UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POST-CONSTRUCTION PERFORMANCE
EVALUATION REPORT – YEAR 3 (2000)

COTTONWOOD ISLAND HABITAT REHABILITATION AND ENHANCEMENT

JUNE 2001

US Army Corps
of Engineers
Rock Island District

POOL 21
MISSISSIPPI RIVER MILES 328.5 – 331.0
LEWIS AND MARION COUNTIES, MISSOURI

CEMVR

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US Army Corps of Engineers
Rock Island District

EXECUTIVE SUMMARY

1. General. As stated in the Definite Project Report, the Cottonwood Island project was initiated in response to a rapid accumulation of sediment that had greatly reduced the quantity and quality of the important wetland habitat in the low swales present on Cottonwood Island and deep water aquatic habitat in Cottonwood Chute. Sedimentation has been especially acute in the chute's upper end and in forested portions of the island adjacent to the Mississippi River. In the chute's shallow areas, 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 project completion in 1997.

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

a. Restore Aquatic Overwintering Habitat

(1) Improve water quality for fish through chute restoration and enhancement
(2) Provide overwintering water habitat for fish through deep hole creation

b. Restore Main Channel Border Habitat

(1) Provide flowing water habitat for fish through wing dam notches
(2) Provide additional habitat and substrate for benthic and aquatic organisms through rock placement below wing dams

c. Restore Wetland Habitat

(1) Increase food, shelter, and breeding habitat for wildlife through pothole creation
(2) Increase bottomland hardwood diversity and quality through establishment of hardwood trees in existing forest management, crop, and dredge placement areas

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

a. Restore Aquatic Overwintering Habitat

(1) <u>Improve Water Quality for Fish</u>
(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 3 (2000) reported a minimum, maximum, and average DO concentration of 4.67, 23.08, and 11.36 milligrams per Liter, respectively
(c) During the monitoring period of December 1997 to September 2000, the DO concentration fell below 5 milligrams per Liter on one out of 34 occasions
(d) Post-project DO concentrations showed some improvement relative to pre-project values

(2) Provide Overwintering Water Habitat for Fish
(a) Year 50 Target for chute excavation is to maintain greater than or equal to 4.5 acres of water area with a flat pool depth between 6 and 10 feet while the Year 50 Target for deep hole creation is to maintain greater than or equal to 0.3 acres per hole of water area with a flat pool depth greater than or equal to 10 feet
(b) Based on water quality data in lieu of sedimentation transects, Year 3 (2000) reported an average water depth of 7.04 feet for chute excavation and 11.66 feet for deep hole creation
(c) Sedimentation transects according to the monitoring plan will more accurately access sediment deposition and allow determination of overwintering water habitat in acres
(d) Additional sedimentation transects should be accomplished in Year 5 (2002) to fully evaluate this objective
(e) Sedimentation rates have varied from Year 0 (1997) to Year 3 (2000), which may indicate that the chute has not stabilized

b. Restore Main Channel Border Habitat

(1) Provide Flowing Water Habitat for Fish
(a) Year 50 Target is to maintain velocities greater than or equal to 0.35, 0.5, and 0.4 feet per second at the following locations; 100 feet upstream of the notch, at the notch, and 100 feet downstream of the notch, respectively
(b) Year 3 (2000) reported average velocities for Wing Dam Nos. 6 and 15 of 1.17, 1.67, and 1.54 feet per second at the respective locations described above
(c) Average velocity measurements at the notch and 100 feet downstream from the notch were considerably higher than those observed 100 feet upstream, which agrees with the results of similar studies reported by the IADNR and WES

(2) Provide Additional Habitat and Substrate for Benthic and Aquatic Organisms
(a) Year 50 Target is to maintain constant numbers of benthic and aquatic numbers

(b) Based on water quality data in lieu of transects, Year 3 (2000) reported average scour depths for Wing Dam Nos. 6 and 15 of 3.38 and 1.71 feet, respectively
(c) Transects according to the monitoring plan will more accurately access and quantify scour area in square feet
(d) Additional transects should be accomplished in Year 5 (2002) to fully evaluate this objective

c. Restore Wetland Habitat.

(1) Increase Food, Shelter, and Breeding Habitat for Wildlife
(a) Year 50 Target is to maintain a cross-sectional area (short chord) similar to that determined at project completion with some allowance for sediment deposition
(b) Sedimentation transects according to the monitoring plan will more accurately access sediment deposition and allow determination of wildlife habitat in square feet
(c) Additional sedimentation transects should be accomplished in Year 5 (2002) to fully evaluate this objective
(d) Post–construction field observations of the potholes have shown regular use by various animals but limited use by waterfowl

(2) Increase Bottomland Hardwood Diversity and Quality
(a) Year 50 Target is to maintain a survival rate greater than or equal to 20% within the forest management units
(b) Survival survey is scheduled for completion in 2001 by MDOC
(c) Forest management units were mowed twice during 2001
(d) Post–construction field observations of the potholes have shown regular use by various animals but limited use by waterfowl

5. Conclusions and Recommendations. Based on data and observations collected since project completion, the goals and objectives evaluated for the Cottonwood Island project are being met (see Table 9-1). Since this is the first performance evaluation report, continued data collection should better define the levels to which all goals and objectives are being met.

In general, monitoring efforts for the Cottonwood Island project have been performed according to the Post-Construction Performance Evaluation Plan in Appendix B and 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.

Project operation and maintenance has been conducted in accordance with the O&M Manual. There are no operational requirements attached to the Cottonwood Island project. Annual project inspections by the MDOC have resulted in proper corrective maintenance actions.

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1. INTRODUCTION

The Cottonwood Island Habitat Rehabilitation and Enhancement Project (HREP), hereafter referred to as "the Cottonwood Island project," is a part of the Upper Mississippi River System (UMRS) Environmental Management Program (EMP). The Cottonwood Island project is located in Pool 21 on the Missouri side of the Mississippi River navigation channel between River Miles (RM) 328.5 and 331.0. Plate 1 in Appendix J contains the vicinity map for the Cottonwood Island project. The Cottonwood Island project is maintained and operated by the Missouri Department of Conservation (MDOC) under the terms of a Cooperative Agreement with the United States Fish and Wildlife Service (USFWS).

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

(1) Summarize the performance of the Cottonwood Island project, based on the project goals and objectives;

(2) Review the monitoring plan for possible revision;

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

(4) Review engineering performance criteria to aid in the design of future 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 MDOC for the period from project completion through December 31, 2000.

2. PROJECT GOALS AND OBJECTIVES

a. General. As stated in the Definite Project Report (DPR), the Cottonwood Island project was initiated in response to a rapid accumulation of sediment that had greatly reduced the quantity and quality of the important wetland habitat in the low swales present on Cottonwood Island and aquatic overwintering habitat in the deep areas of Cottonwood Chute. Sedimentation has been especially acute in the chute's upper end and in forested portions of the island adjacent to the Mississippi River. In the shallow areas of Cottonwood Chute, 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
Restore Aquatic Overwintering Habitat	Improve water quality for fish	Chute restoration & enhancement
	Provide overwintering water habitat for fish	Create deep holes
Restore Main Channel Border Habitat	Provide flowing water habitat for fish	Notch wing dams
	Provide additional habitat and substrate for benthic and aquatic organisms	Rock placement below wing dams
Restore Wetland Habitat	Increase food, shelter, and breeding habitat for wildlife	Potholes
	Increase bottomland hardwood diversity and quality	Establish hardwood trees in existing forest management, crop, and dredge placement areas

Table 2-1. Project Goals and Objectives

3. PROJECT DESCRIPTION

a. Project Features. The Cottonwood Island project consists of mechanically excavated side channel and deep holes to restore aquatic overwintering habitat, notched wing dams to restore main channel border habitat, and mechanically excavated potholes and planting mast trees to restore wetland habitat. Plate 2 in Appendix J contains the site plan for the Cottonwood Island project.

(1) Side Channel Excavation. The lower 4,550 feet of Cottonwood Chute was mechanically excavated to improve water quality and provide overwintering water habitat for fish. The bottom width of the dredge cut was 40 feet, with a depth of 9 feet below flat pool (Elevation 470 feet MSL 1912). Cottonwood Chute includes 4 deep holes, 300 feet long and 15 feet below flat pool. Side slopes are approximately 2H:1V. For side channel cross sections, refer to the Operation and Maintenance (O&M) Manual, Plates 11 through 13. For side channel profiles, refer to the O&M Manual, Plates 14 through 16.

(2) Wing Dam Notches. Six wing dams were notched to provide flowing water habitat for fish and additional habitat and substrate for benthic and aquatic organisms. The notches were created by removing existing wing dam material to the original river bottom or a maximum of 10 feet below flat pool. Each notch was 100 feet long. For wing dam notching details, refer to O&M Manual, Plate 17. Notches were staggered in anticipation that flow would increase in the vicinity of the notch, creating a scour hole behind the wind dams and stimulating a meander to the next wing dam. Preliminary post-construction monitoring efforts indicate the formation of scour holes behind the wing dams and an increase in velocity at and below the notches.

(3) Potholes. For the Cottonwood Island project, two 1-acre potholes, one ¾-acre pothole, and two ½-acre potholes were mechanically excavated to increase food, shelter, and breeding habitat for wildlife. In general, the potholes are larger and feature a 20-foot bottom width and final elevation approximately 3 feet below flat pool. The sides of the potholes are stepped. Each “step” is approximately 10 feet wide, with a 1-foot transition zone to the next step. The transition slope is 3H:1V. For pothole details and transects, refer to the O&M Manual, Plates 18 through 23. The potholes have filled with water and were being used by deer, herons, frogs, and tadpoles less than a week after completion of construction in 1997. Fish were observed in the potholes following high water in the spring of 1998.

(4) Mast Trees. As a preparatory measure, the MDOC in June of 1998 constructed raised planting beds in the agricultural field and reseeded those areas with redtop grass. During Stage II of the Cottonwood Island project, mast trees were planted in the agricultural field / forest management areas (FMAs), around the pothole perimeters, and on top of the excavated dredged material berm to increase bottomland hardwood diversity and quality. In the agricultural field and FMAs, trees were planted on 8-inch to 10-inch berms with 30 feet between berms.

As part of a field study during the Stage II contract, 75 trees received protective fencing while another 75 trees were sprayed with deer repellent in the agricultural field and FMAs

5 / 6. The MDOC is responsible for maintaining this protective fencing and annual application of the deer repellent over a 3-year period. At the end of this period, the efficacy of both methods shall be summarized and conclusions drawn for the best method of protecting the saplings from deer. For mast tree details, refer to the O&M Manual, Plates 25 through 29.

b. Project Construction. There were three construction phases for the Cottonwood Island project. The Stage I contract was awarded to Massman Construction Company, on 28 February 1997. This contract included all of the major project features except for the planting of mast trees. This feature was completed in the Stage II contract during the 1999 construction season. Stage III of the Cottonwood Island project consisted of a modification to the existing causeway road. Construction was complete in the spring of 2000.

c. Project Operation and Maintenance. Operation and maintenance of the Cottonwood Island project is the responsibility of the MDOC 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 operation and maintenance instructions for the major project features. These features were designed and constructed to minimize the operation and maintenance requirements.

Specific operation requirements for the Cottonwood Island project shall be performed as determined by the MDOC Site Manager. Annual maintenance inspections of the side channel excavation, wing dam notches, and potholes shall be made by the MDOC Site Manager to record the presence of undesirable debris, waste materials, and unauthorized structures. The potholes should be inspected following high water events.

The Corps through annual inspections of the planting sites shall monitor survival and growth of mast trees. Remedial action shall be performed by the MDOC Site Manager as necessary to ensure survival. The MDOC Site Manager shall keep records of any herbicide and deer repellant application, in addition to records of inspections and any corrective actions taken to ensure survival of the saplings. Vegetation between mast trees shall be controlled for a minimum of two growing seasons by either mowing or herbicide application. Vegetation between the planted rows shall not be allowed to exceed a height of 1 foot during this maintenance period.

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 Cottonwood Island 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 MDOC through monitoring data, inspection records, 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 MDOC 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 operation and maintenance costs.

c. U.S. Fish and Wildlife Service. The USFWS does not have project-specific monitoring responsibilities. However, the USFWS should be present at the joint inspections with the Corps and MDOC as described in the previous paragraph.

d. Missouri Department of Conservation. The MDOC 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 USFWS shall also be conducted as described above. During all inspections, the MDOC 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.

5. EVALUATION OF AQUATIC HABITAT OBJECTIVES

a. Improve Water Quality for Fish.

(1) Monitoring Results. One of the objectives for restoring aquatic overwintering habitat is to improve water quality for fish through chute restoration and enhancement. Over the years, sediment had accumulated in Cottonwood Chute, thus resulting in a loss of deep, off-channel aquatic habitat. This reduction of depth in the chute also adversely impacted dissolved oxygen (DO) concentrations. Previous researchers reported DO concentrations below the Missouri State Standard for the Protection of Aquatic Life (5 mg/L) in the upper reaches of the chute. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a DO concentration greater than or equal to 5 milligrams per Liter.

One objective of deepening the lower portion of the chute was to improve water quality by allowing for a greater volume of oxygen to sustain fish during extended periods of ice cover. The goal was to maintain a DO concentration above 5 mg/L during the winter months. In order to determine the effectiveness of the project in attaining this goal, post-project water quality monitoring commenced on December 23, 1997 at Stations W-M328.7B and W-M329.3B (see Appendix J, Plate 3 for water quality station locations). This report discusses data collected from December 23, 1997 through September 19, 2000.

Data were obtained through a combination of periodic grab samples and the use of *in-situ* continuous water quality monitors. Grab samples were collected just below the surface on 34 occasions. The two water quality stations were usually 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 from Stations W-M328.7B and W-M329.3B are found in Appendix E, Tables E-2 and E-3, respectively. These tables include the results from DO and ancillary parameters that are useful in the interpretation of DO data. At Station W-M328.7B, only one DO concentration was below the 5 mg/L Missouri State Standard for the Protection of Aquatic Life (4.67 mg/L on June 3, 1998). At Station W-M329.3B, two DO concentrations were below the 5 mg/L state standard (3.55 mg/L on June 3, 1998 and 2.41 mg/L on August 25, 1998). The average DO concentrations at the two water quality stations were more than twice the state standard (11.36 and 10.76 mg/L at Stations W-M328.7B and W-M329.3B, respectively). All DO concentrations during the winter months were above the state standard. In fact, on many occasions supersaturated conditions were observed.

TABLE 5-1
Improve Water Quality for Fish

Water Quality Station W-M328.7B	Pre-Project 4/7/92–11/17/95	Post-Project 12/23/97–9/19/00
Total Number of Samples	41	34
Winter (October – March) Samples	16	10
Summer (April – September) Samples	25	24
Total DO Concentrations < 5 mg/L	2 (4.9%)	1 (2.9%)
Winter DO Concentrations < 5 mg/L	0	0
Summer DO Concentrations < 5 mg/L	2 (8.0%)	1 (4.2%)
Minimum DO Concentration (mg/L)	2.96	4.67
Maximum DO Concentration (mg/L)	22.70	23.08
Average DO Concentration (mg/L)	10.39	11.36

Table 5-1. Improve Water Quality for Fish

In-situ continuous water quality monitors (YSI model 6000UPG or 6600UPG sondes) were deployed on 23 occasions at Station W-M328.7B. Sondes were positioned 3 feet and 12 feet from the bottom during all deployments except for on February 24, 1998 when only one sonde was deployed 12 feet from the bottom. 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.

