UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POST-CONSTRUCTION PERFORMANCE
EVALUATION REPORT – YEAR 9 (2000)

BIG TIMBER REFUGE HABITAT REHABILITATION AND ENHANCEMENT

JUNE 2001

US Army Corps
of Engineers
Rock Island District

POOL 17
MISSISSIPPI RIVER MILES 443.5 – 445.0
LOUISA COUNTY, IOWA

CEMVR

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ACKNOWLEDGMENT

Many individuals of the Rock Island District, United States Army Corps of Engineers; the United States Fish and Wildlife Service; and the Iowa Department of Natural Resources contributed to the development of this Post-Construction Performance Evaluation Report for the Big Timber Refuge Habitat Rehabilitation and Enhancement Project. These individuals are listed below:

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EXECUTIVE SUMMARY

1. General. As stated in the Definite Project Report, the Big Timber project was initiated in response to a rapid accumulation of sediment that had greatly reduced the quantity and quality of the wetland habitat in the low swales present on Big Timber Refuge and aquatic habitat in the deep areas of the interior channels. In the shallow areas of the interior channels, dissolved oxygen values had fallen to critical levels and fish species diversity had decreased.

2. Purpose. The purpose of this report is to provide a summary of the monitoring data and field observations, as well as project operation and maintenance, since completion of the last Performance Evaluation Report in August 1998.

3. Project Goals, Objectives, and Features. The three goals and associated objectives for the Big Timber project are as follows:

a. Enhance Aquatic Habitat

(1) Restore deep aquatic habitat (depth ≥ 6') through hydraulic dredging
(2) Restore shallow aquatic habitat (2' ≥ depth ≥ 3') through mechanical excavation
(3) Improve levels of dissolved oxygen during critical seasonal stress periods through hydraulic dredging and mechanical excavation
(4) Provide year-round habitat access through hydraulic dredging and mechanical excavation

b. Enhance Terrestrial Habitat

(1) Produce mast tree dominated areas through revegetation

c. Enhance Migratory Waterfowl Habitat

(1) Increase reliable resting and feeding water areas through pothole creation, hydraulic dredging, and mechanical excavation
(2) Provide isolated resting, feeding, and brooding pools through pothole creation

4. Observations and Conclusions. For the evaluation period of July 1997 to December 2000, the objectives to meet each goal had the following observations and conclusions.

a. Enhance Aquatic Habitat

(1) Restore Deep Aquatic Habitat
   (a) Year 50 Target is to maintain a flat pool depth greater than or equal to 6 feet of deep aquatic habitat
   (b) Based on water quality data, Year 9 (2000) reported an average water depth of 5.1 feet – transects according to the monitoring plan will more accurately access sediment deposition

(c) Additional sedimentation transects should be accomplished in Year 11 (2002) to reevaluate this objective
(d) While the deep aquatic habitat has fallen below the ideal depth of 6 feet, the sedimentation rates have appeared to decreased substantially from an average rate of 6.8 inches per year in Year 6 (1997) to 0.78 inches per year in Year 9 (2000)

(2) Restore Shallow Aquatic Habitat
(a) Year 50 Target is to maintain a flat pool depth greater than or equal to 2 feet of shallow aquatic habitat
(b) Based on random survey data, Year 9 (2000) reported an average water depth of 2.0 feet near the entrance to Little Denny and 2.5 feet near the entrance to Big Denny in addition to Round Pond and Timber Chute – transects according to the monitoring plan will more accurately access sediment deposition
(c) Additional sedimentation transects should be accomplished in Year 11 (2002) to reevaluate this objective
(d) Sedimentation rates in Year 9 (2000) range from 2.25 to 3 inches per year while the DPR estimate for shallow aquatic habitat ranged from 0.51 to 0.62 inches per year.

(3) Improve Levels of Dissolved Oxygen During Critical Seasonal Stress Periods
(a) Year 50 Target is to maintain a DO concentration greater than or equal to 5 milligrams per Liter
(b) Based on water quality data, Year 9 (2000) reported a minimum, maximum, and average DO concentration of 3.15, 19.66, and 9.16 milligrams per Liter for Station W-M443.6G and 2.10, 18.44, and 7.52 milligrams per Liter for Station W-M444.4H
(c) During the monitoring period of July 1997 to September 2000, the DO concentration fell below 5 milligrams per Liter on six out of 38 occasions at Station W-M443.6G and sixteen out of 38 occasions at Station W-M44.4H

(4) Provide Year-Round Habitat Access
(a) Year 50 Target is to maintain a flat pool depth greater than or equal to 3.5 feet of year-round habitat
(b) Based on water quality data, Year 9 (2000) reported an average water depth of 5.1 feet for Round Pond, 3.85 feet for Willow Chute, and 5.35 feet for Timber Chute – transects according to the monitoring plan will more accurately access sedimentation
(c) Additional sedimentation transects should be accomplished in Year 11 (2002) to reevaluate this objective
(d) Sediment deposition has been higher than estimated in the DPR, ranging from an average depth of 8 feet in Year 0 (1991) to an

average depth of 4.77 feet in Year 9 (2000) – the remaining life of this objective is cause for concern

b. Enhance Terrestrial Habitat

(1) Produce Mast Tree Dominated Areas

(a) Year 50 Target is to maintain a mast tree dominated area greater than or equal to 240 acres

(b) Based on results from the 1998 PER, Year 6 (1997) reported 354 acres of mast tree dominated areas

(c) Additional opportunities to plant buttonbush or other desirable vegetation at the check dams and dredged material placement site may be a viable option in the future

c. Enhance Migratory Waterfowl Habitat.

(1) Increase Reliable Resting and Feeding Water Areas

(a) Year 50 Target is to maintain a reliable resting and feeding water area greater than or equal to 21 acres

(b) Based on results from the 1998 PER, Year 6 (1997) reported 26 acres of reliable resting and feeding water areas

(c) Waterfowl surveys of these water areas have documented regular use while field observations have reported limited use

(2) Provide Isolated Resting, Feeding, and Brooding Pools

(a) Year 50 Target is to maintain a total number of 10 potholes

(b) Year 9 (2000) reported 10 potholes but with no performance

(c) Field observations have concluded that the size of the potholes is too small to encourage use by migratory waterfowl

5. Conclusions and Recommendations. Data and observations collected since the last PER suggest that most of the goals and objectives evaluated for the Big Timber project are being met (see Table 9-1), except for deep aquatic habitat restoration. Further data collection should better define sedimentation rates, survival of mast trees, and project utilization by migratory waterfowl and other wildlife.

Monitoring efforts for the Big Timber project have been performed according to Table B-1 in Appendix B and Table C-2 in Appendix C. The next PER will be an abbreviated report completed in March of 2002 following collection of field data from January 1, 2001 through December 31, 2001. This report should include new sedimentation transects since Timber Chute has surpassed a flat pool depth of 4 feet based on the requirement that was added to Appendix C, Table C-2 in the August 1998 PER.

Project O&M has been conducted in accordance with the O&M Manual. There are no operational requirements attached to the Big Timber project. The maintenance of project features has been adequate. Annual project inspections by the USFWS have resulted in proper corrective maintenance actions.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF PLATES

LIST OF FIGURES

LIST OF TABLES

UPPER MISSISSIPPI RIVER SYSTEM
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1. INTRODUCTION

The Big Timber Refuge Habitat Rehabilitation and Enhancement Project (HREP), hereafter referred to as "the Big Timber project," is a part of the Upper Mississippi River System (UMRS) Environmental Management Program (EMP). The Big Timber project is located in Pool 17 on the Iowa side of the Mississippi River navigation channel between River Miles (RM) 443.5 and 445.0. Plate 1 in Appendix J contains a general plan of the Big Timber project. The Big Timber project is a United States Fish and Wildlife Service (USFWS) management unit of the Port Louisa National Wildlife Refuge.

a. Purpose. The purposes of this Performance Evaluation Report (PER) are as follows:

(1) Supplement monitoring results and project operation and maintenance discussed in the August 1998 Post-Construction Supplemental PER;

(2) Summarize the performance of the Big Timber project, based on the project goals and objectives;

(3) Review the monitoring plan for possible revision;

(4) Summarize project operation and maintenance efforts to date; and

(5) Review engineering performance criteria to aid in the design of future HREP projects.

b. Scope. This report summarizes available project monitoring data, inspection records, and field observations made by the United States Army Corps of Engineers (Corps), the USFWS, and the Iowa Department of Natural Resources (IADNR) for the period from July 31, 1997 through December 31, 2000.

2. PROJECT GOALS AND OBJECTIVES

a. General. As stated in the Definite Project Report (DPR), the Big Timber project was initiated in response to a rapid accumulation of sediment that had greatly reduced the quantity and quality of the wetland habitat in the low swales present on Big Timber Refuge and aquatic habitat in the deep areas of the interior channels. In the shallow areas of the interior channels, dissolved oxygen values had fallen to critical levels and fish species diversity had decreased.

b. Goals and Objectives. Goals and objectives, formulated during the project design phase, are summarized in Table 2-1.

TABLE 2-1
Project Goals and Objectives

Goals	Objectives	Project Features
Enhance Aquatic Habitat	Restore deep aquatic habitat (Depth $\geq$ 6')	Hydraulic dredging
	Restore shallow aquatic habitat (2' $\leq$ Depth $\leq$ 3')	Mechanical excavation
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging and excavation
	Provide year-round habitat access	Dredging and excavation
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation
Enhance Migratory Waterfowl Habitat	Increase reliable resting and feeding water areas	Pothole creation, dredging, and excavation
	Provide isolated resting, feeding, and brooding pools	Pothole creation

Table 2-1. Project Goals and Objectives

3. PROJECT DESCRIPTION

a. Project Features. The Big Timber project consists of hydraulic dredging and mechanical excavation to enhance aquatic habitat; pothole creation, hydraulic dredging, and mechanical excavation to enhance migratory waterfowl habitat; and revegetation to enhance terrestrial habitat. Plate 2 in Appendix J displays the main features of the Big Timber project.

(1) Confined Dredged Material Placement Site. The confined placement site was designed to contain the dredged material from the Big Timber project. This feature included construction of a clay containment dike approximately 6,400 feet in length along the banks of Big and Little Denny to an elevation of 544 feet MSL. This dike in combination with the natural bank along the Mississippi River at approximately 544 feet MSL created the confined placement site. The approximate capacity and size of this site is 157,000 cubic yards (CY) and 73 acres, respectively, with a perimeter of approximately 9,200 feet. Prior to construction, the average ground elevation was approximately 540 feet MSL. After project completion, the average elevation of the dredged material within the placement site was 541.5 feet MSL.

(2) Hydraulic Dredging. The Big Timber project was hydraulically dredged to enhance aquatic habitat. The objective was to restore deep aquatic habitat, improve levels of dissolved oxygen during critical seasonal stress periods, and provide year-round habitat access. The dredge cuts for deep aquatic habitat were 35 feet to 50 feet wide with a bottom elevation of 528 feet MSL or 9 feet below flat pool. Approximately 73,757 CY of dredged material was removed from Coolegar Slough to the mouth of Big Denny, which created a channel approximately 5,400 feet in length.

(3) Mechanical Excavation. The Big Timber project was mechanically excavated to enhance aquatic habitat. The objective was to restore shallow aquatic habitat, improve levels of dissolved oxygen during critical seasonal stress periods, and provide year-round habitat access. The excavated areas for shallow aquatic habitat were 40 to 50 wide with a bottom elevation of 533 feet MSL or 4 feet below flat pool. In addition, Timber Chute was mechanically excavated for deep aquatic habitat to a bottom elevation of 528 feet MSL with a width of 35 feet. Cleared timber was placed in the finished channel at several locations including the mouth of Little Denny. Approximately 69,224 CY of material was excavated from the mouth of Willow Chute to the tails of Big and Little Denny, which provided a channel approximately 9,400 feet in length.

(4) Check Dams. In areas where mud flats were encroaching on existing ponds or channels, the material from mechanical excavation was placed along the bank of the mud flat. Such check dams were constructed at 4 locations to an approximate elevation of 543 feet MSL where overland flood flows were depositing sediments at the project site.

(5) Pothole Creation. Explosives were used to blast 10 holes in the mud flats where willows were encroaching. These holes have since filled with water and now

provide secluded open water areas for wood duck broods to rest, feed, and breed. The potholes were constructed to have a surface area of approximately 40 feet by 70 feet with a depth of 8 feet.

(6) Revegetation. Revegetation consisted of planting 450 hardwood trees, mostly hickory and oak, on the containment dike. The trees selected for use included 11 mast-producing species. In addition, 450 buttonbushes were planted within the confined placement site on approximately 2.5 acres.

b. Project Construction. Following award of the first contract on May 22, 1990, dredging began during late summer and was essentially completed in the fall of 1991. Final inspection of the vegetation at the confined dredged material placement site was accomplished following the first growing season. Prior to final inspection of the vegetation, some concerns were raised that additional seeding or earthwork may be needed in the sandy areas to induce sufficient vegetative growth. However, adequate vegetation established itself and additional work was not required. Final inspection of the Big Timber project was conducted in the summer of 1992. Following award of the second contract on June 2, 1993, mast trees were planted during the fall with all work completed in the spring of 1995. The Big Timber project was then turned over to the USFWS for operation and maintenance.

c. Project Operation and Maintenance. Operation and maintenance (O&M) of the Big Timber project is the responsibility of the USFWS in accordance with Section 107(b) of the Water Resources Development Act of 1992, Public Law 102-580. These functions are further defined in the O&M Manual. The following paragraphs outline the O&M instructions for the major project features. These features were designed and constructed to minimize the O&M requirements. For all project features, specific operation requirements shall be performed as determined by the USFWS Site Manager.

