POST-CONSTRUCTION PERFORMANCE EVALUATION REPORT

BROWN'S LAKE HABITAT REHABILITATION AND ENHANCEMENT PROJECT

YEAR 25 (2015)

US Army Corps of Engineers®
Rock Island District

POOL 13

MISSISSIPPI RIVER MILE 545.8

JACKSON COUNTY, IOWA

ACKNOWLEDGEMENTS
&
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EXECUTIVE SUMMARY

General. The design of the Brown's Lake Habitat Rehabilitation and Enhancement Project (HREP) was to provide the physical conditions necessary to improve and enhance wetland habitat quality. As stated in the Definite Project Report, the Brown's Lake HREP was undertaken to address the following primary problems: accumulation of sediment and deterioration of water quality. These problems were contributing to the direct loss of aquatic and wetland habitat.

Purpose. The purposes of this Performance Evaluation Report are as follows:

1. Document the pre- and post-construction monitoring activities for the Brown's Lake HREP
2. Summarize and evaluate project performance on the basis of the project goals and objectives as stated in the Definite Project Report (DPR)
3. Summarize project operation and maintenance efforts, to date
4. Provide recommendations concerning future project performance evaluation
5. Share lessons learned and provide recommendations concerning the planning and design of future HREP projects

Project Goals and Objectives. The specific goals and objectives as stated in the DPR were to:

1. Enhance Aquatic Habitat
    a. Retard the loss of fish and wildlife aquatic habitat by reducing sedimentation.
    b. Improve water quality.
    c. Increase fish habitat and diversity by providing varied water depths.
    d. Increase habitat available for overwintering fish.
2. Enhance Wetland Habitat
    a. Increase bottomland hardwood diversity.

Project Performance Monitoring. Pre- and post-project monitoring, both qualitative and quantitative, was conducted by the U.S. Army Corps of Engineers, Rock Island District, the US Fish and Wildlife Service, and the Iowa Department of Natural Resource. The period of data collection covered in this report includes pre-project monitoring, and quantitative and qualitative post-project monitoring through 2014.

Evaluation of Project Objectives. For the evaluation period, observations were made with regard to the efficacy of the objectives in meeting project goals. In addition, general conclusions were drawn regarding project measures that may affect future project design.

1. **Enhance Aquatic Habitat**

   a. **Reduce loss of fish and wildlife aquatic habitat by reducing sedimentation.**
      i. Evaluation Criteria: 20 acre-feet of sedimentation reduction volume by Year 50.
      ii. General Observation: Sedimentation within the dredge cuts has occurred.
      iii. Results: Average annual sedimentation volume of 23.7 acre-feet. Expected average annual sedimentation volume without project was 30.8 acre-feet, The HREP reduced the average annual sedimentation volume by 7.1 acre-feet.
      iv. Success: The Year 50 Goal has not been met.
      v. Conclusion: Reduction in overall sedimentation rates is occurring, but the dredge cuts appear to be bearing the majority of the deposition in the HREP.
      vi. Lessons Learned & Recommendations: Orientation and length of the sedimentation transect may skew the sedimentation rates due to the nature of deposition in the HREP. It is recommended that a bathymetric review of these areas be pursued in future PERs.

   b. **Improve water quality by decreasing suspended sediment concentrations.**
      i. Evaluation Criteria: Total suspended solids (TSS) concentrations at or below 50 mg/L by Year 50.
      ii. General Observation: Closure of the water control structure during the spring through fall, coupled with the additional protection provided by the deflection levee effectively shielded the lake from high main channel TSS loads the majority of the time.
      iii. Results: For the time period 2000 to 2013, only exceeded the target eight times out of 374 samples (2.1 %).
      iv. Success: The target of 50 mg/L or less for TSS has been met the majority of the time.
      v. Conclusion: The project was successful in meeting the objective.
      vi. Lessons Learned & Recommendations: Keeping the gates closed during times when the main channel can typically experience high TSS concentrations helps prevent sediment from entering the backwater complex.

   c. **Improve water quality by increasing winter dissolved oxygen concentrations.**
      i. Evaluation Criteria: Dissolved oxygen (DO) concentrations maintained at 5 mg/L or greater than by Year 50.
      ii. General Observation: Minimum DO concentrations were lower and maximum DO concentrations were higher for the most recent evaluation period.
      iii. Results: Of the four monitoring sites, the lowest average DO for the 2000-2013 time period was 9.62 mg/L.

iv. Success: The target DO concentration has been met the majority of the time.
v. Conclusion: The project was successful in meeting the DO objective.
vi. Lessons Learned & Recommendations: Low winter DO concentrations during the observation period were primarily due to timing of the opening and closing of the inlet gate and accretion of sediment in the inlet channel. Most low winter DO concentrations could be avoided by opening the inlet gate by the second week of December, rather than waiting for low DO concentrations to be measured first before opening the gate, as is the current protocol. Should the extended forecast call for heavy rainfall, or a warming trend which would delay freeze-up, the gate opening could be delayed a few days. Opening the inlet gate during the summer could help alleviate low DO concentrations during this time period; however, close monitoring of main channel TSS concentrations would be required to assure that the gate is only opened during periods of low TSS.

d. Increase fish habitat and diversity by provided varied water depths.

i. Evaluation Criteria: As-constructed dredge cuts created an additional 230 acre-feet of additional lake volume.
ii. General Observation: Additional lake volume has decreased since project construction.
iii. Results: Not determined.
iv. Success: Not determined.
v. Conclusion: The evaluation criteria of additional lake volume is insufficient to make a determination on depth diversity.
vi. Lessons Learned & Recommendations: It is recommended that a bathymetric review of the HREP be pursued in future PERs. Future HREP monitoring plans need to modify the additional lake volume measurement criteria as to more accurately represent depth diversity.

e. Increase habitat available for overwintering fish by providing deeper areas.

i. Evaluation Criteria: Five deep-dredged holes greater than 6 feet in depth remaining by Year 50.
ii. General Observation: No assessment due to lack of current survey. Assumed decrease in depth of dredged holes based on sedimentation observed in dredged cuts.
iii. Lessons Learned & Recommendations: Include dredged holes in future sedimentation surveys.

