrigation demand, the average fall aquifer levels are 3.7 feet lower than the preceding spring recharge level of 3.5 feet. The average decline in aquifer levels has been approximately 0.2 foot per year since 1980 (Arthur, 2001). Long-term analysis of monitoring well data suggests, however, that localized aquifer levels have increased in areas with large numbers of out-of-production catfish farms (YMD, 2005).

201. The YMD has supplemented fall low flow in the Big Sunflower River since 1990. In addition, runoff from agricultural fields, particularly rice fields in the late summer, is important to supplementing streamflow. Some have voiced concern that tail water recovery systems would remove this late summer benefit to Delta streams. Prior to 1975, it was not uncommon for the Little Sunflower River to experience extended periods of low water during the summer. The Steele Bayou structure (completed in 1969), the Little Sunflower River structure (completed in 1975), and the Connecting Channel (completed in 1978) allowed water levels to be regulated during the summer such that water was maintained in most of the lower study area streams, including the Little Sunflower River. Currently, the Steele Bayou structure is operated to maintain a minimum water elevation of 68.5 feet, NGVD, during the summer. The current maximum water elevation is 70.0 feet, NGVD. The YBWP proposes to change the operation of the structure to increase the maximum summer water elevation by 3 feet to a water elevation of 73.0 feet, NGVD.

202. Reports of fishkills and thermal stratification in the lower pool just upstream of the Steele Bayou structure have caused concern that increasing the summer water depth by 3 feet might further reduce summer DO concentrations below the state criterion of 5.0 mg/L. During the summer, phytoplankton primary productivity is the major source of DO in the lower backwater streams and lakes. Any disruption of this process could cause temporary depletion of DO and place stress on susceptible fish species. The two fishkills discussed in the "Impacts from Increased Water Depth Behind the Steele Bayou Structure" section suggest DO stress can occur after backwater floods that extend into early summer. It is likely that during early summer when organic loading is high, phytoplankton populations are not well established or cannot be maintained at the Steele Bayou structure during flood discharge. Both fishkills also occurred during periods of increased precipitation. Increased cloud cover would have reduced population recovery and photosynthesis rates. Given the flooding and climatological conditions reported at the time, increased rainfall and floodwater discharge could introduce additional organic carbon load creating an imbalance between photosynthesis and respiration rates. It is likely that this type of climate-induced oxygen depletion is responsible for many of the fishkills attributed to low DO in the Delta. It is also likely that once the flooding and rainfall events pass, phytoplankton primary productivity will return to normal, with supersaturated levels of DO near the surface and acceptable levels at mid-depth. The YBWP will not have an impact on these events.

203. Engineers at Mississippi State University used the EPA WASP water quality model and site-specific water quality data provided by the Vicksburg District to predict the project impacts on DO concentrations in the Big Sunflower River down to the Steele Bayou structure during the late summer critical period if the Steele Bayou pool were raised. The model looked at (1) preproject conditions, (2) post-YBWP only conditions, (3) post-Big Sunflower River Maintenance Project only conditions, and (4) post-Yazoo Backwater and Big Sunflower Maintenance combined conditions. Model results showed none of the conditions modeled would result in DO concentrations below the state criterion (5.0 mg/L) for any of the river reaches. The model showed that increases in phytoplankton productivity typical of the late summer, low-flow critical period should keep average DO concentrations above 5.0 mg/L. Thus, the operational changes proposed in the YBWP should not impact DO concentrations upstream of the Steele Bayou structure. Results of the MSU WASP model are found in Attachment 2 to Appendix 16.

204. There are few water quality data available from the 1970s and 1980s. Most of the earliest water quality studies were conducted by the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) and the Mississippi Department of Wildlife Conservation. These early reports addressed pesticide concentrations in water, sediment, and fish tissue in various Delta lakes (Cotton and Herring, 1970; Herring and Cotton, 1969; Herring and Cotton, 1974). Not surprisingly, DDT and toxaphene were detected in high concentrations during the period when DDT and toxaphene were being applied to Delta crops. Total DDT fish tissue levels in a 1969 study (Herring and Cotton, 1969) ranged from 0.5 to 29.0 mg/kg. A subsequent study in 1974 found DDT fish tissue levels ranging from 0.05 to 9.1 mg/kg. Fish tissue levels exceeding the

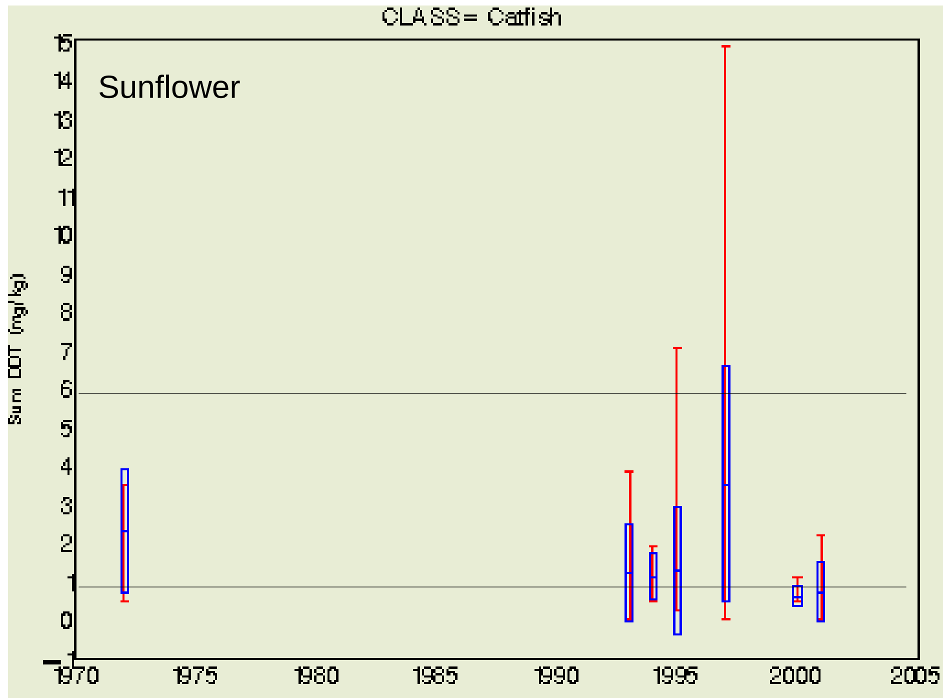
existing FDA action levels in three Delta lakes (Wolf, Mossy, and Washington) forced their closings to commercial fishing in 1973. Mossy and Washington were reopened in 1977 when fish tissue levels fell below the FDA maximum allowable levels. Wolf Lake remained closed until 1982. Data collected by FWS (Schmitt, et al., 1990) for their National Contaminant Biomonitoring Program showed a marked decline in the national average DDT levels in freshwater fish collected between 1971 and 1984 following the ban on DDT. Although this trend has continued, fish tissue concentrations in the Mississippi Delta continued to exceed safe consumptions limits. In 2001, the state issued a fish consumption advisory for certain species of fish in the Delta. As was mentioned in the discussion on Steele Bayou, fish tissue concentrations of DDT appear to have decreased since channel work was completed in the mid-1990s (Figure 16-5). Fish tissue collections in the Big Sunflower River Basin have not followed a similar trend (Figure 16-22).

205. Although the YBWP has no dredging component other than periodic maintenance dredging at the pump station site, proposed dredging for the Big Sunflower Maintenance Project has led some to express concern about disturbing sediments contaminated with legacy pesticides. The Vicksburg District had ERDC perform toxicity and bioaccumulation tests on sediment from the Big Sunflower River Maintenance Project Area. The results of these assays were presented in the section, "Sediment Toxicity Bioassay." Assay results show that the sediments were not toxic to the freshwater aquatic organisms tested. Bioaccumulation studies also showed that the final observed DDX concentrations in the test organisms were considerably lower than the published lethal residue concentration that would cause 50 percent mortality (LR_{50}). The corresponding LR_{50} $\sum$DDT sediment concentration was found to be higher than the $\sum$DDT concentrations in the test sediments and in the sediment samples in the Big Sunflower River Maintenance Project Area.

206. Used as a model for the benefits of removing loose, unconsolidated contaminated sediment and the cooperative application of BMPs by state and Federal agencies and local farmers, the Steele Bayou demonstrates environmental restoration of a Mississippi Delta stream. Removal of sediment from sluggish low-flow areas that typically collect sediment such as the old Sunflower bendway and Little Sunflower River would be significant first steps to the same type of restoration in the Big Sunflower River Basin. Cumulatively, the completion of the projects described would benefit sediment, nutrient, and pesticide removal from backwater floods by 5 percent; improve fishery habitat; and could lower fish tissue pesticides concentrations.

ESTIMATED PROJECT IMPACT ON NUTRIENT AND SEDIMENT LOADING IN THE MISSISSIPPI RIVER

207. In 2000, EPA presented a national action plan to reduce the frequency, duration, and extent of oxygen depletion (hypoxia) off the northern Gulf of Mexico (EPA, 2000c). The action plan was designed to reduce the amount of nitrogen entering the Gulf of Mexico through the Mississippi/Atchafalaya River Basin over the next 15 years. States, tribes, and the relevant Federal agencies along the Mississippi and Atchafalaya River Basins and the Gulf agreed to



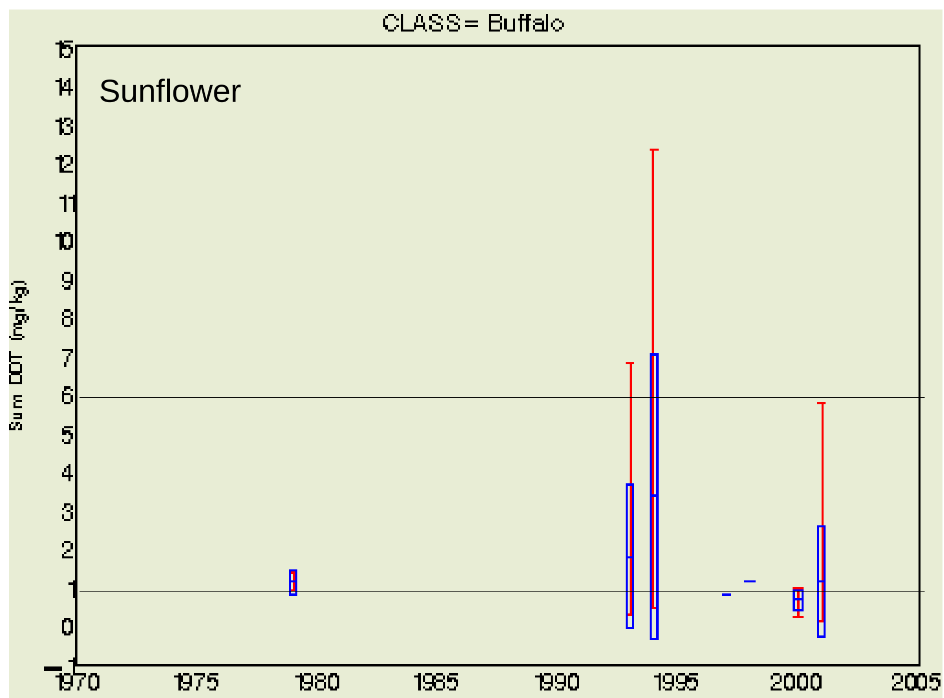


Figure 16-22. Catfish and buffalo collected in the Big Sunflower River do not show a noticeable decrease in ∑DDT.

develop watershed strategies to reduce the amount of nutrients, particularly nitrogen, entering their waters. Best current scientific understanding of the hypoxic zone indicates that watershed strategies should aim at achieving a 20 to 40 percent reduction in nitrogen discharges to the Gulf of Mexico. One of the long-term goals stated in the action plan is to reduce annual discharges of nitrogen into the Gulf by 350,000 to 650,000 metric tons by 2010.

208. The action plan identified USACE and USDA as key players responsible for managing resources along the Mississippi River in order to enhance nitrogen removal during critical periods of the year. In addition, state and Federal agencies are to work together to identify land use changes and monitor priority areas of likely nitrogen loss to streams. The USDA CRP and WRP programs were identified specifically as environmental restoration programs that will protect surface waters and restore natural nutrient cycling in aquatic systems. Other conservation measures identified were establishment of streamside buffers and the increased use of conservation tillage.