In general, the USFWS shall conduct annual project inspections of the confined dredged material placement site, channels (Round Pond, Timber Chute, Willow Chute, Little Denny, and Big Denny), check dams, and potholes to record the presence of undesirable debris, waste materials, and unauthorized structures. Appropriate maintenance actions shall then be determined as needed by the USFWS Site Manager. In addition, annual project inspections of the Little Denny entrance access control shall be accomplished to discover any necessary debris removal and placement.

The mast trees shall be monitored by the Corps through annual inspections of the planting sites, while remedial actions shall be accomplished by the USFWS Site Manager to ensure growth and survival. The USFWS Site Manager shall document any remedial actions, as well as herbicide and deer repellant application, in the project inspection report.

4. PROJECT MONITORING

a. General. Appendix B presents the Post-Construction Evaluation Plan, along with the Sedimentation Transect Project Objectives Evaluation. These references were developed during the design phase and serve as a guide for measuring and documenting project performance. The Post-Construction Evaluation Plan also outlines the monitoring responsibilities for each agency. Appendix C contains the Monitoring and Performance Evaluation Matrix and Resource Monitoring and Data Collection Summary. The Monitoring and Performance Evaluation Matrix outlines the monitoring responsibilities for each agency. The Resource Monitoring and Data Collection Summary presents the types and frequency of data needed to meet the requirements of the Post-Construction Evaluation Plan. Plate 3 in Appendix J contains the monitoring plan for the Big Timber project.

b. U.S. Army Corps of Engineers. The success of the project relative to original project objectives shall be measured by the Corps, USFWS, and IADNR through data collection and field observations. The Corps has overall responsibility to evaluate and document project performance.

The Corps is responsible for collecting field data as outlined in the Post-Construction Evaluation Plan at the specified time intervals. The Corps shall also perform joint inspections with the USFWS and IADNR in accordance with ER 1130-2-339. The purpose of these inspections is to assure that adequate maintenance is being performed as presented in the DPR and O&M Manual. Joint inspections should also occur after any event that causes damage in excess of annual O&M costs.

c. U.S. Fish and Wildlife Service. The USFWS does not have project-specific monitoring responsibilities. This is a Corps responsibility, as identified in the 6th Annual Addendum for the UMRS-EMP. However, the USFWS is responsible for O&M, as well as monitoring the project through field observations during inspections. Project inspections should be performed on an annual basis following the guidance presented in the O&M Manual. It is recommended that the inspections be conducted in May or June, which is representative of conditions after spring floods. Joint inspections with the Corps and IADNR shall also be conducted as mentioned above. During all inspections, the USFWS should complete the checklist form as provided in the O&M Manual. This form should also include a brief summary of the overall condition of the project and any maintenance work completed since the last inspection. Once completed, a copy of the form shall be sent to the Corps.

d. Iowa Department of Natural Resources. The IADNR has collected fish data at the Big Timber project, which is not currently identified as a monitoring requirement. Therefore, the IADNR should be present at the joint inspections with the Corps and USFWS as described above.

5. EVALUATION OF AQUATIC HABITAT OBJECTIVES

a. Restore Deep Aquatic Habitat (Depth ≥ 6').

(1) Monitoring Results. One of the objectives for enhancing aquatic habitat is to restore deep aquatic habitat through hydraulic dredging. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a flat pool depth greater than or equal to 6 feet. Sedimentation transects for Round Pond, Timber Chute, and Willow Chute were conducted at project completion to reflect as-built conditions of the deep aquatic habitat. Sedimentation transects were conducted again in 1994 and 1997. A discussion of this data was included in the August 1998 PER. Since then, additional transects have not been completed. According to Table C-2 in Appendix C, sedimentation transects are only required every five years.

However, during water quality monitoring, channel depths at both stations were recorded. Station W-M443.6G is located in Round Pond between sedimentation transects "A" and "B". This portion of the channel was designed to have an ideal flat pool depth greater than or equal to 6 feet at Year 50 and is labeled as deep aquatic habitat on the monitoring plan. Station W-M444.4H is located in Willow Chute between sedimentation transects "I" and "L". This portion of the channel was designed to have an ideal flat pool depth greater than or equal to 6 feet or between 2 and 3 feet at Year 50 and is labeled as combination shallow/deep aquatic habitat on the monitoring plan.

TABLE 5-1.
Restore Deep Aquatic Habitat

Year	W-M443.6G (Round Pond) Flat Pool Depth (feet)	W-M443.6G (Round Pond) Sedimentation Rate (in/yr)	W-M444.4H (Willow Chute) Flat Pool Depth (feet)	W-M444.4H (Willow Chute) Sedimentation Rate (in/yr)	Average Flat Pool Depth (feet)
0	9.00		9.00		9.00
0-6		6.74		6.86	
6	5.63		5.57		5.60
6-7		2.28		0.72	
7	5.44		5.51		5.48
7-8		5.40		2.16	
8	4.99		5.33		5.16
8-9		0.24		1.32	
9	**4.97**		**5.22**		**5.10**
0-9		5.37		5.04	
50	**6**		**6**		**6**

Table 5-1. Restore Deep Aquatic Habitat

As seen in Table 5-1, Station W-M443.6G has an average depth of 4.97 feet at Year 9, which is less than the ideal water depth of 6 feet. Station W-M444.4H has an average depth of 5.22 feet at Year 9, which is also less than the ideal water depth of 6 feet. The flat pool depths for both stations were determined by adjusting the water depths recorded during site visits from July 1997 to September 2000. Using historical water profiles, the pool elevation for each day data was collected could be determined by interpolating between two stream gages on the Mississippi River. To view individual water depths for each site visit and the steps taken to adjust these values to depths relative to flat pool, refer to Tables F-1 and F-2 in Appendix F. Based on this data, annual sedimentation rates were also determined as illustrated in Table 5-1.

Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber project. However, the DPR estimated an average annual sedimentation rate of 0.62 inches per year in channeled areas (Round Pond) since this area is more susceptible to sediment deposition. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. In general, deep aquatic habitat depths in 1991 averaged 9 feet after project completion. In 2000, deep aquatic habitat depths averaged 5.1 feet in Round Pond and Willow Chute. This equates to an average annual sedimentation rate of 5.2 inches per year for these two areas.

To aid in the evaluation of sedimentation rates, two sets of hydrologic data were reviewed. These two sets consist of pre-project (1982 to 1990) and post-construction (1992-2000) stage values. The hydrologic data was acquired from the Muscatine stream gage (MUSI4) approximately 9 miles upstream and the Lock and Dam 17 stream gage (MI17) approximately 7 miles downstream. This data was then interpolated to calculate daily pool elevations for the Big Timber project.

Once this task was complete, the daily pool elevations were compared to the natural bank elevation of 544 feet MSL. Daily pool elevations exceeding 544 feet MSL would be representative of island submergence throughout the Big Timber project. During periods of island submergence, the project area becomes highly susceptible to sediment deposition. For the 1982 to 1990 data, the bank elevation was exceeded 2.8% of the time. However, for the 1992 to 2000 data, the bank elevation was exceeded 5.9% of the time. Therefore, since project completion, island submergence has occurred more than twice the amount seen prior to construction.

Next, the daily pool elevations were compared to the average ground elevation of 541 feet MSL for the Big Timber project. Daily pool elevations exceeding 541 feet MSL would be representative of overland flow. During periods of overland flow, the project area becomes more susceptible to sediment deposition. For the 1982 to 1990 data, the ground elevation was exceeded 11.5% of the time. However, for the 1992 to 2000 data, the ground elevation was exceeded 14.8% of the time. Therefore, since project completion, overland flow has occurred almost 30% more than the amount seen prior to construction.

IADNR employees at the Fairport Fishery conducted electofishing surveys for largemouth bass within and adjacent to the Big Timber project during the year 2000. Table 5-2 illustrates the catch per unit effort (CPUE) rate for each of the 7 runs completed. The run within the Big Timber project had the lowest CPUE rate. The IADNR suggests that the reason for this may be due to the lack of large woody structure near the water surface along the channel, which is preferred by largemouth bass.

TABLE 5-2.
Summary of Largemouth Bass Survey

Area Surveyed	**Survey Length (meters)**	**CPUE (#/hour)**
North Boat Ramp	800	83.83
South Boat Ramp	650	168.60
South Slough	650	108.73
Coolegar South	1400	127.14
Coolegar Northwest	1100	109.12
Coolegar East	1000	70.47
Big Timber Project	1300	61.36

Table 5-2. Summary of Largemouth Bass Survey

For the largemouth bass captured, Sheet 2 in Appendix D displays the length frequency for all areas, while Sheet 3 only shows the length frequency for the Big Timber project. A total of 45 largemouth bass were recorded during the run within the Big Timber project. For each run, the size structure was similar to that found in the other areas, meaning that all sizes of largemouth bass are utilizing the Big Timber project. Sheet 4 in Appendix D is a combination of the first two figures to better demonstrate the overall numbers of largemouth bass captured in the Big Timber project relative to those in the other areas.

Population estimates for the Year 2000 in all areas as a whole are presented on Sheet 5. The Peterson estimates were determined for 6-inch, 8-inch, and 14-inch largemouth bass. For comparison, the population estimate in 2000 was 5,123 for greater than 8-inch while the previous estimate in 1994 was 2,595 for greater than 8-inch. The first Schnabel estimate was entirely based on the electrofishing surveys. The last two Schnabel estimates included data from a bass tournament, assuming a mortality rate of 25% and 50%, respectively. All population estimates are still preliminary as they are based on unpublished information that has not been fully analyzed yet. Therefore, these numbers may be erroneous until quality control procedures have been performed.

(2) Conclusions. With respect to Round Pond and Willow Chute, the Big Timber project is not meeting the objective of restoring deep aquatic habitat by maintaining an average flat pool depth greater than or equal to 6 feet. It could be assumed that these depths are representative of the entire project area but since the monitoring results were

based solely on data collected at the two water quality stations, it is not known for sure if this is indeed the case. In addition, the locations of the water quality stations are determined through use of landmarks rather than coordinates, so channel depths are not necessarily recorded in the exact same spot each time. While the data from the water quality stations may provide some idea of deep aquatic habitat depths, it is not their intended purpose. Therefore, future sedimentation transects based on the monitoring plan should result in more adequate data to better define deep aquatic habitat depths throughout the entire project area.

Since project completion, island submergence has occurred more than twice the amount seen prior to construction. It is anticipated that over the life of the project this frequency should approach the historical average of 2.8%. In addition, overland flow has happened approximately 30% more since project completion in comparison with data prior to construction. It is anticipated that over the life of the project this frequency should also approach the historical average of 11.5%.

Variable annual sedimentation rates from year to year as shown in Table 5-1 can be expected and may be due to the type of flood hydrograph, such as a long flood as seen in 1993 or a short flood as seen in 1997. Flood types, such as rainfall as seen in 1993 or snowmelt as seen in 1997, may also contribute to variability in annual sedimentation rates. In addition, suspended sediment loads vary throughout the year depending on frequency or amount of rainfall and absence or presence of vegetation. Continued monitoring should better define annual sedimentation rates and their relationship with respect to the life of the project.

Average annual sedimentation rates are markedly higher than estimated in the DPR. Besides a higher frequency of island submergence and overland flow than originally anticipated, there may be other reasons for the high sedimentation rates. One factor may be those areas where ground cover is minimal on the banks due to shading by woody vegetation. As a result, the banks are less stable and likely to erode.

Another explanation may be the fact that prior to construction, year-round aquatic habitat was essentially limited to Coolegar Slough and a portion of Round Pond. Timber Chute, Willow Chute, Little Denny, and Big Denny were susceptible to drying and freeze out at lower pool elevations. When this happened, these backwater areas were subject to consolidation of sediments. After project completion, this phenomenon no longer occurred and may be the reason for the substantial decrease of deep aquatic habitat during the first few years of the project.

In addition, reviewing sedimentation rates on a linear basis is not appropriate in the early years of a project when the channels are relatively new and have not yet stabilized. The sedimentation rates should stabilize over time and remain constant as the Big Timber project ages. All of these factors combined allow for the Big Timber project to be more susceptible to sediment deposition.

Despite concerns about the high sedimentation rates, the Big Timber project has benefited aquatic habitat. The largemouth bass population estimate in 2000 was 5,123 for greater than 8-inch while the previous estimate in 1994 was 2,595 for greater than 8-inch. The 1997 USFWS Site Manager's project inspection report stated that fish kills had not been noted nor communicated to the USFWS Site Manager by IADNR fisheries personnel. Prior to construction, there was not year-round fisheries access throughout most of the area. Overall, the results of these investigations suggest a positive response by fisheries.

b. Restore Shallow Aquatic Habitat (2' $\leq$ Depth $\leq$ 3').

(1) Monitoring Results. Another objective for enhancing aquatic habitat is to restore shallow aquatic habitat through mechanical excavation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a flat pool depth greater than or equal to 2 feet. Sedimentation transects for Round Pond, Timber Chute, and Willow Chute were conducted at project completion to reflect as-built conditions of the shallow aquatic habitat. Sedimentation transects were conducted again in 1994 and 1997. A discussion of this data was included in the August 1998 PER. Since then, additional transects have not been completed. According to Table C-2 in Appendix C, sedimentation transects are only required every five years.