2. Enhance Wetland Habitat

a. Increase bottomland hardwood diversity.

i. Evaluation Criteria: 35 acres of mast-producing tree species by Year 50.
ii. General Observation: Mast-producing trees were only present in the east cell of the planting area.

iii. Results: Bur oak, pin oak and northern red oak were present but limited in extent. Estimated area of surviving mast–producing trees is less than 30 acres.
iv. Success: The project was minimally successfully in increasing bottomland hardwood diversity.
v. Conclusion: The HREP planting areas soil conditions are not well suited for tree survival. Soil conditions range from having too much fine material with very poor drainage and heavy amounts of gravel and sand that restrict root development and moisture retention. Areas where mast-producing trees did not establish from planting efforts are unlikely to ever regenerate with mast-producing trees naturally.
vi. Lessons Learned & Recommendations: Moderate thinning needs to occur to maintain current stand of desirable species. The variation in dredged materials in which the trees were planted lead to the low survival rate. Further examination of soil characteristics comparing areas having high, low, and no survivability from the diverse tree plantings should include testing the soil drainage, particle size, nutrient capability, and water retention.

Evaluation of Project Operation and Maintenance. The HREP Operation and Maintenance (O&M) Manual was completed in January 1991. Project features that require O&M including the deflection levee, water control structure, and inlet channel. Regular site inspections by the Refuge Manager have resulted in proper coordination and corrective maintenance actions.

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INTRODUCTION

The Upper Mississippi River Restoration Program (UMRR) is a Federal-State partnership established to manage, restore and monitor the UMR ecosystem. The UMRR was authorized by Congress in Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) and reauthorized in 1999. Subsequent amendments have helped shape the two major components of EMP—the Habitat Rehabilitation and Enhancement Projects (HREPs) and Long Term Resource Monitoring (LTRM). Together, HREPs and LTRM are designed to improve the environmental health of the UMR and increase our understanding of its natural resources.

Habitat Rehabilitation and Enhancement Project construction is one element of the UMRR-EMP. In general, the projects provide site-specific ecosystem restoration, and are intended and designed to counteract the adverse ecological effects of impoundment and river regulation through a variety of modifications, including flow introductions, modification of channel training structures, dredging, island construction, and water level management. Interagency, multi-disciplinary teams work together to plan and design these projects.

The Brown's Lake HREP is part of the UMRR. This project consisted of hydraulic dredging to enhance aquatic and overwintering habitat, construction of a deflection levee to lower sedimentation rates and planting mast trees to enhance terrestrial habitat and diversity.

1. Purpose of Project Evaluation Reports

The purpose of this Project Evaluation Report for Brown's Lake is to:

a. Document the pre- and post-construction monitoring activities for the Brown's Lake

b. Summarize and evaluate project performance on the basis of project goals and objectives as stated in the Definite Project Report (DPR)

c. Summarize project operation and maintenance efforts, to date

d. Provide recommendations concerning future project performance evaluation

e. Share lessons learned and provide recommendations concerning the planning and design of future HREPs

2. Scope

This report summarizes available monitoring data, Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) information, and project observations made by the U.S. Army Corps of Engineers, Rock Island District (District); the U.S. Fish and Wildlife Service (USFWS); and the Iowa Department of Natural Resources (IDNR). The period of data collection covered in this report includes the pre-construction monitoring (1989) to post-construction monitoring as of 2014.

3. Project References

Published reports which relate to the Brown's Lake HREP include:

- *Definite Project Report with Integrated Environmental Assessment, Brown's Lake Habitat Rehabilitation and Enhancement Project*, Rock Island District Corps of Engineers, November 1987.
- *Operation and Maintenance Manual, Brown's Lake Rehabilitation and Enhancement*, Rock Island District Corps of Engineers, January 1991.
- *Post Construction Performance Evaluation Report, Brown's Lake Rehabilitation and Enhancement,* Rock Island District Corps of Engineers, February 1993.
- *Post Construction Performance Evaluation Report, Brown's Lake Rehabilitation and Enhancement*, Rock Island District Corps of Engineers, May 1993.
- *Post Construction Performance Evaluation Report, Brown's Lake Rehabilitation and Enhancement*, Rock Island District Corps of Engineers, September 1996.
- *Post Construction Performance Evaluation Report Supplement (PERS2F), Brown's Lake Rehabilitation and Enhancement*, Rock Island District Corps of Engineers, April 1997.
- *Post Construction Performance Evaluation Report Supplement (12-Years Post Construction), Brown's Lake Habitat Rehabilitation and Enhancement Project*, Rock Island District Corps of Engineers, October 2003.
- *Brown's Lake HREP, 2007 Annual Inspection Report, US Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge*, October 2007.
- *Brown's Lake HREP, 2008 Annual Inspection Report, US Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge*, October 2008.
- *Brown's Lake HREP, 2011 Annual Inspection Report, US Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge*, July 2011.
- *Brown's Lake HREP, 2013 Annual Inspection Report, US Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge*, December 2014.

4. Project Location

The Brown's Lake HREP is located in Jackson County, Iowa, on the right descending bank of Pool 13 of the Mississippi River, between River Miles 544.0-546.0 (Figure 1). The Brown's Lake HREP is operated by the USFWS and is part of the Upper Mississippi River National Wildlife and Fish Refuge.

PROJECT PURPOSE

1. Overview. The design of the Brown's Lake was to provide the physical conditions necessary to improve habitat quality. The specific goals as stated in the DPR) were to: a) enhance aquatic habitat quality and b) enhance wetland habitat quality. In order to achieve these goals, continuing sedimentation at the site needed to be addressed. These problems were contributing to the direct loss of water quality, fish habitat, wildlife habitat and bottomland hardwood diversity. The problem, opportunity, goals, objectives, and restoration measures implemented to address the goals and objectives are listed in Table 1.

2. Management Plan. A formal management plan was developed for Brown's Lake by the USFWS and is shown in Table 2. The Brown's Lake project is operated as generally outlined in the O&M Manual, dated January 1991.