In-situ continuous water quality monitors were deployed at Station W-M328.7B on 6 occasions during the winter months. All DO concentrations were greater than the state standard and supersaturated conditions were common. Figure E-1 in Appendix E is an example of DO data collected during the winter with a continuous monitor. The graph depicts DO concentrations during the February 25 through March 23, 1999 deployment as measured at points 3 feet (bottom) and 12 feet (surface) from the bottom. Supersaturated conditions existed for most of the deployment. DO concentrations close to the bottom generally paralleled and were almost always lower than those observed near the surface. Data from the bottom sonde only extended to March 19, 2000 due to a loss of battery power. Daily fluctuations in DO concentrations near the surface were greater than those observed near the bottom due to algal photosynthesis.

In-situ continuous water quality monitors were deployed at Station W-M328.7B on 17 occasions during the summer months. During this period, stratification was more intense. DO concentrations measured 3 feet from the bottom were frequently below the state

standard, while those measured near the surface only occasionally fell below the state standard. Figure E-2 in Appendix E is an example of DO data collected during the summer with a continuous monitor. The graph depicts DO concentrations during the July 25 through August 8, 2000 deployment as measured at points 3 feet (bottom) and 12 feet (surface) from the bottom. On occasion, the DO concentration at the surface fell below the 5 mg/L state standard. However, these excursions were short lived. Conversely, the DO concentration near the bottom during this deployment was rarely above the state standard. During two extended periods, the DO concentration near the bottom showed little diurnal variation. A sonde malfunction may have been responsible for these anomalies.

(2) Conclusions. The Cottonwood Island project has been successful in attaining the target DO concentration (>5 mg/L) during the critical winter months. Another indication of the project's success is that USFWS and MDOC personnel have not observed any fish stress or kills since project completion.

Station W-M328.7B pre-project DO and related parameter results are found in Appendix E, Table E-1. Pre-project samples were not collected at Station W-M329.3B. Comparisons of pre-project and post-project DO data from surface samples collected at Station W-M328.7B are summarized in Table 5-1. Post-project percent DO concentrations $\leq$ 5 mg/L, minimum DO concentration, maximum DO concentration and average DO concentration values showed some improvement relative to pre-project values.

b. Provide Overwintering Water Habitat for Fish.

(1) Monitoring Results. The other objective for restoring aquatic overwintering habitat is to provide overwintering water habitat for fish through chute excavation and deep hole creation. As shown in Appendix B, Table B-1, the Year 50 Target for chute excavation is to maintain 4.5 acres of water area with a flat pool depth between 6 and 10 feet. The Year 50 Target for deep hole creation is to maintain 0.3 acre per hole of water area with a flat pool depth greater than or equal to 10 feet. Sedimentation transects for Cottonwood Chute were conducted at project completion to reflect as-built conditions of the over-wintering water habitat. 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, chute depths at both stations were recorded. Station W-M328.7B is located adjacent to sedimentation transect "C". This portion of the chute was designed to have an ideal water depth greater than or equal to 10 feet at Year 50 and is labeled as a deep hole on the monitoring plan. Station W-M329.3B is located adjacent to sedimentation transect "J". This portion of the chute was designed to have an ideal water depth of 6 to 10 feet at Year 50.

As seen in Table 5-2, Station W-M328.7B or transect "C" has an average depth of 11.66 feet at Year 3, which clearly exceeds the ideal water depth of 10 feet. Station W-M329.3B or transect "J" has an average depth of 7.04 feet at Year 3, which meets the ideal water depth of 6 to 10 feet. The flat pool depths for both transects were determined by adjusting

the water depths recorded during site visits from December 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. 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 shown in Table 5-2.

TABLE 5-2.
Provide Overwintering Water Habitat for Fish

Year	W-M328.7B Flat Pool Depth (feet)	W-M328.7B Sedimentation Rate (in/yr)	W-M329.3B Flat Pool Depth (feet)	W-M329.3B Sedimentation Rate (in/yr)
0	14.22		9.65	
0-1		7.8		6.36
1	13.57		9.12	
1-2		14.28		17.52
2	12.38		7.66	
2-3		8.64		7.44
3	**11.66**		**7.04**	
0-3		10.24		10.44
50 (Target)	**10.00**		**6.00**	

Table 5-2. Provide Overwintering Water Habitat for Fish

Based on 1938 through 1994 data, the DPR estimated an overall average sedimentation rate for the Cottonwood Island area of 0.46 inches per year, or 2.16 feet over 56 years. Sedimentation as stated in the DPR varies greatly throughout the Cottonwood Island project, with the majority of the sediment deposition occurring in Cottonwood Chute upstream of the causeway. The DPR estimate of the sedimentation rate in the lower portion of Cottonwood Chute, or near Transect C, was lower than the estimated overall average. This rate was estimated to be approximately 0.11 inches per year. In general, deep aquatic habitat depths in 1997 at project completion averaged 14.22 feet. In 2000, deep aquatic habitat depths averaged 11.66 feet. This equates to an average sedimentation rate of 10.24 inches per year.

The DPR estimate of the sedimentation rate in the middle portion of Cottonwood Chute, or near Transect J, was also lower than the estimated overall average. This rate was estimated to be approximately 0.16 inches per year. In general, chute excavation depths in 1997 at project completion averaged 9.65 feet. In 2000, deep aquatic habitat depths averaged 7.04 feet. This equates to an average sedimentation rate of 10.44 inches per year, which is essentially the same as that for Transect C.

A couple of factors may explain why the actual sedimentation rate of approximately 10.34 inches per year for both transects is higher than the estimated numbers. First, the deep

holes were excavated to a depth of approximately 15 feet, as illustrated in the O&M Manual on Plates 11 through 13. In essence, these holes were over-excavated to allow for sloughing of the vertical slopes. Therefore, it appears logical to assume that some of the chute bottom deposits are a result of the deep holes attempting to reach a stable condition or more gradual slope. Another factor that may explain the higher sedimentation rate is the occurrence of spring flood events. At high river levels, the causeway is overtopped, which carries sediment-laden water into the chute. According to the MDOC, the causeway was overtopped three times in the first two years following project completion. Both of these factors allow Cottonwood Chute to be more susceptible to sediment deposition.

In November 2000, the MDOC conducted an electrofishing survey in Cottonwood Chute. A water surface temperature of 53° Fahrenheit was recorded at the time of the sample. Secchi visibility was not measured, but water transparency was variable with distance along the chute from the mouth to the upper end. The upper end of the chute had a light coverage of duckweed and watermeal. The Mississippi River was estimated at one to two feet below normal pool elevation due to drought conditions at that time.

TABLE 5-3
Summary of Electrofishing Survey

Species	No.	Length Range (Inches)	Average Length (Inches)
Paddlefish	1	33.0	-
Bowfin	2	17.6 - 21.1	19.4
Gizzard shad	37	3.9 - 8.6	6.1
Grass carp	1	18.2	-
Common carp	29	17.0 - 27.2	20.8
Emerald shiner	2	1.5 - 1.8	1.7
River carpsucker	12	14.6 - 17.3	16.3
Quillback	1	14.1	-
Smallmouth buffalo	8	10.7 - 16.7	13.4
Bigmouth buffalo	16	13.2 - 20.8	16.0
Channel catfish	7	15.9 - 24.8	19.7
Brook silversides	1	2.8	-
White bass	4	12.8 - 14.5	13.6
Green sunfish	5	2.4 - 8.7	4.6
Orangespotted sunfish	6	2.0 - 3.0	2.5
Bluegill	93	1.8 - 6.6	4.3
Largemouth bass	69	3.1 - 13.8	5.8
White crappie	35	3.0 - 13.0	9.4
Black crappie	10	4.7 - 10.6	7.7
Hybrid sunfish	1	4.4	-

Table 5-3. Summary of Electrofishing Survey

A total of 340 fish were captured, representing 19 species and one hybrid. Two sampling runs along the portion of the chute where deep holes were constructed comprised nearly two-thirds of the effort and yielded nearly three-fourths of the catch.

A previous electrofishing survey was conducted by the MDOC in October 1998. This survey yielded 398 fish representing 20 species. When comparing the two surveys, fewer gizzard shad, carp, and white bass were found in 2000. The combination of these lower numbers with the absence of freshwater drum resulted in a decrease of the total count. However, the 2000 survey did contain more largemouth bass, bluegill, and white crappie. Most of the largemouth bass consisted of young-of-the-year and yearlings, causing the average length to be lower than in 1998.

The MDOC has expressed concerns about the construction of an impermeable causeway road and the effects this may have on fish numbers in Cottonwood Chute. Further monitoring of water quality parameters and fish numbers should determine these effects.

(2) Conclusions. The Cottonwood Island project is meeting the objective of providing overwintering water habitat for fish in areas where an ideal depth of 10 feet is desired as well as areas where an ideal depth of 6 to 10 feet is desired. 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 chute depths are not necessarily recorded in the exact same spot each time. While the data from the water quality stations give some idea of overwintering water habitat for fish, it is not their intended purpose. Therefore, future sedimentation transects based on the monitoring plan should provide more adequate data to better define overwintering water habitat for fish throughout the entire project area.

Average sedimentation rates are higher in the lower portion of Cottonwood Chute than estimated in the DPR. However, assuming sedimentation rates are linear is not appropriate in the early years of a project when the chute is relatively new and has not yet stabilized. The sedimentation rate should stabilize over time and may more closely approach the predicted number as the project ages.

Despite concerns about the higher average sedimentation rate in the lower portion of the chute, the project has increased the quality of fish habitat. Before the project, there was little fishery value in most areas along the chute. Results of the electrofishing surveys showed a decrease in overall fish numbers from 1998 to 2000, with the majority of this decline seen in the numbers of gizzard shad, carp, and white bass. However, there was an increase in largemouth bass, bluegill, and white crappie. Overall, the results of these investigations suggest a positive response by fisheries to chute and deep hole excavation.

6. EVALUATION OF MAIN CHANNEL BORDER REHABILITATION

a. Provide Flowing Water Habitat for Fish.

(1) Monitoring Results. One of the objectives for restoring main channel border habitat is to provide flowing water habitat for fish through wing dam notches. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain velocities of 0.35, 0.5, and 0.4 feet per second at the following locations; 100 feet upstream of the notch, at the notch, and 100 feet downstream of the notch, respectively.

During construction, several wing dams extending from Cottonwood Island were notched in an effort to restore main channel border habitat. It was anticipated that water velocity would increase downstream of the notch and create a scour hole, as was the case in Iowa DNR and Waterways Experiment Station studies referenced in Appendix I of the Cottonwood Island DPR. Appendix I (DPR) also discusses the use of a FastTABS model to estimate the effect of wing dam notches on velocity. However, the results of this FastTABS predicted that wing dam notches would have only a slight impact on velocity patterns.

TABLE 6-1.
Summary of Notch Velocities at Wing Dams

Year	100' U/S No. 6 (ft/s)	100' U/S No. 15 (ft/s)	At No. 6 (ft/s)	At No. 15 (ft/s)	100' D/S No. 6 (ft/s)	100' D/S No. 15 (ft/s)
0 (1997)	1.05	0.88	2.06	1.29	1.93	1.32
	0.97		1.67		1.62	
1 (1998)	1.68	1.33	2.18	1.57	1.80	1.64
	1.50		1.87		1.72	
2 (1999)	1.22	1.10	1.85	1.33	1.47	1.47
	1.16		1.59		1.47	
3 (2000)	0.57	0.51	1.24	0.77	0.81	0.60
	0.54		1.01		0.70	
0-3 (97-00)	1.28	1.06	1.99	1.35	1.69	1.40
	1.17		**1.67**		**1.54**	
50	**0.35**		**0.50**		**0.40**	

Table 6-1. Summary of Notch Velocities at Wing Dams

In an effort to determine the actual impact on this project, post-construction velocity measurements were taken on 21 occasions from June 1997 through September 2000 at Wing Dam Nos. 6 and 15. At each wing dam, velocity measurements were taken with a

Price meter at approximately 100 feet upstream from the notch, at the notch, and approximately 100 feet downstream from the notch. The results of these velocity measurements, including ancillary data, are found in Appendix E, Tables E-4 through E-9. A summary of individual notch velocities is illustrated in Appendix F, Table F-10.

As seen in Table 6-1, the overall average velocity 100 feet upstream from Wing Dam No. 6 was 1.3 feet per second. This value increased to 2.0 feet per second at the notch and then fell to 1.7 feet per second 100 feet downstream from the notch. At Wing Dam No. 15, the overall average velocity 100 feet upstream was 1.1 feet per second. This value increased to 1.4 feet per second at the notch and 1.4 feet per second 100 feet downstream from the notch. The velocity measurements observed do not support the FastTABS modeling results.

(2) Conclusions. Post-project measurements taken at Wing Dam Nos. 6 and 15 indicate that notching does have an impact on velocity. At both wing dams, average velocity measurements at the notch and 100 feet downstream from the notch were considerably higher than those observed 100 feet upstream. These findings tend to agree with the results of similar studies reported by the Iowa DNR and Waterways Experiment Station. The FastTABS modeling did not predict the observed velocity measurements. The FastTABS model appeared to have two flaws. First, the model did not show a concentration of flow into the notch. Instead, the discharge was distributed equally per unit length along the crest of the wing dam and across the notch. This could be because the flow grid prepared for the model should have been smaller not only in the notch, but also up and downstream from the notch. Because of this flaw, as the depth increased at the notch, the velocity decreased, and as the depth decreased downstream of the scour hole, the velocity increased to the upstream value. Secondly, the size of the scour hole was underestimated (in the model it was less than 50 feet long). This resulted in an underestimation of the amount of water flowing into the notch and scour hole. The actual scour hole could be considerably longer and deeper. Upon completion of sediment transect measurements, the actual size of the scour hole should be known.

b. Provide Additional Habitat and Substrate for Benthic and Aquatic Organisms.

(1) Monitoring Results. The other objective for restoring main channel border habitat is to provide additional habitat and substrate for benthic and aquatic organisms through rock placement below the wing dams. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain constant numbers of benthic and aquatic organisms. As part of the ancillary data for the velocity measurements, water depths were recorded. These water depths were used to analyze the scour depth downstream of the wing dams. The flat pool depths for both wing dams, as shown in Table 6-2, were determined by adjusting the channel depths recorded during site visits from June 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. To view individual channel depths for each site visit and the steps taken to adjust these values to depths relative to flat pool,

refer to Appendix F, Tables F-3 and F-8. A summary of individual scour depths is illustrated in Appendix F, Table F-9.

The average flat pool channel depth for Year 0 was used as the base line in determining scour depth. The overall average scour depth 100 feet downstream from Wing Dam No. 6 was 3.88 feet. At Wing Dam No. 15, the overall average scour velocity 100 feet downstream was 1.71 feet. As seen in Table 6-2, Wing Dams No. 6 and 15 achieved a scour depth greater than one foot by Years 2 and 3, respectively.

TABLE 6-2.
Summary of Notch Scour Depths 100' D/S of Wing Dams

Year	No. 6 Water Depth (feet)	No. 6 Scour Depth (feet)	No. 15 Water Depth (feet)	No. 15 Scour Depth (feet)
0	19.39		10.95	
0-1		1.39		0.21
1	20.78		11.16	
1-2		0.18		0.33
2	20.96		11.49	
2-3		2.31		1.17
3	23.27		12.66	
0-3		**3.88**		**1.71**

Table 6-2. Summary of Notch Scour Depths 100' D/S of Wing Dams

(2) Conclusions. With respect to Wing Dam No. 6 and No. 15, the Cottonwood Island project is meeting the goal of rehabilitating main channel border habitat by creating scour depths greater than or equal to 1 foot downstream from the notch. It could be assumed that these depths are representative of all notched wing dams but since the monitoring results were based solely on ancillary data collected at only two wing dams, it is not known for sure if this is indeed the case. In addition, the locations of the velocity measurements 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 ancillary data from the velocity measurements give some idea of scour depths, it is not their intended purpose. Therefore, future sedimentation transects based on the monitoring plan should provide more adequate data to better define scour depths and size for all of the notched wing dams. At both wing dams, average channel depths at the notch and 100 feet upstream from the notch essentially remained the same while those depths 100 feet downstream from the notch gradually increased. By the end of Year 3, both wing dams had scour depths greater than one foot. Cross sections are necessary downstream from the notches to determine the extent and size of these scour areas.