However, the USFWS performed a channel survey at four locations on July 1, 1999. At each location, water depths were typically determined near both banks and at the middle of the channel. The first site was between Round Pond and Timber Chute. The second site was near the bend in Timber Chute. These two sites were designed to have an ideal flat pool depth of 6 feet or between 2 and 3 feet at Year 50 and are labeled as combination shallow/deep aquatic habitat on the monitoring plan. However, the data collected at the second site was not used in the following discussion since the only water depth recorded was at the middle of the channel. The third and fourth sites were near the junctions of Willow Chute with Little Denny and Big Denny, respectively. The last two sites were designed to have an ideal flat pool depth between 2 and 3 feet at Year 50 and are labeled as shallow aquatic habitat on the monitoring plan.

As seen in Table 5-3, the channel depths recorded for each area were nearly consistent at Year 8. All three values fall within the range of an ideal flat pool depth between 2 and 3 feet. Based on this data, annual sedimentation rates were also determined as illustrated in Table 5-3. Based on 1938 and 1988 data, the DPR estimated an average annual sedimentation rate of 0.51 inches per year throughout the Big Timber project. However, the DPR estimated an average annual sedimentation rate of 0.62 inches per year for Round Pond since this area is more susceptible to sediment deposition. The DPR also stated that detailed historical records of sedimentation rates were practically nonexistent. In general, shallow aquatic habitat depths in 1991 averaged 4 feet after project completion. In 1999, shallow aquatic habitat depths averaged 2.33 feet below flat pool for Timber Chute, Little Denny, and Big Denny. This equates to an average annual sedimentation rate of 2.5 inches per year for these areas.

Year	Timber Chute Flat Pool Depth (feet)	Timber Chute Sediment Rate (in/yr)	Little Denny Flat Pool Depth (feet)	Little Denny Sediment Rate (in/yr)	Big Denny Flat Pool Depth (feet)	Big Denny Sediment Rate (in/yr)
0	4.0		4.0		4.0	
0-8		2.25		3.0		2.25
8	**2.5**		**2.0**		**2.5**	
50	**2.0**		**2.0**		**2.0**	

TABLE 5-3. Restore Shallow Aquatic Habitat

Table 5-3. Restore Shallow Aquatic Habitat

(2) Conclusions. With respect to Timber Chute, Little Denny, and Big Denny, the Big Timber project is meeting the objective of restoring shallow aquatic habitat by maintaining an average flat pool depth between 2 and 3 feet. It could be assumed that these depths are representative of the entire project area but since the monitoring results were based only on a few random cross sections, it is not known for sure if this is indeed the case. Future sedimentation transects based on the monitoring plan should provide a lot more data to better define shallow aquatic habitat depths throughout the entire project area.

Average annual sedimentation rates are markedly higher than estimated in the DPR. As previously mentioned, there may be several reasons for the high sedimentation rates. One factor may be those areas where ground cover is minimal on the banks due to shading by woody vegetation. As a result, the banks are less stable and likely to erode. Another explanation may be the fact that prior to construction, year-round aquatic habitat was essentially limited to Coolegar Slough and a portion of Round Pond. Timber Chute, Willow Chute, Little Denny, and Big Denny were susceptible to drying and freeze out at lower pool elevations. When this happened, these backwater areas were subject to consolidation of sediments. After project completion, this phenomenon no longer occurred and may be the reason for the substantial decrease of shallow aquatic habitat during the first few years of the project.

In addition, reviewing sedimentation rates on a linear basis is not appropriate in the early years of a project when the channels are relatively new and have not yet stabilized. The sedimentation rates should stabilize over time and remain constant as the Big Timber project ages. All of these factors combined allow for the Big Timber project to be more susceptible to sediment deposition.

c. Improve Levels of Dissolved Oxygen During Critical Seasonal Stress Periods.

(1) Monitoring Results. The water quality objective of the Big Timber project is to improve levels of dissolved oxygen (DO) during critical seasonal stress periods. Critical seasonal stress periods often occur during the summer months when high temperatures are observed and during winter months when snow cover is maintained, causing DO concentrations to reach undesirable levels for fish habitat. The length of a stress period may last for only a few days. However, a low DO condition for a day or two may be enough to precipitate a fish kill. Fish kills are more likely to be observed in the winter when ice cover may prevent fish from leaving the area experiencing a DO crash, whereas in the summer, there is a greater opportunity to escape.

As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a DO concentration greater than or equal to 5 mg/L. The locations of the water quality stations can be found on Plate 3 in Appendix J. Pre-project baseline monitoring was initiated at Station W-M443.6G on May 6, 1989. Post-project monitoring commenced at Station W-M443.6G on September 24, 1991 and is currently ongoing. An additional water quality station (W-M444.4H) was added on November 7, 1995 in Willow Chute. The project's original fact sheet identified several resource problems. Severe summer and winter fish kills attributable to low DO levels and freeze outs, respectively, were reported. The purpose of the monitoring program was to analyze baseline and post-construction water quality conditions to determine the project's impact on aquatic habitat.

Reported herein are water quality data collected from July 31, 1997 through September 19, 2000. Data were obtained through a combination of periodic grab samples and the use of *in-situ* continuous monitors. Grab samples were collected just below the surface on 38 occasions. The sites were generally visited twice per month from June through September and monthly from December through March. Sampling was usually not performed during April, May, October, and November. The following variables were typically measured: water depth, velocity, wave height, air and water temperature, cloud cover, wind speed and direction, DO, pH, total alkalinity, specific conductance, Secchi disk depth, turbidity, suspended solids, chlorophyll (a, b and c) and pheophytin a.

The results from periodic grab samples collected at Station W-M443.6G are found in Appendix E, Table E-1. This table includes the results from DO and ancillary parameters that are useful in the interpretation of DO data. DO concentrations ranged from 3.15 mg/L to 19.66 mg/L. Six of the 38 DO measurements were below the 5 mg/L target level. One of the six occurred during the winter (4.66 mg/L on January 28, 1999). However, during most winter samplings, supersaturated conditions were observed. The average DO concentration was 9.16 mg/L.

TABLE 5-4
Summary of Dissolved Oxygen Concentrations

Parameter Description	Station W-M443.6G			Station W-M444.4H	
	Post-Project 9/24/91 to 11/7/95	Post-Project 6/19/96 to 7/17/97	Post-Project 7/31/97 to 9/19/00	Post-Project 6/19/96 to 7/17/97	Post-Project 7/31/97 to 9/19/00
Total Number of Samples	48	11	38	11	38
Winter (October – March) Samples	18	4	10	3	10
Summer (April – September) Samples	30	7	28	8	28
Total DO Concentrations < 5 mg/L	8 (16.7%)	3 (27.3%)	6 (15.8%)	3 (27.3%)	16 (42.1%)
Winter DO Concentrations < 5 mg/L	0	0	1 (10.0%)	0	1 (10.0%)
Summer DO Concentrations < 5 mg/L	8 (26.7%)	3 (42.9%)	5 (17.9%)	3 (37.5%)	15 (53.6%)
Minimum DO Concentration (mg/L)	1.74	3.40	3.15	1.63	2.10
Maximum DO Concentration (mg/L)	16.61	17.64	19.66	10.46	18.84
Average DO Concentration (mg/L)	9.18	8.89	9.16	6.29	7.52

Table 5-4. Summary of Dissolved Oxygen Concentrations

Table E-2 in Appendix E presents the results from periodic grab samples collected at Station W-M444.4H. DO concentrations ranged from 2.10 mg/L to 18.84 mg/L. Sixteen of the 38 DO measurements were below the 5 mg/L target level. Only one occurred during the winter (3.72 mg/L on January 28, 1999). This was the same day the low winter DO concentration was observed at Station W-M443.6G. Supersaturated conditions were observed at Station W-M444.4H during half of the winter samplings. The average DO concentration at was 7.52 mg/L. This value is 1.64 mg/L lower than the average determined at Station W-M443.6G. This would be expected since Station W-M444.4H is farther removed from the influence of the main channel. Table 5-4 presents a summary of the data collected at Stations W-M443.6G and W-M444.4H.

Commencing on August 25, 1998, DO measurements were taken in the navigation channel near the project during summer sampling trips. Navigation channel DO concentrations were always greater than 5 mg/L when low summer values were seen at the two water quality stations.

In-situ water quality monitors (YSI model 6000UPG or 6600UPG sondes) were deployed on 22 (18 summer and 4 winter) occasions at Station W-M443.6G and 14 (11 summer and 3 winter) occasions at Station W-M444.4H. Sondes were positioned 3 feet above the bottom during most deployments. Deployments were typically for a period of two weeks during the summer months and four to five weeks during the winter months. The sondes were normally equipped to measure DO, temperature, pH, specific conductance, depth and turbidity.

Most winter DO concentrations at Station W-M443.6G were above the target level and supersaturated conditions were common. Figure E-1 in Appendix E displays the results from the <u>one</u> winter deployment (January 28, 1999 through February 25, 1999) when the DO concentration fell below 5 mg/L. When the sonde was deployed, the DO concentration was below 5 mg/L and the ice was cloudy and 6 inches thick. The DO concentration oscillated around 5 mg/L for the first five days of the deployment and thereafter steadily rose to supersaturated conditions. When the sonde was retrieved, the ice was clear and less than 1 inch thick. Apparently, when the sonde was deployed insufficient sunlight was reaching the water surface and the DO consumed by plant respiration exceeded that produced by plant photosynthesis. As the ice melted, there was greater light penetration and DO production eventually surpassed DO consumption. The ice cover prevented the excess DO from escaping and therefore supersaturated conditions were eventually observed.

The DO data from two of the three winter deployments at Station W-M444.4H were not useable due to sonde malfunction. DO concentrations during the remaining deployment exceeded 5 mg/L. Data from summer deployments was often not useable. Occasionally the flotation mechanism would fail and the sonde would sink, and on other occasions the data were suspect. Sonde malfunction is probably responsible for some of the suspect data along with biofouling of the DO probe. It was not uncommon for the sonde to be covered with organisms (primarily chironomids) following a two-week deployment. During the summer, nighttime DO concentrations often fell below the 5 mg/L target level. However, the DO concentration usually recovered during the day. Daytime DO concentrations usually exceeded 5 mg/L as a result of plant photosynthesis. Figure E-2 in Appendix E is an example of DO data collected during the summer (August 22, 2000 through September 5, 2000) showing the typical diurnal pattern. In general, the summer DO concentrations at Station W-M444.4H were lower than those observed at Station W-M443.6G. Occasionally the DO concentration at Station W-M444.4H remained below 5 mg/L for several days, as shown in Appendix E, Figure E-3, for the June 22, 1999 through July 8, 1999 deployment.

(2) Conclusions. The water quality objective of the Big Timber Refuge project is to improve levels of DO during critical seasonal stress periods. The Year 50 Target is to maintain a DO concentration greater than or equal to 5 mg/L. The project was highly successful in achieving this goal during the critical winter months. The only time the DO concentration fell below 5 mg/L during winter was in late January and early February 1999. During this time period, the ice was cloudy and relatively thick at both sampling locations, thus inhibiting light penetration and photosynthesis. Supersaturated conditions were often observed during the winter.

In the summer, DO concentrations commonly fell below 5 mg/L during the night. However, daytime values were usually greater than 5 mg/L. In general, the summer DO concentrations at Station W-M444.4H were lower than those observed at Station W-M443.6G, occasionally remaining below 5 mg/L for several days. This would be expected, as Station W-M444.4H is farther from the influence of the main channel. Although low DO concentrations were occasionally measured, according to Bernard Schonhoff, Natural Resources Biologist with the IADNR, no unusual fish kills were reported during the July 31, 1997 through September 19, 2000 monitoring period.

Table 5-4 indicates that during all post-project evaluation periods, DO concentrations below the target level were relatively rare during the winter months. A greater percentage of the samples collected during the summer months were less than the target level. One reason for this could be that algal productivity is much greater during the summer and these sites were usually sampled during mid-morning, when photosynthetic DO production may have not yet compensated for the nighttime DO sag.

d. Provide Year-Round Habitat Access (Cross-Sectional Area).

(1) Monitoring Results. The final objective for enhancing aquatic habitat is to provide year-round habitat access through hydraulic dredging and mechanical excavation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a flat pool depth greater than or equal to 3.5 feet. Sedimentation transects for Round Pond, Timber Chute, and Willow Chute were conducted at project completion to reflect as-built conditions of the year-round habitat access. Sedimentation transects were conducted again in 1994 and 1997. A discussion of this data was included in the August 1998 PER. Since then, additional transects have not been completed. According to Table C-2 in Appendix C, sedimentation transects are only required every five years.

However, during water quality monitoring (July 31, 1997 through September 19, 2000), channel depths at both stations were recorded. Station W-M443.6G is located in Round Pond between sedimentation transects “A” and “B”. Station W-M444.4H is located in Willow Chute between sedimentation transects “I” and “L”. In addition, the USFWS recorded channel depths at four locations on July 1, 1999. The first site was between Round Pond and Willow Chute. The second site was near the bend in Timber Chute. The third and fourth sites were near the junctions of Willow Chute with Little Denny and Big Denny, respectively.

TABLE 5-5
Provide Year Round Habitat Access

Location	**Depth (Feet)**				
	Year 6 (1997)	**Year 7 (1998)**	**Year 8 (1999)**	**Year 9 (2000)**	**Average**
Round Pond Round/Timber	5.63	5.44	4.99 **5.2**	**4.97**	**5.1**
Timber Chute			**3.85**		**3.85**
Willow Chute Willow/Little Denny Willow/Big Denny	5.57	5.51	5.33 **4.95** **5.9**	**5.22**	**5.35**

Table 5-6. Provide Year Round Habitat Access

It is evident from Table 5-5 that the water depths for Round Pond and Willow Chute have steadily decreased from monitoring event to monitoring event. Continued stabilization of the channel side slopes contributes to this decline in depths. In addition, the average depths from 1999 to 2000 only decreased by two-hundredths of a foot for Round Pond and eleven-hundredths of a foot for Willow Chute. This may suggest that these areas are approaching a stable condition. Overall, the average depths at all locations are fairly similar except for Timber Chute, which is substantially lower.