209. Farmers within the Mississippi Delta and the YBWP Area have made good use of USDA and NRCS programs identified by the national action plan. In the last 20 years, 61,000 acres of previously farmed land in the Mississippi Delta have been reforested under the CRP and WRP programs. However these programs are reaching their maximum enrollment in the two counties that make up most of the Yazoo Backwater study area. The USDA programs may not be an option to landowners in the future (see the Mitigation Appendix for additional information on the USDA WRP and CRP). Many landowners have also converted to conservation tillage practices or have installed edge-of-field water control structures to conserve irrigation water and manage waterfowl in the winter. In the TMDL for Black Bayou, MDEQ attributed the stabilization of sediment loadings in the Upper Steele Bayou Watershed to these changes in farming practices (MDEQ, 2003b). Additionally, as part of the recommended plan for the YBWP, the Vicksburg District proposes to reforest up to 55,600 acres of cropland. This nonstructural feature of the YBWP will provide additional nutrient and sediment removal benefits. The HGM (B1) analysis for Plan 5 presented in Table 16-27 shows that the proposed reforestation will increase nitrate removal by 9 percent and TP and TSS removal by 4 percent. Results of the HGM (B2) analysis, including the cumulative effects of the YBWP and the Big Sunflower River Maintenance Project, are presented in Table 16-28. This section will discuss reductions in nutrient and sediment-loading into the Mississippi River due to the proposed YBWP and the continued maturation of forests in the USDA programs.

210. In the 1990s, USGS developed a method for using spatially referenced regressions of contaminant transport on watershed attributes (SPARROW) in regional water quality assessments. One of the applications of the model was the analysis of USGS data to predict transport and fate of nitrogen and phosphorus inputs along the Mississippi River to the Gulf of Mexico. The model predicted that larger tributaries along the lower Mississippi River, such as the Yazoo River, would be major sources of unprocessed nitrogen (nitrate) into the Gulf of

Mexico (Alexander, et al., 2000). However, data collected by USGS for the NAWQA Program has shown that nitrate contributions from the Yazoo River were lower than was predicted (Coupe, 1998 and Runner et al., 2002). This apparent over prediction of unprocessed nitrogen input by larger tributaries on the lower Mississippi River was, in part, due to predictions that nitrate from the upper tributaries would decay before reaching the Gulf (personal communication, July 26, 2007, Mr. Richard A. Rebich, USGS, Pearl, Mississippi). Subsequent studies have shown that, while the southern river basins process nitrate before it is delivered to the Mississippi River, very little processing of nitrates actually occurs within the Mississippi River itself. The USGS is currently revising the regional SPARROW models to include additional data and revised processing assumptions. Both the Yazoo Basin and the Mississippi River are included as separate components of the regional reanalysis. The model for the Yazoo Basin is scheduled to be completed in 2009.

211. The USGS (Runner, et al., 2002) used nutrient and streamflow data collected between 1996 and 2000 to estimate the average annual load of nitrogen and phosphorus discharged from the Yazoo River. They also used estimates of the average annual load of the Mississippi River (Goolsby, et al., 1999) to present these data as percentages of the Mississippi River's long-term loading. Average annual loads of nitrate and TP in the Yazoo River for 1996 to 2000 were 6,420 and 4,670 metric tons, respectively. The YBWP encompasses 1,445 square miles, approximately 11 percent of the Yazoo Basin. The average annual discharge from the project area was estimated to be 1,839 cfs or 11 percent of the 1996 to 2001 USGS average annual discharge for the Yazoo River. Using these data and the average annual concentrations of nitrate and TP from YBWP area samples, an estimate of the impact of completion of the proposed YBWP can be determined (Table 16-32).

212. Nitrate is the primary focus of the Gulf of Mexico hypoxia studies. Runner and others (2002) found that the nitrate load in the Yazoo River was less than expected based upon annual discharge. The authors found that the Yazoo River nitrate load was 0.7 percent of the long-term load in the Mississippi River. For the Yazoo Backwater study area (B1), the average preproject nitrate load into the Yazoo River is 657 metric tons per year based upon current conditions and an average nitrate concentration of 0.40 mg/L. This represents 10.2 percent of the nitrate load in the Yazoo River and 0.07 percent of the nitrate load in the Mississippi River. The estimated postproject nitrate load from the Yazoo Backwater study area for Plan 5 will be 598 metric tons per year. This represents 9.3 percent of the Yazoo River annual nitrate load and 0.06 percent of the Mississippi River nitrate load. Table 16-32 also lists cumulative estimates of postproject nitrate loading based upon inclusion of the proposed Big Sunflower River Maintenance Project (YBWP B2) and the USDA WRP and CRP reforested acres (YBWP + WRP (B1 and B2)). Cumulative benefits from the YBWP + WRP (B1) show the greatest increase in nitrate removal, 24 percent or an estimated reduction of 158 metric tons nitrate per year. Acquisition of fewer acres would provide fewer benefits. After the 15,029 acres that are guaranteed before the pump station can begin operation are acquired, nitrate loading would be reduced by 93 metric tons per year.

TABLE 16-32
ESTIMATED CHANGES IN NUTRIENT AND SEDIMENT LOADING

BACKGROUND DATA			
YBWP - area (mi^2)	1,445		
YBWP – average discharge (cfs)	1,839		
Yazoo River Basin – area (mi^2)	13,355		
Yazoo River Basin – average discharge (cfs)	17,000		
	NO3	TP	TSS
Yazoo River - Average Load [a/] (metric tons/yr)	6,420[a/]	4,670 [a/]	3.80E+06 [b/]
Yazoo River Load as a Percentage of the MS River	0.7 %	3.4 %	2 %
MS River - Average Load (metric tons/yr)	952,700 [c/]	136,500 [c/]	198E+06 [b/]
YBWPA Average Concentration (mg/L) [d/]	0.40	0.32	135
LOAD BASED ON PREPROJECT CONDITIONS			
	NO3	TP	TSS
YBWP Base - Load (metric tons/yr)	657	526	221,747
YBWP Base - Load - % of Yazoo River	10.2 %	11.3 %	5.84 %
YBWP Base - Load - % of MS River	0.07 %	0.39 %	0.11 %
POSTPROJECT LOAD – YAZOO BACKWATER PROJECT ONLY			
YBWP (B1) Plan 5 HGM functional improvement	9 %	4 %	4 %
YBWP (B1) Load after HGM improvement (metric tons/yr)	598	504	212,887
YBWP (B1) Reduction in Load (metric tons/yr)	59	21	8,870
YBWP (B1) Load - % of Yazoo River	9.3 %	10.8 %	5.6 %
YBWP (B1) Load - % of MS River	0.06 %	0.37 %	0.11 %
POSTPROJECT LOAD – YAZOO BACKWATER PROJECT AND WRP/CRP FORESTS			
YBWP + WRP (B1) HGM functional improvement	24 %	15 %	15 %
YBWP + WRP (B1) Load after HGM improvement (metric tons/yr)	499	447	188,485
YBWP + WRP (B1) Reduction in Load (metric tons/yr)	158	79	33,262
YBWP + WRP (B1) Load - % of Yazoo River	7.8 %	9.6 %	5.0 %
YBWP + WRP (B1) Load - % of MS River	0.05 %	0.33 %	0.10 %
POSTPROJECT LOAD – YAZOO BACKWATER PROJECT AND BIG SUNFLOWER RIVER MAINTENANCE PROJECT			
YBWP (B2) HGM functional improvement	8 %	3 %	3 %
YBWP (B2) Load after HGM improvement (metric tons/yr)	604	510	215,095
YBWP (B2) Reduction in Load (metric tons/yr)	53	16	6,652
YBWP (B2) Load - % of Yazoo River	9.4 %	11.0 %	5.7 %
YBWP (B2) Load - % of MS River	0.06 %	0.37 %	0.11 %
POSTPROJECT LOAD – YAZOO BACKWATER PROJECT, WRP/CRP FORESTS, AND BIG SUNFLOWER RIVER MAINTENANCE PROJECT			
YBWP + WRP (B2) HGM functional improvement	23 %	14 %	14 %
YBWP + WRP (B2) Load after HGM improvement (metric tons/yr)	506	452	190,702
YBWP + WRP (B2) Reduction in Load (metric tons/yr)	151	74	31,045
YBWP + WRP (B2) Load - % of Yazoo River	7.9 %	9.7 %	5.0 %
YBWP + WRP (B2) Load - % of MS River	0.05 %	0.33 %	0.10 %

a/ Runner, et al.
b/ Moody and Meade
c/ Goolsby, et al.
d/ Table 16-2

213. Runner and others (2002) found that TP load in the Yazoo River was higher than expected based upon annual discharge. The average TP concentration in the YBWP Area was 0.32 mg/L. The current preproject TP load into the Yazoo River was calculated to be 526 metric tons TP per year (Table 16-32). This represents 11.3 percent of the load in the Yazoo River and 0.39 percent of the load in the Mississippi River. For the postproject YBWP Plan 5, the reforestation feature increases the HGM functional units for TP by 4 percent. This increase in TP removal translates into a decrease in TP load into the Yazoo River by 21 metric tons per year. The TP load into the Yazoo River from the YBWP (B1) was 10.8 percent of the Yazoo River load and 0.37 percent of the long-term load in the Mississippi River. The YBWP and WRP/CRP (B1) combination resulted in the greatest TP reduction, 79 metric tons TP per year or 0.33 percent of the Mississippi River annual TP load. After 15,029 acres are reforested, the TP load would be reduced by 41 metric tons per year.

214. Changes in TSS load from the YBWP Area can also be estimated from the data available. Historic sediment loading in the Yazoo and Mississippi Rivers was taken from Moody and Meade (1992). The authors published results of USGS high-water surveys on the Mississippi River and tributaries. In the study, the USGS collected data on discharge, bed sediment, and suspended sediment. The data show that during that period, the Yazoo River drainage area was supplying 2 percent of the Mississippi River’s annual water and sediment load.

215. Based on an average TSS concentration of 135 mg/L in the YBWP Area and acquisition of all 55,600 acres of cleared land targeted for Plan 5, the estimated preproject TSS load into the Yazoo River is 221,747 metric tons per year (Table 16-32). This represents 5.84 percent of the total Yazoo River TSS load and 0.11 percent of the Mississippi River load. Implementation of the YBWP Plan 5 would decrease the TSS load into the Yazoo River by 8,870 metric tons per year. The postproject load would be 5.6 percent of the Yazoo River’s load and 0.11 percent of the Mississippi River’s sediment load. As with the nutrients, the combined YBWP and CRP/WRP (B1) analysis provided the most reduction in sediment loading, 33,262 metric tons per year. After the 15,029 acres are reforested, sediment loading from the YBWP Area would be reduced by 17,300 metric tons per year.

216. Overall, this simplistic analysis of predicted reduction of the nutrient and sediment loads coming out of the Yazoo Backwater study area as a result of implementation of the nonstructural reforestation feature in Plan 5 combined with maturation of the existing USDA WRP and CRP forests is a realistic estimate of load reduction in the project area. The estimates reflect improvements in wetland functions of nutrient and sediment removal as reforested cropland matures. The estimates do not reflect reductions in loading resulting from soil stabilization as cropland is taken out of production and fertilizers are no longer applied. The 1996 to 2000, USGS data show that the Yazoo River supplied 0.7 percent of the Mississippi River’s nitrate load. This analysis shows that the Yazoo Backwater study area supplies approximately one tenth

of that load, 0.07 percent. The recommended reforestation of 55,600 acres within the Yazoo Backwater study area combined with maturation of existing USDA CRP and WRP forests could reduce the load by 158 metric tons per year, reducing the Yazoo Backwater study area's nitrate contribution to 0.05 percent of the Mississippi River's long term average.