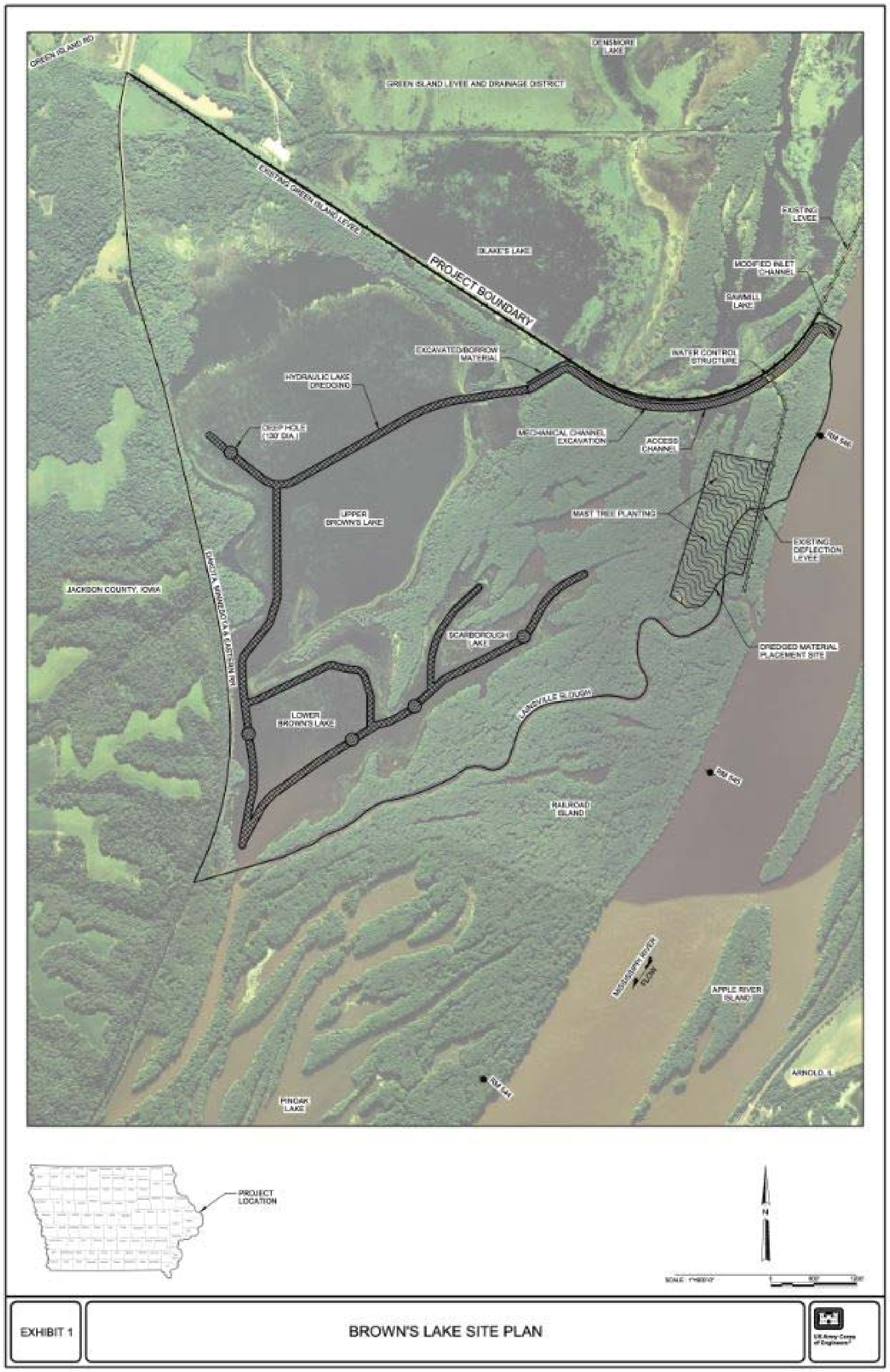


Figure 1. Brown's Lake HREP Area.

Table 1. Problem, Opportunity, Goal, Objectives, and Restoration Measures

Problem	Opportunity	Goals	Objectives	Restoration Measures
Sedimentation	Reduce Sedimentation Rate	Enhance Aquatic Habitat	Retard the loss of fish and wildlife aquatic habitat by reducing sedimentation	Deflection Levee
			Improve water quality	Water Control Structure/Inlet Channel
			Increase fish habitat and diversity by providing varied water depths	Dredging
			Increase habitat available for overwintering	Dredging
		Enhance Wetland Habitat	Increase bottomland hardwood diversity	Mast Tree Plantings

Table 2. Original Management Plan for Brown's Lake as Stated in the DPR

Time Frame	Management Action	Purpose
Winter	Open water control structure 10 inches after ice cover.	Increase DO concentrations for overwintering fish in backwaters.
Spring	Close water control structure when turbidity levels reach 40 NTU in the main channel or 100 NTU in the Maquoketa River. All gates will be closed prior to spring runoff.	Improve water quality in important backwater habitat by decreasing suspended sediment concentrations.

PROJECT DESCRIPTION

1. Project Measures. The Brown's Lake HREP included a combination of dredging, deflection levee construction, a water control structure, and mast tree plantings. A detailed description of each of these measures is provided below.

- **Deflection Levee.** The deflection levee was built to elevation 598.5 feet mean sea level (MSL NAVD88), an approximate 2% chance flood event. This elevation is approximately equivalent to the elevation of the existing Green Island Levee System. The deflection levee functions as a water deflection feature to prevent continuous flow through and subsequent sedimentation during Mississippi River flood events. The levee was built parallel to the Mississippi River approximately 200 feet from the main shore line. The levee connects to the existing Green Island Levee and extends approximately 3,500 feet westward to the Lainsville Slough. The average height of the levee is 9 feet, with side slopes of three horizontal to one vertical.
- **Water Control Structure.** Connecting the deflection levee with the Green Island Levee is a water control structure which controls the amount of water entering Upper Brown's Lake. This structure consists of four slide gates, each 5 feet by 5 feet, with individual operating stems.
- **Inlet Channel Improvement.** The 1200-foot long inlet channel was modified to restrict debris and bed load sedimentation from reaching the water control structure and Brown's Lake by re-orienting the mouth downstream rather than the previous upstream orientation. Finished side slopes are four horizontal to one vertical.
- **Side Channel Excavation.** The centerline of the excavation was placed 115 feet from the Green Island Levee centerline to ensure levee stability. Excavated material was placed onto the riverside of the Green Island Levee. The side channel is approximately 4,000 feet long, 30 feet wide, with slopes of two horizontal to one vertical.
- **Lake Dredging.** Dredging to approximately 9 feet below flat pool was performed to ensure a maintained water depth of 7 feet below flat pool. In addition, five deep holes were dredged to a depth of 20 feet below flat pool to provide habitat diversity. Each deep hole was 130 feet in diameter. Approximately 370,000 cubic yards of material was excavated and placed into a terrestrial dredged material placement site. Channels were dredged 60 feet in width.
- **Mast Tree Planting.** Approximately 25,000 acorns were dropped from a helicopter onto a 150-foot wide strip adjacent to the dredged material placement site. In addition 11,080 seedlings of mast producing trees and shrubs were planted within the placement site.