7. EVALUATION OF WETLAND HABITAT RESTORATION

a. Increase Food, Shelter, and Breeding Habitat for Wildlife

(1) Monitoring Results. One of the objectives for restoring wetland habitat is to increase food, shelter, and breeding habitat for wildlife through pothole creation. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a cross-sectional area (short chord) similar to that determined at project completion with some allowance for sedimentation. Pothole transects were conducted at project completion to reflect as-built conditions of the food, shelter, and breeding habitat. Since then, additional transects have not been completed. According to Table C-2 in Appendix C, pothole transects are only required every five years.

However, general comments regarding pothole use have been made by the MDOC. In particular, the MDOC Site Manager has not observed any pothole use by waterfowl. However, field observations indicate that these areas are receiving use by amphibians, particularly bullfrogs and possibly tree frogs, and are visited regularly by great blue herons. In addition, deer and turkey tracks are typically abundant around the perimeter of the potholes. In the past year, waterfowl surveys or any other type of scientific survey based on wildlife usage for Cottonwood Island have not been conducted. Waterfowl surveys are only performed every other year.

(2) Conclusions. Overall, the Cottonwood Island project is meeting the objective of increasing food, shelter, and breeding habitat for wildlife through pothole creation. Post–construction field observations have shown pothole use by various animals. Hopefully, future monitoring will show an increase in pothole use by waterfowl.

b. Increase Bottomland Hardwood Diversity and Quality

(1) Monitoring Results. The other objective for restoring wetland habitat is to increase bottomland hardwood diversity and quality through establishment of hardwood trees within the forest management unit. As shown in Appendix B, Table B-1, the Year 50 Target is to maintain a survival rate greater than or equal to 20%. Since project completion, a mast tree survey has not been completed. However, regular maintenance of the forest management units has been performed by the MDOC Site Manager. During the year 2000, the mast tree planting sites were mowed twice. In addition, the MDOC is planning to conduct a survival survey in Spring 2001 when the trees begin to turn green again. Due to manpower constraints, a survival survey was not completed in Fall 2000.

(2) Conclusions. Continual maintenance and further monitoring of the forest management units will determine if the objective of increasing hardwood diversity and quality is being met. A discussion on mast tree survival rate shall be included in the next PER scheduled for March 2002.

8. OPERATION AND MAINTENANCE SUMMARY

a. Operation. The Cottonwood Island project has no general operating requirements.

b. Maintenance.

(1) Inspections. The MDOC has visited the Cottonwood Island project on various occasions since project completion.

(2) Maintenance Based on Inspections. The MDOC has not observed any waste materials or unauthorized structures within the project area. In addition, the access control remains in place. Therefore, no maintenance has been required since project completion.

9. CONCLUSIONS AND RECOMMENDATIONS

a. Project Goals, Objectives, and Management Plan. Based on data and observations collected since project completion, the goals and objectives evaluated for the Cottonwood Island project are being met, as illustrated in Table 9-1. Since this is the first performance evaluation report, continued data collection should better define the levels to which all goals and objectives are being met.

TABLE 9-1
Project Goals and Objectives

Goals	Objectives	Project Features	Unit	Year 3 (2000)	Year 50 Target	Status
Restore Aquatic Over-wintering Habitat	Improve water quality for fish	Chute restoration & enhancement	Mg/L D.O.	11.36 [1/]	5	Met
	Provide overwintering water habitat for fish	Create deep holes	Fish count	340	--	Met
		(6' ≤ Depth ≤ 10')	Acre	4.5 [3/]	4.5	Met
		(Depth ≥ 10')	Acre/hole	0.3 [3/]	0.3	Met
Restore Main Channel Border Habitat	Provide flowing water habitat for fish	Notch wing dams				
		(100' upstream)	Ft/s	1.17	0.35	Met
		(at wing dam)	Ft/s	1.67	0.5	Met
		(100' downstream)	Ft/s	1.54	0.4	Met
		(scour depth ≥ 1')	Ft^2	0 [3/]	--	--
	Provide additional habitat & substrate for benthic & aquatic organisms	Rock placement below wing dams	Organism numbers	-- [3/]	--	--
Restore Wetland Habitat	Increase food, shelter, & breeding habitat for wildlife	Potholes				
		(water surface area)	Ft^2	-- [3/]	--	--
		(cross sectional area)	Ft^2	850 [2/ 3/]	--	--
	Increase bottomland hardwood diversity & quality	Establish hardwood trees in selected areas				
		(survival rate)	%	100 [3/]	20	Met
		(basal area)	Ft^2	2.14 [3/]	2.14	Met
		(crown area)	Ft^2	54.0 [3/]	54.0	Met

Table 9-1. Project Goals and Objectives

[1/] This value is an average concentration

[2/] Cross sectional area is average of all potholes using short chord below elevation 475 feet MSL

[3/] This number reflects that summarized at project completion 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. In general, monitoring efforts for the Cottonwood Island 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.

TABLE 9-2
Project Goals and Objectives (revised for this PER only)

Goals	Objectives	Project Features	Unit	Year 3 (2000)	Year 50 Target	Status
Restore Aquatic Over-wintering Habitat	Improve water quality for fish	Chute restoration & enhancement	Mg/L D.O.	11.36 [1/]	5	Met
	Provide overwintering water habitat for fish	Create deep holes	Fish count	340	--	Met
		(6' ≤ Depth ≤ 10')	**Feet**	7.04	**6**	Met
		(Depth ≥ 10')	**Feet**	11.66	**10**	Met
Restore Main Channel Border Habitat	Provide flowing water habitat for fish	Notch wing dams				
		(100' upstream)	Ft/s	1.17	0.35	Met
		(at wing dam)	Ft/s	1.67	0.5	Met
		(100' downstream)	Ft/s	1.54	0.4	Met
		(scour depth ≥ 1')	**Feet**	2.8	**1**	Met
	Provide additional habitat & substrate for benthic & aquatic organisms	Rock placement below wing dams	Organism numbers	-- [3/]	--	--
Restore Wetland Habitat	Increase food, shelter, & breeding habitat for wildlife	Potholes				
		(water surface area)	Ft^2	-- [3/]	--	--
		(cross sectional area)	Ft^2	850 [2/ 3/]	--	--
	Increase bottomland hardwood diversity & quality	Establish hardwood trees in selected areas				
		(survival rate)	%	100 [3/]	20	Met
		(basal area)	Ft^2	2.14 [3/]	2.14	Met
		(crown area)	Ft^2	54.0 [3/]	54.0	Met

Table 9-2. Project Goals and Objectives (revised for this PER only)
[1/] This value is an average concentration
[2/] Cross sectional area is average of all potholes using short chord below elevation 475 feet MSL
[3/] This number reflects that summarized at project completion since sedimentation transects are only required every five years – the next round of transects should be completed in 2002

For this PER only, a revised table was developed in order to quantify and evaluate certain project objectives. Since additional sediment transects have not been completed post-

construction, the following objectives were evaluated based on depth in feet rather than area in acres, provide overwintering water habitat for fish and provide flowing water habitat for fish. As a result, the "Unit" and "Year 50 Target" columns were modified. These objectives and their modified performance evaluation parameters are highlighted in Table 9-2.

(1) Improve Water Quality for Fish. Due to expressed concerns by the MDOC about the construction of an impermeable causeway road and the associated effects this may have on fish numbers in Cottonwood Chute, a detailed analysis of DO concentrations to note any extreme changes just downstream of this area should be included in the next PER. In addition, any related observations of fish stress or kills should be recorded in the MDOC Site Manager's project inspection report.

(2) Provide Overwintering Water Habitat for Fish. It is not only apparent for the Cottonwood Island 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 chute becomes stabilized and sedimentation rates begin to level off. If this is indeed the case, then it seems practical to conduct sediment 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.

c. Project Operation and Maintenance. Project operation and maintenance has been conducted in accordance with the O&M Manual. There are no operational requirements attached to the Cottonwood Island project. Annual project inspections by the MDOC have resulted in proper corrective maintenance actions.

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

(1) Causeway. The intent of raising the causeway was to reduce flow through Cottonwood Chute except during high river levels. If the average DO concentration falls below the Year 50 Target and as a result, fish kills are observed, then the option of rehabilitation may be considered. Any decision would be carried forth only upon written mutual agreement between the Corps, USFWS, and MDOC. Included within this agreement would be a description of the agreed-upon course of action and funding responsibilities, if any. The likely course of action would be to replace the existing rock in the causeway with a larger stone.

APPENDIX A

ACRONYMS

ACRONYMS

CEMVR	Corps of Engineers, Mississippi Valley Division, Rock Island District
DO	Dissolved Oxygen
DNR	Department of Natural Resources
DPR	Definite Project Report
EMP	Environmental Management Program
ER	Engineer Regulation
FMA	Forest Management Areas
HREP	Habitat Rehabilitation and Enhancement Project
LTRMP	Long-Term Resource Monitoring Program
MDOC	Missouri Department of Conservation
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

Goal	Objective	Enhancement Feature	Unit	Year 0 (1997) Without Project	Year 0 (1997) With Project	Year 3 (2000) With Project	Year 50 (2047) Target With Project	Feature Measurement	Annual Field Observations by MDOC Site Manager
Restore Aquatic Over-wintering Habitat	Improve water quality for fish	Chute restoration and enhancement	Mg/L D.O.	<5	>5	11.36 [1/]	5	Perform water quality tests at stations	Describe presence of fish stress or kills
	Provide overwintering water habitat for fish	Create deep holes	Fish count	--	--	340	--	Electrofishing, netting	Qualitative observations
		(6' ≤ Depth ≤ 10')	Acre	1.9	4.5	4.5 [3/]	4.5	Sediment transects	Describe presence or absence of debris snags, chute sedimentation, or vegetation
		(Depth ≥ 10')	Acre/hole	0	0.3	0.3 [3/]	0.3	Sediment transects	
Restore Main Channel Border Habitat	Provide flowing water habitat for fish	Notch wing dams							
		(100' upstream)	Ft/s	0.3	0.35	1.17	0.35	Velocity measurements	Describe presence or absence of debris snags, channel sedimentation, or vegetation
		(at wing dam)	Ft/s	1.0	0.5	1.67	0.5	Velocity measurements	
		(100' downstream)	Ft/s	0.3	0.4	1.54	0.4	Velocity measurements	
		(scour area ≥ 1')	Ft^2	0	0	0 [3/]	--	Sediment transects	
	Provide additional habitat & substrate for benthic & aquatic organisms	Rock placement below wing dams	Organism numbers	--	--	-- [3/]	--	Substrate evaluation	Qualitative observations
Restore Wetland Habitat	Increase food, shelter, & breeding habitat for wildlife	Potholes							
		(water surface area)	Ft^2	0	--	-- [3/]	--	Sediment transects	Areal survey of wildlife use, vegetation types, and density a well as invertebrate studies
		(cross sectional area)	Ft^2	0	850 [2/]	850 [2/ 3/]	--	Sediment transects	
	Increase bottomland hardwood diversity & quality	Establish hardwood trees in selected areas							Estimate effective acreage and wildlife use
		(survival rate)	%	0	100	100 [3/]	20	Tree count	
		(basal area)	Ft^2	0	2.14	2.14 [3/]	2.14	Random sample	
		(crown area)	Ft^2	0	54.0	54.0 [3/]	54.0	Random sample	Presence or absence of mast

Table B-1. Post Construction Evaluation Plan

[1/] This value is an average concentration

[2/] Cross sectional area is average of all five potholes using short chord below elevation 475 feet MSL

[3/] This number reflects that summarized at project completion since sedimentation transects are only required every five years

TABLE B-2
Sedimentation Transect Project Objectives Evaluation

Transect	Project Objectives to Be Evaluated			
	Improve Water Quality for Fish	**Provide Overwintering Water Habitat for Fish**	**Provide Flowing Water Habitat for Fish**	**Increase Food, Shelter, and Breeding Habitat for Wildlife**
Cottonwood Chute				
(A)	X			
(B)	X			
(C)	X	X		
(D)	X	X		
(E)	X	X		
(F)	X	X		
(G)	X			
(H)	X			
(I)	X			
(J)	X			
Wing Dam Notches [1/]			X	
Potholes				
(1a)				X
(1b)				X
(2a)				X
(2b)				X
(3a)				X
(3b)				X
(4a)				X
(4b)				X
(5a)				X
(5b)				X

Table B-2. Sedimentation Transect Project Objectives Evaluation

[1/] Bathymetric mapping of the dike field as water levels permit

APPENDIX C

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

TABLE C-1
Monitoring and Performance Evaluation Matrix

Project Phase	Type of Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Implementation Instructions
Pre-Project	Sedimentation Problem Analysis	System-wide problem definition; evaluates planning assumptions	USGS	USGS	LTRMP	--
	Pre-Project Monitoring	Identifies and defines problems at HREP site; establishes need of proposed project features	MDOC	MDOC	MDOC	--
	Baseline Monitoring	Establishes baselines for performance evaluation	Corps	Corps / MDOC	HREP / MDOC	See Table C-2
Design	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
Construction	Construction Monitoring	Assesses construction impacts; assures permit conditions are met	Corps	Corps	HREP	See State Sectio 401 Stipulations
Post-Construction	Performance Evaluation Monitoring	Determines success of project as related to objectives	Corps / MDOC	Corps / MDOC	HREP / MDOC	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	--

able C-1. Monitoring and Performance Evaluation Matrix

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

e surement	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								
NT MEASUREMENTS														
er Quality Stations [2/]													Corps	
rbidity			2W	M	2W	M								
cchi Disk Transparency	2W		2W	M	2W	M								
spended Solids	2W		2W	M	2W	M								
ssolved Oxygen	2W		2W	M	2W	M								
ecific Conductance	2W		2W	M	2W	M								
ter Temperature	2W		2W	M	2W	M								
	2W		2W	M	2W	M								
tal Alkalinity	--		2W	M	2W	M								
lorophyll	2W		2W	M	2W	M								
locity	--		2W	M	2W	M								
ter Depth	2W		2W	M	2W	M								
ter Elevation	2W		2W	M	2W	M								
rcent Ice Cover				M		M								
Depth				M		M								
rcent Snow Cover				M		M								
ow Depth				M		M								
nd Direction			2W	M	2W	M								
nd Velocity			2W	M	2W	M								
ve Height			2W	M	2W	M								
Temperature			2W	M	2W	M								
rcent Cloud Cover			2W	M	2W	M								
lk Sediment Sampling [3/]			1											
mn Settling Stations [4/]													Corps	
lumn Settling Analysis								1						
ng Stations [5/]													Corps	
otechnical Borings								1						
Stations [6/]													MDOC	
ctrofishing												2Y		
oles [7/]													MDOC	
terfowl / Wading Bird Use												2Y		

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

e surement	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 [8/]													Corps	
drographic Soundings							1		5Y					
tholes									5Y					
A MEASUREMENTS														
t Tree Survey [9/]													Corps	
e Count												5Y		
ping [10/]													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 Plate 3 in Appendix J for Monitoring Plan