CITIZENS' CONCERNS ABOUT WATER QUALITY IN THE YAZOO BACKWATER PROJECT AREA

217. In a public meeting held on November 9, 2000, in Rolling Fork, Mississippi, citizens in the YBWP Area expressed concern that the project would increase their exposure to DDT and other pesticides. Some of those concerns are mentioned below.

a. Ms. Patricia Ware was "concerned about the pesticide level that has been spilled into the Big Sunflower River and into Deer Creek in Leland" where she lives. She believes the project will expose her children to deadly chemicals and pesticides because it will not protect her home from flooding.

b. Ms. Margaret Hollins said, "I am not in favor of the Yazoo pumps for any activities that will increase pesticides in our area." Ms. Hollins expressed concern about "more pesticides being used on farmlands that will have flood control" and increased DDT levels in rivers, lakes, and fish. She continued to say, "We need to clean up the waters, get the pesticides out of our rivers and lakes."

c. Ms. Cynthia Sarthou expressed concern over health problems that might be related to pesticide use, chemical use, and residual sediment contamination. Ms. Sarthou was concerned about the high number of water bodies identified as impaired by MDEQ and the fact that the Yazoo Backwater pump "would not help that pollution." One of her concerns was that pollution would only be worsened "by moving waters more quickly without residual time for absorption of pollutants" and the impact loss of pollution removal would have on people. Ms. Sarthou also brought up the need for the Corps to address nutrient reduction.

d. Ms. Latoya Davis was concerned about agricultural intensification and the belief that by allowing more lands to be farmed, the Yazoo pumps will result in the increased use of pesticides. She was also concerned that the Yazoo pumps would encourage the dredging project in the Big Sunflower River that would dig up DDT from contaminated river bottoms and deposit them on the riverbank, thus causing health problems.

e. Ms. Jaribu Hill was concerned that the YBWP would increase exposure to "deadly pesticides."

f. Ms. Nathalie Walker believed the project would increase agriculture, which means pesticide use.

g. Ms. Monique Harden was concerned that changes in hydrology would "worsen water quality, result in increased pesticide use." She was concerned that the YBWP would encourage dredging projects that would circulate DDT contaminated sediments back into the environment and contaminate fish.

h. Mr. Elbert Redmon was concerned about fish dying because of chemicals.

i. Ms. Willie Mae Moore wanted to know if the standing floodwater had pesticides in it, was it not contaminating everything where the floodwater was standing.

218. Information relative to these concerns is provided in the discussion above and is summarized here.

219. Changes in Hydrology. The Yazoo Backwater pump would only be in operation on average for a few weeks each year and would have the effect of reducing the peak flood elevation during those times when gravity outflow through the existing Steele Bayou structure is not possible. Plan 5, for example, would reduce the 100-year flood at the Steele Bayou structure from 100.3 to 95.6 feet, NGVD. Operation of the pump station will change the water surface elevation and duration of floods greater than the 1-year frequency flood. These changes to flood extend and duration would be slow and gradual. If the pump station was the sole means of evacuating floodwater, it would take 25.2 days to reduce the water surface elevation at the Steele Bayou structure from 91 to 87 feet, NGVD. This amounts to an average daily change in the water surface elevation of 0.16 foot. It would take just over 6 days to lower the water surface elevation 1 foot. Lowering the water surface elevations during floods greater than the 2-year frequency would result in smaller average daily changes in the water surface elevation at the Steele Bayou structure. The actual change in the water surface elevation will be greatest near the pump station and less in the headwaters.

220. Sediment/Pesticide Removal Efficiency. Sediment removal efficiency from postproject floodwaters was discussed in the sections on "Impacts on Efficiency of Suspended Sediment Removal" and "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area." Studies during backwater flooding in the DNF and adjacent USDA WRP reforested lands have shown that changes in hydrology (i.e., flood extent and duration) should not have significant effects on suspended sediment removal (this includes DDT removal as will be discussed in succeeding paragraphs in this section). The data show that more that 60 percent of the suspended sediment was removed from floodwaters over a period of 17 days during local flooding that lasted approximately 23 days. Although the number of flooded forest acres will change, the sediment removal efficiency is not expected to change because of the project. Addition of up to 55,600 acres of forest in the nonstructural feature will reduce sediment yield from erosion by 11 percent and reduce pesticide yield from erosion by 2 percent. Reforestation of 55,600 acres will also improve the wetland functions that are directly related to sediment and pesticide removal from out-of-bank floodwaters. Based upon wetland function alone, sediment and pesticide removal from floodwater should increase by 4 percent each. Total reduction in sediment and pesticide removal was estimated to be 15 percent and

6 percent, respectively. Calculations to estimate sediment removal show that the recommended plan in conjunction with other reforestation projects in the Yazoo Backwater study area would decrease the sediment load into the Mississippi River between 17,300 and 31,300 metric tons per year, depending upon the level of reforestation achieved. In addition to the benefits of soils stabilization and increased filtering capacity, forested lands will be taken out of agricultural production and will no longer receive applications of agriculture chemicals.

221. Nutrient Removal. Nutrient removal is addressed in several sections of this appendix including: "Reduction and Improved Quality of Stormwater Runoff"; "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area"; and "Estimated Project Impact on Nutrient and Sediment Loading in the Mississippi River." Nutrient removal involves removal of dissolved substances, usually nitrate, through biochemical processes and removal of sorbed nutrients, phosphorus, through physical settling processes. In addition, reforestation takes agricultural land out of production stabilizing the soil and reducing fertilization requirements, thus reducing nutrient yield into adjacent streams and lakes. The analyses reported elsewhere in this appendix show that the combined nutrient removal benefits from reforestation should increase by 16 percent as agricultural land is taken out of production and the new forests mature. Calculations to estimate nutrient removal from increases in wetland function alone show that the recommended plan in conjunction with other reforestation projects in the Yazoo Backwater study area would decrease the nitrate load into the Mississippi River between 93 and 158 metric tons per year, depending upon the level of reforestation achieved. As described above, these calculations understate the nutrient removal because the calculations do not capture all the benefits of removing land from agriculture.

222. Agricultural Intensification and Increased Pesticide Use. Agricultural intensification is addressed in the section "Land Use – Agricultural Intensification." The trend in the Yazoo Backwater study area is away from land clearing, in part, because of Federal programs that discourage the practice, and in part because of increased value of wildlife area (hunting) and timber production. Significant shifts in land use are unlikely unless there are major changes in agricultural policy. While crops in the study area are expected to change from year to year over the life of the project, total land in agricultural production is expected to remain relatively constant. The major change expected would be earlier planting of soybeans once flood protection becomes available. Early planting of soybeans would reduce the amount of fungicide required to control Asian Soybean Rust and could reduce irrigation requirements. Because soybeans are not routinely fertilized, there should be no increases in nutrient runoff from early soybeans. Many crops currently grown have been genetically engineered to require fewer applications of chemicals. This transition to genetically engineered seed enables farmers to

move away from conventional tillage and utilize conservation tillage and no-till planting practices, which should further reduce erosion and sorbed pesticide transport during the spring rainy season. In addition, the transition to genetically engineered seed has also resulted in a significant shift in the quantities and types of chemicals needed for successful crop production (personal communication, March 8, 2006, Dr. Robert Williams, MSU, Starkville, Mississippi). Most of the current-use pesticides are less persistent in the environment than are the organochlorine DDT compounds. Current-use pesticides are discussed elsewhere in this appendix.

223. Project Impact on Impaired and TMDL Water Bodies. The Vicksburg District is aware of and complies with water quality standards have been established for surface waters in Mississippi. The water quality analysis for the YBWP evaluated project impacts on the impaired waters within the study area including those with TMDL. Lists of TMDL waters are presented in Table 16-34. Lists of impaired waters are presented in Table 16-35. Reforestation will provided benefits to water quality in two ways. Reforestation will remove agricultural land from production and will decrease erosion and runoff of sediment, nutrient, and pesticides into adjacent water bodies. In addition, reforestation of wetlands will increase the filtering capacity of these areas to remove sediment, pesticides, and nutrients from flood waters passing through them. The impact analysis utilized the HGM wetland functional analysis to help determine impacts for the major impairment categories (sediment, nutrients, pesticides, and organic enrichment). These same impairment categories were also addressed in the stormwater runoff analysis. Results of the HGM and the stormwater runoff analyses are summarized in Table 16-36. Results of these two analyses were summed to determine the reforestation impact for each of the alternative plans as agricultural land is taken out of production and new forests mature. Project impacts to the impairment categories are discussed in the section "Project Impact on Impaired Water Bodies." The analysis shows that reforestation for the recommended plan should reduce sediment by 15 percent, pesticides by 6 percent, and nutrients by 16 percent. Overall, reforestation of 55,600 acres would improve water quality by an average of 12 percent above existing/base conditions. If only the 15,029 acres required for mitigation were acquired, the benefit would be enough (1 percent) to offset any water quality impacts from construction and operation of the Yazoo Backwater pump station. In addition, studies conducted during backwater floods and hydraulic analysis of pump effects have shown that operation of the pumps will leave sufficient water depth and duration for the sediments suspended in the water column to resettle naturally.

224. DDT Background Information. The pesticides DDT and toxaphene belong to a class of organochlorine pesticides widely used for agricultural pest control between the 1940s and 1980s. DDT was banned from use in the United States in 1973 while toxaphene was banned from most uses in 1982 and from all uses in 1990. These compounds were banned, in part, due to their persistence in the environment and to their tendency to accumulate in sediment and fish tissue. These organochlorine pesticides have been replaced with classes of compounds that break down more easily and do not accumulate in sediment or fish tissue. Until recently, DDT was banned

for most uses throughout the world. In September 2006, however, the World Health Organization (WHO) recommended the resumed use of DDT for residual spraying inside homes to control malaria (WHO, 2006). Since the 1980s, extensive research and testing have demonstrated that well-managed indoor residual spraying programs using DDT pose no harm to wildlife or humans.

225. Based upon current conditions and using DDT as an example, organochlorine pesticides cycle in the environment in the following manner. Fine-grained soil and organic material contaminated with historic applications of DDT erode into adjacent water bodies. Microbial processes degrade the original DDT compound into DDD and DDE. At the same time, resuspension of these sediments releases small, often undetectable concentrations into the surface water. Small organisms consuming sediment and organic material containing DDT adsorb DDT in their bodies. Fish, in turn, consume these small organisms and accumulate DDT into their fatty tissue. When these fish are caught and consumed, DDT moves up the food chain. Data from fish surveys show that bottom-feeding fish have the highest concentrations of DDT in their tissue.

226. Historic data collected by MDWFP in the 1960s showed high concentrations of DDT in water, sediment, and fish tissue (Herring and Cotton, 1969). This was especially true during the period when DDT was still being applied to fields and the pesticide could make its way to adjacent water bodies either though surface runoff or aerial drift. More recent FWS reports have shown that DDT concentrations have continually decreased since the 1973 ban (Schmitt et al., 1990 and EPA, 2003). Current data show that although DDT is still found in sediment, the highest concentrations are found in agricultural soil. Nowadays, DDT is rarely detected in surface water.

227. Organochlorine pesticides, such as DDT and toxaphene, are hydrophobic (water hating) compounds. Because of this, they are more likely to be found in fine-grained soil or sediment than dissolved in water. In fact, the amount of each of these pesticides that can exist in solution in water is based on each pesticide's chemical characteristics. Equilibrium partitioning is the scientific method that describes a compound's tendency to exist in one phase or another (i.e., dissolved in water or attached to sediment) based on its chemical characteristics (Clarke and McFarland, 1991). Equilibrium partitioning equations show that DDT concentrations in water, for example, are approximately 2,000 times less than DDT concentrations in sediment. The highest sediment concentration of DDT in the YBWP Area was 0.121 parts per million (expressed in mg/kg). Equilibrium partitioning predicts the corresponding surface water concentration would be 0.00005 parts per million (expressed in mg/L). This concentration, however, is still greater than the DDT human health criterion in surface water, 0.00059 parts per billion (expressed in μg/L).