For Timber Chute, the flat pool depth in 1999 was 3.85 feet. In the previous PER, the average flat pool depth based on sedimentation transects from 1997 was approximately 5 feet for Timber Chute. This equates to a sedimentation rate of 6.9 inches per year, which is slightly higher than that found in deep aquatic habitat (Table 5-1) and more than twice the amount seen in shallow aquatic habitat (Table 5-3).

(2) Conclusions. With respect to Round Pond, Willow Chute, and Timber Chute, the Big Timber project is meeting the objective of providing year-round habitat

access by maintaining an average flat pool depth greater than or equal to 3.5 feet. It could be assumed that these depths are representative of the entire project area but since the monitoring results were based solely on data collected at the water quality stations and a few random cross sections, it is not known for sure if this is indeed the case. In addition, the locations of the water quality stations are determined through use of landmarks rather than coordinates, so channel depths are not necessarily recorded in the exact same spot each time. While the data from the water quality stations may provide some idea of year-round habitat access, it is not their intended purpose. Therefore, future sedimentation transects based on the monitoring plan should result in more data to better analyze year-round habitat access throughout the entire project area.

The Big Timber project is currently meeting the objective of providing year-round habitat access. Sufficient depth exists to permit fish access during the harshest of winters when ice cover would be anticipated to approach a 2-foot thickness. The Big Timber project was designed to provide 8 feet of deep aquatic habitat at Year 0. Since the depths in Round Pond and Willow Chute are approximately 5 feet in Year 9, the remaining life of this objective is cause for concern, and increased monitoring efforts are warranted.

When the deep aquatic habitat depth approaches 3 feet, it could be said that year-round fisheries habitat has been lost. Should this loss of depth occur in the migratory path (primarily Timber Chute), it would effectively isolate the project from flowing water, stranding fish during severe winter ice conditions. This point would represent the critical ending for the objective of providing year-round habitat access. At Year 9 in Timber Chute, this critical point has almost been reached. As sedimentation progresses, a natural transition from deep to shallow aquatic habitat should take place. Although year-round habitat access may diminish, the shallow aquatic habitat shall continue to have significant long-term benefits for waterfowl and other wildlife, even though other portions of the project area may have depths greater than 3 feet.

As stated in the August 1998 PER, it was suggested that sedimentation transects be performed on two occasions in addition to the scheduled interval of 5 years. Based on input from the USFWS, the Corps was to survey the sedimentation transects when average depths in the migratory path, or Timber Chute, reach 4 feet and then 3.5 feet below flat pool. Following analysis of data from the latter, the options of project rehabilitation and/or abandonment may be considered at that time. Table C-2 in Appendix C was revised to reflect this requirement. At this time, the Big Timber project has surpassed a depth of 4 feet and is approaching a depth of 3.5 feet below flat pool so it is recommended that a survey be conducted during the next monitoring period.

6. EVALUATION OF TERRESTRIAL HABITAT OBJECTIVES

a. Produce Mast Tree Dominated Areas.

(1) Monitoring Results. The objective for enhancing terrestrial habitat is to produce mast tree dominated areas through revegetation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain greater than or equal to 204 acres of mast trees. Prior to construction, a forest inventory delineated 348 acres with an over story dominated by mast-producing species. In 1997, 354 acres of mast trees existed. A discussion of this data was included in the August 1998 PER. This acreage is not anticipated to remain constant, since the dominance of oak, pecan, and walnut is only a temporal stage in the dynamic life cycle of a bottomland forest. As the existing forest ages, natural succession should result in a gradual attrition of these species to be replaced by more shade tolerant species. Therefore, a reduction in mast tree acreage is expected over the life of the project.

In addition to the 348 acres available at project completion, 11 species of mast-producing trees and shrubs were planted on the containment dike in November 1993, adding an additional 6 acres to the Big Timber project. More importantly, the tree and shrub plantings introduced a diverse mixture of mast species in a linear strip traversing a large portion of the project area. By locating the new plantings on the containment dike above the surrounding floodplain, they are protected during most flood events. As a result, these species are available as a seed source for the future. Silvicultural practices shall be performed throughout the project life to provide for the regeneration of mast-producing species in the project area. Through proper forest management, a minimum of 204 acres of mast trees should be available at Year 50.

Table 6-1 lists the relative survival and growth rates in 1995 and also summarizes a partial inspection of the mast trees conducted in 1997. The USFWS Site Manager’s project inspection report for 1997 noted that seedling survival appears to be approximately 50%. In addition, the surviving trees appear to be quite healthy especially the bur oak, swamp white oak, dogwood, high bush cranberry, and even a few northern red oaks. The USFWS Site Manager’s project inspection report for 2001 documented the presence of some perennial wetland sedges, wild cucumber, willow, and green ash saplings.

Most of the trees that existed within the confined placement site prior to construction have died or will die due to the dredged material and related stresses. In addition, the Great Flood of 1993 may have increased the rate of tree mortality and undoubtedly slowed vegetation response not only in the confined placement site but also throughout the entire project area. Approximately 4 to 6 inches of terrestrial sediment deposition was measured within the Big Timber project in 1994. The entire containment area appears to have naturally seeded to cottonwood, green ash, silver maple, and elm. The condition of the mature mast-producing trees within the containment area is unknown at this time. Prior to construction, these trees were located on low elevation ridges paralleling the flow of the river. The dredged material was anticipated to fill the lowest areas within the placement site and that little deposition would occur on the ridges.

TABLE 6-1
Tree and Shrub Plantings
Relative Survival and Growth Rates

Species	Number Planted	1995 Survival	1997 Survival
Northern Red Oak	82	Good/excellent	Good
Pin Oak	82	Good/good	None found
Bur Oak	50	Fair/fair	Good
Swamp White Oak	96	Excellent/good	Good
Northern Pecan	50	Fair/poor	None found
Black Walnut	50	Poor/poor	None found
Butternut	150	Good/good	None found
Sycamore	50	Good/excellent	Good
Serviceberry	75	Poor/fair	Poor
Red Osier Dogwood	75	Fair/good	Fair
Gray Dogwood	75	Fair/good	Fair
Highbush Cranberry	75	Good/excellent	Fair

Table 6-1. Tree and Shrub Plantings Relative Survival and Growth Rates

(2) Conclusions. Black walnut, butternut, and northern red oak are species not recommended for planting at similar sites. While northern red oak at the Big Timber project appears to be doing well, an extended high water event during the growing season would probably be fatal. Continued monitoring may prove this to be a false expectation. However, the virtual absence of naturally occurring northern red oak stands at similar sites remains the overriding factor when considering this species as recommended planting stock. The usefulness of planting serviceberry, cranberry, and the dogwood species at HREP projects is still questionable. The abundance of naturally seeded buttonbush is evidence of the suitability for this species at the Big Timber project. Additional opportunities to plant buttonbush or other desirable vegetation at the check dams and dredged material placement site may be a viable option in the future.

Most of the shrub species and the oaks have been browsed back to the ground by deer. The sprouts from the stumps appeared to be healthy. It is unclear whether browse protection methods are cost effective. As long as the root system maintains enough reserves to produce a top that competes with other vegetation, the planting should be viewed as successful. While tree form may suffer, HREP projects are not designed to be timber plantations.

Herbicide application is very much on a case-by-case and year-by-year situation. As much flexibility as possible should be allowed for the USFWS Site Manager to react to dynamic competing vegetation conditions. At the time of the 1997 survey, weed competition was not overtopping or overwhelming the tree and shrub plantings.

The higher elevation of the confined placement site may provide the geomorphic opportunity to establish mast-producing species. However, dredged material composition can present different problems for revegetation. Fine material may not provide pore space for oxygen to reach plant roots. Sand, on the other hand, does not hold water and may heat up too much to allow for woody material to establish. Lack of soil fertility is also an issue. In addition, without adequate drainage, a rise in elevation alone will not make the site suitable. As dredged material placement sites consolidate, they may become convex. As a result, the sites become perched wetlands, unsuitable for mast trees except at the higher and drier perimeter. Successful planting of the site after placement is dependent on consolidation of the dredged material and suitable topography. Typical natural landforms supporting mast-producing trees are low, narrow ridges paralleling the flow of the river.

Annual deposition of fine materials from flood events may range from less than ½-inch to 4 inches depending on duration and timing. Light deposition is not generally harmful to the existing trees. However, increasing depth of sediment deposition may increase tree mortality, especially for first or second year seedlings. In general, larger trees fare better. Deposition of course materials occurs during large flood events, such as the Flood of 1993, and from channel maintenance dredging.

Observations have indicated that dredged material placed in areas with trees have shown survival to be very site specific. There are channel maintenance sites with live trees in greater than 10 feet of dredged material and dead trees in as little as 2 feet of dredged material. It is hypothesized that sand deposition would cause less mortality than silt deposition of the same depths. If placement of the dredged material has not caused mortality of the pre-project mature mast trees, then the seed source is in place to potentially vegetate the site. Tree mortality within the dredged material placement site should be expected. If the parent mast trees are dead, however, revegetation of the dredged material placement site should be considered. If the elevation of the dredged material is essentially the same as the pre-project ridges, the assumption can be made that this area is high enough in elevation to support future generations of mast-producing trees.

7. EVALUATION OF MIGRATORY WATERFOWL HABITAT OBJECTIVES

a. Increase Reliable Resting and Feeding Water Area.

(1) Monitoring Results. One of the objectives for enhancing migratory waterfowl habitat is to increase the reliable resting and feeding water area through aquatic habitat and pothole creation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain greater than or equal to 21 acres of water surface area within the Big Timber project. In the August 1998 PER, nearly 26 acres of reliable resting and feeding water area existed based on current aerial photography at that time. Since then, additional mapping has not been completed. According to Table C-2 in Appendix C, aerial photography is only required every five years. However, the USFWS conducted waterfowl surveys within the Big Timber project on one occasion in 1997 and four occasions in 1998. The data collected is summarized in Table 7-1.

TABLE 7-1
Summary of Waterfowl Surveys

Waterfowl Type	Number Counted				
	10/2/97	2/25/98	3/23/98	9/25/98	10/6/98
Large Canada Geese	13	-	-	16	-
Medium Canada Geese	-	29	2	-	5
Mallard	3	108	74	-	8
Green-winged Teal	-	-	40	11	-
Blue-winged Teal	57	-	2	13	13
Wood Duck	50	-	30	3	7
Ring-necked Duck	-	-	20	-	-
Lesser Scaup	-	-	1200	-	-
Bufflehead	-	-	4	-	-
Common Merganser	-	-	27	-	-
Adult Bald Eagle	-	16	5	-	-
Immature Bald Eagle	-	10	15	-	-
Great Blue Heron	35	-	40	-	-
Great Egret	5	-	-	-	-
Red-tailed Hawk	1	-	-	-	-
Barrel Owl	1	-	-	-	-
TOTAL	165	163	1459	43	33

Table 7-1. Summary of Waterfowl Surveys

The results of the waterfowl surveys indicate that there are many types of waterfowl utilizing the Big Timber project. Those types seen the most often are the Mallard, Blue-winged Teal, and Wood Duck, each seen on four of the five occasions. Canada Geese were documented on all five occasions, when looking at all size ranges. From the 1998 data at first glance, it appears that more types of waterfowl as well as greater numbers are seen in the spring rather than the fall. The raw data collected by the USFWS can be found in Appendix D.

(2) Conclusions. According to the waterfowl surveys, the Big Timber project is meeting the objective of increasing the reliable resting and feeding water area through aquatic habitat and pothole creation. However, other field observations have documented limited use of both aquatic habitat and potholes by migratory waterfowl.

The 1997 USFWS Site Manager's project inspection report noted that emergent vegetation had not been established in any of the water areas. However, observations by the USFWS indicate that some preferred waterfowl foods are available, in particular, duckweed. In the 1997 report, the presence of duckweed was documented in some areas of Timber Chute, Big Denny, and Little Denny, as well as the perimeter of several potholes. The report also stated that the potholes may be used occasionally by wood ducks, but this occurrence had not been actually observed. The small size of the potholes likely precludes regular use by waterfowl and broods.

The 2001 USFWS Site Manager's project inspection report documented the presence of very little vegetation at the aquatic habitat areas and potholes. The reason for the sparse amount of vegetation has not been determined. As previously mentioned in Section 5, a higher frequency of island submergence and overland flow since project completion has been discovered and may be one of the reasons for this limited growth of vegetation.

b. Provide Isolated Resting, Feeding, and Brooding Pools.

(1) Monitoring Results. The other objective for enhancing migratory waterfowl habitat is to provide isolated resting, feeding, and brooding pools through pothole creation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a total number of 10 potholes throughout the design life of the Big Timber project. Pothole sedimentation transects for were conducted at project completion to reflect as-built conditions of the isolated resting, feeding, and brooding pools. Pothole sedimentation transects were conducted again in 1995 and 1997. A discussion of this data was included in the August 1998 PER. Since then, additional transects have not been completed. According to Table C-2 in Appendix C, pothole sedimentation transects are only required every five years. However, the USFWS conducted frog and toad surveys within the Big Timber project on two occasions, once in 1998 and again in 1999. The data collected is presented in Table 7-2.

The results of the frog and toad surveys indicate that there are many types utilizing the Big Timber project. Those types seen the most often are the Chorus Frog, Eastern Tree Frog, Cope's Tree Frog, and Woodhouse Toad, each seen on both occasions. Overall, the Chorus Frog was documented the most and appears to be more consistent than the others.