[2/] Water Quality Stations

W-M328.7B
W-M329.3B

[3/] Bulk Sediment Stations (Design Phase)

E-M330.1A
E-M328.7B
E-M329.6A

[4/] Column Settling Stations (Design Phase)

Station Code	Boring Number
C-M330.4A	C-94-2, EMP #1
C-M329.2A	C-94-2, EMP #2

[5/] Boring Stations (Design Phase)

Station Code	Boring Number	Date
C-M330.4A	C-94-1	02-08-94
C-M329.2A	C-94-2	02-08-94
B-M330.8D	C-94-3	11-29-94
B-M330.7C	C-94-4	11-30-94
B-M329.7A	C-94-5	11-30-94
B-M330.0H	C-94-6	11-30-94
B-M330.2H	C-94-7	11-30-94
B-M330.5H	C-94-8	12-01-94
B-M330.5B	C-94-9	12-01-94
B-M330.3D	C-94-10	12-01-94
B-M330.5M	C-94-11	12-01-94
B-M330.8H	C-94-12	12-01-94
B-M328.7B	C-95-1	12-05-95
B-M328.9B	C-95-2	12-05-95
B-M329.2B	C-95-3	12-05-95

[6/] Fish Stations - Monitor overwintering and midsummer use of side channel and deep holes

[7/] Potholes – Monitor waterfowl / wading bird use

[8/] Sedimentation Transects (Pre-Project Phase)

Station Code	to	Station Code
S-M328.7A		S-M328.7C
S-M329.2A		S-M329.2B
S-M329.5A		S-M329.5C
S-M330.0G		S-M330.0I
S-M330.2A		S-M330.2B
S-M330.2H		S-M330.2I
S-M330.6D		S-M330.6D
S-M330.7B		S-M330.7D
S-M330.9D		S-M330.9E

Sedimentation Transects (Post-Construction Phase) – See Table B-2 for Sediment Transect Project Objectives Evaluation

[9/] Mast Tree Survey (Post-Construction Phase) – Test of treatment effects for alternative exclusion methods shall be evaluated by an analysis of variance for tree growth

[10/] Mapping (Post-Construction Phase)

APPENDIX D

COOPERATING AGENCY CORRESPONDENCE

APPENDIX E

WATER QUALITY DATA

TABLE E-1
Pre-Project Monitoring Results at Station W-M328.7B

Date	Water Depth (m)	Velocity (ft/s)	Water Temp (^{o}C)	DO (mg/L)	pH (SU)	Chlorophyll a (mg/m^{3})
4/7/92	1.97	*	11.4	10.96	7.97	19.0
5/5/92	3.23	0.22	15.8	8.56	8.18	15.0
5/19/92	1.92	0.09	26.6	15.10	8.92	40.0
7/23/92	2.04	0.06	26.5	8.96	8.22	37.0
8/13/92	1.78	0.05	25.1	4.52	7.55	33.0
8/27/92	1.80	0.17	24.7	2.96	7.52	20.7
9/17/92	1.84	0.27	23.8	6.11	*	21.9
10/27/92	1.74	0.11	13.7	8.62	7.95	67.8
11/24/92	3.40	0.24	5.7	*	7.88	29.1
1/25/93	1.98	0.00	0.7	11.30	8.35	20.8
10/27/93	2.03	0.12	12.3	5.78	7.95	43.4
11/10/93	1.89	0.13	6.7	20.40	8.98	8.2
2/8/94	1.51	0.00	0.4	9.92	8.04	45.2
3/23/94	2.21	0.13	11.0	9.63	8.17	38.0
4/19/94	2.07	0.08	18.3	12.34	8.69	110.0
5/10/94	2.55	0.05	17.7	7.62	7.42	17.0
5/24/94	1.95	0.08	26.1	7.14	7.91	15.0
6/14/94	1.34	0.12	29.8	6.70	8.02	14.0
7/7/94	1.84	*	29.8	8.69	8.24	29.0
7/19/94	1.87	0.14	30.3	9.35	8.21	33.0
8/9/94	1.52	0.00	29.1	12.94	8.81	56.0
8/30/94	1.62	0.15	25.8	8.81	8.19	86.0
9/13/94	1.52	0.07	26.1	12.03	8.63	96.0
10/4/94	1.65	0.00	21.2	10.42	8.46	53.0
10/25/94	1.46	0.22	14.0	8.46	8.48	18.0
12/6/94	1.71	0.13	5.5	11.48	8.23	16.0
1/10/95	1.48	0.00	0.3	17.70	8.90	44.0
2/15/95	1.43	0.01	1.7	20.70	*	65.0
3/14/95	1.60	0.15	14.0	22.70	9.03	**
4/11/95	3.72	0.16	6.4	9.74	7.84	8.9
5/2/95	3.35	0.33	13.7	7.76	8.38	20.0
5/16/95	3.23	0.88	17.9	7.70	7.72	4.0
6/13/95	2.36	0.05	24.7	6.72	7.97	8.1
7/11/95	1.74	*	30.6	9.75	8.38	24.0
7/25/95	1.62	0.00	31.6	14.31	8.63	51.0
8/29/95	1.77	*	32.8	12.99	8.59	31.0
9/12/95	1.68	0.00	23.0	8.39	*	34.0
9/27/95	1.69	0.00	18.9	12.62	*	31.0
10/10/95	1.86	0.00	18.2	9.53	8.26	12.0
10/24/95	1.52	0.00	11.8	7.87	8.10	16.0
11/7/95	1.89	0.16	6.3	8.46	8.00	9.8
MIN	**1.34**	0.00	0.3	2.96	7.42	4.0
MAX	3.72	0.88	32.8	22.70	9.03	110.0
AVG	1.98	0.12	17.8	10.39	-	33.5

Table E-1. Pre-Project Monitoring Results at Station W-M328.7B

TABLE E-2
Post-Project Monitoring Results at Station W-M328.7B

Date	Water Depth (m)	Velocity (ft/s)	Water Temp (^{o}C)	DO (mg/L)	pH (SU)	Chlorophyll a (mg/m^{3})
12/23/97	4.42	0.00	2.6	17.44	*	18.0
1/27/98	4.63	0.00	1.5	12.41	8.19	11.0
2/24/98	4.50	*	7.3	10.76	8.13	18.0
3/24/98	4.80	0.06	5.7	11.17	6.79	7.5
6/3/98	4.48	0.15	22.9	4.67	7.49	11.0
7/2/98	6.28	0.12	29.8	5.99	7.57	4.4
7/14/98	5.65	0.05	29.0	7.20	7.90	6.7
7/28/98	4.34	0.00	29.6	13.90	8.44	42.0
8/13/98	4.11	0.14	27.9	9.13	8.20	59.0
8/25/98	4.18	0.11	30.6	11.95	8.53	93.0
9/10/98	3.98	0.05	26.6	8.92	8.14	33.0
9/29/98	4.34	0.12	24.2	6.30	7.28	34.0
12/29/98	3.90	0.00	1.6	21.26	8.40	52.0
1/28/99	4.33	0.00	0.7	13.65	7.90	2.9
2/25/99	4.19	0.00	4.6	19.18	8.80	54.0
3/23/99	4.11	0.10	9.9	19.68	9.00	80.0
5/27/99	6.37	0.40	20.3	7.48	7.32	4.9
6/22/99	4.88	0.08	26.8	9.29	8.20	19.0
7/8/99	4.07	0.20	31.2	10.19	8.50	26.0
7/27/99	4.37	0.00	34.3	16.65	8.90	120.0
8/10/99	3.96	0.11	29.6	13.42	8.60	54.0
8/24/99	3.90	*	25.5	7.07	8.10	45.0
9/8/99	3.78	**	26.4	10.04	8.40	33.0
9/21/99	3.88	**	20.7	7.40	8.00	27.0
2/8/00	3.80	0.00	2.9	23.08	8.70	70.0
3/7/00	3.95	0.10	13.8	10.53	8.00	31.0
5/31/00	3.77	0.08	27.4	7.51	8.10	14.0
6/15/00	4.74	-	27.4	9.33	8.40	17.0
7/6/00	4.78	-	29.6	11.03	8.40	22.0
7/25/00	3.97	-	27.8	12.24	8.50	34.0
8/8/00	3.55	-	26.2	5.75	7.80	6.2
8/22/00	3.95	-	28.6	11.66	8.70	28.0
9/5/00	3.75	-	27.8	8.98	8.20	45.0
9/19/00	3.62	-	23.6	10.81	8.30	74.0
MIN	3.55	0.00	0.7	4.67	6.79	2.9
MAX	6.37	0.40	34.3	23.08	9.00	120.0
AVG	4.33	0.08	20.7	11.36	-	35.2

Table E-2. Post-Project Monitoring Results at Station W-M328.7B
* = Meter malfunction ** = Too windy

TABLE E-3
Post-Project Monitoring Results at Station W-M329.3B

Date	Water Depth (m)	Velocity (ft/s)	Water Temp (^{o}C)	DO (mg/L)	pH (SU)	Chlorophyll a (mg/m^{3})
12/23/97	3.05	0.00	3.6	14.30	*	18.0
1/27/98	3.03	0.00	2.1	13.68	8.08	17.0
2/24/98	3.32	*	7.4	12.45	8.15	15.0
3/24/98	2.99	0.00	6.5	9.53	6.77	7.7
6/3/98	3.35	0.07	22.7	3.55	7.35	22.0
7/2/98	5.04	0.22	26.4	5.18	7.46	8.0
7/14/98	4.57	0.00	27.8	5.51	7.71	4.3
7/28/98	2.85	0.00	33.9	>20	8.75	78.0
8/13/98	2.88	0.11	28.3	8.71	8.03	110.0
8/25/98	3.25	0.00	28.8	2.41	7.64	24.0
9/10/98	-	**	27.8	14.39	8.49	129.0
9/29/98	2.70	0.10	24.0	6.60	7.44	150.0
12/29/98	2.70	0.00	3.0	21.13	8.80	50.0
1/28/99	3.14	0.00	1.0	11.99	7.80	7.1
2/25/99	2.73	0.00	6.5	18.75	8.90	32.0
3/23/99	2.94	0.00	11.4	20.13	9.00	81.0
5/27/99	5.09	0.59	20.0	7.57	7.53	4.8
6/22/99	3.69	0.16	25.6	7.82	8.20	12.0
7/8/99	2.71	0.21	34.0	13.92	8.70	52.0
7/27/99	2.94	0.00	34.6	19.27	8.60	210.0
8/10/99	2.53	0.00	28.0	11.19	8.60	53.0
8/24/99	2.27	*	25.1	7.06	8.10	85.0
9/8/99	2.44	**	25.9	8.61	8.30	28.0
9/21/99	2.30	0.00	18.8	5.65	7.80	39.0
2/8/00	2.27	0.00	3.0	9.50	7.70	16.0
3/7/00	2.60	0.10	16.1	8.90	7.90	85.0
5/31/00	2.47	0.03	31.0	12.02	8.50	47.0
6/15/00	3.95	-	28.8	9.85	8.50	9.0
7/6/00	3.70	-	28.5	9.70	8.00	69.0
7/25/00	2.44	-	29.6	>20	9.00	430.0
8/8/00	2.30	-	26.7	6.48	8.00	9.0
8/22/00	2.05	-	30.4	16.20	8.90	46.0
9/5/00	2.16	-	29.1	8.87	8.20	43.0
9/19/00	2.19	-	24.8	14.80	8.70	190.0
MIN	2.05	0.00	1.0	2.41	6.77	4.3
MAX	5.09	0.59	34.6	21.13	9.00	430.0
AVG	2.99	0.07	21.2	10.80	-	64.1

Table E-3. Post-Project Monitoring Results at Station W-M329.3B
* = Meter malfunction ** = Too windy

FIGURE E-1. Post-Project Dissolved Oxygen Concentrations Collected with Continuous Monitors Near the Surface and Bottom at Station W-M328.7B (February 25, 1999 - March 23, 1999)

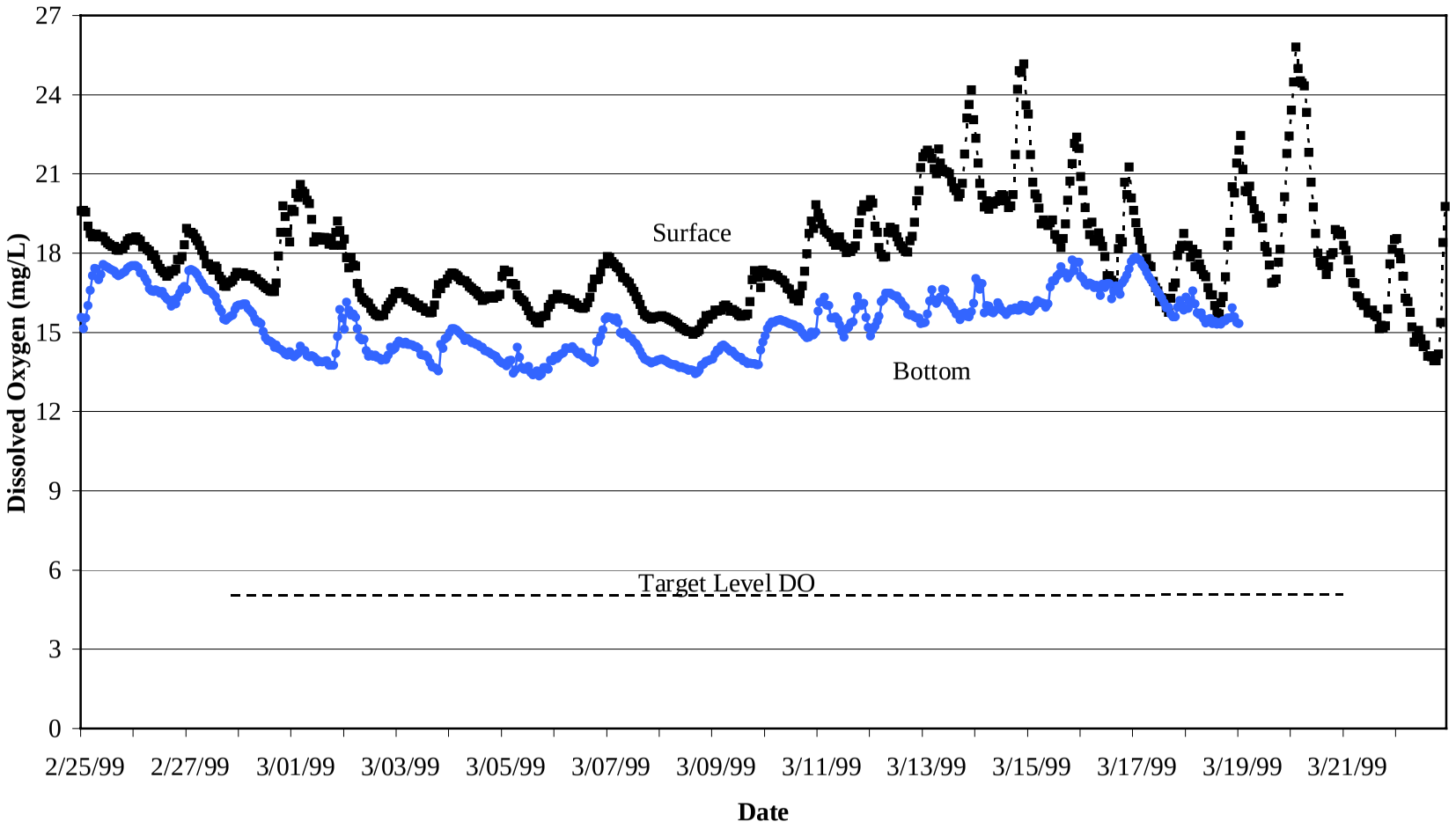

Figure E-1. Monitoring Results at Station W-M328.7B during Winter 1999

FIGURE E-2. Post-Project Dissolved Oxygen Concentrations Collected with Continuous Monitors Near the Surface and Bottom at Station W-M328.7B (July 25, 2000 - August 8, 2000)