228. <u>Existing DDT Sediment Concentrations – Put into Perspective</u>. Results of the YBWP sediment analysis are presented in the section "Sediment Organochlorine Pesticides Data." Overall, 78 percent of the 149 sediment samples evaluated had pesticide concentrations too low to be classified as likely causes of harmful biological effects to aquatic organisms based on

comparisons to their respective EPA probable effect concentrations (PECs). In addition, all of the sediments collected for evaluation in the YBWP had DDT concentrations less than the EPA risk-based criteria that are used in site evaluation and remediation of soils containing DDT compounds. The chemical-specific target remediation goals for unrestricted development of a site for these compounds are DDD – 2.66 mg/kg, DDE – 1.88 mg/kg, and DDT – 1.88 mg/kg (MDEQ, 2002b). The highest YBWP Area concentrations of these compounds, found in sediment collected in Deer Creek, were DDD – 0.155 mg/kg, DDE – 0.482 mg/kg, and DDT – 0.121 mg/kg. Based on these data, a piece of land with soil DDT concentrations identical to the Deer Creek sediment concentrations would be suitable for unrestricted residential development without concern for human health.

229. We know from sampling in historic cotton fields that these soils have much higher concentrations of organochlorine pesticides than are found in sediment. Any feature that controls the amount of soil entering an adjacent water body will also reduce the amount of organochlorine pesticides entering that water body and would reduce environmental exposure to these pesticides. Implementation of the YBWP recommended plan's reforestation feature would have the direct impact of reducing erosion. Runoff calculations for the Yazoo Backwater study area indicate reforestation would reduce sediment yield by 11 percent and reduce legacy pesticide yield by 2 percent. In addition, the reforestation feature should increase the filtering capacity of suspended sediment from out-of-bank floodwater by up to 4 percent. Since DDT and other organochlorine pesticides are attached to sediment, reducing the amount of suspended sediment will also reduce the amount of DDT in the water by 4 percent.

230. The YBWP is not a dredging project; nor is it a prerequisite to the Big Sunflower River Maintenance Project. The inlet and outlet channels, which were constructed at the pump station site in 1987, are the only locations that will have periodic sediment removal as needed to maintain channel depth. Since the pump station site is not in an agricultural area and these channels have not been connected to Steele Bayou, the Connecting Channel, or the Yazoo River, it is unlikely that they would contain large deposits of DDT-contaminated sediment. Therefore, there is no project feature that would increase short-term resuspension of DDT-contaminated sediment. For these reasons, it is more likely that the YBWP would have the long-term effect of decreasing DDT concentrations in sediment and surface water rather than increasing them. After project completion, erosion control and increases in wetland functional value due to the reforestation feature should ensure that the concentrations of organochlorine pesticides in water that is pumped out of the YBWP area will be less than or equal to the concentrations that are currently flowing through the Steele Bayou structure. When the sediments in the inlet and outlet channels are periodically removed, they will be disposed of in borrow/disposal areas at the pump station site. These areas will be vegetated once they dewater. There will be little opportunity for air-borne release of these sediments in the form of dust.

231. <u>DDT in Fish</u>. One of the major concerns with DDT is that it bioaccumulates in the food chain. Toxicity tests using project area sediment show that the concentrations in the sediment are below the threshold that would kill many of the sensitive aquatic organisms that are used as food by fish. Because these organisms do not die, pesticides become concentrated in the bodies of these organisms and, eventually, in the fatty tissue of fish. Consumption of fish containing

DDT is the major pathway that DDT enters the body of higher consumers, including humans. In 2001, the state listed a fish advisory for DDT and toxaphene in the Mississippi Delta. It stands to reason that reducing the amount of DDT available in sediment would lead to reductions in fish tissue concentrations. As discussed above, DDT adheres to fine-grained soils such as clay. When these soils wash into adjacent streams, they become deposited in areas that do not maintain enough velocity to keep the sediment suspended and flushed out of the stream. It also stands to reason that removing existing sediment from these areas should reduce the opportunity for DDT uptake in fish. In fact, this is exactly what has been observed in the Steele Bayou Basin. A comparison of pre- and postproject sediment data has shown a significant reduction in postproject DDT sediment concentrations in upper Steele Bayou (Figure 16-4). The combination of removing existing sediment contaminated with DDT and installing agricultural best management practices to prevent erosion has led to decreases in DDT fish tissue concentrations. In 2005, only 2 of the 69 Steele Bayou fish analyzed for DDT exceeded the 1.0 mg/kg fish consumption criterion (Figure 16-3). The average DDT fish tissue concentration for the 2005 Steele Bayou fish was 0.182 mg/kg.

232. Summary. Historic DDT residues can enter the environment and subsequently the food chain. The processes involved have been described above, including pesticide adherence to soil, release of soil, and uptake from small organisms into larger animals, such as fish. The potential impacts of the YBWP have been evaluated by looking at these various processes. Regional data on DDT indicate an ongoing and gradual decline in DDT in fish tissue. The features of the YBWP do not affect the stages or pathway that DDT follows to result in fish tissue concentrations or fish consumption advisories. The soil and sediment disturbance (that might put soil with DDT adhered into the water column) will be limited to initial construction and periodic dredging of the inlet and outlet channels. At those locations, there is little soil or sediment with pesticides concentrations. The hydraulic, flood-reducing operation of the pump station, which will change the duration of floodwater over land, will operate in a manner that leaves sufficient water depth and duration for the sediments disturbed (and suspended in the water column) to resettle naturally.

233. The YBWP will not result in increased exposure to legacy organochlorine pesticides. The YBWP does not have a significant dredging feature that will disturb sediments contaminated with DDT and toxaphene. As discussed in the section "Land Use – Agricultural Intensification," the Vicksburg District has explained that the YBWP will not increase the amount of cleared land in agriculture, such that newly planted land would be the source of additional pesticide applications. On the contrary, reforestation of low-lying agricultural fields will stabilize soil, reduce erosion, and reduce sediment and pesticide yields from those fields. In time, these reforested wetlands will increase their effectiveness in filtering sediment and pesticides from out-of-bank floodwaters.

MDEQ IMPAIRED WATER BODIES WITHIN THE YAZOO BACKWATER STUDY AREA

234. Most water bodies in the Yazoo Backwater study area have been designated for the propagation of fish and wildlife. Many of these waters were determined to be only partially supporting their designated use and were determined to be impaired when compared to existing 1992 State water quality benchmarks as required by Section 303(d) of the Clean Water Act (CWA) and the implementing Federal Regulations at 40 C.F.R. §130.7. These documents required the State to identify those waters within its jurisdiction for which effluent limitations were not sufficient to implement one or more applicable water quality standards and for which TMDLs were not yet completed. Some of the reasons cited for these impairments were excessive loadings of nutrients, suspended solids, and pesticides from both point and nonpoint sources. A part of the 1972 CWA, TMDL development in Mississippi was not aggressively pursued until the 1998 Federal Consent Decree between the EPA Region 4 and the Sierra Club. At this time, water bodies on the State's 1996 Section 303(d) list were mandatorily scheduled for TMDL development. The regulations at 40 C.F.R. §130.7 allow modifications to the 1996 and subsequent Section 303(d) lists when a TMDL is completed or when a good cause justification exists for such modification. The MDEQ has completed numerous TMDL, monitored numerous previously unmonitored water bodies to determine water quality status, identified impairments more specifically, and removed duplications and errors found on the 1996, 1998, and subsequent lists. As a result, many water body pollutant causes have been modified either by substitution, TMDL completion, error elimination, or by determining a good cause justification that the water does not require a TMDL.

235. The TMDL are not numerical criteria to be used to evaluate water quality. Rather, they represent the pollutant load that a water body can assimilate without exceeding the established water quality standard for that pollutant. This total load includes pollutants that come from the end of a pipe (point sources) and from stormwater runoff and ground-water flow (nonpoint sources), as well as a "margin of safety," which provides a cushion needed because of uncertainties naturally associated with estimates. A TMDL may also include an allowance for future increases in pollutant loads due to changes in land use, population growth, and the expansion of business activity (Martin and Kennedy, 2000). TMDL and Section 303(d) list waters are important to the YBWP because Mississippi's most recent edition of its water quality criteria states that these waters shall not be further impaired for any designated use (MDEQ, 2002a). The TMDL and Section 303(d) list water bodies within the Yazoo Backwater study area are identified in the following sections. Expected project impacts to these water bodies will be discussed in greater detail in the section on "Project Impact on Impaired Water Bodies."

TMDL DEVELOPED FOR WATERS
WITHIN THE YBWP AREA

236. The YBWP Area consists of three major basins: Steele Bayou, Deer Creek, and the Big Sunflower River. For the analysis of impaired water bodies, the study area was defined as the extent of the 100-year flood. As of April 2007, nine TMDL have been developed collectively for Steele Bayou (2), Deer Creek (3), the Big Sunflower River Basin (3), and the Yazoo Basin (1). As the receiving water for the Yazoo Backwater study area, the Yazoo River has two additional TMDL that may be applicable. An examination of the extent of the out-of-bank influence of the Yazoo Backwater preproject 100-year flood and the effects of historic alterations of Deer Creek shows that only four TMDL apply to the Yazoo Backwater study area (Plate 16-4). Applicable TMDL are listed in Table 16-33 and include organic enrichment, nutrients, and sediment for the Big Sunflower River; biological impairment by toxicity or unknown pollutants for Wade Bayou, Howlett Bayou, and Cypress Bayou; fecal coliform for the Yazoo River; and legacy pesticides DDT and toxaphene in the Yazoo River Basin. None of the Steele Bayou or Deer Creek TMDL apply to the Yazoo Backwater study area. For Steele Bayou, all of the TMDL segments are upstream of the out-of-bank 100-year backwater flood. For Deer Creek, all of the impaired segments are upstream of the Rolling Fork Creek diversion.

TABLE 16-33
TMDL APPLICABLE TO THE
YAZOO BACKWATER PROJECT AREA

Basin	TMDL	Year
Big Sunflower River	TMDL for Organic Enrichment, Nutrients, and Sediment for the Big Sunflower River - Sunflower, Coahoma, Washington, Humphreys, and Sharkey Counties, Mississippi	2003
Big Sunflower River	TMDL for Biological Impairments by Toxicity or Unknown Pollutants – Wade Bayou, Howlett Bayou, and Cypress Bayou	2003
Yazoo River	Fecal Coliform TMDL for the Yazoo River – Carroll, Holmes, Leflore, and Warren Counties	2003
Yazoo River	TMDL for Legacy Pesticides DDT and Toxaphene in the Yazoo River Basin	2005

237. Of the impaired segments listed in the four TMDL, only six are located within the preproject 100-year flood zone (Table 16-34). These include the lower Bogue Phalia, the Big Sunflower from the confluence of the Bogue Phalia to the Yazoo River, Cypress Bayou, Howlett Bayou, Holly Bluff Cutoff, and the Yazoo River downstream of Redwood. Impairments for each listed segment vary and may be due to nutrients, organic enrichment/low dissolved oxygen (DO), DDT and toxaphene, sediment/siltation, pathogens, or biological impairment by unknown pollutants. The TMDL and impaired segments that affect the Yazoo Backwater study area are discussed in the following sections.