Besides waterfowl, amphibians appear to be utilizing the Big Timber project as well. To view the raw data collected by the USFWS, refer to Appendix D.

TABLE 7-2
Summary of Frog and Toad Surveys

Frog or Toad Type	Number Counted 5/14/98	Number Counted 7/8/99
Chorus Frog	17	18
Leopard Frog	1	-
American Toad	5	-
Eastern Tree Frog	6	23
Cope's Tree Frog	4	19
Cricket Frog	7	1
Woodhouse Toad	13	9
Bull Frog	-	3
TOTAL	53	73

Table 7-2. Summary of Frog and Toad Surveys

(2) Conclusions. According to field observations by the USFWS Site Manager, the Big Timber project is not meeting the objective of increasing the isolated resting, feeding, and brooding pools through pothole creation.

As discussed in the previous subsection, the 1997 USFWS Site Manager's project inspection report noted that emergent vegetation had not been established in the potholes. However, observations by the USFWS indicate that some preferred waterfowl foods are available, in particular, duckweed. The 1997 report documented the presence of duckweed was around the perimeter of several potholes. The USFWS Site Manager suggested that the potholes may be used occasionally by wood ducks, but this occurrence had not been actually observed. The small size of the potholes likely precludes regular use by waterfowl and broods.

The 2001 USFWS Site Manager's project inspection report also noted very little presence of vegetation at the potholes. The reason for the sparse amount of vegetation has not been determined, but may be the result of frequent high water causing overland flow and island submergence. Future pothole sedimentation transects based on the monitoring plan should provide a lot more data to better analyze this objective.

8. OPERATION AND MAINTENANCE SUMMARY

a. Operation. The Big Timber project has no general operating requirements.

b. Maintenance.

(1) Inspections. The USFWS Site Manager performed an inspection of the Big Timber project on July 24, 1997. A project inspection report was completed on February 20, 2001 as well. The project inspection and monitoring results can be found in Appendix D.

(2) Maintenance Based on Inspections. The 1997 USFWS Site Manager's project inspection report noted that no waste materials or unauthorized structures were found in the project area, and that the Little Denny entrance access control remained in place. In addition, the 1997 report mentioned concerns about the sedimentation rate in Timber Chute. With depths already approaching the design life of the project prior to 1997, it was anticipated that the existing depths would only be worse or at best, the same. It was recommend that the Corps and USFWS continue to closely monitor the sedimentation rate to determine if corrective measures are required if sediment continues to accumulate at a rate greater than that estimated in the DPR.

The 2001 USFWS Site Manager's project inspection report noted that in aquatic habitat areas there was very little presence of emergent vegetation, which is consistent with the previous report. Considerable sloughing of the bank along Big Denny was documented, which may be partly due to boat traffic. The Big Timber project is designated as a no-wake zone at the entrance to Round Pond. The report also noted a considerable number of snags along Big and Little Denny. In addition, rapid sedimentation of areas along the channel with little or no vegetation was observed.

Since the last PER, the Big Timber project has required little maintenance. Further maintenance, with respect to erosion and sediment deposition, shall be determined once the next round of sedimentation transects are conducted and analyzed.

9. CONCLUSIONS AND RECOMMENDATIONS

a. Project Goals, Objectives, and Management Plan. Data and observations collected since the last PER suggest that most of the goals and objectives evaluated for the Big Timber project are being met, as illustrated in Table 9-1, except for deep aquatic habitat restoration. Further data collection should better define sedimentation rates, survival of mast trees, and project utilization by migratory waterfowl and other wildlife.

TABLE 9-1
Project Goals and Objectives

Goals	Objectives	Project Features	Unit	Year 9 (2000)	Year 50 Target	Status
Enhance Aquatic Habitat	Restore deep aquatic Habitat (Depth $\geq$ 6')	Hydraulic dredging	Feet	5.1	6	Not Met
	Restore shallow aquatic habitat (2' $\leq$ Depth $\leq$ 3')	Mechanical excavation				
		(Round / Timber)	Feet	2.5	2	Met
		(Willow / Little Denny)	Feet	2.0	2	Met
		(Willow / Big Denny)	Feet	2.5	2	Met
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & excavation				
		(W-M443.6G)	Mg/L	9.16 [1/]	5	Met
		(W-M444.4H)	Mg/L	7.52 [1/]	5	Met
	Provide year-round habitat access	Dredging & excavation				
		(Round Pond)	Feet	5.1	3.5	Met
		(Timber Chute)	Feet	3.85	3.5	Met
		(Willow Chute)	Feet	5.35	3.5	Met
Enhance Terrestrial Habitat	Produce mast tree dominated areas	Revegetation	Acres	354 [2/]	204	Met
Enhance Migratory Waterfowl Habitat	Increase reliable resting & feeding water area	Pothole creation, dredging, & excavation	Acres	29.4 [2/]	21	Met
	Provide isolated resting, feeding, & brooding pools	Pothole creation	Each	10	10	Met

Table 9-1. Project Goals and Objectives

[1/] This value is an average concentration

[2/] This number reflects that summarized in the 1998 PER since sedimentation transects are only required every five years – the next round of transects should be completed in 2002

b. Post-Construction Evaluation and Monitoring Schedules. Monitoring efforts for the Big Timber project have been performed according to the Post-Construction Performance Evaluation Plan in Appendix B and the Resource Monitoring and Data Collection Summary in Appendix C. The next PER will be an abbreviated report completed in March of 2002 following collection of field data from January 1, 2001 through December 31, 2001. This report should include new sedimentation transects since Timber Chute has surpassed a flat pool depth of 4 feet based on the requirement that was added to Appendix C, Table C-2 in the August 1998 PER.

(1) Restore Deep Aquatic Habitat. It is not only apparent for the Big Timber project but for other HREP projects as well that the annual sedimentation rates are consistently underestimated. This may be due to the fact that many of the existing HREP projects are still in the younger years of their design life and that sediment deposition is not linear, but rather logarithmic. The result is higher sedimentation rates in the earlier years of the project until the channel becomes stabilized and sedimentation rates begin to level off. If this is indeed the case, then it seems practical to conduct sedimentation transects on a similar scale. Transects should be performed more frequently in the first ten years and less often in later years. This in turn would closely follow the implementation schedule for PERs. More importantly, a better relationship between sedimentation rates versus project life could be determined and used in the design of future HREP projects.

(2) Provide Year-Round Habitat Access. Timber Chute has experienced excessive erosion since project completion. The flat pool depths in Timber Chute are approaching the critical point of 3.5 feet and no longer meet the criteria for deep aquatic habitat (Depth $\geq$ 6'). In regard to maintenance of a migratory path for fish, the remaining life of this objective is cause for concern. Sediment transect monitoring intervals have been revised to collect data when projects depths in the migratory path reach 4 feet and 3.5 feet below flat pool. When project depths reach 3.5 feet, the options of rehabilitation or abandonment of this objective may be considered. Any decision would be carried forth only upon written mutual agreement of the USFWS and Corps. Included within this agreement would be a description of the agreed-upon course of action and funding responsibilities, if any. At this point, year-round fisheries habitat access seems unlikely to meet the Year 50 Target without additional dredging in the future.

c. Project Operation and Maintenance. Project O&M has been conducted in accordance with the O&M Manual. There are no operational requirements attached to the Big Timber project. The maintenance of project features has been adequate. Annual project inspections by the USFWS have resulted in proper corrective maintenance actions.

d. Project Design Enhancement. Discussions with those involved in operation, maintenance, and monitoring activities at the Big Timber project have resulted in the following general conclusions regarding project features that may affect future HREP project design.

(1) Hydraulic Dredging / Check Dams. To reduce project sediment deposition in Timber Chute and the lower end of Willow Chute, two options should be evaluated. The first option would be to extend the Willow Chute check dam downstream, which would move the expansion zone and associated sediment deposition downstream. The second option would be to raising the effective height of the excavated dredged material adjacent to Timber Chute to match the check dam. This would maintain the expansion zone bordering Timber Chute but should prevent sediment from entering the channel provided the check dam is partially fortified. Hydraulic modeling of the expansion zone would identify the benefits of these options, and should be scheduled for inclusion in the next PER. This analysis should be done in an approximate fashion, using existing data.

(2) Revegetation. If the elevation of the dredged material within the confined placement site is approximately the same as the pre-project ridges, the assumption can be made that this area should be high enough to support future generations of mast producing trees. Long-range (20 years +/-) plans for the Big Timber project should consider mast tree plantings. These plantings would be most likely to succeed after a new cottonwood and/or silver maple canopy has been established and competition from the herbaceous growth that immediately follows placement of dredged material is no longer an issue. Two years after this second planting, the canopy closure could be reduced to 40% to provide increased light availability for enhanced growth. Additional opportunities to plant buttonbush or other desirable vegetation on the check dams and dredged material exist.

(3) Pothole Creation. Pothole construction by blasting is particularly suited to the Big Timber project, which is located in a remote area of the floodplain. However, potholes less than 0.1 acre appear to be too small for floodplain bottomland forest areas. The potholes range from 0.03 acre to 0.08 acre in size. Coupled with the steep side slopes, these potholes are better suited to hiding predators than providing isolated pools for rearing duck broods. Consequently, this information was utilized in determining the charges and dimensions for blasted and mechanically excavated potholes for other HREP projects. Since the Big Timber project, blasted potholes are typically larger at approximately 1/3 acre and have more gradual side slopes. Analysis results indicate a positive response to pothole construction when these parameters are utilized.

APPENDIX A

ACRONYMS

ACRONYMS

CEMVR	Corps of Engineers, Mississippi Valley Division, Rock Island District
CPUE	Catch Per Unit Effort
CY	Cubic Yards
DO	Dissolved Oxygen
DPR	Definite Project Report
EMP	Environmental Management Program
ER	Engineer Regulation
HREP	Habitat Rehabilitation and Enhancement Project
IADNR	Iowa Department of Natural Resources
LTRMP	Long-Term Resource Monitoring Program
MSL	Mean Sea Level
O&M	Operation and Maintenance
PER	Performance Evaluation Report
RM	River Mile
UMRS	Upper Mississippi River System
USFWS	United States Fish and Wildlife Service

APPENDIX B

POST-CONSTRUCTION EVALUATION PLAN
AND
SEDIMENTATION TRANSECT PROJECT OBJECTIVES EVALUATION

TABLE B-1
Post-Construction Evaluation Plan

oal	Objective	Enhancement Feature	Unit	Year 0 (1991) Without Project	Year 0 (1991) With Project	Year 9 (2000) With Project	Year 50 Target With Project	Feature Measurement	Annual Field Observations by USFWS Site Manager
nhance quatic abitat	Restore deep aquatic habitat (Depth ≥ 6’)	Hydraulic dredging	Feet	0	9	5.1	6	Perform hydrographic soundings of transects	Development of emerge vegetation within deep dredged area
	Restore shallow aquatic habitat (2’ ≤ Depth ≤ 3’)	Mechanical excavation							
		(Round / Timber)	Feet	0	4	2.5	2	Perform hydrographic soundings of transects	Encroachment of bank o obvious shoaling in shallow dredged areas
		(Willow / Little Denny)	Feet	0	4	2.0	2		
		(Willow / Big Denny)	Feet	0	4	2.5	2		
	Improve levels of dissolved oxygen during critical seasonal stress periods	Dredging & excavation							
		(W-M443.6G)	Mg/L	0	> 5	9.16 [1/]	5	Perform water quality tests	Fish stress (at surface) or fish kills
		(W-M444.4H)	Mg/L	0	> 5	7.52 [1/]	5		
	Provide year-round habitat access	Dredging & excavation							
		(Round Pond)	Feet	0	9	5.1	3.5	Perform hydrographic soundings of transects	Development of emerge vegetation within access area
		(Willow Chute)	Feet	0	9	3.85	3.5		
		(Timber Chute)	Feet	0	9	5.35	3.5		
nhance errestrial abitat	Produce mast tree Dominated areas	Revegetation	Acre	348	354	354 [2/]	204	Perform vegetation transects in mast tree area	Seedling survival
nhance igratory aterfowl abitat	Increase reliable resting & feeding water areas	Pothole creation & dredging/excavation	Acre	0	23.8	29.4 [2/]	21	Perform hydrographic soundings of transects	Waterfowl presence or absence
	Provide isolated resting, Feeding, & brooding pools	Pothole creation	Each	0	10	10	10	Perform areal survey of project area	

able B-1. Post-Construction Evaluation Plan

This value is an average concentration

This number reflects that summarized in the 1998 PER since sedimentation transects are only required every five years - the next round of transects should be mpleted in 2002

TABLE B-2 Sedimentation Transect Project Objectives Evaluation				
Transect	Project Objectives to Be Evaluated			
	Restore Deep Aquatic Habitat	Restore Shallow Aquatic Habitat	Provide Year-Round Habitat Access	Increase Reliable Resting and Feeding Water Areas
Round Pond – Timber Chute - Willow Chute - Big Denny				
(A)	X		X	X
(B)	X		X	X
(C)	X		X	X
(D)	X		X	X
(E)	X	X	X	X
(F)	X	X	X	X
(G)	X	X	X	X
(H)	X	X	X	X
(I)	X	X	X	X
(L)		X		X
(M)		X		X
(N)		X		X
Little Denny				
(J)		X		X
(K)		X		X
Potholes				
(1)				X
(2)				X
(3)				X
(4)				X
(5)				X
(6)				X
(7)				X
(8)				X
(9)				X
(10)				X