2. Project Construction. The Brown's Lake HREP was approved for construction in July 1988. Contract DACW25-88-C-0077 was for levee construction, dredging activities, side channel excavation, water control structure construction, and confined dredged material placement site construction.

Mast tree planting was completed with joint USFWS/Rock Island District and Iowa State University efforts.

3. Project Operation and Maintenance

General. Operation and maintenance responsibilities for the Brown's Lake HREP were originally outlined in the DPR. The acceptance of these responsibilities was formally recognized by an agreement signed by the USFWS and the Rock Island District.

A detailed description of all operation and maintenance requirements can be found in the Project's OMRR&R Manual. The OMRR&R Manual for the project delegated responsibilities and procedures for post project activities. Project operation and maintenance generally consists of the following:

a. advancing measures ensuring availability of labor and materials;

b. conducting project inspections annually;

c. inspecting deflection levee during and after periods of high water;

d. maintaining/repairing deflection levee as to maintain cross section;

e. inspecting water control structure during and after periods of high water;

f. lubricating water control gates semi-annually;

g. inspecting inlet channel/side channel; after periods of high water. Removal of debris as required;

h. inspecting dredged channels as required to remove debris; and

i. maintaining plantings in dredged material placement site.

j. raising and lowering of gates in water control structure as required.

Project Measures Requiring Operation and Maintenance. Maintenance of the project measures was to be completed on an as-needed basis to maintain their structural integrity and continued function in the manner for which they were designed. Opening of the inlet gate at the proper time is crucial to maintaining desired DO and TSS levels and maintenance of the inlet channel is crucial to be able to successfully operate the gate.

PROJECT PERFORMANCE MONITORING

1. General. Performance monitoring of the Brown's Lake HREP has been conducted by the District to help determine the extent to which the design meets the habitat improvement objectives. Information from this monitoring will also be used, if required, for adaptive management.

The monitoring and performance evaluation matrix is outlined in Table 3. Pre- and post-project monitoring, both qualitative and quantitative by each of the involved agencies is summarized below.

U.S. Army Corps of Engineers: The success of the project relative to original project objectives shall be measured utilizing data, field observations, and project inspections provided by USFWS, IDNR, and the Rock Island District. The District is responsible for post-project analyses of water quality, sedimentation and vegetation. The District has overall responsibility to measure and document project performance.

U.S. Fish and Wildlife Service: The USFWS is responsible for operating and maintaining the Brown's Lake HREP, as well as annual inspections.

Iowa Department of Natural Resources: The IDNR was responsible for post-project analyses of sedimentation and fish stations. As of 2004 no further analyses of sedimentation was being conducted by the IDNR.

2. Project-Induced Habitat Changes. Fish kills were reported for Brown's Lake prior to project completion. No fish kills were reported during the current monitoring period. Improvements in post-project water quality have undoubtedly contributed to this success.

Table 3. Monitoring and Performance Evaluation Matrix

Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Remarks
Sedimentation Problem Analysis	System-wide problem definition. Evaluate planning assumptions	USFWS	USGS (UMESC)	LTRMP	Leads into pre-project monitoring; defines desired conditions for plan formulation
Pre-project Monitoring	Identify and define problems at HREP site. Establish need for proposed project feature	USFWS	USFWS	USFWS	Attempts to begin defining baseline. See DPR.
Baseline Monitoring	Establish baselines for performance evaluation	USACE	Field station or USFWS thru Cooperative Agreements or Corps	LTRMP	See DPR for location and sites for data collection and baseline information. Actual data collection will be accomplished during Plans & Specification phase.
Data Collection for Design	Include identification of project objectives, design of project, and development of performance evaluation plan	USACE	USACE	HREP	Comes after fact sheet. This data aids in defining the baseline
Construction Monitoring	Assess construction impacts; assess permit conditions are met	USACE	USACE	HREP	Environmental protection specifications to be included in construction contract documents. Inter-agency field inspections will be accomplished during project construction phase
Performance Evaluation Monitoring	Determine success of project as related to objectives	USACE (quantitative) USFWS (field observations)	Field station or USFWS thru Cooperative Agreements or Corps	LTRMP Cooperative	Comes after construction phase of project
Analysis of Biological Responses to Project	Evaluate predictions and assumptions of habitat unit analysis. Determine critical impact levels, cause-effect relationships, and effect on long-term losses of significant habitat	USFWS	USGS (UMESC)	LTRMP	Problem Analysis and Trend Analysis studies of habitat projects

PROJECT EVALUATION

1. Construction and Engineering. Construction began in July 1988 and was initially completed in September 1990, except for mast tree plantings. These plantings were completed in May 1993.

2. Costs. In the original DPR, cost estimates for the entirety of the project were $2,873,000. Initial construction costs (planning, design, construction and construction management) were $1,992,498.

Inlet channel dredging was conducted October 2009. Costs for the dredging was $113,990 and removed 15,000 cubic yards utilizing UMRR funds. These dredging funds were executed due to the 2008 Flood event causing excessive inlet sedimentation. Annual water quality monitoring determined that dissolved oxygen levels were critically low, threatening a fish kill in the project. USACE operations staff performed the work in coordination with USFWS.

3. Operation and Maintenance. In the original DPR, an average annual operation and maintenance cost was estimated to be $11,260. Per the USFWS 2013 Annual Inspection Report the Sponsor's total OMRR&R cost has been $27,200 for the period 1991 to 2013. Table 4 provides OMRR&R history and cost for the Brown's Lake HREP. OMRR&R activities included water control structure operation, inspections, mowing, flood repairs, inlet dredging, tree removal, herbicide application and debris removal. The Sponsor's OMRR&R costs do not included costs incurred by USACE for the 1996 and 2009 inlet dredging, or for the 2008 Green Island Levee breach repairs.