TABLE 16-34
TMDL SEGMENTS
YAZOO BACKWATER PROJECT AREA

Name	ID	County	HUC	Cause	Mon/Eval
BIG SUNFLOWER RIVER BASIN					
Bogue Phalia	MS392M	Washington Sunflower	08030207	Sediment/Siltation	Evaluated
At Leland from confluence with Clear Creek to Big Sunflower River (MDEQ, 2003c)					
Big Sunflower	MSBIGSUNRM4	Washington Humphreys Sharkey	08030207	Nutrients Organic Enrichment/ Low DO Suspended Solids Turbidity	Monitored
Near Anguilla from confluence with Bogue Phalia to Yazoo River (MDEQ, 2003c)					
Holly Bluff Cutoff	MSHBCUTM	Washington Humphreys Sharkey	08030207	Nutrients Organic Enrichment/ Low DO Sediment/Siltation	Evaluated
Near Anguilla from Chappel Landing to Holly Bluff (MDEQ, 2003c)					
Cypress Bayou	MS396M1	Sharkey	08030207	Biological Impairment	Monitored
Near Spanish Fort from headwaters including parts of Six Mile Bayou and Ten Mile Bayou. (MDEQ, 2003j)					
Howlett Bayou	MS396M2	Sharkey	08030207	Biological Impairment	Monitored
Near Red Rock from headwaters to the Little Sunflower River (MDEQ, 2003j)					
Big Sunflower	MSBIGSUNRM4	Washington Humphreys Sharkey	08030207	DDT	Monitored
Near Anguilla from confluence with Bogue Phalia to mouth at Yazoo River (MDEQ, 2003i)					
Holly Bluff Cutoff	MSHBCUTM	Sharkey Yazoo	08030207	DDT	Monitored
Near Anguilla from confluence with Bogue Phalia to mouth of Yazoo River (MDEQ, 2003i)					
YAZOO RIVER					
Yazoo River	MS400M	Warren	08030208	Pathogens	Evaluated
At Redwood from Anderson Tully Outfall to confluence with Steele Bayou. (MDEQ, 2003h)					

BIG SUNFLOWER RIVER BASIN

TMDL for Organic Enrichment, Nutrients, and Sediment for the Big Sunflower River (MDEQ, 2003c)

238. This TMDL addresses listings from the 1996 Mississippi Section 303(d) list that fall within the Yazoo Backwater study area. These water bodies are listed as either evaluated or monitored for low DO/organic enrichment, nutrients, or sediment. The water bodies impacted by the out-of-bank 100-year Yazoo Backwater flood are identified in Table 16-34. These include Bogue Phalia near Darlove (MS392M), the Big Sunflower River near Anguilla (MSBIGSUNRM4), and Holly Bluff Cutoff (MSHBCUTM).

239. Low DO typically occurs during seasonal low-flow, high-temperature periods that occur during the late summer and early fall. Elevated oxygen demand is of primary concern during low-flow periods because the effects of minimum dilution potential and high temperatures combine to produce the worst-case potential effect on water quality. Because the normal base flow has decreased in recent years, the Big Sunflower River is augmented by YMD to maintain a minimum instream flow of 50 cfs at Sunflower, Mississippi. Additional flow augmentation is being considered. The instream DO target for this TMDL is a daily average of not less than 5.0 mg/L. While Mississippi currently does not have standards for allowable nutrient concentrations, it is understood that elevated levels of nutrients may decrease DO concentrations. Therefore, this TMDL developed for DO also addresses the potential impact of elevated nutrients.

240. Instream processes that impact DO concentrations are algal growth and respiration and oxidation of organic material in the water and sediment. Any point source discharge containing ammonia also places a burden on a stream's DO and can be toxic to aquatic life. Nonpoint source (NPS) loading into a water body results from the transport of pollutants into receiving waters by overland surface runoff, atmospheric deposition, and weathering of rocks and soil. For organic enrichment/low DO and nutrients, impairments were predicted in two of the five segments evaluated (MSBIGSUNRM4 and MSHBCUT). Impairments in these two segments were determined to be the result of the combination of upstream nonpoint sources above the confluence of the Big Sunflower River with the Bogue Phalia and the effects of the hydraulic control structures located within these segments. Decreased velocities and increased depths were determined to decrease reaeration and increase the impact of sediment oxygen demand upstream of the structures. The MDEQ stated that manmade structures such as weirs were considered to be forms of pollution and should not require TMDL development. The MDEQ recommended that the cause of impairment for these segments be reclassified as a pollution cause for this water body. The model used to develop the TMDL showed that a combination of increased flow and

reduction in NPS loading and/or upstream load reductions would be needed to remove the predicted impairments. For NPS loading, an overall reduction ranging from 38 to 71 percent is needed in order for the model to show compliance with the TMDL endpoint in these two segments.

Total Maximum Daily Loads for Biological Impairment by Toxicity or Unknown Pollutants – Wade Bayou, Howlett Bayou, and Cypress Bayou (MDEQ, 2003j)

241. This TMDL addresses water bodies impaired for their aquatic life protection designated use due to impairment by unknown toxicity. While there is no applicable water quality standard, a narrative standard for the protection of aquatic life was interpreted to determine an applicable target for this TMDL. The narrative standard states "that waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended solids, or other conditions in such degree as to create a nuisance, render the waters injurious to public heath, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses" (MDEQ, 2003j). This is a phased TMDL established to protect the biology of the listed segments against chronic toxicity due to pollutants that may cause toxicity to aquatic organisms. For this TMDL, Howlett Bayou (MS396M2) and Cypress Bayou (MS396M1) lie within the Yazoo Backwater study area. These water bodies were determined to be impaired using screening level biological methods that have since been determined inappropriate for water bodies in the Mississippi Delta (MDEQ, 2003j). This TMDL was finalized on June 23, 2003. The impairment status has not been changed.

YAZOO RIVER BASIN

Total Maximum Daily Loads for the Legacy Pesticides DDT and Toxaphene (MDEQ, 2003i)

242. This TMDL addresses listings in the Yazoo River Basin from the 1996 Mississippi Section 303(d) list for water bodies listed as monitored for DDT and toxaphene. The water bodies impacted by the Yazoo Backwater Area Reformulation are identified in Table 16-34. These include Holly Bluff Cutoff (MSHBCUTM) and the Big Sunflower River near Anguilla (MSBIGSUNRM4). The target concentration for the DDT TMDL is 0.00059 µg/L, the human health water concentration and organisms limit. The target concentration for toxaphene is the 0.0002 µg/L freshwater chronic aquatic life concentration (FWC) limit. The intermediate goal is

the elimination of fish advisories based on DDT and toxaphene. The TMDL target will be water column concentrations below the standards for the pollutants. This TMDL does not create new BMPs or implement any actions. It does, however, recognize the importance of BMPs in the Yazoo Basin to keep soil on the fields and out of streams and rivers.

Fecal Coliform TMDL for the
Yazoo River (MDEQ, 2003h)

243. This TMDL addresses segments in the Yazoo River from the 1996 Mississippi Section 303(d) list for water bodies listed as evaluated and monitored for fecal coliform. The Yazoo River downstream of Redwood (MS400M) will be the receiving water for the Yazoo Backwater Area Reformulation Project (Table 16-34). It will be the only Yazoo River TMDL segment affected by the project.

244. For this TMDL, fecal coliform is used as an indicator organism for pathogenic bacteria. Fecal coliform/pathogens can be attributed to both nonpoint and point sources. For NPSs, impairment usually occurs during periods of wet weather and high surface runoff. The critical period for point source dominated systems occurs during low-flow, low-dilution conditions. NPSs of fecal coliform can be runoff from pastureland, forests with high game populations, and flooded areas with high waterfowl populations. In the YBWP area, forests with high game populations and flooded areas with high waterfowl would be the dominant contributors. Point sources are controlled under the National Pollutant Discharge Elimination System (NPDES) permitting authority. The NPDES facilities have regulated discharge amounts and should be monitored. Unregulated point sources would be leaking or improperly drained septic tanks from individual homes along the river. The fecal coliform TMDL calls for a 39 percent reduction in fecal coliform in the impacted river segment. This would be done by affecting the NPDES discharges and individual septic dischargers to ensure the State fecal coliform limit is met. At the time of TMDL development, however, the only NPDES discharger within the segment was determined not to need permit modification to meet fecal coliform limits.

SECTION 303(D) LIST IMPAIRED WATERS
WITHIN THE YAZOO BACKWATER STUDY AREA

245. In addition to the water body segments with completed TMDL, the Yazoo Backwater study area also contains numerous segments on the Mississippi Section 2004 303(d) list for TMDL development (Plate 16-5). A listing of these water bodies is presented in Table 16-35. The Section 303(d) list includes a total of 14 impaired water bodies from the study area: the Steele Bayou Basin (4), the Big Sunflower Basin (8), Deer Creek (1), and the Yazoo River (1). Only one of the segment listings was based on monitored data--the DDT and toxaphene fish consumption impairment for Steele Bayou south of Highway 1. Causes of the other impairments include nutrients, organic enrichment/low DO, pesticides, sediment/siltation, and unknown causes. Although state water quality criteria apply to the Section 303(d) list water bodies, no load allocations have been developed; however, the state antidegradation policy of no further impairment does apply. Based on information contained in the Mississippi 2004 Section 303(d) report, 11 of the segments are targeted for TMDL completion by 31 December 2007.

TABLE 16-35
MISSISSIPPI SECTION 303(D) LIST WATERS WITHIN
THE YAZOO BACKWATER REFORMULATION AREA

Name	ID	County	HUC	Impaired Use/Cause	Mon/Eval
STEELE BAYOU					
Steele Bayou	MS407S	Issaquena Warren	08030209	Fish Consumption DDT, Toxaphene	Monitored No Date [b/]
Near Onward from HWY 1 to the Yazoo River					
Indian Bayou	MA406E	Sharkey Issaquena	08030209	ALS [a/] Nutrients Organic Enrichment/Low DO Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
Near Fitler from Headwaters to Watershed 405 Boundary					
Steele Bayou	MS404E	Washington Issaquena	08030209	ALS Nutrients Organic Enrichment/Low DO Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
Near Issaquena from Black Bayou to the Yazoo River					
Cypress Lake	MS407CLE	Issaquena	08030209	ALS Nutrients Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
Oxbow lake near Valley Park					
BIG SUNFLOWER					
Big Sunflower River	MSBIGSUNRE	Coahoma Sunflower Sharkey	08030207	ALS Pesticides	Evaluated 12-31-07[b/]
From headwaters at confluence with Whittaker Bayou to the Yazoo River					
Big Sunflower River Diversion Channel	MSBGSND1E	Warren Issaquena	08030209	ALS Nutrients Organic Enrichment/Low DO Pesticides	Evaluated 12-31-07[b/]
From HUC Boundary 08030208 to Confluence with Steele Bayou					
Big Sunflower River Diversion Channel	MSBGSND2E	Yazoo Warren	08030208	ALS Nutrients Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
From HUC Boundary 08030207 to HUC Boundary 08030209					
Bogue Phalia	MS392E	Washington	08030207	ALS[1] Nutrients Organic Enrichment/Low DO Pesticides	Evaluated 12-31-07[b/]

TABLE 16-35 (Cont)

Name	ID	County	HUC	Impaired Use/Cause	Mon/Eval
Near Darlove from Clear Creek to the Big Sunflower River					
False River	MS396E	Sharkey Issaquena	08030207	ALS Nutrients Organic Enrichment/Low DO Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
Near Smedes from Headwaters to the Little Sunflower River					
Jaynes Bayou	MS393E	Sharkey	08030207	ALS Nutrients Organic Enrichment/Low DO Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
Near Rolling Fork from Headwaters to the Big Sunflower River					
Murphey Bayou	MS392MB	Washington	08030207	ALS Cause Unknown	Evaluated No Date [b/]
Near Hollendale from Headwaters to the Big Sunflower River					
Silver Creek	MS394E	Sharkey Humphreys Yazoo	08030207	ALS Nutrients Organic Enrichment/Low DO Pesticides Sediment/Siltation	Evaluated 12-31-07[b/]
Near Holly Bluff from Headwaters to the Big Sunflower River					
DEER CREEK					
Deer Creek	MS407M1	Sharkey Issaquena	08030209	ALS Nutrients, Organic Enrichment/low DO Pesticides	Evaluated No date [b/]
From Smedes to Valley Park					
YAZOO RIVER					
Yazoo River	MSYAZR1E	Yazoo Warren	08030208	ALS Nutrients Pesticide Sediment/Siltation	Evaluated 12-31-07[b/]
From Confluence with Big Sunflower River to Confluence with the Mississippi River					

[a/] Aquatic Life Support
[b/] Date TMDL due

PROJECT IMPACT ON IMPAIRED WATER BODIES

246. In this appendix, the water quality impacts from reforestation have been evaluated without knowledge of the exact location of the reforestation other than it would occur on the cleared lands primarily in the 1-year flood plain. For impaired waters and TMDL waters, the precise location of the reforestation could be important. To reduce impairment, the reforestation needs to be at the source of the impairment for erosion control or downstream or downgradient of the impairment in order to fully utilize wetland function as described by HGM wetland functional model. Maps identifying cleared land remaining in the Yazoo Backwater study area show that the majority of cleared land in the 1-year flood plain is located in the ponding areas above the Steele Bayou and the Little Sunflower River structures. Floodwaters ponding in these two areas would receive maximum benefits from increases in wetland functional value. In addition, the agricultural land surrounding the 1- and 2-year flood frequency cleared lands are up-gradient such that runoff from higher elevation agricultural land often passes through 2- and 1-year land before entering streams. This type of filtering through progressive layers of reforested wetlands maximizes YBWP reforestation benefits to water quality.