Table B-2. Sedimentation Transect Project Objectives Evaluation

APPENDIX C

MONITORING AND PERFORMANCE EVALUATION MATRIX
AND
RESOURCE MONITORING AND DATA COLLECTION SUMMARY

TABLE C-1
Monitoring and Performance Evaluation Matrix

roject hase	Type of Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Implementation Instructions
re-Project	Sedimentation Problem Analysis	System-wide problem definition; evaluates planning assumptions	USFWS	USFWS	LTRMP	--
	Pre-Project Monitoring	Identifies and defines problems at HREP site; establishes need of proposed project features	USFWS	USFWS	USFWS	--
	Baseline Monitoring	Establishes baselines for performance evaluation	Corps	Corps	HREP	See Table C-2
esign	Data Collection for Design	Includes quantification of project objectives, design of project, and development of performance evaluation plan	Corps	Corps	HREP	See Table C-2
onstruction	Construction Monitoring	Assesses construction impacts; assures permit conditions are met	Corps	Corps	HREP	See Section 401 Stipulations
ost-onstruction	Performance Evaluation Monitoring	Determines success of project as related to objectives	Corps / USFWS	Corps / USFWS	HREP / USFWS	See Table C-2
	Analysis of Biological Responses to Projects	Evaluates predictions and assumptions of habitat unit analysis; studies beyond scope of performance evaluation, or if projects do not have desired biological results	Corps	Corps	HREP	--

Table C-1. Monitoring and Performance Evaluation Matrix

TABLE C-2
Resource Monitoring and Data Collection Summary [1/]

e surement	Water Quality Data: Pre-Project Phase Apr-Sep	Pre-Project Phase Oct-Mar	Design Phase Apr-Sep	Design Phase Oct-Mar	Post-Const Phase Jun-Sep	Post-Const Phase Dec-Mar	Engineering Data: Pre-Project Phase	Design Phase	Post-Const Phase	Natural Resource Data: Pre-Project Phase	Design Phase	Post-Const Phase	Sampling Agency	Remarks
NT MEASUREMENTS														
er Quality Stations [2/]													Corps	
rbidity	2W		2W		2W	M								
cchi Disk Transparency	2W		2W		2W	M								
spended Solids	2W		2W		2W	M								
ssolved Oxygen	2W		2W		2W	M								
ecific Conductance	2W		2W		2W	M								
ter Temperature	2W		2W		2W	M								
	2W		2W		2W	M								
tal Alkalinity	--		--		2W	M								
lorophyll	2W		2W		2W	M								
locity	--		--		2W	M								
ter Depth	2W		2W		2W	M								
ter Elevation	2W		2W		2W	M								
rcent Ice Cover						M								
Depth						M								
rcent Snow Cover						M								
ow Depth						M								
nd Direction					2W	M								
nd Velocity					2W	M								
ve Height					2W	M								
Temperature					2W	M								
rcent Cloud Cover					2W	M								
ment Test Stations [3/]													Corps	
triate			1											
lk Sediment			1											
mn Settling Stations [4/]													Corps	
lumn Settling Analysis								1						
ng Stations [5/]													Corps	
otechnical Borings								1						

TABLE C-2 (Continued)
Resource Monitoring and Data Collection Summary [1/]

e Measurement	Water Quality Data						Engineering Data			Natural Resource Data			Sampling Agency	Remarks
	Pre-Project Phase		Design Phase		Post-Const Phase		Pre-Project Phase	Design Phase	Post-Const Phase	Pre-Project Phase	Design Phase	Post-Const Phase		
	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar	Jun-Sep	Dec-Mar								
NSECT MEASUREMENTS														
mentation Transects [6/]													Corps	
drographic Soundings							1		5Y					
etation Transects [7/]													Corps	
st Tree Survey												Y		
A MEASUREMENTS														
ping [8/]													Corps	
rial Photos / Remote Sensing										1		5Y		

ble C-2. Resource Monitoring and Data Collection Summary

GEND

= Weekly
Monthly
Yearly
= n-Weekly interval
= n-Yearly interval
,3, --- = number of times data is collected within designated project phase

TABLE C-2 (Continued)
Resource Monitoring and Data Collection Summary [1/]

[1/] Resource Monitoring and Data Collection Summary - See Plate3 in Appendix J for Monitoring Plan

[2/] Water Quality Stations

W-M443.6G
W-M444.4H
W-M442.8F (summer DO and temperature only)

[3/] Sediment Test Stations (Design Phase)

DPR-BT-1
DPR-BT-2
DPR-BT-3
DPR-BT-4

[4/] Column Settling Stations (Design Phase)

DPR-BT-88-2-1
DPR-BT-88-2-2

[5/] Boring Stations (Design Phase)

DPR-BT-88-1
DPR-BT-88-2
DPR-BT-88-3
DPR-BT-88-4
DPR-BT-88-5
DPR-BT-88-6
DPR-BT-88-7
DPR-BT-88-8
DPR-BT-88-9

[6/] Sedimentation Transects (Post-Construction Phase) – See Table B-2 for Sediment Transect Project Objectives Evaluation. Based on USFWS project inspection reports, the Corps shall adjust the monitoring interval as necessary to survey the sedimentation transects when depths in the migratory path reach 4 feet and then 3.5 feet below flat pool

[7/] Vegetation Transects (Post-Construction Phase) – Mast tree survey of hardwood trees planted in the confined dredged material placement site

[8/] Mapping (Post-Construction Phase) – aerial photography

APPENDIX D

COOPERATING AGENCY CORRESPONDENCE

APPENDIX E

WATER QUALITY DATA

TABLE E-1.
Post-Project Monitoring Results at Station W-M443.6G

Date	Depth (m)	Velocity (ft/s)	Temp (°C)	DO (mg/L)	pH (SU)	Chlorophyll a (mg/m^3)
7/31/97	2.29	0.00	25.5	6.90	8.30	120.0
8/19/97	2.07	0.07	23.2	4.68	7.67	44.0
9/3/97	2.04	0.13	23.1	5.60	7.88	44.0
9/25/97	1.98	0.00	18.9	8.39	8.29	50.0
12/23/97	1.86	0.00	1.9	16.75	1/	17.0
1/27/98	1.68	0.00	2.4	14.69	8.34	4.9
2/24/98	2.07	1/	6.5	12.73	8.53	11.0
3/24/98	2.41	0.00	6.0	17.81	8.07	69.0
6/3/98	2.04	0.26	21.8	3.83	7.54	59.0
7/2/98	3.44	0.19	27.1	3.15	7.26	9.8
7/14/98	3.11	0.00	27.2	6.19	7.48	12.0
7/28/98	1.97	0.00	27.7	5.80	7.92	72.0
8/13/98	1.92	0.00	26.7	8.33	8.44	70.0
8/25/98	1.83	0.07	26.5	4.50	7.90	52.0
9/10/98	1.75	0.06	21.6	7.35	8.22	54.0
9/29/98	1.87	0.00	26.0	13.54	8.56	65.0
12/29/98	1.83	0.00	3.2	19.66	8.70	17.0
1/28/99	1.83	0.00	1.7	4.66	7.70	8.3
2/25/99	1.83	0.00	3.5	19.10	9.00	25.0
3/23/99	1.98	0.00	8.0	15.00	9.00	34.0
5/27/99	4.54	0.00	18.6	5.80	6.73	<1
6/22/99	2.68	0.05	24.5	11.10	8.20	49.0
7/8/99	1.83	0.05	28.2	7.46	8.20	80.0
7/27/99	2.90	0.13	29.5	7.09	8.10	34.0
8/10/99	1.92	0.15	24.6	5.76	7.70	68.0
8/24/99	1.77	0.10	22.9	6.57	8.20	64.0
9/8/99	1.68	0.00	23.3	5.24	8.20	42.0
9/21/99	1.81	0.00	15.0	7.74	8.50	32.0
2/8/00	1.30	0.00	1.6	12.13	7.90	11.0
3/7/00	2.10	0.00	11.7	18.82	8.90	94.0
5/31/00	1.97	2/	19.9	6.32	7.80	40.0
6/15/00	4.12	-	22.9	5.04	7.50	5.6
7/6/00	2.87	-	24.9	4.60	7.50	10.0
7/25/00	1.83	-	24.7	12.45	8.30	54.0
8/8/00	1.79	-	28.6	13.42	8.80	19.0
8/22/00	1.97	-	24.2	6.84	8.30	60.0
9/5/00	1.71	-	21.2	6.00	7.90	59.0
9/19/00	1.76	-	20.4	7.17	8.50	71.0
MIN	1.30	0.00	1.6	3.15	6.73	4.9
MAX	4.54	0.26	29.5	19.66	9.00	120.0
AVG	2.17	0.04	18.8	9.16	-	44.1

Table E-1. Post-Project Monitoring Results at Station W-M443.6G

1/ Meter malfunction

2/ Too windy

TABLE E-2.
Post-Project Monitoring Results at Station W-M444.4H

Date	Depth (m)	Velocity (ft/s)	Temp (°C)	DO (mg/L)	pH (SU)	Chlorophyll a (mg/m^3)
7/31/97	2.32	0.00	25.8	5.68	7.93	80.0
8/19/97	2.10	0.08	24.3	2.10	7.47	36.0
9/3/97	2.04	0.14	24.5	2.66	7.61	24.0
9/25/97	2.07	0.15	19.0	4.98	7.77	22.0
12/23/97	1.83	0.00	3.5	11.84	1/	24.0
1/27/98	1.89	0.00	3.1	12.43	7.72	32.0
2/24/98	2.13	1/	6.8	9.35	7.78	12.0
3/24/98	2.21	0.03	6.6	18.84	8.38	95.0
6/3/98	1.98	0.11	22.2	6.84	7.47	35.0
7/2/98	3.73	0.00	27.2	3.26	7.28	10.0
7/14/98	3.19	0.05	28.1	5.22	7.40	13.0
7/28/98	1.98	0.00	28.1	6.36	7.86	51.0
8/13/98	2.01	0.00	26.8	3.71	7.73	64.0
8/25/98	1.92	0.00	27.8	2.99	7.67	62.0
9/10/98	1.78	0.08	22.9	4.73	7.68	82.0
9/29/98	1.87	0.05	24.7	11.25	8.30	78.0
12/29/98	1.94	0.00	3.9	16.90	8.80	28.0
1/28/99	2.04	0.00	0.4	3.72	7.60	6.7
2/25/99	1.91	0.00	3.0	13.83	8.50	31.0
3/23/99	2.13	0.00	9.3	13.55	8.90	48.0
5/27/99	4.51	0.12	18.1	5.51	7.23	2.7
6/22/99	2.74	0.08	24.5	11.20	8.20	33.0
7/8/99	2.13	2/	28.2	4.61	8.10	56.0
7/27/99	3.02	0.00	29.9	6.37	8.10	28.0
8/10/99	2.07	0.16	26.2	6.87	7.70	67.0
8/24/99	2.07	1/	23.8	4.48	7.80	65.0
9/8/99	1.80	0.00	25.1	4.96	8.00	77.0
9/21/99	1.98	0.00	17.5	4.72	8.00	36.0
2/8/00	1.86	0.00	1.3	6.10	7.50	8.5
3/7/00	2.15	0.12	11.8	16.13	8.70	100.0
5/31/00	2.05	2/	20.4	7.08	8.00	48.0
6/15/00	4.22	-	23.1	2.55	7.40	5.7
7/6/00	3.02	-	24.6	4.91	7.50	20.0
7/25/00	1.91	-	25.1	10.84	7.90	80.0
8/8/00	1.78	-	29.6	13.58	8.50	19.0
8/22/00	2.01	-	24.7	4.90	7.70	36.0
9/5/00	1.74	-	23.8	3.31	7.80	45.0
9/19/00	1.80	-	21.4	7.25	8.50	70.0
MIN	1.74	0.00	0.4	2.10	7.23	2.7
MAX	4.51	0.16	29.9	18.84	8.90	100.0
AVG	2.26	0.04	19.4	7.52	-	42.9