4. History of Major Disturbances. Following flooding in 1993, further excavation of the inlet channel was required. Inlet channel re-excavation was begun in August 1995 and completed in September 1996 by the USACE. Flooding in 2008 caused a breach in the Green Island Levee (Station 375+00), which forms the western border of the Brown's Lake HREP. Levee repair material was taken from a borrow site (spur dike) adjacent to the breach within the HREP.

5. Ecological Effectiveness. Table 5 summarizes the performance evaluation plan and schedule for the Brown's Lake HREP goals and objectives.

Table 4. Operation and Maintenance History for the Brown's Lake HREP

Year[1]	Years in O&M	Estimated Annual Cost w/ Inflation	Actual USFWS Costs	Activities
FY1991	1	$13,941	None	None
FY1994	4	$14,685	$1,400	Operate water control structure (WCS), mow, inspection
FY1995	5	$15,096	$800	Operate WCS, mow, inspection
FY1996	6	$15,534	$900	Operate WCS, mow, inspection
FY1997	7	$15,891	$700	Operate WCS, mow, inspection
FY1998	8	$16,146	$4,700	Operate WCS, mow, inspection, clean up after 1997 flood
FY2003	13	$18,230	$1400	Operate WCS, mow, inspection
FY2004	14	$18,722	$100	Operate WCS
FY2005	15	$19,359	$9,500	Operate WCS, remove inlet silt plug, inspection, lubricate stems
FY2006	16	$19,979	$100	Operate WCS
FY2007	17	$20,558	$1,100	Operate WCS, inspections
FY2008	18	$21,380	$800	Operate WCS, inspections
FY2009	19	$21,254	$1,100	Operate WCS, inspections
FY2010	20	$21,891	$2,700	Operate WCS, inspections, remove sediment from inlet
FY2011	21	$22,285	$400	Operate WCS, mowing, inspections
FY2012	22	$22,753	$300	Operate WCS, inspections
FY2013	23	$23,094	$1,200	Operate WCS, mowing, tree removal, inspections

1: Information not available for FY1992, 1993, 1999, 2000, 2001 and 2002.

Table 5. Performance Evaluation and Monitoring Schedule

Goal	Objectives	Enhancement Measures	Units	Year 0 w/out Project (1990)	Year 0 w/ Project(as-built)	Year 11 w/ Project(2001)	Year 25 w/ Project (2015)	Year 50 Target w/ Project	Monitoring Schedule
Enhance Aquatic Habitat	Retard loss of aquatic habitat by reducing sedimentation	Deflection levee	Annual reduction in sedimentation (Acre-feet)	0	21.6	11.4	7.1[a]	20	Hydrographic soundings of transects
	Increase fish habitat and diversity	Dredging	Acre-feet of additional lake volume	0	230	140	Not Defined	8	Hydrographic soundings of transects
	Increase overwintering fish habitat	Dredging	Number of deep water holes (>6-8')	0	5	5	Not Measured	5	Hydrographic soundings of holes
	Improve water quality	Water Control Structure/ Inlet Channel Improvement	Dissolved Oxygen (mg/L)	<5	>5	>5	Avg range 9.62 to 10.6 mg/L	>5	Water quality testing
			Total Suspended Solids (mg/L)	300	Not Measured	<50	Avg range 16.3 to 20.7 mg/L	50	Water quality testing
Enhance Wetland Habitat	Increase bottomland hardwoods diversity	Plantings	Acres of mast trees	0	Not Measured	Not Measured	Not measured	35	Use forest inventory methods in 2019 to calculate canopy species composition and proportion of canopy species that are mast trees. Use aerial imagery in 2020 to calculate acreage of all trees. Adjust acreage of all trees using composition values generated from 2019 forest inventory data to generate a value for acreage of mast trees.[c] Repeat in 2029/2030 and 2039/2040.
			Density of mast trees	Not Measured	Not Measured	Not Measured	150 oaks/acre[b]	NA	Repeat in 2030 and 2040

a: Calculated for the 1995 to 2014 time period, b: Based on 2008 survey, c: Vegetation transects removed from monitoring schedule in 1997 PER

a. Reduce the Loss of Fish and Wildlife Aquatic Habitat by Reducing Sedimentation

General. One of the specific project objectives for the Brown's Lake HREP was to reduce sedimentation in the lake. The deflection levee was installed to reduce the volume of sedimentation in the lake. The Year 50 Goal of this objective is an annual reduction in sedimentation volume by 20 acre-feet, from a pre-construction expected volume of 30.8 acre-feet annually.

Pre- and Post-Project Conditions. In the 1930's, Brown's Lake was up to 6 feet deep. Due to continued inundation and sedimentation, by the mid to late 1980's most of the lake had been converted to a 6 to 18 inch deep marsh complex. The DPR estimated a pre-project sedimentation rate of 0.45 inches per year at Brown's Lake. The DPR also noted that Smith's Creek is the predominant watershed adjacent to Brown's lake, and contributes a significant amount of sediment. An estimate of 30.8 acre-feet of sediment was deposited annually in the pre-construction period, with an estimated 82% of the sediment from the Mississippi River, and 18% from Smith's Creek.

The HREP was designed and constructed to provide a reduction in annual sedimentation volume of 21.6 acre-feet. Sedimentation transects Range A, B, C, D and E were surveyed in 1989, 1995 and 2014 (transect plates and cross sections are included in Appendix A, Survey Transects and Cross Section Plates). The 2006 PER indicated a sediment deposition rate of 4.6 inches per year in the dredge cuts. A dredge cut sedimentation rate of 1.8 inches per year was determined for the period 1995 to 2014. This sedimentation rate correlates to an average annual sedimentation volume of 23.7 acre-feet. Given the estimated 30.8 acre-feet of annual sedimentation volume prior to construction, the HREP features have reduced the average annual sedimentation volume by 7.1 acre-feet for the period 1995-2014. The Year 50 Goal for sedimentation reduction volume as prescribed in the PER is 20 acre-feet. The Year 11 average annual sedimentation reduction volume was calculated as 11.4 acre-feet. The current value of 7.1 acre-feet is less than the Year 11 value and the Year 50 goal. Further discussion of the sedimentation rate determination is included in Appendix D, Brown's Lake Sediment Deposition Rate Evaluation.