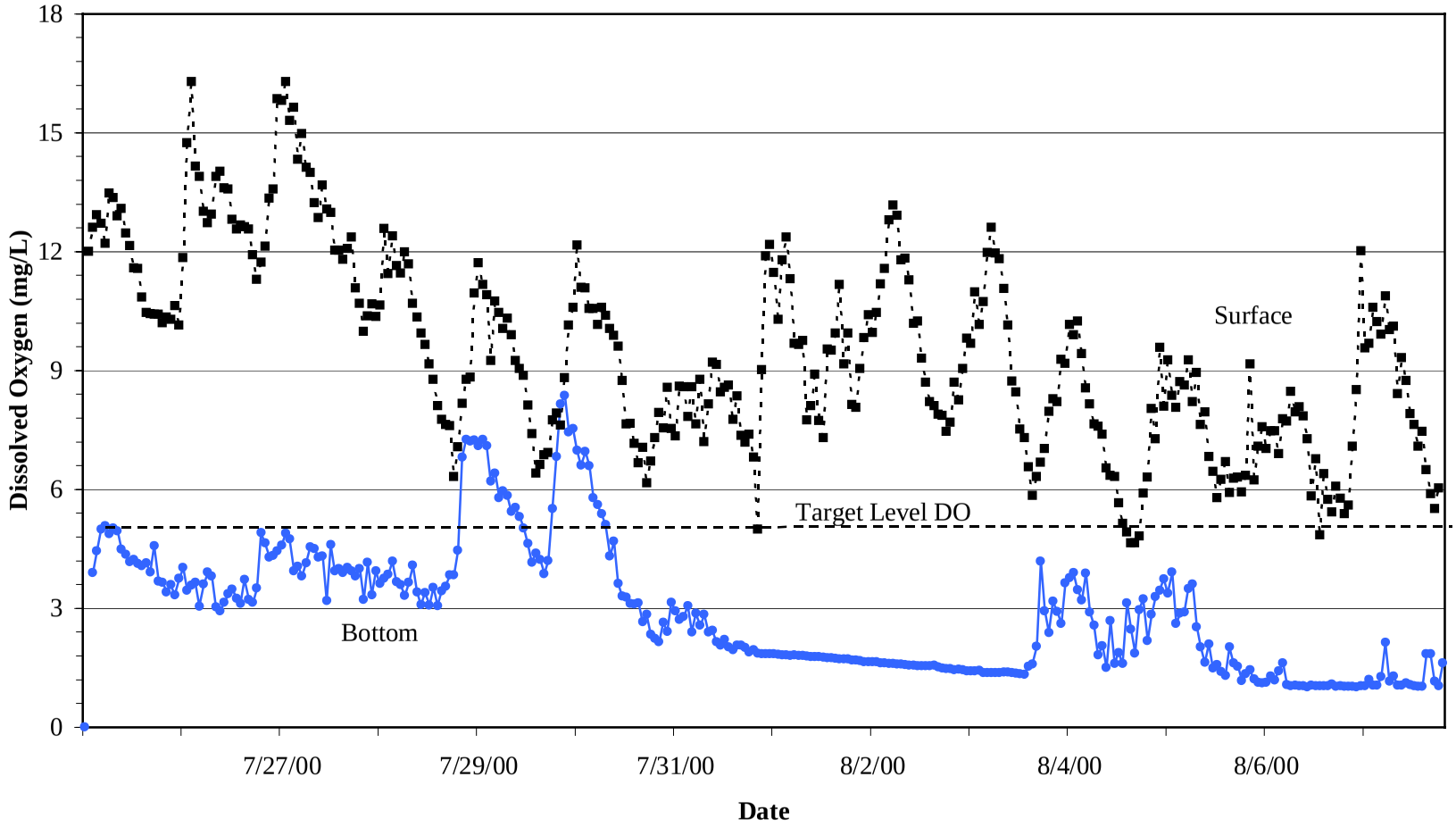

Figure E-2. Monitoring Results at Station W-M328.7B during Summer 2000

TABLE E-4
Post-Project Monitoring Results 100' U/S Notch in Wing Dam No. 6

Date	Air Temp (°C)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Water Depth (m)	Wave Height (cm)	Velocity (ft/s)
6/18/97	30	6	NW	15	2.225	9	1.078
7/2/97	28	7	NW	0	2.103	9	1.456
7/17/97	31	6	S	35	2.103	6	1.217
7/31/97	26	3	SE	40	2.164	6	1.364
8/19/97	18	8	E	100	2.195	6	0.846
9/3/97	20	7	NE	35	1.951	9	0.618
9/25/97	18	2	NW	0	2.225	3	0.785
6/3/98	15	13	N	95	2.667	12	1.655
7/2/98	29	4	NE	35	2.835	6	4.229
7/14/98	31	8	S	90	-	12	3.235
7/28/98	29	2	S	5	2.819	6	1.525
8/13/98	26	2	N	80	2.423	3	1.269
8/25/98	29	8	N	45	2.164	12	0.785
9/10/98	27	6	SE	0	1.951	9	0.409
9/29/98	21	8	S	95	1.920	9	0.366
7/8/99	-	-	-	-	3.002	9	1.977
8/10/99	-	-	-	-	2.499	9	1.610
9/8/99	-	-	-	-	2.408	24	0.728
9/21/99	-	-	-	-	2.420	12	0.574
9/5/00	-	-	-	-	2.800	15	0.431
9/19/00	-	-	-	-	2.850	13	0.704
MIN	15	2	-	0	1.920	3	0.366
MAX	31	13	-	100	3.002	24	4.229
AVG	25	6	-	45	2.386	10	1.279

Table E-4. Post-Project Monitoring Results 100' U/S Notch in Wing Dam No. 6

TABLE E-5
Post-Project Monitoring Results at Notch in Wing Dam No. 6

Date	Air Temp (°C)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Water Depth (m)	Wave Height (cm)	Velocity (ft/s)
6/18/97	30	6	NW	15	3.018	9	1.361
7/2/97	28	7	NW	0	3.795	9	3.135
7/17/97	31	6	S	35	2.865	6	2.359
7/31/97	26	3	SE	40	2.957	6	2.521
8/19/97	18	8	E	100	2.728	3	1.874
9/3/97	20	7	NE	35	3.414	6	1.392
9/25/97	18	2	NW	0	3.399	3	1.764
6/3/98	15	13	N	95	3.246	9	2.468
7/2/98	29	4	NE	35	4.755	6	2.682
7/14/98	31	8	S	90	-	15	3.100
7/28/98	29	2	S	5	3.536	6	3.073
8/13/98	26	2	N	80	2.972	3	2.359
8/25/98	29	8	N	45	3.277	9	1.719
9/10/98	27	6	SE	0	2.728	15	1.016
9/29/98	21	8	S	95	3.825	12	0.993
7/8/99	-	-	-	-	-	24	2.326
8/10/99	-	-	-	-	2.301	6	3.135
9/8/99	-	-	-	-	3.536	21	1.810
9/21/99	-	-	-	-	3.020	9	0.145
9/5/00	-	-	-	-	3.040	9	0.873
9/19/00	-	-	-	-	3.545	15	1.614
MIN	15	2	-	0	2.301	3	0.145
MAX	31	13	-	100	4.755	24	3.135
AVG	25	6	-	45	3.261	10	1.987

Table E-5. Post-Project Monitoring Results at Notch in Wing Dam No. 6

TABLE E-6
Post-Project Monitoring Results 100' D/S Notch in Wing Dam No. 6

Date	Air Temp (°C)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Water Depth (m)	Wave Height (cm)	Velocity (ft/s)
6/18/97	30	6	NW	15	5.532	12	1.354
7/2/97	28	7	NW	0	5.974	9	3.046
7/17/97	31	6	S	35	5.913	15	2.013
7/31/97	26	3	SE	40	6.523	12	2.669
8/19/97	18	8	E	100	6.706	6	2.125
9/3/97	20	7	NE	35	5.639	6	1.673
9/25/97	18	2	NW	0	6.797	3	0.602
6/3/98	15	13	N	95	6.629	12	1.891
7/2/98	29	4	NE	35	6.614	12	3.581
7/14/98	31	8	S	90	4.877	9	2.071
7/28/98	29	2	S	5	6.553	3	1.310
8/13/98	26	2	N	80	7.803	6	2.729
8/25/98	29	8	N	45	6.340	9	1.460
9/10/98	27	6	SE	0	5.944	9	0.669
9/29/98	21	8	S	95	6.325	9	0.696
7/8/99	-	-	-	-	5.700	21	1.914
8/10/99	-	-	-	-	6.888	6	2.348
9/8/99	-	-	-	-	6.126	15	1.491
9/21/99	-	-	-	-	7.050	12	0.140
9/5/00	-	-	-	-	7.310	12	0.863
9/19/00	-	-	-	-	7.130	13	0.747
MIN	15	2	-	0	4.877	3	0.140
MAX	31	13	-	100	7.803	21	3.581
AVG	25	6	-	45	6.399	10	1.685

Table E-6. Post-Project Monitoring Results 100' D/S Notch in Wing Dam No. 6

TABLE E-7
Post-Project Monitoring Results 100' U/S Notch in Wing Dam No. 15

Date	Air Temp (°C)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Water Depth (m)	Wave Height (cm)	Velocity (ft/s)
6/18/97	30	6	NW	15	1.478	9	0.937
7/2/97	28	7	NW	0	1.463	12	1.132
7/17/97	31	6	S	35	1.494	6	0.993
7/31/97	26	3	SE	40	1.737	9	1.132
8/19/97	18	8	E	100	2.195	6	0.846
9/3/97	20	7	NE	35	1.265	15	0.528
9/25/97	18	2	NW	0	1.311	3	0.581
6/3/98	15	13	N	95	1.737	15	1.418
7/2/98	29	4	NE	35	4.633	6	2.851
7/14/98	31	8	S	90	3.109	9	2.648
7/28/98	29	2	S	5	1.494	3	1.273
8/13/98	26	2	N	80	1.509	6	0.973
8/25/98	29	8	N	45	1.615	18	0.645
9/10/98	27	6	SE	0	1.494	9	0.492
9/29/98	21	8	S	95	1.600	6	0.300
7/8/99	-	-	-	-	2.179	9	1.936
8/10/99	-	-	-	-	1.814	9	1.375
9/8/99	-	-	-	-	1.478	24	0.675
9/21/99	-	-	-	-	1.480	21	0.419
9/5/00	-	-	-	-	1.620	18	0.501
9/19/00	-	-	-	-	1.620	5	0.515
MIN	15	2	-	0	1.265	3	0.300
MAX	31	13	-	100	4.633	24	2.851
AVG	25	6	-	45	1.825	11	1.056

Table E-7. Post-Project Monitoring Results 100' U/S Notch in Wing Dam No. 15

TABLE E-8
Post-Project Monitoring Results at Notch in Wing Dam No. 15

Date	Air Temp (°C)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Water Depth (m)	Wave Height (cm)	Velocity (ft/s)
6/18/97	30	6	NW	15	3.094	12	1.467
7/2/97	28	7	NW	0	2.850	15	1.810
7/17/97	31	6	S	35	3.078	12	1.358
7/31/97	26	3	SE	40	3.307	12	1.378
8/19/97	18	8	E	100	2.896	9	1.357
9/3/97	20	7	NE	35	2.606	12	0.789
9/25/97	18	2	NW	0	3.033	3	0.877
6/3/98	15	13	N	95	2.896	12	1.641
7/2/98	29	4	NE	35	5.822	6	2.608
7/14/98	31	8	S	90	4.343	15	2.810
7/28/98	29	2	S	5	2.576	3	1.596
8/13/98	26	2	N	80	2.667	6	1.477
8/25/98	29	8	N	45	2.941	15	1.132
9/10/98	27	6	SE	0	2.560	6	0.627
9/29/98	21	8	S	95	2.454	6	0.630
7/8/99	-	-	-	-	2.804	9	1.624
8/10/99	-	-	-	-	2.835	9	1.837
9/8/99	-	-	-	-	2.377	21	1.124
9/21/99	-	-	-	-	2.600	18	0.730
9/5/00	-	-	-	-	2.800	16	0.550
9/19/00	-	-	-	-	3.030	7	0.989
MIN	15	2	-	0	2.377	3	0.550
MAX	31	13	-	100	5.822	21	2.810
AVG	25	6	-	45	3.027	11	1.353

Table E-8. Post-Project Monitoring Results at Notch in Wing Dam No. 15

TABLE E-9
Post-Project Monitoring Results 100' D/S Notch in Wing Dam No. 15

Date	Air Temp (°C)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Water Depth (m)	Wave Height (cm)	Velocity (ft/s)
6/18/97	30	6	NW	15	3.048	9	0.910
7/2/97	28	7	NW	0	3.048	15	1.501
7/17/97	31	6	S	35	2.865	15	1.719
7/31/97	26	3	SE	40	3.932	15	1.536
8/19/97	18	8	E	100	4.511	9	1.436
9/3/97	20	7	NE	35	3.932	6	1.170
9/25/97	18	2	NW	0	3.048	3	0.939
6/3/98	15	13	N	95	3.856	12	1.923
7/2/98	29	4	NE	35	5.578	6	2.513
7/14/98	31	8	S	90	4.999	12	2.251
7/28/98	29	2	S	5	2.758	3	1.941
8/13/98	26	2	N	80	3.520	6	1.901
8/25/98	29	8	N	45	3.490	15	1.225
9/10/98	27	6	SE	0	3.459	9	0.762
9/29/98	21	8	S	95	4.450	6	0.600
7/8/99	-	-	-	-	2.957	18	1.855
8/10/99	-	-	-	-	4.115	9	1.990
9/8/99	-	-	-	-	3.962	18	1.208
9/21/99	-	-	-	-	3.960	15	0.846
9/5/00	-	-	-	-	4.090	14	0.606
9/19/00	-	-	-	-	3.795	5	0.592
MIN	15	2	-	0	2.758	3	0.592
MAX	31	13	-	100	5.578	18	2.513
AVG	25	6	-	45	3.780	11	1.401