247. This section addresses the impacts of each of the proposed alternative plans on the water quality impairments identified for water bodies within the Yazoo Backwater study area. This section utilizes information already presented in the Project Impacts Sections including an analysis of stormwater runoff from agricultural land and an analysis of the three water quality wetland functions from the HGM functional assessment. In addition to evaluating the impacts from the YBWP, the HGM analysis includes the cumulative impacts expected if the Big Sunflower River Maintenance Project were completed first. The percent change in sediment, pesticide, and nutrient export from stormwater runoff is presented in Table 16-25; while the percent change in FCU for each of the project alternatives and scenarios is presented in Table 16-29. Table 16-36 summarizes the combined benefits of reforestation for each of the four major impairments (sediment, pesticides, nutrients, and organic enrichment) and restates the data from Table 16-25 and Table 16-29 for easy comparison. The tables identify the expected percent change for both the B1 and B2 scenarios. The nonstructural reforestation component of the recommended plan decreases sediment, nutrient, and pesticide yield in stormwater runoff and increases wetland functional capacity. These combined benefits should maintain or improve existing water quality conditions within Yazoo Backwater study area. For the recommended plan, reforestation of 55,600 acres would improve water quality by an average of 12 percent above existing/base conditions. Reforestation of the 15,029 acres guaranteed for mitigation will be enough (1 percent) to offset any water quality impacts from construction and operation of the Yazoo Backwater pump station.

TABLE 16-36
CHANGES IN WATER QUALITY FROM REFORESTATION
FOR THE B1 AND B2 SCENARIOS FOR LISTED WATER BODY
IMPAIRMENTS IN THE YAZOO BACKWATER STUDY AREA

Total Change in Water Quality by Impairment (%)

a.	Sediment		Pesticides		Nutrients		Organic Enrichment	
	B1	B2	B1	B2	B1	B2	B1	B2
Plan 2	+ 41	+ 41	+ 25	+ 25	+ 43	+ 43	+ 31	+ 31
Plan 2A	+ 30	+ 30	+ 16	+ 16	+ 30	+ 30	+ 20	+ 20
Plan 2B	- 10	- 10	- 13	- 13	- 9	- 9	- 11	- 11
Plan 2C	+ 39	+ 39	+ 23	+ 23	+ 40	+ 40	+ 29	+ 29
Plan 3	- 1	- 1	- 10	- 10	- 2	- 2	- 10	-11
Plan 4	+ 3	+ 1	- 3	- 5	+ 4	+ 1	- 1	- 3
Plan 5	+ 15	+ 14	+ 6	+ 5	+ 16	+ 15	+ 9	+ 8
Plan 6	+ 27	+ 26	+ 13	+ 12	+ 27	+ 27	+ 17	+ 17
Plan 7	+ 39	+ 39	+ 23	+ 23	+ 41	41	+ 30	+ 30

Change in Water Quality from HGM Wetland Functional Analysis a/ (%)

b.	Sediment		Pesticides		Nutrients		Organic Enrichment	
	B1	B2	B1	B2	B1	B2	B1	B2
Plan 2	+ 22	+ 22	+ 22	+ 22	+ 27	+ 27	+ 31	+ 31
Plan 2A	+ 14	+ 14	+ 14	+ 14	+ 17	+ 17	+ 20	+ 20
Plan 2B	- 14	- 14	- 14	- 14	- 12	- 12	- 11	- 11
Plan 2C	+ 20	+ 20	+ 20	+ 20	+ 24	+ 24	+ 29	+ 29
Plan 3	- 12	- 12	- 12	- 12	- 11	- 11	- 10	- 11
Plan 4	- 4	- 6	- 4	- 6	- 2	- 5	- 1	- 3
Plan 5	+ 4	+ 3	+ 4	+ 3	+ 7	+ 6	+ 9	+ 8
Plan 6	+ 11	+ 10	+ 11	+ 10	+ 14	+ 14	+ 17	+ 17
Plan 7	+ 20	+ 20	+ 20	+ 20	+ 25	+ 25	+ 30	+ 30

Change in Water Quality from Conversion of Agricultural Land to Forest Land b/ (%)

c.	Sediment		Pesticides		Nutrients		Organic Enrichment	
	B1	B2	B1	B2	B1	B2	B1	B2
Plan 2	+ 19	+ 19	+ 3	+ 3	+ 16	+ 16	-	-
Plan 2A	+ 16	+ 16	+ 2	+ 2	+ 13	+ 13	-	-
Plan 2B	+ 4	+ 4	+ 1	+ 1	+ 4	+ 4	-	-
Plan 2C	+ 19	+ 19	+ 3	+ 3	+ 16	+ 16	-	-
Plan 3	+ 11	+ 11	+ 2	+ 2	+ 9	+ 9	-	-
Plan 4	+ 7	+ 7	+ 1	+ 1	+ 6	+ 6	-	-
Plan 5	+ 11	+ 11	+ 2	+ 2	+ 9	+ 9	-	-
Plan 6	+ 16	+ 16	+ 2	+ 2	+ 13	+ 13	-	-
Plan 7	+ 19	+ 19	+ 3	+ 3	+ 16	+ 16	-	-

NOTE: B1 Changes due Yazoo Backwater Project alone
B2 Cumulative changes for Yazoo Backwater Project and the Big Sunflower Maintenance Project

a/ Table 16-29
b/ from Table 16-25

248. Plan 1, the no-action alternative, would forego the water quality benefits of the nonstructural reforestation and conservation features of the recommended plan and many other alternative plans and will receive no additional discussion.

PROJECT IMPACT ON WATER BODIES IMPAIRED BY SEDIMENT

249. Three TMDL segments and eight 2004 303(d) list segments are impaired due to sediment/siltation (Plate 16-6). Construction of the pump station could have a direct impact on the lower Steele Bayou and Yazoo River, segments impaired due to sediment/siltation. Potential impacts to water quality were discussed in the section on “Impacts of Construction." Impacts will be minimized through utilization of steps outlined in the Stormwater Prevention Plan. Any impacts will be short term, lasting until construction is completed and new vegetation can be established on disturbed areas.

250. The impact of reforestation on erosion prevention and reduced sediment yield in area streams was discussed in the section on Reduction and Improved Quality of Storm Water Runoff. The USGS (Smith, et al., 1993) showed that cropland sediment yield in the 1980s was significantly higher (approximately 70 percent) than forest land sediment yield. In addition, movement to no-till planting methods should also decrease the amount of suspended sediment reaching area streams. Some estimates say that no-till planting methods can reduce sediment yield by up to 70 percent. The addition of water control structures to some of the lands targeted for reforestation will also provide sediment reduction benefits to the project. Again, any practice that keeps soil on the field will also keep nutrients and legacy pesticides out of area streams.

251. Another concern is the potential for the pump station to increase the transport of suspended solids and associated pollutants from the Yazoo Backwater study area. Preproject monitoring studies in the DNF area of the Little Sunflower River have shown that at these sampling sites in the lowest flood duration band (5 to 7.5 percent) floodwater suspended sediment concentrations were reduced by at least 60 percent in as little as 17 days (Figures 16-7 through 16-12). During this period, there was also a 72 percent reduction in suspended sediment concentrations in the Little Sunflower River samples. An analysis of the change in preproject wetland forested acres (Table 16-23) shows that 88 percent of the existing forest land will remain wetlands and will continue to perform the HGM function, Physical Removal of Elements and Compounds at current sediment removal efficiencies. Based on the preceding data, it is reasonable to expect that most of the future backwater floods would be of sufficient duration to maintain current rates and efficiencies of TSS removal.

252. Reforesting existing agricultural land would benefit the Yazoo Backwater study area in two ways. Reforestation of agricultural land would remove the land from active farming, eliminate or reduce future applications of agricultural chemicals, and stabilize the soil to reduce sediment, phosphorus, and legacy pesticide yield. Reforestation of frequently flooded agricultural land would also increase the filtering capacity of suspended sediment and associated pollutants from flood water. These topics are discussed in the sections on "Reduction and Improved Quality of Stormwater Runoff" and "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area." Tables 16-36b and 16-36c summarize the expected changes to water quality based upon the analysis of the HGM wetland functions for each alternative plan and upon analysis of sediment yield reductions from stormwater runoff. The tables also include an estimate of cumulative impacts expected as a result of the combination of the YBWP and the Big Sunflower River Maintenance Project. In Table 16-36c, the B2 scenario impacts for each plan and impairment were assigned the same value as the corresponding B1 scenario. Table 16-36a summarizes the combined impact to YBWP water bodies.

253. Plan 2. Plan 2 would reforest up to 124,400 acres of currently farmed land. Plan 2 would increase sediment removal from study area waters by 41 percent for the YBWP alone (B1) and increase sediment removal from study area waters by 41 percent for the combined YBWP and Big Sunflower Maintenance Project (B2).

254. Plan 2A. Plan 2A would reforest up to 81,400 acres of currently farmed land. Plan 2A would increase sediment removal from study area waters by 30 percent for the B1 scenario and increase sediment removal from study area waters by 30 percent for the B2 scenario.

255. Plan 2B. Plan 2B would provide for the construction of 14 ring levees and would reforest up to 26,400 acres of currently farmed land. Plan 2B would decrease sediment removal from study area waters by 10 percent for the B1 scenario and decrease sediment removal from study area waters by 10 percent for the B2 scenario.

256. Plan 2C. Plan 2C would reforest up to 114,400 acres of currently farmed land. Plan 2C would increase sediment removal from study area waters by 39 percent for the B1 scenario and increase sediment removal from study area waters by 39 percent for the B2 scenario.

257. Plan 3. Plan 3 has a pump-on elevation of 80.0 feet, NGVD, between 1 March and 31 October and a pump-on elevation of 85.0 feet, NGVD, between 1 November and 28 February. Plan 3 does not have a nonstructural reforestation feature, but would require 53,363 acres of mitigation. Plan 3 would decrease sediment removal from study area waters by 1 percent for the B1 scenario and decrease sediment removal from study area waters by 1 percent for the B2 scenario.

258. Plan 4. Plan 4 has a pump-on elevation of 85.0 feet, NGVD, and will reforest up to 37,200 acres of currently farmed land. Plan 4 would increase sediment removal from study area waters by 3 percent for the B1 scenario and increase sediment removal from study area waters by 1 percent for the B2 scenario.

259. <u>Plan 5 (the recommended plan)</u>. Plan 5 has a pump-on elevation of 87.0 feet, NGVD, and will reforest up to 55,600 acres of currently farmed land. Plan 5 would increase sediment removal from study area waters by 15 percent for the B1 scenario and increase sediment removal from study area waters by 14 percent for the B2 scenario.

260. <u>Plan 6</u>. Plan 6 has a pump-on elevation of 88.5 feet, NGVD, and will reforest up to 81,400 acres of currently farmed land. Plan 6 would increase sediment removal from study area waters by 27 percent for the B1 scenario and increase sediment removal from study area waters by 26 percent for the B2 scenario.

261. <u>Plan 7</u>. Plan 7 has a pump-on elevation of 91.0 feet, NGVD, and will reforest up to 124,400 acres of currently farmed land. Plan 7 would increase sediment removal from study area waters by 39 percent for the B1 scenario and increase sediment removal from study area water by 39 percent for the B2 scenario.