Conclusion. The project measures appear unsuccessful in providing the ability to meet the desired reduction in annual sedimentation volume. The vertical dredge cut design may have contributed to the initially higher sedimentation rates observed in previous PERS.

b. Improve Water Quality by Decreasing Suspended Sediment Concentrations and Increasing Dissolved Oxygen Concentrations

General. The water control structure and inlet control improvements were installed to keep total suspended solids (TSS) concentrations at or below 50 mg/L and to maintain dissolved oxygen (DO) concentrations greater than 5 mg/L by year 50.

Pre- and Post-Project Conditions. Winter fish kills were common prior to project completion and were attributed to low DO concentrations in conjunction with decreasing water depths due to sedimentation. In an effort to avoid future winter kills, a water control structure was constructed in the Upper Brown's Lake inlet channel. The gated structure was designed to allow oxygen-rich Mississippi River water to flow into the lake, particularly during the critical winter months, while keeping sediment laden waters from the lake the remainder of the year.

Post-project water quality data were collected by USACE Water Quality and Sedimentation Section (EC-HQ) personnel from December 27, 2000 through March 6, 2002 and December 19, 2006 through September 10, 2013 at three Brown's Lake sites (W-M545.8F, W-M544.2C and W-M544.6F); while IDNR personnel monitored one site (W-M545.5B) from December 13, 2000 through September 16, 2002 and April 5, 2004 through September 3, 2013. Water quality data were obtained through a combination of periodic grab samples and the use of *in-situ* continuous monitors (sondes).

The results from grab samples showed the number of DO measurements below 5 mg/ L at each of the four sites during a winter month is as follows: W-M545.8F(2), W-M544.2C (1), W-M544.6F (4) and W-M545.5B (2). Most of these low DO concentrations were due to the inlet gate not being open yet, or accretion of sediment in the inlet channel preventing oxygenated Mississippi River water from entering the lake.

In addition to grab samples, water quality sondes were deployed by EC-HQ personnel on 59 occasions at site W-M544.6F, eight occasions at site W-M544.2C and seven occasions at site W-M545.8F. It was common for supersaturated DO concentrations to be measured by sondes deployed during the winter months. Periods of low winter DO concentrations were occasionally recorded; however, most of these occurred when the inlet gate was not open or there was a sediment blockage in the inlet channel. During the summer months, nighttime DO concentrations frequently fell below the 5 mg/L target level; however, they often recovered the following day, often to supersaturated levels.

All TSS concentrations at sites W-M545.8F and W-M544.6F were below 50 mg/L. The TSS concentration exceeded 50 mg/L on four occasions at both sites W-M544.2C and W-M545.5B. Some of these exceedances were attributed to algal blooms, wind generated waves that caused resuspension of bottom sediments, or a "backwater" effect from Lainsville Slough. Appendix B, *Water Quality Report*, contains in depth discussion, data tables and graphs.

Conclusion. Results from the current evaluation period show that the Brown's Lake project continues to have a positive impact on water quality as long as the inlet gate is opened at the proper time and sediment is not allowed to accumulate in the inlet channel. Most low winter DO concentrations could be avoided by opening the inlet gate by the second week of December rather than waiting for low DO concentrations to be measured first before opening the gate, as is the current protocol. Such early winter gate opening would need to take weather and river conditions into consideration as to not create a public safety hazard (due to thin ice), to prevent introduction of sediment, and maintain ideal overwintering conditions for fish. Should the extended forecast call for heavy rainfall, or a warming trend which would delay freeze-up, the gate opening could be delayed a few days. Although low DO concentrations were occasionally measured, no fish kills were reported according to IDNR fisheries personnel.

Closure of the water control structure during the spring through fall, coupled with the additional protection provided by the deflection levee effectively shielded the lake from high main channel TSS loads the majority of the time. The few instances when the TSS concentration exceeded 50 mg/L were primarily caused by resuspension of bottom sediments due to high winds, high velocities keeping sediment in suspension, or high algal concentrations.

Results from the current evaluation period indicate the ability to introduce oxygenated water into, and exclude sediment laden water from, the Brown's Lake HREP continue to be key elements of the project's success.

c. Increase Fish Habitat and Diversity by Providing Varied Water Depths

General. Channels were dredged to provide varying water depth within the HREP. Dredging initially created an additional 230 acre-feet of lake volume. The Year 50 Goal of this objective 8 acre-feet of additional lake volume remaining at the conclusion of the project life.

Pre- and Post-Project Conditions. Pre-project assessments indicated Brown's Lake was converting to a terrestrial habitat, with eventual loss of the current (at the time of the DPR) diversity in fish and wildlife species. Average lake bottom elevation in the HREP was approximately 582 feet MSL.

Dredging was conducted to provide varied water depths within the HREP. As-built dredge cuts were excavated to a depth of 9 feet (574 feet MSL) below flat pool (583 feet MSL). Approximately 370,000 cubic yards were hydraulically dredged along 19,520 linear feet in the HREP, and the materials placed in the dredged material placement site. The dredging initially added 230 acre-feet of additional lake volume to the HREP.

Conclusion. The measurement of additional lake volume is not beneficial to determining if varied water depths are present in the HREP. The layout of transects does not adequately capture the variation in depths in the dredged areas. Bathymetric surveys of the dredge cuts in both the Upper and Lower Lake are recommended.

d. Increase Habitat Available for Overwintering Fish by Providing Deeper Areas

General. During dredging activities, five deep water areas were created along the path of the dredge cuts. These deeper areas were installed to create additional habitat area available for overwintering fish.

Pre- and Post-Project Conditions. See Section 4a for pre project conditions regarding sedimentation. Pre-project assessments indicated Brown's Lake was converting to a terrestrial habitat, with eventual loss of the current (at the time of the DPR) diversity in fish and wildlife species. Average lake bottom elevation in the HREP was approximately 582 feet MSL.

Five deep water areas ('holes') were constructed as a part of the dredging activities. Each hole was initially 130 feet in diameter, and dredged to a depth of 17 feet below flat pool (583 feet MSL). Surveys of the holes have not been conducted since 1997. At that time the average depth of the holes was 14.5 feet. Although no survey of the deep water holes were conducted in 2014 survey, based on the sedimentation observed in the dredge cut areas, it is anticipated that further reduction in deep water area depths has occurred.