Table E-9. Post-Project Monitoring Results 100' D/S Notch in Wing Dam No. 15

APPENDIX F

TECHNICAL COMPUTATIONS

TABLE F-1.
Summary of Chute Depths at Station W-M328.7B

Date	W-M 328.7B Chute Depth (meters)	W-M 328.7B Chute Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	W-M 328.7B Pool Elevation (feet)	W-M 328.7B Bottom Elevation (feet) [3/]	W-M 328.7B Flat Pool Depth (feet) [4/]
12/23/97	4.42	14.50	6.53	471.13	11.48	470.07	470.28	455.78	14.22
1/27/98	4.63	15.20	6.73	471.33	11.46	470.05	470.30	455.10	14.90
2/24/98	4.50	14.75	8.65	473.25	11.47	470.06	470.68	455.94	14.06
3/24/98	4.80	15.75	7.67	472.27	11.83	470.42	470.78	455.04	14.96
6/3/98	4.48	14.70	9.50	474.10	11.70	470.29	471.03	456.34	13.66
7/2/98	6.28	20.59	15.60	480.20	17.43	476.02	476.84	456.24	13.76
7/14/98	5.65	18.55	14.75	479.35	16.57	475.16	475.98	457.43	12.57
7/28/98	4.34	14.25	8.70	473.30	11.66	470.25	470.85	456.60	13.40
8/13/98	4.11	13.50	8.55	473.15	11.33	469.92	470.55	457.05	12.95
8/25/98	4.18	13.70	7.45	472.05	11.68	470.27	470.62	456.92	13.08
9/10/98	3.98	13.05	6.43	471.03	11.45	470.04	470.23	457.19	12.81
9/29/98	4.34	14.25	6.20	470.80	11.42	470.01	470.16	455.92	14.08
12/29/98	3.90	12.80	6.30	470.90	11.45	470.04	470.21	457.41	12.59
1/28/99	4.33	14.20	9.10	473.70	11.89	470.48	471.11	456.91	13.09
2/25/99	4.19	13.75	7.95	472.55	11.81	470.40	470.82	457.07	12.93
3/23/99	4.11	13.50	8.68	473.28	11.91	470.50	471.04	457.55	12.45
5/27/99	6.37	20.89	16.60	481.20	18.37	476.96	477.79	456.89	13.11
6/22/99	4.88	16.00	13.15	477.75	14.62	473.21	474.10	458.10	11.90
7/8/99	4.07	13.35	10.40	475.00	11.82	470.41	471.31	457.96	12.04
7/27/99	4.37	14.35	11.75	476.35	12.54	471.13	472.15	457.80	12.20
8/10/99	3.96	13.00	9.75	474.35	11.80	470.39	471.16	458.17	11.83
8/24/99	3.90	12.80	7.75	472.35	11.26	469.85	470.34	457.54	12.46
9/8/99	3.78	12.40	7.30	471.90	11.75	470.34	470.64	458.25	11.75
9/21/99	3.88	12.73	6.75	471.35	11.40	469.99	470.26	457.53	12.47
2/8/00	3.80	12.46	-	-	11.41	470.00	-	-	-
3/7/00	3.95	12.96	-	-	11.90	470.49	-	-	-
5/31/00	3.77	12.37	8.00	472.60	11.47	470.06	470.56	458.19	11.81
6/15/00	4.74	15.55	13.65	478.25	14.80	473.39	474.34	458.79	11.21
7/6/00	4.78	15.66	13.70	478.30	14.86	473.45	474.40	458.74	11.26
7/25/00	3.97	13.02	9.20	473.80	11.79	470.38	471.05	458.03	11.97
8/8/00	3.55	11.64	6.85	471.45	11.92	470.51	470.69	459.05	10.95
8/22/00	3.95	12.96	6.90	471.50	11.64	470.23	470.48	457.52	12.48
9/5/00	3.75	12.28	5.90	470.50	11.48	470.07	470.15	457.87	12.13
9/19/00	3.62	11.87	7.05	471.65	11.52	470.11	470.41	458.54	11.46

TABLE F-1. (Continued)
Summary of Chute Depths at Station W-M328.7B

Date	W-M 328.7B Chute Depth (meters)	W-M 328.7B Chute Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	W-M 328.7B Pool Elevation (feet)	W-M 328.7B Bottom Elevation (feet) [3/]	W-M 328.7B Flat Pool Depth (feet) [4/]
97 MIN	4.42	14.50	6.53	471.13	11.48	470.07	470.28	455.78	14.22
97 MAX	4.42	14.50	6.53	471.13	11.48	470.07	470.28	455.78	14.22
97 AVG	4.42	14.50	6.53	471.13	11.48	470.07	470.28	455.78	14.22
98 MIN	3.90	12.80	6.20	470.80	11.33	469.92	470.16	455.04	12.57
98 MAX	6.28	20.59	15.60	480.20	17.43	476.02	476.84	457.43	14.96
98 AVG	4.60	15.09	8.88	473.48	12.45	471.04	471.52	456.43	13.57
99 MIN	3.78	12.40	6.75	471.35	11.26	469.85	470.26	456.89	11.75
99 MAX	6.37	20.89	16.60	481.20	18.37	476.96	477.79	458.25	13.11
99 AVG	4.35	14.27	9.93	474.53	12.65	471.24	471.88	457.62	12.38
00 MIN	3.55	11.64	5.90	470.50	11.41	470.00	470.15	457.52	10.95
00 MAX	4.78	15.66	13.70	478.30	14.86	473.45	474.40	459.05	12.48
00 AVG	3.99	13.08	8.91	473.51	12.28	470.87	471.51	458.34	11.66
97-00 MIN	3.55	11.64	5.90	470.50	11.26	469.85	470.15	455.04	10.95
97-00 MAX	6.37	20.89	16.60	481.20	18.37	476.96	477.79	459.05	14.96
97-00 AVG	4.33	14.21	9.17	473.77	12.44	471.03	471.60	457.30	12.70

Table F-1. Summary of Chute Depths at Station W-M328.7B

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero
where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero
where Gage Zero = 458.59 feet MSL (1912)

[3/] W-M328.7B Bottom Elevation = W-M328.7B Pool Elevation - W-M328.7B Chute Depth

[4/] W-M328.7B Flat Pool Depth = Flat Pool - W-M328.7B Bottom Elevation
where Flat Pool = 470 feet MSL

TABLE F-2.
Summary of Chute Depths at Station W-M329.3B

Date	W-M 329.3B Chute Depth (meters)	W-M 329.3B Chute Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	W-M 329.3B Pool Elevation (feet)	W-M 329.3B Bottom Elevation (feet) [3/]	W-M 329.3B Flat Pool Depth (feet) [4/]
12/23/97	3.05	10.00	6.53	471.13	11.48	470.07	470.35	460.35	9.65
1/27/98	3.03	9.95	6.73	471.33	11.46	470.05	470.39	460.44	9.56
2/24/98	3.32	10.90	8.65	473.25	11.47	470.06	470.90	460.01	9.99
3/24/98	2.99	9.80	7.67	472.27	11.83	470.42	470.91	461.11	8.89
6/3/98	3.35	11.00	9.50	474.10	11.70	470.29	471.30	460.30	9.70
7/2/98	5.04	16.55	15.60	480.20	17.43	476.02	477.13	460.58	9.42
7/14/98	4.57	15.00	14.75	479.35	16.57	475.16	476.27	461.27	8.73
7/28/98	2.85	9.35	8.70	473.30	11.66	470.25	471.06	461.71	8.29
8/13/98	2.88	9.45	8.55	473.15	11.33	469.92	470.77	461.33	8.67
8/25/98	3.25	10.65	7.45	472.05	11.68	470.27	470.74	460.09	9.91
9/10/98	-	-	6.43	471.03	11.45	470.04	470.30	-	-
9/29/98	2.70	8.85	6.20	470.80	11.42	470.01	470.22	461.37	8.63
12/29/98	2.70	8.85	6.30	470.90	11.45	470.04	470.27	461.42	8.58
1/28/99	3.14	10.30	9.10	473.70	11.89	470.48	471.33	461.03	8.97
2/25/99	2.73	8.95	7.95	472.55	11.81	470.40	470.97	462.02	7.98
3/23/99	2.94	9.65	8.68	473.28	11.91	470.50	471.23	461.59	8.41
5/27/99	5.09	16.70	16.60	481.20	18.37	476.96	478.08	461.39	8.61
6/22/99	3.69	12.10	13.15	477.75	14.62	473.21	474.41	462.31	7.69
7/8/99	2.71	8.90	10.40	475.00	11.82	470.41	471.62	462.73	7.27
7/27/99	2.94	9.65	11.75	476.35	12.54	471.13	472.51	462.86	7.14
8/10/99	2.53	8.30	9.75	474.35	11.80	470.39	471.44	463.14	6.86
8/24/99	2.27	7.45	7.75	472.35	11.26	469.85	470.51	463.06	6.94
9/8/99	2.44	8.00	7.30	471.90	11.75	470.34	470.75	462.75	7.25
9/21/99	2.30	7.54	6.75	471.35	11.40	469.99	470.35	462.81	7.19
2/8/00	2.27	7.45	-	-	11.41	470.00	-	-	-
3/7/00	2.60	8.53	-	-	11.90	470.49	-	-	-
5/31/00	2.47	8.10	8.00	472.60	11.47	470.06	470.73	462.63	7.37
6/15/00	3.95	12.96	13.65	478.25	14.80	473.39	474.67	461.72	8.28
7/6/00	3.70	12.14	13.70	478.30	14.86	473.45	474.73	462.59	7.41
7/25/00	2.44	8.00	9.20	473.80	11.79	470.38	471.28	463.28	6.72
8/8/00	2.30	7.54	6.85	471.45	11.92	470.51	470.76	463.21	6.79
8/22/00	2.05	6.72	6.90	471.50	11.64	470.23	470.57	463.84	6.16
9/5/00	2.16	7.08	5.90	470.50	11.48	470.07	470.18	463.10	6.90
9/19/00	2.19	7.18	7.05	471.65	11.52	470.11	470.52	463.33	6.67

TABLE F-2. (Continued)
Summary of Chute Depths at Station W-M329.3B

Date	W-M 329.3B Chute Depth (meters)	W-M 329.3B Chute Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	W-M 329.3B Pool Elevation (feet)	W-M 329.3B Bottom Elevation (feet) [3/]	W-M 329.3B Flat Pool Depth (feet) [4/]
97 MIN	3.05	10.00	6.53	471.13	11.48	470.07	470.35	460.35	9.65
97 MAX	3.05	10.00	6.53	471.13	11.48	470.07	470.35	460.35	9.65
97 AVG	3.05	10.00	6.53	471.13	11.48	470.07	470.35	460.35	9.65
98 MIN	2.70	8.85	6.20	470.80	11.33	469.92	470.22	460.01	8.29
98 MAX	5.04	16.55	15.60	480.20	17.43	476.02	477.13	461.71	9.99
98 AVG	3.33	10.94	8.88	473.48	12.45	471.04	471.69	460.88	9.12
99 MIN	2.27	7.45	6.75	471.35	11.26	469.85	470.35	461.03	6.86
99 MAX	5.09	16.70	16.60	481.20	18.37	476.96	478.08	463.14	8.97
99 AVG	2.98	9.77	9.93	474.53	12.65	471.24	472.11	462.34	7.66
00 MIN	2.05	6.72	5.90	470.50	11.41	470.00	470.18	461.72	6.16
00 MAX	3.95	12.96	13.70	478.30	14.86	473.45	474.73	463.84	8.28
00 AVG	2.61	8.57	8.91	473.51	12.28	470.87	471.68	462.96	7.04
97-00 MIN	2.05	6.72	5.90	470.50	11.26	469.85	470.18	460.01	6.16
97-00 MAX	5.09	16.70	16.60	481.20	18.37	476.96	478.08	463.84	9.99
97-00 AVG	2.99	9.80	9.17	473.77	12.44	471.03	471.79	461.92	8.08

Table F-2. Summary of Chute Depths at Station W-M329.3B

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero
where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero
where Gage Zero = 458.59 feet MSL (1912)

[3/] W-M329.3B Bottom Elevation = W-M329.3B Pool Elevation - W-M329.3B Chute Depth

[4/] W-M329.3B Flat Pool Depth = Flat Pool - W-M329.3B Bottom Elevation
where Flat Pool = 470 feet MSL

TABLE F-3.
Summary of Channel Depths 100' U/S Notch in Wing Dam No. 6

Date	U/S No. 6 329.8 Channel Depth (meters)	U/S No. 6 329.8 Channel Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	U/S No. 6 329.8 Pool Elevation (feet)	U/S No. 6 329.8 Bottom Elevation (feet) [3/]	U/S No. 6 329.8 Flat Pool Depth (feet) [4/]
6/18/97	2.23	7.30	7.40	472.00	11.25	469.84	470.54	463.24	6.76
7/2/97	2.10	6.90	8.52	473.12	11.55	470.14	471.10	464.20	5.80
7/17/97	2.10	6.90	8.52	473.12	11.78	470.37	471.26	464.36	5.64
7/31/97	2.16	7.10	8.51	473.11	11.89	470.48	471.33	464.23	5.77
8/19/97	2.19	7.20	7.20	471.80	11.17	469.76	470.42	463.22	6.78
9/3/97	1.95	6.40	7.05	471.65	11.09	469.68	470.31	463.92	6.08
9/25/97	2.23	7.30	7.05	471.65	11.55	470.14	470.63	463.33	6.67
6/3/98	2.67	8.75	9.50	474.10	11.70	470.29	471.52	462.77	7.23
7/2/98	-	-	15.60	480.20	17.43	476.02	477.37	-	-
7/14/98	-	-	14.75	479.35	16.57	475.16	476.51	-	-
7/28/98	2.82	9.25	8.70	473.30	11.66	470.25	471.23	461.98	8.02
8/13/98	2.42	7.95	8.55	473.15	11.33	469.92	470.96	463.01	6.99
8/25/98	2.16	7.10	7.45	472.05	11.68	470.27	470.84	463.74	6.26
9/10/98	1.95	6.40	6.43	471.03	11.45	470.04	470.36	463.96	6.04
9/29/98	1.92	6.30	6.20	470.80	11.42	470.01	470.26	463.97	6.03
7/8/99	3.00	9.85	10.40	475.00	11.82	470.41	471.89	462.04	7.96
8/10/99	2.50	8.20	9.75	474.35	11.80	470.39	471.66	463.47	6.53
9/8/99	2.41	7.90	7.30	471.90	11.75	470.34	470.84	462.94	7.06
9/21/99	2.42	7.94	6.75	471.35	11.40	469.99	470.43	462.49	7.51
9/5/00	2.80	9.18	5.90	470.50	11.48	470.07	470.21	461.02	8.98
9/19/00	2.85	9.35	7.05	471.65	11.52	470.11	470.61	461.26	8.74
97 MIN	1.95	6.40	7.05	471.65	11.09	469.68	470.31	463.22	5.64
97 MAX	2.23	7.30	8.52	473.12	11.89	470.48	471.33	464.36	6.78
97 AVG	2.14	7.01	7.75	472.35	11.47	470.06	470.80	463.78	6.22
98 MIN	1.92	6.30	6.20	470.80	11.33	469.92	470.26	461.98	6.03
98 MAX	2.82	9.25	15.60	480.20	17.43	476.02	477.37	463.97	8.02
98 AVG	2.32	7.62	9.65	474.25	12.91	471.50	472.38	463.24	6.76
99 MIN	2.41	7.90	6.75	471.35	11.40	469.99	470.43	462.04	6.53
99 MAX	3.00	9.85	10.40	475.00	11.82	470.41	471.89	463.47	7.96
99 AVG	2.58	8.47	8.55	473.15	11.69	470.28	471.21	462.74	7.26
00 MIN	2.80	9.18	5.90	470.50	11.48	470.07	470.21	461.02	8.74
00 MAX	2.85	9.35	7.05	471.65	11.52	470.11	470.61	461.26	8.98
00 AVG	2.83	9.27	6.48	471.08	11.50	470.09	470.41	461.14	8.86
97-00 MIN	1.92	6.30	5.90	470.50	11.09	469.68	470.21	461.02	5.64
97-00 MAX	3.00	9.85	15.60	480.20	17.43	476.02	477.37	464.36	8.98
97-00 AVG	2.36	7.75	8.50	473.10	12.06	470.65	471.44	463.11	6.89

Table F-3. Summary of Channel Depths 100' U/S Notch in Wing Dam No. 6

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero where Gage Zero = 458.59 feet MSL (1912)

[3/] U/S No. 6 329.8 Bottom Elevation = U/S No. 6 329.8 Pool Elevation – U/S No. 6 329.8 Channel Depth

[4/] U/S No. 6 329.8 Flat Pool Depth = Flat Pool - U/S No. 6 329.8 Bottom Elevation where Flat Pool = 470 feet MSL