PROJECT IMPACT ON WATER BODIES IMPAIRED BY LEGACY PESTICIDES DDT AND TOXAPHENE AND UNKNOWN PESTICIDES

262. Clearly, organochlorine pesticides already impact rivers in the YBWP area. This has been demonstrated by the analysis of agricultural soil, sediments, bank material, and fish tissue. There are two TMDL segments and thirteen 303(d) list water body segments listed as impaired for pesticides in the Yazoo Backwater study area (Plate 16-7). Operation of the YBWP could impact these water bodies in various ways. As was discussed in the previous section, both the reforestation and water control structure features will benefit the project by curbing erosion and reducing sediment yield. These features will also have the indirect benefit of reducing DDT and toxaphene input to study area streams. Removal of floodwater through pumping will reduce the extent and duration of flooding depending on the pump-on elevation selected. This could have the effect of moving suspended sediments and the pesticides associated with them out of the system before they have a chance to settle. Monitoring studies along the Little Sunflower River, however, have shown significant decreases in TSS in as little as 17 days. Suspended sediment was also observed to decrease as floodwaters moved away from the river through brush and grass of the developing WRP forest. The duration of future floods and the extent of existing and proposed forested wetlands should be sufficient to maintain current removal rates for TSS and associated pollutants.

263. The legacy pesticides, DDT and toxaphene, listed in the water quality impairments within the Yazoo Backwater study area are sorbed onto sediments. Any function that removes sediments will also remove these pesticides. Reforestation of existing agricultural land would reduce sediment/pesticide yield into adjacent waters and would increase the filtering capacity from flood waters passing through these reforested areas. These topics were discussed in more detail in the sections on "Reduction and Improved Quality of Stormwater Runoff" and "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater study area." The discussion also includes cumulative impacts expected as a result of

the combination of the YBWP and the Big Sunflower River Maintenance Project. Table 16-36a summarizes the combined impacts to the pesticide impaired water bodies. Data found in Table 16-36b and Table 16-36c represent changes expected based upon the analysis of the HGM wetland function, Physical Export of E/C, and upon decreased pesticide yield in stormwater runoff from reforested land.

264. Plan 2. Plan 2 would reforest up to 124,400 acres of currently farmed land. Plan 2 would increase pesticide removal from study area waters by 25 percent for the YBWP alone (B1) and increase pesticide removal from study area waters by 25 percent for the combined YBWP and Big Sunflower Maintenance Project (B2).

265. Plan 2A. Plan 2A would reforest up to 81,400 acres of currently farmed land. Plan 2A would increase pesticide removal from study area waters by 16 percent for the B1 scenario and increase pesticide removal from study area waters by 16 percent for the B2 scenario.

266. Plan 2B. Plan 2B would provide for the construction of 14 ring levees and would reforest up to 26,400 acres of currently farmed land. Plan 2B would decrease pesticide removal from study area waters by 13 percent for the B1 scenario and decrease pesticide removal from study area waters by 13 percent for the B2 scenario.

267. Plan 2C. Plan 2C would reforest up to 114,400 acres of currently farmed land. Plan 2C would increase pesticide removal from study area waters by 23 percent for the B1 scenario and increase pesticide removal from study area waters by 23 percent for the B2 scenario.

268. Plan 3. Plan 3 has a pump-on elevation of 80.0 feet, NGVD, between 1 March and 31 October and a pump-on elevation of 85.0 feet, NGVD, between 1 November and 28 February. Plan 3 does not have a nonstructural reforestation feature, but would require 53,363 acres of mitigation. Plan 3 would decrease pesticide removal from study area waters by 10 percent for the B1 scenario and decrease pesticide removal from study area waters by 10 percent for the B2 scenario.

269. Plan 4. Plan 4 has a pump-on elevation of 85.0 feet, NGVD, and will reforest up to 37,200 acres of currently farmed land. Plan 4 would decrease pesticide removal from study area waters by 3 percent for the B1 scenario and decrease pesticide removal from study area waters by 5 percent for the B2 scenario.

270. Plan 5 (the recommended plan). Plan 5 has a pump-on elevation of 87.0 feet, NGVD, and will reforest up to 55,600 acres of currently farmed land. Plan 5 would increase pesticide removal from study area waters by 6 percent for the B1 scenario and increase pesticide removal from study area waters by 5 percent for the B2 scenario.

271. Plan 6. Plan 6 has a pump-on elevation of 88.5 feet, NGVD, and will reforest up to 81,400 acres of currently farmed land. Plan 6 would increase pesticide removal from study area waters by 13 percent for the B1 scenario and increase pesticide removal from study area waters by 12 percent for the B2 scenario.

272. Plan 7. Plan 7 has a pump-on elevation of 91.0 feet, NGVD, and will reforest up to 124,400 acres of currently farmed land. Plan 7 would increase pesticide removal from study area waters by 23 percent for the B1 scenario and increase pesticide removal from study area waters by 23 percent for the B2 scenario.

PROJECT IMPACT ON WATER BODIES IMPAIRED BY NUTRIENTS

273. Two TMDL segments and eleven 2004 303(d) list segments are impaired due to nutrients (Plate 16-8). The impact on project area water bodies identified as impaired by nutrients was addressed in discussions on DO. Based on the TMDL for nutrients in the Big Sunflower River, the critical period is the same as organic enrichment/low DO, the low-flow period in late summer. This is because the nitrification process utilizes DO to place an oxygen demand on the water body.

274. Studies have shown that in-stream nutrient concentrations are highest in the Mississippi Delta during the spring, corresponding to fertilizer application and rain events. Nutrient concentrations are generally at their lowest during the extended low-flow period in the late summer (Figure 16-18). The TP can be correlated to suspended sediment data (Coupe, 1998 and Pennington, 1999). Removal of TSS or use of BMPs to keep soil out of Delta streams will also have the effect of reducing concentrations of TP in these water bodies. Nitrogen, on the other hand, is processed microbially in wetlands during the processes of nitrification/denitrification into forms that are less toxic to the aquatic environment or that can be sequestered onto clay soils and temporarily removed from the aquatic environment (Smith and Klimas, 2002). Under anaerobic conditions, nitrogen gas can be lost to the atmosphere.

275. The nonstructural reforestation component of the YBWP will have the effect of increasing the wetland functions that remove nutrients, the Remove Elements and Compounds Function. This wetland function is discussed in greater detail in the section entitled "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area." Smith and Klimas (2002) subdivided the Remove Elements and Compounds Function into two processes that address the mechanisms used to remove these materials. The Physical Removal of Elements and Compounds Function addresses removal of materials adsorbed onto TSS, such as TP. These materials are removed from waters passing through a wetland by the physical act of settling. The Biological Removal of Elements and Compounds Function addresses removal of materials such as nitrogen through biological processes. For the nutrient HGM analysis, both the Physical Removal of Elements and Compounds and the Biological Removal of Elements and Compounds FCU were used. Runoff from agricultural fields can introduce dissolved (nitrogen) and sorbed (phosphorus) nutrients into the aquatic system. This generally occurs during the spring during the period when agricultural lands are being prepared for planting. Wetland processing of nutrients (i.e., the remove elements and compounds function) also occurs during spring floods when overland flow moves through forested wetlands

not in summer when river stages are much lower and nutrients moving into streams could have a more pronounced water quality impact. Reductions in nutrient yield that would occur when currently farmed agricultural land is removed from production were discussed in the section on "Reduction and Improved Quality of Stormwater Runoff." As was done in the HGM analysis, TP and nitrogen were analyzed separately and then combined to obtain the nutrient impact values for each alternative. The percent change in nutrient removal is presented in Table 16-36 for easy comparison. Total changes expected from reforestation are presented in Table 16-36a.

276. Plan 2. Plan 2 would reforest up to 124,400 acres of currently farmed land. Plan 2 would increase nutrient removal from study area waters by 43 percent for the YBWP alone (B1) and increase nutrient removal from study area waters by 43 percent for the combined YBWP and Big Sunflower Maintenance Project (B2).

277. Plan 2A. Plan 2A would reforest up to 81,400 acres of currently farmed land. Plan 2A would increase nutrient removal from study area waters by 30 percent for the B1 scenario and increase nutrient removal from study area waters by 30 percent for the B2 scenario.

278. Plan 2B. Plan 2B would provide for the construction of 14 ring levees and would reforest up to 26,400 acres of currently farmed land. Plan 2B would decrease nutrient removal from study area waters by 9 percent for the B1 scenario and decrease nutrient removal from study area waters by 9 percent for the B2 scenario.

279. Plan 2C. Plan 2C would reforest up to 114,400 acres of currently farmed land. Plan 2C would increase nutrient removal from study area waters by 40 percent for the B1 scenario and increase nutrient removal from study area waters by 40 percent for the B2 scenario.

280. Plan 3. Plan 3 has a pump-on elevation of 80.0 feet, NGVD, between 1 March and 31 October and a pump-on elevation of 85.0 feet, NGVD, between 1 November and 28 February. Plan 3 does not have a nonstructural reforestation feature, but would require 53,363 acres of mitigation. Plan 3 would decrease nutrient removal from study area waters by 2 percent for the B1 scenario and decrease nutrient removal from study area waters by 2 percent for the B2 scenario.

281. Plan 4. Plan 4 has a pump-on elevation of 85.0 feet, NGVD, and will reforest up to 37,200 acres of currently farmed land. Plan 4 would increase nutrient removal from study area waters by 4 percent for the B1 scenario and increase nutrient removal from study area waters by 1 percent for the B2 scenario.

282. Plan 5 (the recommended plan). Plan 5 has a pump-on elevation of 87.0 feet, NGVD, and will reforest up to 55,600 acres of currently farmed land. Plan 5 would increase nutrient removal from study area waters by 16 percent for the B1 scenario and increase nutrient removal from study area waters by 15 percent for the B2 scenario.

283. Plan 6. Plan 6 has a pump-on elevation of 88.5 feet, NGVD, and will reforest up to 81,400 acres of currently farmed land. Plan 6 would increase nutrient removal from study area waters by 27 percent for the B1 scenario and increase nutrient removal from study area waters by 27 percent for the B2 scenario.

284. Plan 7. Plan 7 has a pump-on elevation of 91.0 feet, NGVD, and will reforest up to 124,400 acres of currently farmed land. Plan 7 would increase nutrient removal from study area waters by 41 percent for the B1 scenario and increase nutrient removal from study area waters by 41 percent for the B2 scenario.

PROJECT IMPACT ON WATER
BODIES IMPAIRED BY ORGANIC
ENRICHMENT/LOW DO

285. Within the study area, two TMDL and eight 2004 Section 303(d) list segments are listed as impaired due to organic enrichment/low DO (Plate 16-9). The two TMDL segments on the Big Sunflower River listed as impaired were determined to be impacted from loadings upstream of the segments and from the water control structure within each segment. The eight listed Section 303(d) segments are based on evaluated data and are due for TMDL development by 2007. The critical period identified for organic enrichment/low DO impairment is low-water, high-temperature periods between August and October when low DO conditions have the greatest potential for adverse effects to aquatic life. While the actual measure of organic enrichment/low DO exceedances is DO concentration, ultimate biochemical oxygen demand (BODu) is the metric used to measure the potential for organic enrichment/low DO. Biochemical oxygen demand measures the oxygen required for the biochemical degradation of organic material, the oxygen used to oxidize inorganic materials such as sulfides and ferrous iron, and the oxygen used to reduce forms of nitrogen. For the two TMDL segments on the Big Sunflower River, the source of the upstream BOD is unknown (MDEQ, 2003c). It could originate at NPDES permitted facility outfalls or at unregulated non-point sources such as leaking septic systems, cattle, or aquaculture operations. These loadings were determined to enter the river upstream of the project area and should not increase as a result of the YBWP. The average BOD from data collected on the Big Sunflower River for the water quality modeling study was 5.1 mg/L.

286. Project features that might impact this TMDL are the proposed increase in water level behind the Steele Bayou Structure during the summer and increases in the export of organic carbon wetland function as a result of reforestation of cleared land. Expected impacts of this increase in summer water depth behind the Steele Bayou structure were discussed in the section, "Impact of Increased Water Depth Behind the Steele Bayou Structure." Segments that might be impacted by the proposed feature are: TMDL segment MSHBCUTM and Section 303(d) list segments MS404E, MSBGSND1E, MS396E, and MS394E.