Conclusion. No conclusion can be generated due to lack of surveys on the HREP feature. The sedimentation in the adjoining dredged channels indicate the high probability of a reduction in hole dimensions, and thereby a decrease in deep overwintering habitat. Bathymetric surveys of the dredge cuts and deep water areas in both the Upper and Lower Lake are recommended.

e. Increase Bottomland Hardwood Habitat Diversity

General. Planting of mast trees was conducted based on the anticipated growing conditions in the dredged material placement area. The Year 50 Goal for this objective is 35 acres of mast-producing tree species.

Pre- and Post-Project Conditions. Prior to HREP construction approximately 421 acres of forest was present within project boundaries. However, this forested area was dominated by willow, cottonwood and silver maple. In May 1990, 25,000 pin oak acorns were aerially dropped on a 150-foot wide strip near the dredged material placement area. Additionally, in 1992 and 1993, 11,080 seedlings were planted in the dredge material placement area.

Subsequent surveys determined that by 1993 all the 1990 acorn plantings had not survived. A survey conducted in 1997 of the seedlings planted in the dredged material placement area determined that a small amount of the original 11,080 seedlings had survived. These seedlings were present in the southeast quarter of the placement area, and the middle ridge that separates the cells. Most of the placement area was comprised of willows with some cottonwoods. It was surmised that the poor drainage observed on the placement area surface was the cause of the seedling high mortality rate.

An inventory of the dredge placement area was conducted in 2008. A Memorandum for Record, tree inventory tables and associated maps from the 2008 survey are included in Appendix C, *Bottomland Hardwood Diversity Supporting Documents.* The inventory indicated that hard mast trees were only present in the east cell of the placement area. The majority of the trees were less than 6 inches in diameter at breast height. The hard mast trees present included bur oak, pin oak and northern red oak. Hard mast trees were only seen in the east cell and calculated out to be 151 trees per acre.

During material placement, the dredge pipe was located primarily at the eastern edge of the placement site; hence most of the sand and gravel is toward the eastern side of the area (see Tree Inventory LiDAR Map in Appendix C). This has caused lasting effects and severe growth limitations to the oak. The trees in the far eastern portion of the placement area are more representative of bushes in growth form. The west cell of the placement area did not fill in with as much dredge material thus has a lower elevation, holds surface water and remains moist year round. Desirable trees on site will need opening and releasing from surrounding nurse trees and volunteer tree pressure. Crop tree release cutting by personal on the ground would be most effective means of timber stand improvement. Crop tree release should be done within 3 to 5 years before desirable trees begin to become suppressed. Thick pockets of desirable tree growth will need thinning within 5 to 8 years. Without moderate thinning, desirable trees will most likely be stressed from overstocking complications. The willow and cottonwood that seeded in are acting as nurse crop trees and providing good structural development to the oak.

The Year 50 Goal for this objective of 35 acres of mast-producing tree species has not been met. Since mast producing trees from the 1992 and 1993 seedling plantings are currently only present in the east cell of the dredged material placement area, and given the limited growth areas in the east cell, the actual acreage is likely less than 30.

LESSONS LEARNED AND RECOMMENDATIONS FOR FUTURE SIMILAR PROJECTS

- Degraded backwaters can be rehabilitated with water management and dredging.
    - PDTs need to consider all sedimentation sources, outside of the main stem river. At this location, a new project, Smith's Creek Habitat Rehabilitation and Enhancement Project was initiated and studied, but not implemented. The amount of sediment being transported by this waterway could not be managed or diverted from Brown's Lake within the existing real estate footprint for the project.
    - PDTs need to work closely with other agencies, such as USDA NRCS, to ensure that input from upstream sources can be minimized on private land.
    - Dredge cuts with vertical walls are prone to sloughing and should be discouraged in the design process. The vertical wall design used on the Brown's Lake dredge cuts may be one reason for the dredge cut infilling.
    - Projects should be designed to eliminate or minimize sedimentation at the inlet channel. Sediment accumulates at the inlet channel entrance, which can block flows into Brown's Lake. In addition, this continuous sedimentation issue has been a challenge for Refuge maintenance operations, especially since it was not anticipated during project planning.
- Smaller water control structures may achieve desired results. The inlet structure consists of four (60" x 61") gates. Typically only one gate is opened to 10 inches. This allows for sufficient DO to enter the backwater complex, while keeping velocities relatively low.
- Operation of sites, and varying operation of gates, drawdowns, and other measures may create a more successful project.
    - Opening of the inlet gate at the proper time is crucial to maintaining desired DO and TSS levels.
    - Maintenance of the inlet structure is crucial to be able to successfully operate the gate.
- The varied nature of the materials presents in dredged material placement sites needs to be taken into consideration when mast tree planting is proposed.
    - The dredged material in the west cell was fine grained and was not found to successfully support tree growth. Current and future HREPs are considering amending dredge material placement sites to ensure that subsurface can support tree growth.

- Acorn planting was tried at this site and various other locations throughout the District in the 1990's. It had very low success rates and should not be considered for future projects.

- Seedling plantings in the 1990's at this and other MVR projects was found to have low success rates. Since this era, Root Pruned Method (RPM) trees and/or container grown trees have been found to be more successful.

- In the late 1980's and early 1990's, elevations tied into specific inundation rates were not used to select forest diversity sites. Future planting efforts should consider tree survivability rates at various inundations (such as using the Forest Diversity Index or EFM) prior to investing in planting efforts.