TABLE F-4.
Summary of Channel Depths At Notch in Wing Dam No. 6

Date	At No. 6 329.8 Channel Depth (meters)	At No. 6 329.8 Channel Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	At No. 6 329.8 Pool Elevation (feet)	At No. 6 329.8 Bottom Elevation (feet) [3/]	At No. 6 329.8 Flat Pool Depth (feet) [4/]
6/18/97	3.02	9.90	7.40	472.00	11.25	469.84	470.54	460.64	9.36
7/2/97	3.79	12.45	8.52	473.12	11.55	470.14	471.10	458.65	11.35
7/17/97	2.87	9.40	8.52	473.12	11.78	470.37	471.26	461.86	8.14
7/31/97	2.96	9.70	8.51	473.11	11.89	470.48	471.33	461.63	8.37
8/19/97	2.73	8.95	7.20	471.80	11.17	469.76	470.42	461.47	8.53
9/3/97	3.41	11.20	7.05	471.65	11.09	469.68	470.31	459.12	10.88
9/25/97	3.40	11.15	7.05	471.65	11.55	470.14	470.63	459.48	10.52
6/3/98	3.25	10.65	9.50	474.10	11.70	470.29	471.52	460.87	9.13
7/2/98	4.75	15.60	15.60	480.20	17.43	476.02	477.37	461.77	8.23
7/14/98	-	-	14.75	479.35	16.57	475.16	476.51	-	-
7/28/98	3.54	11.60	8.70	473.30	11.66	470.25	471.23	459.63	10.37
8/13/98	2.97	9.75	8.55	473.15	11.33	469.92	470.96	461.21	8.79
8/25/98	3.28	10.75	7.45	472.05	11.68	470.27	470.84	460.10	9.90
9/10/98	2.73	8.95	6.43	471.03	11.45	470.04	470.36	461.41	8.59
9/29/98	3.83	12.55	6.20	470.80	11.42	470.01	470.26	457.72	12.28
7/8/99	-	-	10.40	475.00	11.82	470.41	471.89	-	-
8/10/99	2.30	7.55	9.75	474.35	11.80	470.39	471.66	464.12	5.88
9/8/99	3.54	11.60	7.30	471.90	11.75	470.34	470.84	459.25	10.75
9/21/99	3.02	9.91	6.75	471.35	11.40	469.99	470.43	460.52	9.48
9/5/00	3.04	9.97	5.90	470.50	11.48	470.07	470.21	460.24	9.76
9/19/00	3.55	11.63	7.05	471.65	11.52	470.11	470.61	458.98	11.02
97 MIN	2.73	8.95	7.05	471.65	11.09	469.68	470.31	458.65	8.14
97 MAX	3.79	12.45	8.52	473.12	11.89	470.48	471.33	461.86	11.35
97 AVG	3.17	10.39	7.75	472.35	11.47	470.06	470.80	460.41	9.59
98 MIN	2.73	8.95	6.20	470.80	11.33	469.92	470.26	457.72	8.23
98 MAX	4.75	15.60	15.60	480.20	17.43	476.02	477.37	461.77	12.28
98 AVG	3.48	11.40	9.65	474.25	12.91	471.50	472.38	460.39	9.61
99 MIN	2.30	7.55	6.75	471.35	11.40	469.99	470.43	459.25	5.88
99 MAX	3.54	11.60	10.40	475.00	11.82	470.41	471.89	464.12	10.75
99 AVG	2.95	9.68	8.55	473.15	11.69	470.28	471.21	461.29	8.71
00 MIN	3.04	9.97	5.90	470.50	11.48	470.07	470.21	458.98	9.76
00 MAX	3.55	11.63	7.05	471.65	11.52	470.11	470.61	460.24	11.02
00 AVG	3.29	10.80	6.48	471.08	11.50	470.09	470.41	459.61	10.39
97-00 MIN	2.30	7.55	5.90	470.50	11.09	469.68	470.21	457.72	5.88
97-00 MAX	4.75	15.60	15.60	480.20	17.43	476.02	477.37	464.12	12.28
97-00 AVG	3.26	10.70	8.50	473.10	12.06	470.65	471.44	460.46	9.54

Table F-4. Summary of Channel Depths at Notch in Wing Dam No. 6

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero where Gage Zero = 458.59 feet MSL (1912)

[3/] At No. 6 329.8 Bottom Elevation = At No. 6 329.8 Pool Elevation - At No. 6 329.8 Channel Depth

[4/] At No. 6 329.8 Flat Pool Depth = Flat Pool - At No. 6 329.8 Bottom Elevation where Flat Pool = 470 feet MSL

TABLE F-5.
Summary of Channel Depths 100' D/S Notch in Wing Dam No. 6

Date	D/S No. 6 329.8 Channel Depth (meters)	D/S No. 6 329.8 Channel Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	D/S No. 6 329.8 Pool Elevation (feet)	D/S No. 6 329.8 Bottom Elevation (feet) [3/]	D/S No. 6 329.8 Flat Pool Depth (feet) [4/]
6/18/97	5.53	18.15	7.40	472.00	11.25	469.84	470.54	452.39	17.61
7/2/97	5.97	19.59	8.52	473.12	11.55	470.14	471.10	451.50	18.50
7/17/97	5.91	19.40	8.52	473.12	11.78	470.37	471.26	451.86	18.14
7/31/97	6.52	21.39	8.51	473.11	11.89	470.48	471.33	449.93	20.07
8/19/97	6.71	21.99	7.20	471.80	11.17	469.76	470.42	448.42	21.58
9/3/97	5.64	18.50	7.05	471.65	11.09	469.68	470.31	451.82	18.18
9/25/97	6.80	22.29	7.05	471.65	11.55	470.14	470.63	448.33	21.67
6/3/98	6.63	21.74	9.50	474.10	11.70	470.29	471.52	449.77	20.23
7/2/98	-	-	15.60	480.20	17.43	476.02	477.37	-	-
7/14/98	-	-	14.75	479.35	16.57	475.16	476.51	-	-
7/28/98	6.55	21.49	8.70	473.30	11.66	470.25	471.23	449.74	20.26
8/13/98	7.80	25.59	8.55	473.15	11.33	469.92	470.96	445.37	24.63
8/25/98	6.34	20.79	7.45	472.05	11.68	470.27	470.84	450.05	19.95
9/10/98	5.94	19.50	6.43	471.03	11.45	470.04	470.36	450.86	19.14
9/29/98	6.32	20.74	6.20	470.80	11.42	470.01	470.26	449.52	20.48
7/8/99	-	-	10.40	475.00	11.82	470.41	471.89	-	-
8/10/99	6.89	22.59	9.75	474.35	11.80	470.39	471.66	449.07	20.93
9/8/99	6.13	20.09	7.30	471.90	11.75	470.34	470.84	450.75	19.25
9/21/99	7.05	23.12	6.75	471.35	11.40	469.99	470.43	447.30	22.70
9/5/00	7.31	23.98	5.90	470.50	11.48	470.07	470.21	446.23	23.77
9/19/00	7.13	23.39	7.05	471.65	11.52	470.11	470.61	447.22	22.78
97 MIN	5.53	18.15	7.05	471.65	11.09	469.68	470.31	448.33	17.61
97 MAX	6.80	22.29	8.52	473.12	11.89	470.48	471.33	452.39	21.67
97 AVG	6.15	20.19	7.75	472.35	11.47	470.06	470.80	450.61	19.39
98 MIN	5.94	19.50	6.20	470.80	11.33	469.92	470.26	445.37	19.14
98 MAX	7.80	25.59	15.60	480.20	17.43	476.02	477.37	450.86	24.63
98 AVG	6.60	21.64	9.65	474.25	12.91	471.50	472.38	449.22	20.78
99 MIN	6.13	20.09	6.75	471.35	11.40	469.99	470.43	447.30	19.25
99 MAX	7.05	23.12	10.40	475.00	11.82	470.41	471.89	450.75	22.70
99 AVG	6.69	21.94	8.55	473.15	11.69	470.28	471.21	449.04	20.96
00 MIN	7.13	23.39	5.90	470.50	11.48	470.07	470.21	446.23	22.78
00 MAX	7.31	23.98	7.05	471.65	11.52	470.11	470.61	447.22	23.77
00 AVG	7.22	23.68	6.48	471.08	11.50	470.09	470.41	446.73	23.27
97-00 MIN	5.53	18.15	5.90	470.50	11.09	469.68	470.21	445.37	17.61
97-00 MAX	7.80	25.59	15.60	480.20	17.43	476.02	477.37	452.39	24.63
97-00 AVG	6.51	21.35	8.50	473.10	12.06	470.65	471.44	449.45	20.55

Table F-5. Summary of Channel Depths 100' D/S Notch in Wing Dam No. 6

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero where Gage Zero = 458.59 feet MSL (1912)

[3/] D/S No. 6 329.8 Bottom Elevation = D/S No. 6 329.8 Pool Elevation - D/S No. 6 329.8 Channel Depth

[4/] D/S No. 6 329.8 Flat Pool Depth = Flat Pool - D/S No. 6 329.8 Bottom Elevation where Flat Pool = 470 feet MSL

TABLE F-6.
Summary of Channel Depths 100' U/S Notch in Wing Dam No. 15

Date	U/S No. 15 328.6 Channel Depth (meters)	U/S No. 15 328.6 Channel Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	U/S No. 15 328.6 Pool Elevation (feet)	U/S No. 15 328.6 Bottom Elevation (feet) [3/]	U/S No. 15 328.6 Flat Pool Depth (feet) [4/]
6/18/97	1.48	4.85	7.40	472.00	11.25	469.84	470.24	465.39	4.61
7/2/97	1.46	4.80	8.52	473.12	11.55	470.14	470.69	465.89	4.11
7/17/97	1.49	4.90	8.52	473.12	11.78	470.37	470.88	465.98	4.02
7/31/97	1.74	5.70	8.51	473.11	11.89	470.48	470.96	465.27	4.73
8/19/97	2.19	7.20	7.20	471.80	11.17	469.76	470.14	462.94	7.06
9/3/97	1.26	4.15	7.05	471.65	11.09	469.68	470.04	465.89	4.11
9/25/97	1.31	4.30	7.05	471.65	11.55	470.14	470.42	466.12	3.88
6/3/98	1.74	5.70	9.50	474.10	11.70	470.29	470.99	465.29	4.71
7/2/98	-	-	15.60	480.20	17.43	476.02	476.79	-	-
7/14/98	3.11	10.20	14.75	479.35	16.57	475.16	475.93	465.73	4.27
7/28/98	1.49	4.90	8.70	473.30	11.66	470.25	470.81	465.91	4.09
8/13/98	1.51	4.95	8.55	473.15	11.33	469.92	470.51	465.57	4.43
8/25/98	1.62	5.30	7.45	472.05	11.68	470.27	470.60	465.30	4.70
9/10/98	1.49	4.90	6.43	471.03	11.45	470.04	470.22	465.32	4.68
9/29/98	1.60	5.25	6.20	470.80	11.42	470.01	470.16	464.91	5.09
7/8/99	2.18	7.15	10.40	475.00	11.82	470.41	471.25	464.11	5.89
8/10/99	1.81	5.95	9.75	474.35	11.80	470.39	471.12	465.17	4.83
9/8/99	1.48	4.85	7.30	471.90	11.75	470.34	470.63	465.78	4.22
9/21/99	1.48	4.85	6.75	471.35	11.40	469.99	470.24	465.39	4.61
9/5/00	1.62	5.31	5.90	470.50	11.48	470.07	470.15	464.84	5.16
9/19/00	1.62	5.31	7.05	471.65	11.52	470.11	470.39	465.08	4.92
97 MIN	1.26	4.15	7.05	471.65	11.09	469.68	470.04	462.94	3.88
97 MAX	2.19	7.20	8.52	473.12	11.89	470.48	470.96	466.12	7.06
97 AVG	1.56	5.13	7.75	472.35	11.47	470.06	470.48	465.35	4.65
98 MIN	1.49	4.90	6.20	470.80	11.33	469.92	470.16	464.91	4.09
98 MAX	3.11	10.20	15.60	480.20	17.43	476.02	476.79	465.91	5.09
98 AVG	1.79	5.88	9.65	474.25	12.91	471.50	472.00	465.43	4.57
99 MIN	1.48	4.85	6.75	471.35	11.40	469.99	470.24	464.11	4.22
99 MAX	2.18	7.15	10.40	475.00	11.82	470.41	471.25	465.78	5.89
99 AVG	1.74	5.70	8.55	473.15	11.69	470.28	470.81	465.11	4.89
00 MIN	1.62	5.31	5.90	470.50	11.48	470.07	470.15	464.84	4.92
00 MAX	1.62	5.31	7.05	471.65	11.52	470.11	470.39	465.08	5.16
00 AVG	1.62	5.31	6.48	471.08	11.50	470.09	470.27	464.96	5.04
97-00 MIN	1.26	4.15	5.90	470.50	11.09	469.68	470.04	462.94	3.88
97-00 MAX	3.11	10.20	15.60	480.20	17.43	476.02	476.79	466.12	7.06
97-00 AVG	1.68	5.53	8.50	473.10	12.06	470.65	471.10	465.29	4.71

Table F-6. Summary of Channel Depths 100' U/S Notch in Wing Dam No. 15

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero where Gage Zero = 458.59 feet MSL (1912)

[3/] U/S No. 15 328.6 Bottom Elevation = U/S No. 15 328.6 Pool Elevation – U/S No. 15 328.6 Channel Depth

[4/] U/S No. 15 328.6 Flat Pool Depth = Flat Pool - U/S No. 15 328.6 Bottom Elevation where Flat Pool = 470 feet MSL