Table E-2. Post-Project Monitoring Results at Station W-M444.4H

1/ Meter malfunction

2/ Too windy

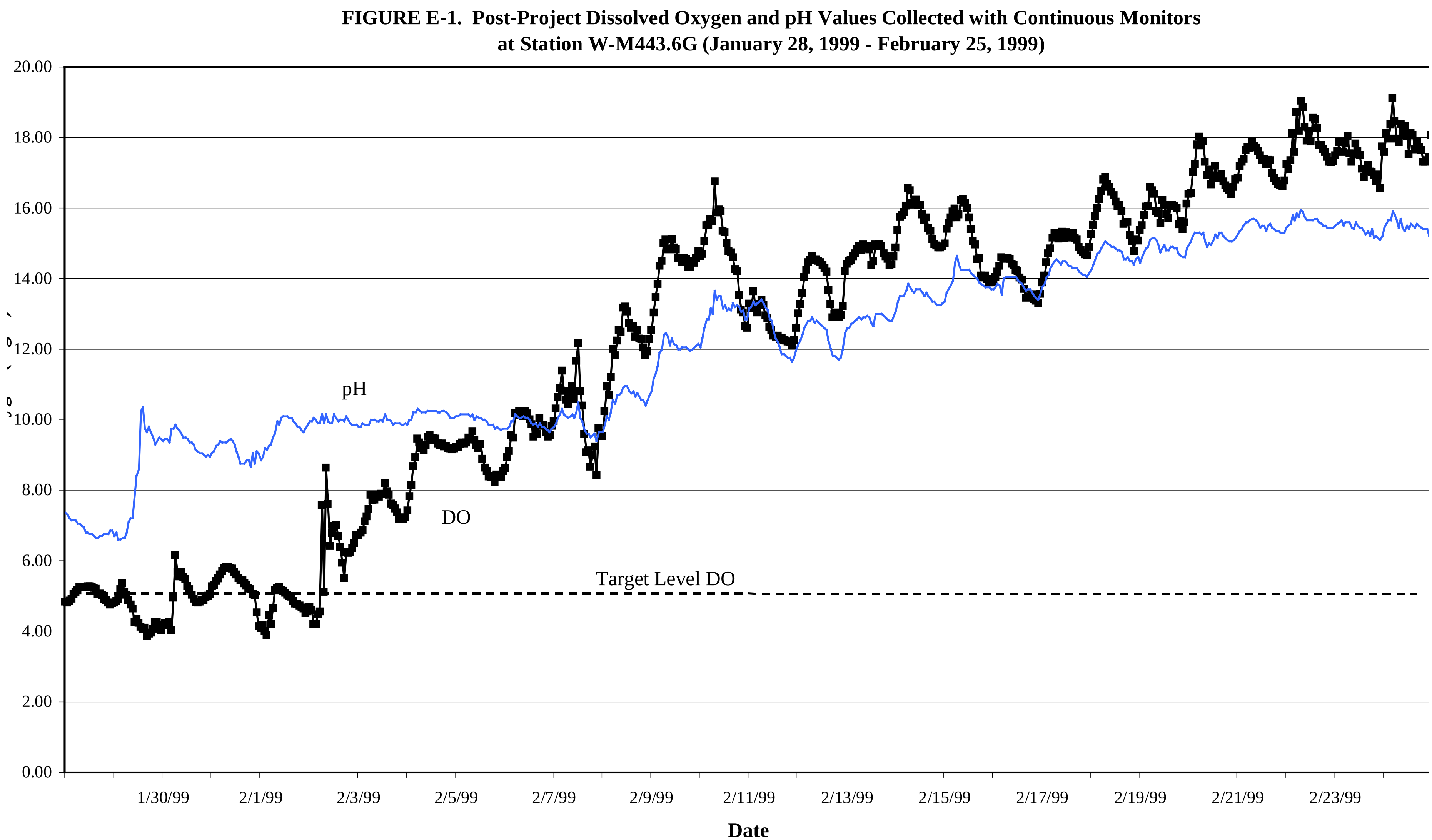

Figure E-1. Monitoring Results at Station W-M443.6G during Winter 1999

FIGURE E-2. Post-Project Dissolved Oxygen and pH Values Collected with Continuous Monitors at Station W-M443.6G (August 22, 2000 - September 5, 2000)

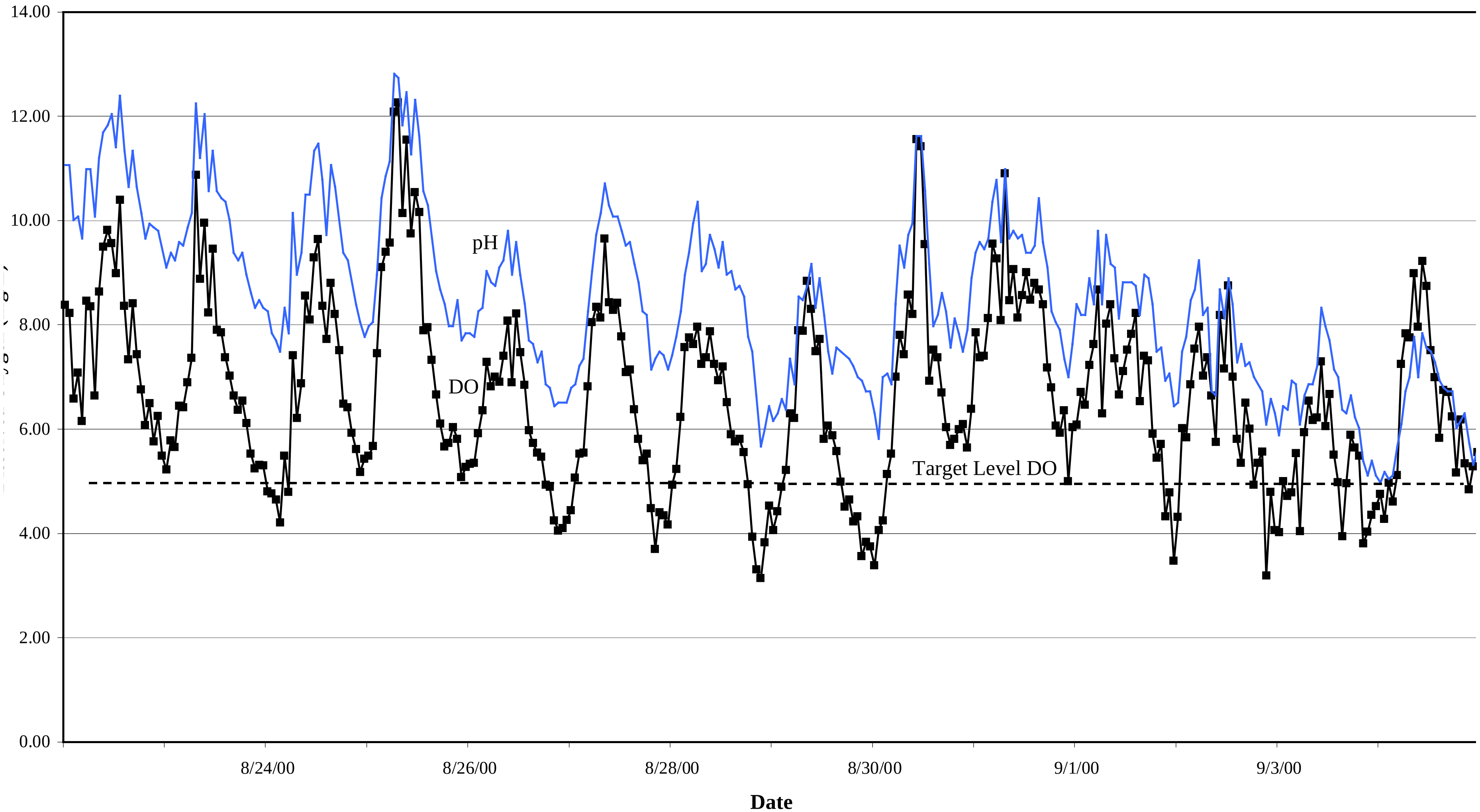

Figure E-2. Monitoring Results at Station W-M443.6G during Summer 2000

FIGURE E-3. Post-Project Dissolved Oxygen and pH Values Collected with Continuous Monitors at Station W-M444.4H (June 22, 1999 - July 8, 1999)

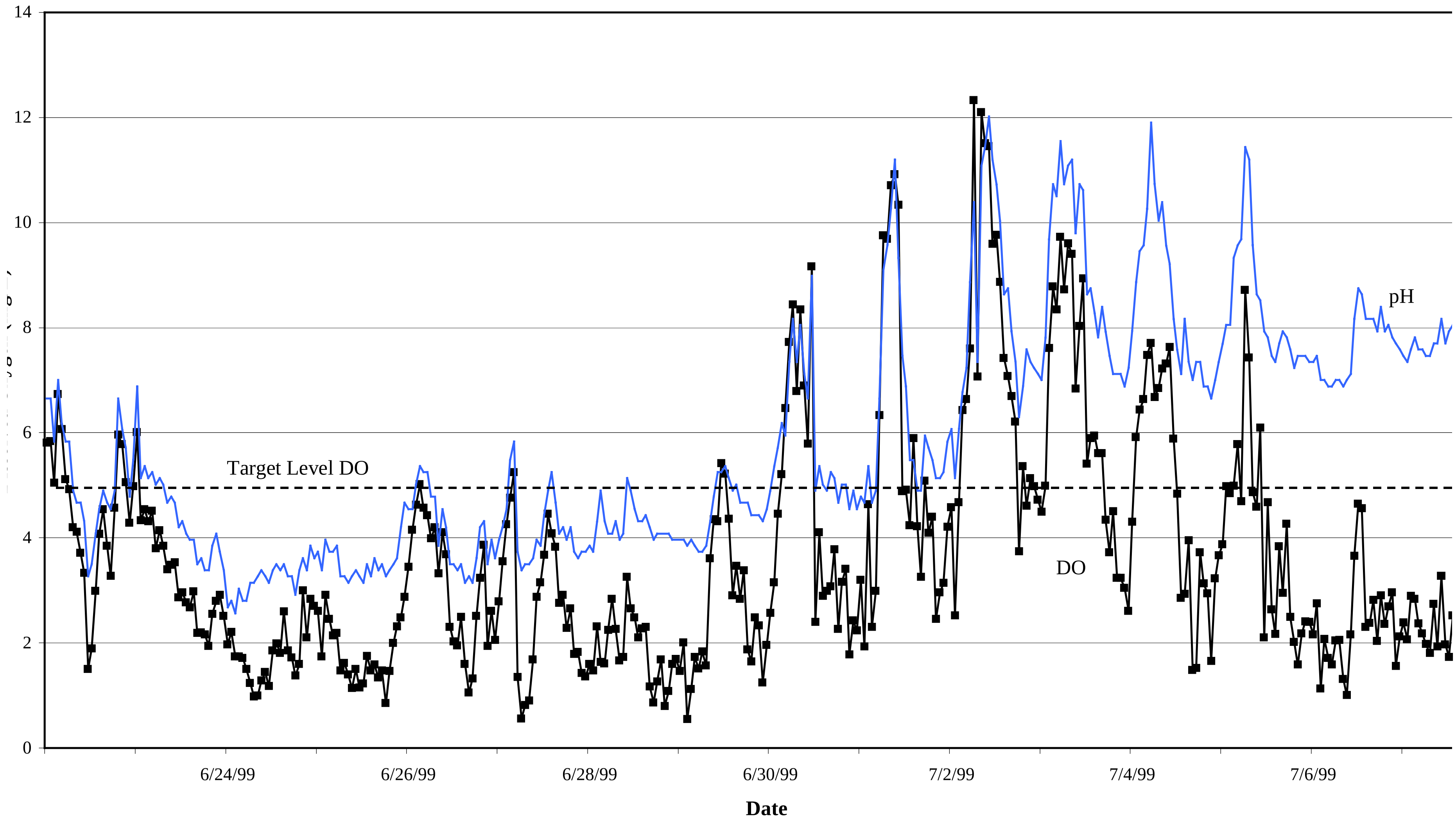

Figure E-3. Monitoring Results at Station W-M444.4H during Summer 1999

APPENDIX F

TECHNICAL COMPUTATIONS

TABLE F-1.
Summary of Channel Depths at Station W-M443.6G

Date	W-M 443.6G Channel Depth (meters)	W-M 443.6G Channel Depth (feet)	MUS14 453.0 Gage Reading (feet)	MUS14 453.0 Pool Elevation (feet) [1/]	MI17 437.1 Gage Reading (feet)	MI17 437.1 Pool Elevation (feet) [2/]	W-M 443.6G Pool Elevation (feet)	W-M 443.6G Bottom Elevation (feet) [3/]	W-M 443.6G Flat Pool Depth (feet) [4/]
7/31/97	2.29	7.50	9.46	540.20	9.45	536.02	537.73	530.23	5.77
8/19/97	2.07	6.80	7.96	538.70	9.53	536.10	537.16	530.36	5.64
9/3/97	2.04	6.70	7.67	538.41	9.30	535.87	536.91	530.21	5.79
9/25/97	1.98	6.50	7.95	538.69	9.58	536.15	537.19	530.69	5.31
12/23/97	1.86	6.10	6.66	537.40	9.25	535.82	536.47	530.37	5.63
1/27/98	1.68	5.50	7.13	537.87	9.20	535.77	536.63	531.13	4.87
2/24/98	2.07	6.80	8.43	539.17	9.62	536.19	537.41	530.61	5.39
3/24/98	2.41	7.90	8.99	539.73	9.53	536.10	537.58	529.69	6.31
6/3/98	2.04	6.70	7.87	538.61	9.29	535.86	536.98	530.29	5.71
7/2/98	3.44	11.30	13.84	544.58	14.53	541.10	542.52	531.23	4.77
7/14/98	3.11	10.20	12.55	543.29	12.90	539.47	541.03	530.83	5.17
7/28/98	1.97	6.45	7.44	538.18	9.49	536.06	536.93	530.48	5.52
8/13/98	1.92	6.30	7.63	538.37	9.59	536.16	537.06	530.77	5.23
8/25/98	1.83	6.00	7.01	537.75	9.26	535.83	536.61	530.62	5.38
9/10/98	1.75	5.75	6.25	536.99	9.19	535.76	536.26	530.51	5.49
9/29/98	1.87	6.15	6.22	536.96	9.36	535.93	536.35	530.20	5.80
12/29/98	1.83	6.00	6.27	537.01	9.42	535.99	536.41	530.41	5.59
1/28/99	1.83	6.00	7.96	538.70	9.29	535.86	537.02	531.02	4.98
2/25/99	1.83	6.00	7.42	538.16	9.09	535.66	536.68	530.68	5.32
3/23/99	1.98	6.50	8.79	539.53	9.58	536.15	537.53	531.03	4.97
5/27/99	4.54	14.90	16.85	547.59	17.08	543.65	545.26	530.36	5.64
6/22/99	2.68	8.80	11.06	541.80	11.43	538.00	539.55	530.76	5.24
7/8/99	1.83	6.00	9.28	540.02	9.94	536.51	537.94	531.95	4.05
7/27/99	2.90	9.50	11.75	542.49	12.02	538.59	540.18	530.69	5.31
8/10/99	1.92	6.30	8.85	539.59	9.19	535.76	537.33	531.03	4.97
8/24/99	1.77	5.80	8.17	538.91	9.74	536.31	537.37	531.57	4.43
9/8/99	1.68	5.50	7.22	537.96	9.19	535.76	536.66	531.16	4.84
9/21/99	1.81	5.94	7.12	537.86	9.45	536.02	536.77	530.84	5.16
2/8/00	1.30	4.26	6.69	537.43	9.34	535.91	536.53	532.27	3.73
3/7/00	2.10	6.89	9.84	540.58	9.38	535.95	537.84	530.95	5.05
5/31/00	1.97	6.46	8.66	539.40	9.68	536.25	537.54	531.08	4.92
6/15/00	4.12	13.51	16.05	546.79	15.71	542.28	544.12	530.61	5.39
7/6/00	2.87	9.42	11.84	542.58	12.17	538.74	540.31	530.89	5.11
7/25/00	1.83	6.01	8.45	539.19	9.19	535.76	537.16	531.16	4.84
8/8/00	1.79	5.87	7.10	537.84	9.47	536.04	536.78	530.90	5.10
8/22/00	1.97	6.45	7.28	538.02	9.72	536.29	537.00	530.55	5.45
9/5/00	1.71	5.61	5.75	536.49	-	-	-	-	-
9/19/00	1.76	5.77	7.11	537.85	9.20	535.77	536.62	530.85	5.15