287. Plans 2, 3 through 7. Each of these plans would increase the water depth behind the Steele Bayou structure to enhance water quality. During the late summer, increased water depth behind the Steele Bayou structure should provide an excellent environment for phytoplankton growth. While this serves to increase the average water column DO concentration, under extreme conditions it could also lead to phytoplankton die-off and oxygen depletion. In addition, holding the summer water level to 73 feet, NGVD, would reduce the reaeration potential

downstream of the Holly Bluff Cutoff weir. It could also slow water velocities behind the weir until the continued minimum discharge lowered the water elevation sufficiently below the weir. The increased summer elevation would not impact the first weir on Steele Bayou; nor would it affect Steele Bayou upstream of that weir. These impacts are discussed in more detail in the section, "Increased Water Depth Behind the Steele Bayou Structure." Plans 6 and 7 would operate the Steele Bayou Structure to maintain water elevations between 73 and 87 feet, NGVD, for most of the year. This would impact Steele Bayou beyond the first weir, decreasing the weir reaeration potential in that stream as well as at the Holly Bluff Cutoff weir. Because there is little change in slope between the Steele Bayou and Little Sunflower River structures and because minor flooding begins in DNF at 85 feet, NGVD, these alternatives would also inundate parts of the DNF for longer periods each year. Plans 6 and 7 would also impact Lock and Dam 1 at Little Calleo, elevation 82.5 feet, NGVD.

288. Increases in the production and export of organic carbon from reforested land are discussed in the "Wetland Functions Related to Removal of Sediments, Nutrients, and Pesticides within the Yazoo Backwater Study Area." This wetland function increases in efficiency as forests mature and increases in quantity as the number of forested acres in the flood zone increases. Organic carbon is critical for the health of a water body. It provides the energy source that fuels the lower levels of the food chain. However, assimilation of high organic carbon loads released during the late spring or summer could place DO stress on the system. The FCU metric alone was used to measure the Export of Organic Carbon Wetland Function since carbon was not addressed in the analysis presented in the section on "Reduction and Improved Quality of Stormwater Runoff." The impact of the Export of Organic Carbon Wetland Function on the organic enrichment /low DO TMDL is minimized by the fact that organic carbon is rarely released from wetlands during the summer when DO concentrations are most critical. Table 16-36 presents the potential increases in organic carbon export based upon the HGM analysis of the Export of Organic Carbon wetland function for the YBWP alone (B1) and the combined Yazoo Backwater and Big Sunflower River Maintenance projects (B2).

289. Plan 2. Plan 2 would reforest up to 124,400 acres of currently farmed land. Plan 2 would increase the export organic carbon function by 31 percent for the YBWP alone (B1) and increase the export organic carbon function by 31 percent for the combined YBWP and Big Sunflower Maintenance Project (B2).

290. Plan 2A. Plan 2A would reforest up to 81,400 acres of currently farmed land. Plan 2A would increase the export organic carbon function by 20 percent for the B1 scenario and increase the export organic carbon function by 20 percent for the B2 scenario.

291. Plan 2B. Plan 2B would provide for the construction of 14 ring levees and would reforest up to 26,400 acres of currently farmed land. Plan 2B would decrease the export organic carbon function by 11 percent for the B1 scenario and decrease the export organic carbon function by 11 percent for the B2 scenario.

292. Plan 2C. Plan 2C would reforest up to 114,400 acres of currently farmed land. Plan 2C would increase the export organic carbon function by 29 percent for the B1 scenario and increase the export organic carbon function by 29 percent for the B2 scenario.

293. Plan 3. Plan 3 has a pump-on elevation of 80.0 feet, NGVD, between 1 March and 31 October and a pump-on elevation of 85.0 feet, NGVD, between 1 November and 28 February. Plan 3 does not have a nonstructural reforestation feature, but would require 53,363 acres of mitigation. Plan 3 would decrease the export organic carbon function by 10 percent for the B1 scenario and decrease the export organic carbon function by 11 percent for the B2 scenario.

294. Plan 4. Plan 4 has a pump-on elevation of 85.0 feet, NGVD, and will reforest up to 37,200 acres of currently farmed land. Plan 4 would decrease the export organic carbon function by 1 percent for the B1 scenario and decrease the export organic carbon function by 3 percent for the B2 scenario.

295. Plan 5 (the recommended plan). Plan 5 has a pump-on elevation of 87.0 feet, NGVD, and will reforest up to 55,600 acres of currently farmed land. Plan 5 would increase the export organic carbon function by 9 percent for the B1 scenario and increase the export organic carbon function by 8 percent for the B2 scenario.

296. Plan 6. Plan 6 has a pump-on elevation of 88.5 feet, NGVD, and will reforest up to 81,400 acres of currently farmed land. Plan 6 would increase the export organic carbon function by 17 percent for the B1 scenario and increase the export organic carbon function by 17 percent for the B2 scenario.

297. Plan 7. Plan 7 has a pump on elevation of 91.0 feet, NGVD, and will reforest up to 124,400 acres of currently farmed land. Plan 7 would increase the export organic carbon function by 30 percent for the B1 scenario and increase the export organic carbon function by 30 percent for the B2 scenario.

PROJECT IMPACT ON WATER BODIES IMPAIRED BY TOXICITY OR UNKNOWN POLLUTANTS

298. Howlett Bayou and Cypress Bayou are the two study area segments impacted under this TMDL (Plate 16-10). Murphey Bayou, along the Big Sunflower River, is listed (303(d) list) as impaired by unknown causes. This discussion is directed toward Howlett Bayou and Cypress Bayou; but could apply to Murphey Bayou. During backwater flood events both Howlett and Cypress Bayou receive over bank flows of floodwater from the Little Sunflower River as the water backs up into DNF. Howlett Bayou becomes a major floodwater distributary for the lakes in the north. Cypress Bayou and Six Mile Bayou become the major floodwater distributaries in the south. Suspended sediments containing nutrients and pesticides settle as the floodwater pushes into the forest. Materials that settle into Howlett Bayou and Cypress Bayou / Six Mile Bayou may be sources of the unknown toxicity impairment. Completion of the backwater pump station could have the effect of reducing the amount of floodwater entering these bayous and of limiting the duration of flooding.

299. Plans 2, 2A, 2B, and 2C. These nonstructural plans will allow flooding to continue in the Yazoo Backwater study area; however, agricultural impacts could be reduced because of the high reforestation elevations proposed in these plans. For Plans 2, 2A, and 2C, increases in reforestation of frequently flooded land could increase methyl mercury production, which could impact the impaired bayous in the DNF where flood waters are retained behind their water control structures. Any ring levee crossing a bayou or stream in Plan 2b would require a water control structure and a pump system to regulate water. The ring levees in Plan 2B could reduce the amount of floodwater entering the impaired bayous, which could eventually moderate the effects of the unknown toxicity impairment. Because of the water control and pump system, these bayous would become more reliant on precipitation to maintain spring and summer water levels.

300. Plans 3, 4, 5, 6, and 7. These plans would decrease the extent of flooding by varying the pump-on elevations. Plans 3 and 4 would prevent most floodwater from entering Howlett and Cypress Bayou, thus limiting possible sources of toxicity. However, since the bayous depend on spring flooding to deliver water behind their weirs, execution of these plans could result in the bayous having less water during the summer. Plans 6 and 7, on the other hand, could increase the yearly frequency of flooding in DNF. This could benefit the bayous by adding water to the system in a different time of the year; but could broaden the seasonal mix of agricultural pollutants entering the system. Plans 6 and 7 could also increase methyl mercury production in areas affected by more frequent higher stages, especially DNF. Plan 5 would still allow floodwater to enter these bayous, but would limit the extent and duration of the flood.

PROJECT IMPACT ON WATER BODIES IMPAIRED BY FECAL COLIFORM/PATHOGENS

301. The Yazoo River below Redwood is the only segment impaired by pathogens (Plate 16-10). This segment will serve as the receiving water for floodwaters removed from the Yazoo Backwater Area. As stated in the discussion of the TMDL, high fecal coliform concentrations are often observed during periods of wet weather and high surface runoff, the same conditions usually associated with backwater flooding. The critical conditions for fecal coliform impairment in this segment are summer and wet weather. The critical period is the summer season from May to October.

302. For project alternatives with extensive reforestation features, increases in game and waterfowl populations could result in minimal increases in fecal coliform in localized areas. Increases in wildlife populations should be kept in check by hunting demands and should not impact study area waters.

303. Plan 2. This plan would have no impact on the impaired Yazoo River segment.

304. Plans 2A and 2C. These plans include features to flood proof or relocate homes within the flood plain. These plans could reduce the nonpoint source fecal coliform loading along affected streams within the Yazoo Backwater study area and could reduce the loading entering the Yazoo River through the Steele Bayou structure.

305. Plan 2B. This proposed alternative includes construction of ring levees surrounding affected communities within the Yazoo Backwater study area. In order to prevent fecal coliform impairment to floodwaters outside of these ring levees, each affected house within the ring levee will have its septic tank replaced with an approved onsite wastewater treatment system. This plan should not have an effect on the impaired segment of the Yazoo River.

306. Plans 3, 4, 5, 6, and 7. These plans will have no impact on the impaired Yazoo River segment. The same water will be removed from the backwater area; only the timing of floodwater discharge will be changed. Because of the volume of water moving through the Yazoo River during wet periods, these alternatives should have little impact on the Yazoo River segment impaired by fecal coliform contamination.

WATER QUALITY CONCLUSIONS

307. Completion of the proposed YBWP will result in a substantial benefit to the quality of water in the project area. Beyond completion and periodic maintenance dredging of the inlet and outlet channels, the recommended plan does not include features that will disturb sediments in project area streams. Furthermore, the proposed reforestation of presently cleared land and inclusion of water control structures on some lands targeted for reforestation has the potential to prevent sediment and other pollutants from entering water bodies and will also increase the removal of these materials from floodwaters. Studies in DNF and adjacent USDA WRP reforested lands have shown that changes in flood extent and duration should not have significant effects on suspended sediment removal from out-of-bank floodwaters. For the recommended plan, reforestation would remove 55,600 acres of agricultural land from production and reduce sediment, pesticide, and nutrient yield in stormwater runoff by 11, 2, and 9 percent, respectively. In addition, reforestation of cleared lands will offset the loss of the three HGM water quality wetland FCUs from construction of the pump station and from changes in hydrology. Scientific HGM analysis of wetland functions shows that reforestation of cleared land will increase the wetland functional capacity for the removal of sediment, nutrients, and legacy pesticides from out-of-bank floodwaters by 4 to 7 percent, and thereby directly reduce the pollutant load into impaired and TMDL water bodies in the Yazoo Backwater study area. Based solely on the HGM analysis, the mature forested acres from the recommended plan nonstructural feature, combined with benefits from existing USDA WRP and CRP reforested lands, would reduce the annual nitrate discharge into the Mississippi River by 158 metric tons and reduce the suspended sediment discharge into the Mississippi River by 33,000 metric tons. Acquisition and reforestation of fewer acres would reduce the sediment removal benefits; however, the annual reduction in nitrate and sediment discharged from the Yazoo Backwater study area would still be

significant if only 15,029 acres were reforested, 93 metric tons of nitrate and 17,300 metric tons of sediment. Because hydraulic conductivity and soil permeability are greatest in river channels, the YBWP should not cause any significant decreases in aquifer recharge. Modifying the operation of the Steele Bayou structure to increase water surface elevation by 3 feet during low-flow periods will also provide increased regulated water depth in the smaller tributary streams and would improve foraging and rearing opportunities for many species of fish. Increased surface area, depth, and volume would improve phytoplankton primary productivity and could provide a DO reservoir to buffer against sediment oxygen demand. Vicksburg District monitoring data show that DO concentrations are typically lowest in early summer in May and June, not during the critical period between July and October. During the summer, phytoplankton primary productivity is an important source of DO to study area water bodies. Water quality modeling studies have shown that modifying the operation of the Steele Bayou structure to increase water depth during low-flow, high temperature periods should not impact DO concentrations because of increases in algal productivity that supply most of the DO for the Steele Bayou pool during this time. Overall, the recommended plan will benefit the water quality of impaired and TMDL water bodies in the Yazoo Backwater study area. Sediment and nutrient loading will be reduced as agricultural acres are taken out of production and increased forested wetland acres will filter more material out of flood waters passing through them. Sediment impaired waters will benefit from a 15 percent increase in sediment removal. There will also be an overall 6 percent increase in legacy pesticide removal and a 16 percent increase in nutrient removal.

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