TABLE F-7.
Summary of Channel Depths At Notch in Wing Dam No. 15

Date	At No. 15 328.6 Channel Depth (meters)	At No. 15 328.6 Channel Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	At No. 15 328.6 Pool Elevation (feet)	At No. 15 328.6 Bottom Elevation (feet) [3/]	At No. 15 328.6 Flat Pool Depth (feet) [4/]
6/18/97	3.09	10.15	7.40	472.00	11.25	469.84	470.24	460.09	9.91
7/2/97	2.85	9.35	8.52	473.12	11.55	470.14	470.69	461.34	8.66
7/17/97	3.08	10.10	8.52	473.12	11.78	470.37	470.88	460.78	9.22
7/31/97	3.31	10.85	8.51	473.11	11.89	470.48	470.96	460.12	9.88
8/19/97	2.90	9.50	7.20	471.80	11.17	469.76	470.14	460.64	9.36
9/3/97	2.61	8.55	7.05	471.65	11.09	469.68	470.04	461.49	8.51
9/25/97	3.03	9.95	7.05	471.65	11.55	470.14	470.42	460.47	9.53
6/3/98	2.90	9.50	9.50	474.10	11.70	470.29	470.99	461.49	8.51
7/2/98	-	-	15.60	480.20	17.43	476.02	476.79	-	-
7/14/98	4.34	14.25	14.75	479.35	16.57	475.16	475.93	461.68	8.32
7/28/98	2.58	8.45	8.70	473.30	11.66	470.25	470.81	462.36	7.64
8/13/98	2.67	8.75	8.55	473.15	11.33	469.92	470.51	461.77	8.23
8/25/98	2.94	9.65	7.45	472.05	11.68	470.27	470.60	460.95	9.05
9/10/98	2.56	8.40	6.43	471.03	11.45	470.04	470.22	461.82	8.18
9/29/98	2.45	8.05	6.20	470.80	11.42	470.01	470.16	462.11	7.89
7/8/99	2.80	9.20	10.40	475.00	11.82	470.41	471.25	462.06	7.94
8/10/99	2.83	9.30	9.75	474.35	11.80	470.39	471.12	461.82	8.18
9/8/99	2.38	7.80	7.30	471.90	11.75	470.34	470.63	462.83	7.17
9/21/99	2.60	8.53	6.75	471.35	11.40	469.99	470.24	461.71	8.29
9/5/00	2.80	9.18	5.90	470.50	11.48	470.07	470.15	460.97	9.03
9/19/00	3.03	9.94	7.05	471.65	11.52	470.11	470.39	460.45	9.55
97 MIN	2.61	8.55	7.05	471.65	11.09	469.68	470.04	460.09	8.51
97 MAX	3.31	10.85	8.52	473.12	11.89	470.48	470.96	461.49	9.91
97 AVG	2.98	9.78	7.75	472.35	11.47	470.06	470.48	460.70	9.30
98 MIN	2.45	8.05	6.20	470.80	11.33	469.92	470.16	460.95	7.64
98 MAX	4.34	14.25	15.60	480.20	17.43	476.02	476.79	462.36	9.05
98 AVG	2.92	9.58	9.65	474.25	12.91	471.50	472.00	461.74	8.26
99 MIN	2.38	7.80	6.75	471.35	11.40	469.99	470.24	461.71	7.17
99 MAX	2.83	9.30	10.40	475.00	11.82	470.41	471.25	462.83	8.29
99 AVG	2.65	8.71	8.55	473.15	11.69	470.28	470.81	462.10	7.90
00 MIN	2.80	9.18	5.90	470.50	11.48	470.07	470.15	460.45	9.03
00 MAX	3.03	9.94	7.05	471.65	11.52	470.11	470.39	460.97	9.55
00 AVG	2.92	9.56	6.48	471.08	11.50	470.09	470.27	460.71	9.29
97-00 MIN	2.38	7.80	5.90	470.50	11.09	469.68	470.04	460.09	7.17
97-00 MAX	4.34	14.25	15.60	480.20	17.43	476.02	476.79	462.83	9.91
97-00 AVG	2.89	9.47	8.50	473.10	12.06	470.65	471.10	461.35	8.65

Table F-7. Summary of Channel Depths at Notch in Wing Dam No. 15

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero where Gage Zero = 458.59 feet MSL (1912)

[3/] At No. 15 328.6 Bottom Elevation = At No. 15 328.6 Pool Elevation – At No. 15 328.6 Channel Depth

[4/] At No. 15 328.6 Flat Pool Depth = Flat Pool - At No. 15 328.6 Bottom Elevation where Flat Pool = 470 feet MSL

TABLE F-8.
Summary of Channel Depths 100' D/S Notch in Wing Dam No. 15

Date	D/S No. 15 328.6 Channel Depth (meters)	D/S No. 15 328.6 Channel Depth (feet)	LGGM7 335.7 Gage Reading (feet)	LGGM7 335.7 Pool Elevation (feet) [1/]	UINI2 327.0 Gage Reading (feet)	UINI2 327.0 Pool Elevation (feet) [2/]	D.S No. 15 328.6 Pool Elevation (feet)	D/S No. 15 328.6 Bottom Elevation (feet) [3/]	D/S No. 15 328.6 Flat Pool Depth (feet) [4/]
6/18/97	3.05	10.00	7.40	472.00	11.25	469.84	470.24	460.24	9.76
7/2/97	3.05	10.00	8.52	473.12	11.55	470.14	470.69	460.69	9.31
7/17/97	2.87	9.40	8.52	473.12	11.78	470.37	470.88	461.48	8.52
7/31/97	3.93	12.90	8.51	473.11	11.89	470.48	470.96	458.07	11.93
8/19/97	4.51	14.80	7.20	471.80	11.17	469.76	470.14	455.34	14.66
9/3/97	3.93	12.90	7.05	471.65	11.09	469.68	470.04	457.15	12.85
9/25/97	3.05	10.00	7.05	471.65	11.55	470.14	470.42	460.42	9.58
6/3/98	3.86	12.65	9.50	474.10	11.70	470.29	470.99	458.34	11.66
7/2/98	5.58	18.30	15.60	480.20	17.43	476.02	476.79	458.49	11.51
7/14/98	5.00	16.40	14.75	479.35	16.57	475.16	475.93	459.53	10.47
7/28/98	2.76	9.05	8.70	473.30	11.66	470.25	470.81	461.76	8.24
8/13/98	3.52	11.55	8.55	473.15	11.33	469.92	470.51	458.97	11.03
8/25/98	3.49	11.45	7.45	472.05	11.68	470.27	470.60	459.15	10.85
9/10/98	3.46	11.35	6.43	471.03	11.45	470.04	470.22	458.87	11.13
9/29/98	4.45	14.60	6.20	470.80	11.42	470.01	470.16	455.56	14.44
7/8/99	2.96	9.70	10.40	475.00	11.82	470.41	471.25	461.56	8.44
8/10/99	4.11	13.50	9.75	474.35	11.80	470.39	471.12	457.62	12.38
9/8/99	3.96	13.00	7.30	471.90	11.75	470.34	470.63	457.63	12.37
9/21/99	3.96	12.99	6.75	471.35	11.40	469.99	470.24	457.25	12.75
9/5/00	4.09	13.42	5.90	470.50	11.48	470.07	470.15	456.73	13.27
9/19/00	3.80	12.45	7.05	471.65	11.52	470.11	470.39	457.95	12.05
97 MIN	2.87	9.40	7.05	471.65	11.09	469.68	470.04	455.34	8.52
97 MAX	4.51	14.80	8.52	473.12	11.89	470.48	470.96	461.48	14.66
97 AVG	3.48	11.43	7.75	472.35	11.47	470.06	470.48	459.05	10.95
98 MIN	2.76	9.05	6.20	470.80	11.33	469.92	470.16	455.56	8.24
98 MAX	5.58	18.30	15.60	480.20	17.43	476.02	476.79	461.76	14.44
98 AVG	4.01	13.17	9.65	474.25	12.91	471.50	472.00	458.84	11.16
99 MIN	2.96	9.70	6.75	471.35	11.40	469.99	470.24	457.25	8.44
99 MAX	4.11	13.50	10.40	475.00	11.82	470.41	471.25	461.56	12.75
99 AVG	3.75	12.29	8.55	473.15	11.69	470.28	470.81	458.51	11.49
00 MIN	3.80	12.45	5.90	470.50	11.48	470.07	470.15	456.73	12.05
00 MAX	4.09	13.42	7.05	471.65	11.52	470.11	470.39	457.95	13.27
00 AVG	3.94	12.93	6.48	471.08	11.50	470.09	470.27	457.34	12.66
97-00 MIN	2.76	9.05	5.90	470.50	11.09	469.68	470.04	455.34	8.24
97-00 MAX	5.58	18.30	15.60	480.20	17.43	476.02	476.79	461.76	14.66
97-00 AVG	3.78	12.40	8.50	473.10	12.06	470.65	471.10	458.71	11.29

Table F-8. Summary of Channel Depths 100' D/S Notch in Wing Dam No. 15

[1/] LGGM7 335.7 Pool Elevation = LGGM7 335.7 Gage Reading + Gage Zero where Gage Zero = 464.6 feet MSL (1912)

[2/] UINI2 327.0 Pool Elevation = UINI 327.0 Gage Reading + Gage Zero where Gage Zero = 458.59 feet MSL (1912)

[3/] D/S No. 15 328.6 Bottom Elevation = D/S No. 15 328.6 Pool Elevation – D/S No. 15 328.6 Channel Depth

[4/] D/S No. 15 328.6 Flat Pool Depth = Flat Pool – D/S No. 15 328.6 Bottom Elevation where Flat Pool = 470 feet MSL

TABLE F-9.
Summary of Wing Dam Notch Scour Depth

Date	100' U/S No. 6 (feet)	100' U/S No. 15 (feet)	At No. 6 (feet)	At No. 15 (feet)	100' D/S No. 6 (feet)	100' D/S No. 15 (feet)
6/18/97	6.76	4.61	9.36	9.91	17.61	9.76
7/2/97	5.80	4.11	11.35	8.66	18.50	9.31
7/17/97	5.64	4.02	8.14	9.22	18.14	8.52
7/31/97	5.77	4.73	8.37	9.88	20.07	11.93
8/19/97	6.78	7.06	8.53	9.36	21.58	14.66
9/3/97	6.08	4.11	10.88	8.51	18.18	12.85
9/25/97	6.67	3.88	10.52	9.53	21.67	9.58
6/3/98	7.23	4.71	9.13	8.51	20.23	11.66
7/2/98	-	-	8.23	-	-	11.51
7/14/98	-	4.27	-	8.32	-	10.47
7/28/98	8.02	4.09	10.37	7.64	20.26	8.24
8/13/98	6.99	4.43	8.79	8.23	24.63	11.03
8/25/98	6.26	4.70	9.90	9.05	19.95	10.85
9/10/98	6.04	4.68	8.59	8.18	19.14	11.13
9/29/98	6.03	5.09	12.28	7.89	20.48	14.44
7/8/99	7.96	5.89	-	7.94	-	8.44
8/10/99	6.53	4.83	5.88	8.18	20.93	12.38
9/8/99	7.06	4.22	10.75	7.17	19.25	12.37
9/21/99	7.51	4.61	9.48	8.29	22.70	12.75
9/5/00	8.98	5.16	9.76	9.03	23.77	13.27
9/19/00	8.74	4.92	11.02	9.55	22.78	12.05
97 MIN	5.64	3.88	8.14	8.51	17.61	8.52
97 MAX	6.78	7.06	11.35	9.91	21.67	14.66
97 AVG	6.22	4.65	9.59	9.30	19.39	10.95
98 MIN	6.03	4.09	8.23	7.64	19.14	8.24
98 MAX	8.02	5.09	12.28	9.05	24.63	14.44
98 AVG	6.76	4.57	9.61	8.26	20.78	11.16
99 MIN	6.53	4.22	5.88	7.17	19.25	8.44
99 MAX	7.96	5.89	10.75	8.29	22.70	12.75
99 AVG	7.26	4.89	8.71	7.90	20.96	11.49
00 MIN	8.74	4.92	9.76	9.03	22.78	12.05
00 MAX	8.98	5.16	11.02	9.55	23.77	13.27
00 AVG	8.86	5.04	10.39	9.29	23.27	12.66
97-00 MIN	5.64	3.88	5.88	7.17	17.61	8.24
97-00 MAX	8.98	7.06	12.28	9.91	24.63	14.66
97-00 AVG	6.89	4.71	9.54	8.65	20.55	11.29

Table F-9. Summary of Wing Dam Notch Scour Depth

TABLE F-10.
Summary of Wing Dam Notch Velocity

Date	100' U/S No. 6 (ft/s)	100' U/S No. 15 (ft/s)	At No. 6 (ft/s)	At No. 15 (ft/s)	100' D/S No. 6 (ft/s)	100' D/S No. 15 (ft/s)
6/18/97	1.08	0.94	1.36	1.47	1.35	0.91
7/2/97	1.46	1.13	3.14	1.81	3.05	1.50
7/17/97	1.22	0.99	2.36	1.36	2.01	1.72
7/31/97	1.36	1.13	2.52	1.38	2.67	1.54
8/19/97	0.85	0.85	1.87	1.36	2.13	1.44
9/3/97	0.62	0.53	1.39	0.79	1.67	1.17
9/25/97	0.79	0.58	1.76	0.88	0.60	0.94
6/3/98	1.66	1.42	2.47	1.64	1.89	1.92
7/2/98	4.23	2.85	2.68	2.61	3.58	2.51
7/14/98	3.24	2.65	3.10	2.81	2.07	2.25
7/28/98	1.53	1.27	3.07	1.60	1.31	1.94
8/13/98	1.27	0.97	2.36	1.48	2.73	1.90
8/25/98	0.79	0.65	1.72	1.13	1.46	1.23
9/10/98	0.41	0.49	1.02	0.63	0.67	0.76
9/29/98	0.37	0.30	0.99	0.63	0.70	0.60
7/8/99	1.98	1.94	2.33	1.62	1.91	1.86
8/10/99	1.61	1.38	3.14	1.84	2.35	1.99
9/8/99	0.73	0.68	1.81	1.12	1.49	1.21
9/21/99	0.57	0.42	0.15	0.73	0.14	0.85
9/5/00	0.43	0.50	0.87	0.55	0.86	0.61
9/19/00	0.70	0.52	1.61	0.99	0.75	0.59
97 MIN	0.62	0.53	1.36	0.79	0.60	0.91
97 MAX	1.46	1.13	3.14	1.81	3.05	1.72
97 AVG	1.05	0.88	2.06	1.29	1.93	1.32
97 AVG	0.97				1.67	
98 MIN	0.37	0.30	0.99	0.63	0.67	0.60
98 MAX	4.23	2.85	3.10	2.81	3.58	2.51
98 AVG	1.68	1.33	2.18	1.57	1.80	1.64
98 AVG	1.50				1.87	
99 MIN	0.57	0.42	0.15	0.73	0.14	0.85
99 MAX	1.98	1.94	3.14	1.84	2.35	1.99
99 AVG	1.22	1.10	1.85	1.33	1.47	1.47
99 AVG	1.16				1.59	
00 MIN	0.43	0.50	0.87	0.55	0.75	0.59
00 MAX	0.70	0.52	1.61	0.99	0.86	0.61
00 AVG	0.57	0.51	1.24	0.77	0.81	0.60
00 AVG	0.54				1.01	
97-00 MIN	0.37	0.30	0.15	0.55	0.14	0.59
97-00 MAX	4.23	2.85	3.14	2.81	3.58	2.51
97-00 AVG	1.28	1.06	1.99	1.35	1.69	1.40
97-00 AVG	1.17				1.67	

Table F-10. Summary of Wing Dam Notch Velocity

APPENDIX G

PROJECT TEAM MEMEBERS

COTTONWOOD ISLAND PROJECT TEAM MEMBERS

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ble G-1. Cottonwood Island Project Team Members

APPENDIX H

REFERENCES

REFERENCES

Published reports relating to the Cottonwood Island 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-16F), Cottonwood Island Habitat Rehabilitation and Enhancement, Upper Mississippi River System Environmental Management Program, Pool 21, Mississippi River Miles 328.5 – 331.0, Lewis and Marion Counties, Missouri, June 1996*. 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, Environmental Management Program, Pool 21, River Miles 328.5 thru 331.0, Cottonwood Island Rehabilitation and Enhancement*, Solicitation No. DACW25-97-B-0011. These documents were prepared to provide sufficient detail for construction of the hydraulically dredged chutes / deep holes and mechanically excavated potholes, as well as notching of the existing wing dams.

(3) Plans and Specifications, *Upper Mississippi River, Environmental Management Program, Pool 21, River Miles 328.5 thru 331.0, Cottonwood Island Rehabilitation and Enhancement, Stage II*, Solicitation No. DACW25-99-B-0005. These documents were prepared to provide sufficient detail for construction of the mast tree areas.

(4) Plans and Specifications, *Upper Mississippi River System, Environmental Management Program, Pool 21, Cottonwood Island, Stage III, Causeway Road Raise*, Solicitation No. DACW25-00-T-0006. These documents were prepared to provide sufficient detail for construction of the causeway road.

(5) *Operation and Maintenance Manual, Cottonwood Island Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 21, River Miles 328.5 Through 331.0, Lewis and Marion Counties, Missouri, January 2001*. This manual was prepared to serve as a guide for the operation and maintenance of the Cottonwood Island project. Operation and maintenance instructions for major features of the project are presented.

APPENDIX I

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APPENDIX J

PLATES