TABLE F-1. (Continued)
Summary of Channel Depths at Station W-M443.6G

Date	W-M 443.6G Channel Depth (meters)	W-M 443.6G Channel Depth (feet)	MUS14 453.0 Gage Reading (feet)	MUS14 453.0 Pool Elevation (feet) [1/]	MI17 437.1 Gage Reading (feet)	MI17 437.1 Pool Elevation (feet) [2/]	W-M 443.6G Pool Elevation (feet)	W-M 443.6G Bottom Elevation (feet) [3/]	W-M 443.6G Flat Pool Depth (feet) [4/]
97 MIN	1.86	6.10	6.66	537.40	9.25	535.82	536.47	530.21	5.31
97 MAX	2.29	7.50	9.46	540.20	9.58	536.15	537.73	530.69	5.79
97 AVG	2.05	6.72	7.94	538.68	9.42	535.99	537.09	530.37	5.63
98 MIN	1.68	5.50	6.22	536.96	9.19	535.76	536.26	529.69	4.77
98 MAX	3.44	11.30	13.84	544.58	14.53	541.10	542.52	531.23	6.31
98 AVG	2.16	7.09	8.30	539.04	10.12	536.69	537.65	530.56	5.44
99 MIN	1.68	5.50	7.12	537.86	9.09	535.66	536.66	530.36	4.05
99 MAX	4.54	14.90	16.85	547.59	17.08	543.65	545.26	531.95	5.64
99 AVG	2.25	7.38	9.50	540.24	10.55	537.12	538.39	531.01	4.99
00 MIN	1.30	4.26	5.75	536.49	9.19	535.76	536.53	530.55	3.73
00 MAX	4.12	13.51	16.05	546.79	15.71	542.28	544.12	532.27	5.45
00 AVG	2.14	7.02	8.88	539.62	10.43	537.00	538.21	531.03	4.97
97-00 MIN	1.30	4.26	5.75	536.49	9.09	535.66	536.26	529.69	3.73
97-00 MAX	4.54	14.90	16.85	547.59	17.08	543.65	545.26	532.27	6.31
97-00 AVG	2.17	7.11	8.75	539.49	10.23	536.80	537.93	530.78	5.22

Table F-1. Summary of Channel Depths at Station W-M443.6G

[1/] MUS14 453.0 Pool Elevation = MUS14 453.0 Gage Reading + Gage Zero
where Gage Zero = 530.74 feet MSL (1912)

[2/] MI17 437.1 Pool Elevation = MI17 437.1 Gage Reading + Gage Zero
where Gage Zero = 526.57 feet MSL (1912)

[3/] W-M443.6G Bottom Elevation = W-M443.6G Pool Elevation - W-M443.6G Channel Depth

[4/] W-M443.6G Flat Pool Depth = Flat Pool - W-M443.6G Bottom Elevation
where Flat Pool = 536 feet MSL

TABLE F-2.
Summary of Channel Depths at Station W-M444.4H

Date	W-M 444.4H Channel Depth (meters)	W-M 444.4H Channel Depth (feet)	MUS14 453.0 Gage Reading (feet)	MUS14 453.0 Pool Elevation (feet) 1/	MI17 437.1 Gage Reading (feet)	MI17 437.1 Pool Elevation (feet) 2/	W-M 444.4H Pool Elevation (feet)	W-M 444.4H Bottom Elevation (feet) 3/	W-M 444.4H Flat Pool Depth (feet) 4/
7/31/97	2.32	7.60	9.46	540.20	9.45	536.02	537.94	530.34	5.66
8/19/97	2.10	6.90	7.96	538.70	9.53	536.10	537.29	530.40	5.60
9/3/97	2.04	6.70	7.67	538.41	9.30	535.87	537.04	530.34	5.66
9/25/97	2.07	6.80	7.95	538.69	9.58	536.15	537.32	530.52	5.48
12/23/97	1.83	6.00	6.66	537.40	9.25	535.82	536.55	530.55	5.45
1/27/98	1.89	6.20	7.13	537.87	9.20	535.77	536.73	530.54	5.46
2/24/98	2.13	7.00	8.43	539.17	9.62	536.19	537.56	530.56	5.44
3/24/98	2.21	7.25	8.99	539.73	9.53	536.10	537.77	530.52	5.48
6/3/98	1.98	6.50	7.87	538.61	9.29	535.86	537.12	530.62	5.38
7/2/98	3.73	12.25	13.84	544.58	14.53	541.10	542.70	530.45	5.55
7/14/98	3.19	10.45	12.55	543.29	12.90	539.47	541.22	530.78	5.22
7/28/98	1.98	6.50	7.44	538.18	9.49	536.06	537.03	530.53	5.47
8/13/98	2.01	6.60	7.63	538.37	9.59	536.16	537.17	530.58	5.42
8/25/98	1.92	6.30	7.01	537.75	9.26	535.83	536.71	530.41	5.59
9/10/98	1.78	5.85	6.25	536.99	9.19	535.76	536.32	530.48	5.52
9/29/98	1.87	6.15	6.22	536.96	9.36	535.93	536.40	530.25	5.75
12/29/98	1.94	6.35	6.27	537.01	9.42	535.99	536.46	530.11	5.89
1/28/99	2.04	6.70	7.96	538.70	9.29	535.86	537.16	530.47	5.53
2/25/99	1.91	6.25	7.42	538.16	9.09	535.66	536.81	530.56	5.44
3/23/99	2.13	7.00	8.79	539.53	9.58	536.15	537.70	530.70	5.30
5/27/99	4.51	14.80	16.85	547.59	17.08	543.65	545.46	530.66	5.34
6/22/99	2.74	9.00	11.06	541.80	11.43	538.00	539.74	530.75	5.25
7/8/99	2.13	7.00	9.28	540.02	9.94	536.51	538.12	531.12	4.88
7/27/99	3.02	9.90	11.75	542.49	12.02	538.59	540.38	530.48	5.52
8/10/99	2.07	6.80	8.85	539.59	9.19	535.76	537.52	530.72	5.28
8/24/99	2.07	6.80	8.17	538.91	9.74	536.31	537.50	530.71	5.29
9/8/99	1.80	5.90	7.22	537.96	9.19	535.76	536.77	530.87	5.13
9/21/99	1.98	6.49	7.12	537.86	9.45	536.02	536.86	530.37	5.63
2/8/00	1.86	6.10	6.69	537.43	9.34	535.91	536.61	530.51	5.49
3/7/00	2.15	7.05	9.84	540.58	9.38	535.95	538.08	531.02	4.98
5/31/00	2.05	6.72	8.66	539.40	9.68	536.25	537.70	530.97	5.03
6/15/00	4.22	13.84	16.05	546.79	15.71	542.28	544.35	530.51	5.49
7/6/00	3.02	9.91	11.84	542.58	12.17	538.74	540.50	530.60	5.40
7/25/00	1.91	6.27	8.45	539.19	9.19	535.76	537.33	531.07	4.93
8/8/00	1.78	5.84	7.10	537.84	9.47	536.04	536.87	531.03	4.97
8/22/00	2.01	6.59	7.28	538.02	9.72	536.29	537.08	530.49	5.51
9/5/00	1.74	5.71	5.75	536.49	-	-	-	-	-
9/19/00	1.80	5.90	7.11	537.85	9.20	535.77	536.72	530.82	5.18

TABLE F-2. (Continued)
Summary of Channel Depths at Station W-M444.4H

Date	W-M 444.4H Channel Depth (meters)	W-M 444.4H Channel Depth (feet)	MUS14 453.0 Gage Reading (feet)	MUS14 453.0 Pool Elevation (feet) [1/]	MI17 437.1 Gage Reading (feet)	MI17 437.1 Pool Elevation (feet) [2/]	W-M 444.4H Pool Elevation (feet)	W-M 444.4H Bottom Elevation (feet) [3/]	W-M 444.4H Flat Pool Depth (feet) [4/]
97 MIN	1.83	6.00	6.66	537.40	9.25	535.82	536.55	530.34	5.45
97 MAX	2.32	7.60	9.46	540.20	9.58	536.15	537.94	530.55	5.66
97 AVG	2.07	6.80	7.94	538.68	9.42	535.99	537.23	530.43	5.57
98 MIN	1.78	5.85	6.22	536.96	9.19	535.76	536.32	530.11	5.22
98 MAX	3.73	12.25	13.84	544.58	14.53	541.10	542.70	530.78	5.89
98 AVG	2.22	7.28	8.30	539.04	10.12	536.69	537.77	530.49	5.51
99 MIN	1.80	5.90	7.12	537.86	9.09	535.66	536.77	530.37	4.88
99 MAX	4.51	14.80	16.85	547.59	17.08	543.65	545.46	531.12	5.63
99 AVG	2.40	7.87	9.50	540.24	10.55	537.12	538.55	530.67	5.33
00 MIN	1.74	5.71	5.75	536.49	9.19	535.76	536.61	530.49	4.93
00 MAX	4.22	13.84	16.05	546.79	15.71	542.28	544.35	531.07	5.51
00 AVG	2.25	7.39	8.88	539.62	10.43	537.00	538.36	530.78	5.22
97-00 MIN	1.74	5.71	5.75	536.49	9.09	535.66	536.32	530.11	4.88
97-00 MAX	4.51	14.80	16.85	547.59	17.08	543.65	545.46	531.12	5.89
97-00 AVG	2.26	7.42	8.75	539.49	10.23	536.80	538.07	530.61	5.39

Table F-2. Summary of Channel Depths at Station W-M444.4H

[1/] MUS14 453.0 Pool Elevation = MUS14 453.0 Gage Reading + Gage Zero
where Gage Zero = 530.74 feet MSL (1912)

[2/] MI17 437.1 Pool Elevation = MI17 437.1 Gage Reading + Gage Zero
where Gage Zero = 526.57 feet MSL (1912)

[3/] W-M444.4H Bottom Elevation = W-M444.4H Pool Elevation - W-M444.4H Channel Depth

[4/] W-M444.4H Flat Pool Depth = Flat Pool - W-M444.4H Bottom Elevation
where Flat Pool = 536 feet MSL

APPENDIX G

PROJECT TEAM MEMBERS

BIG TIMBER PROJECT TEAM MEMBERS

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ble G-1. Big Timber Project Team Members

APPENDIX H

REFERENCES

REFERENCES

Published reports relating to the Big Timber project or which were used as references in the production of this document are presented below.

(1) *Definite Project Report with Integrated Environmental Assessment (R-5), Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Upper Mississippi River, Louisa County, Iowa, July 1989*. The report marks the conclusion of the planning process and serves as a basis for approval of the preparation of final plans and specifications and subsequent project construction.

(2) *Plans and Specifications, Upper Mississippi River System, Environmental Management Program, Pool 17, River Miles 444 - 445, Big Timber*, Solicitation No. DACW25-90-B-0031. These documents were prepared to provide sufficient detail of project features to allow construction of a confined dredged material placement site, hydraulically dredged channels, mechanically excavated channels, potholes, and check dams.

(3) *Plans and Specifications, Upper Mississippi River System, Environmental Management Program, Pool 17, River Miles 443-445, Big Timber Refuge*, Contract No. DACW25-93-C-0034. This document was prepared to provide sufficient detail of project features to allow planting of mast trees.

(4) *Operation and Maintenance Manual, Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 17, River Mile 443 – 445, Louisa County, Iowa, June 1994*. This manual was prepared to serve as a guide for the operation and maintenance of the Big Timber project. Operation and maintenance instructions for major features of the project are presented.

(5) *Post-Construction Performance Evaluation Report (PER5F), Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Upper Mississippi River Mile 443 – 445, Louisa County, Iowa, February 1996*.

(6) *Post-Construction Supplemental Performance Evaluation Report (SPER501F), Big Timber Refuge Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 17, Mississippi River Miles 443.5 – 445, Louisa County, Iowa, August 1998*.

(7) *Site Manager's Project Inspection and Monitoring Results, Big Timber Refuge Rehabilitation and Enhancement, Operation and Maintenance Manual, Upper Mississippi River Environmental Management Program, Pool 17, River Miles 443 through 445, Louisa County, Illinois,* July 1997 and February 2001.

APPENDIX I

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CEMVR-ED
CEMVR-ED-D
CEMVR-ED-DN (2)
CEMVR-ED-DG (Fellman)
CEMVR-ED-H
CEMVR-ED-HQ
CEMVR-ED-HQ (Bierl)
CEMVR-ED-G
CEMVR-ED-S
CEMVR-OD-M
CEMVR-OD-MN
CEMVR-OD-MN (Swenson)

APPENDIX J

PLATES