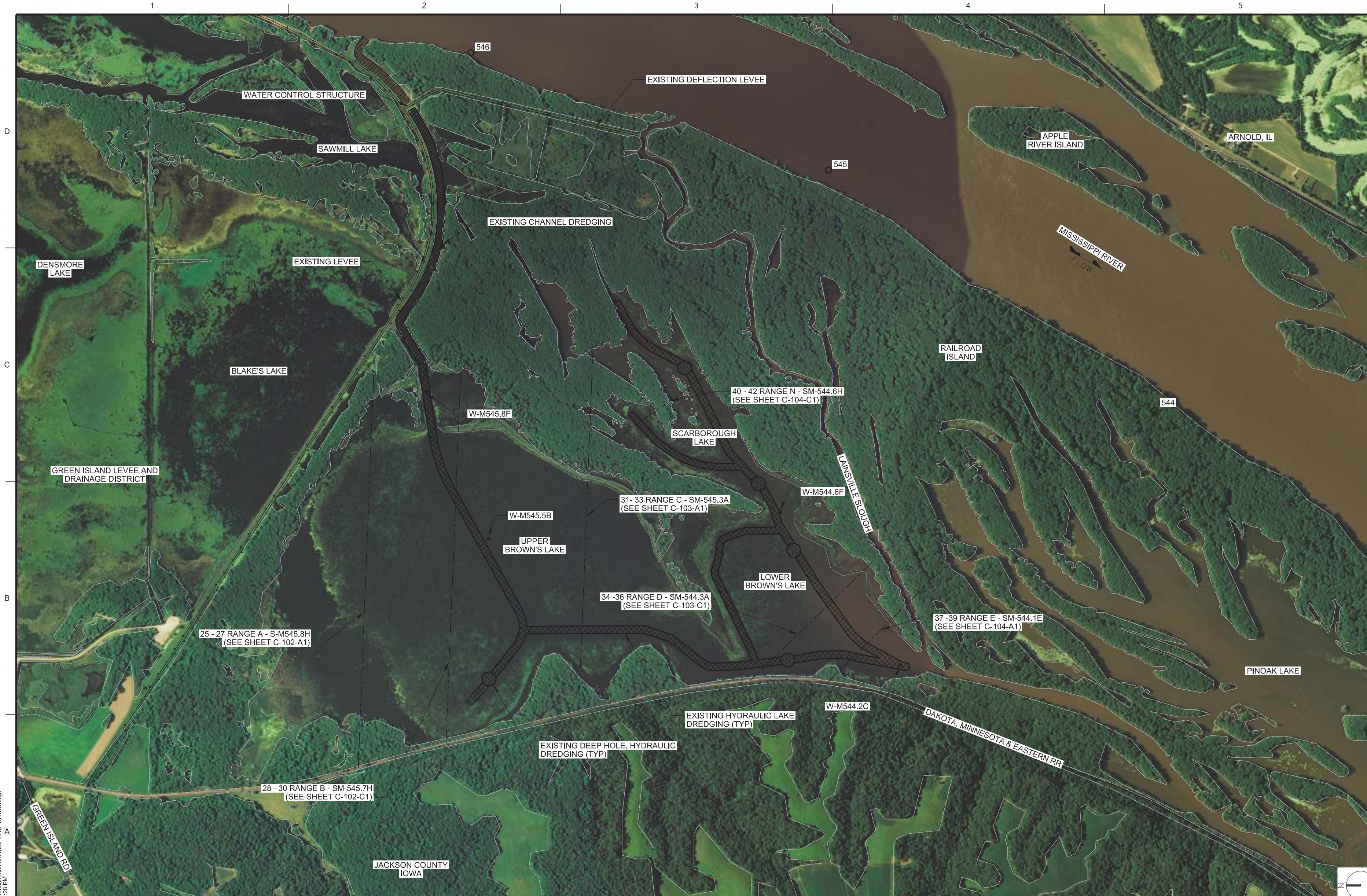
- Management of forest sites in general result in more successful projects. Refer to the recommendations for future management of this site.

POST-CONSTRUCTION
PERFORMANCE EVALUATION REPORT

BROWN'S LAKE
HABITAT REHABILITATION AND ENHANCEMENT PROJECT

APPENDIX A

SURVEY TRANSECTS AND CROSS SECTION PLATES



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JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

SITE PLAN

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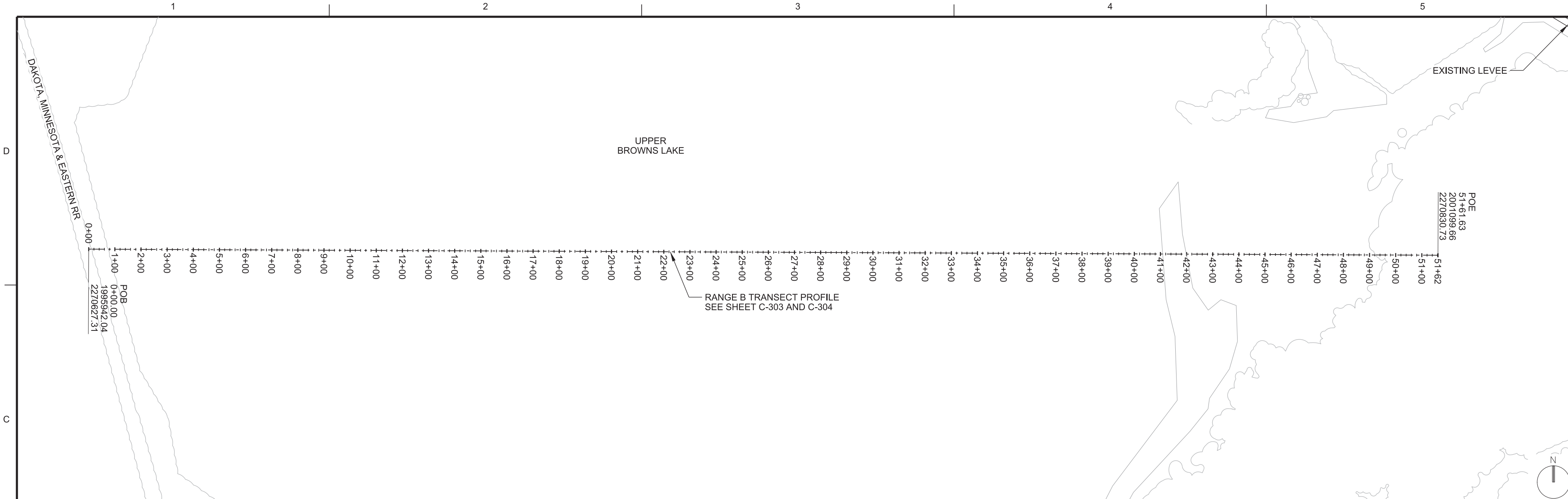

C1 PLAN 28 - 30 RANGE B - SM-545.7H

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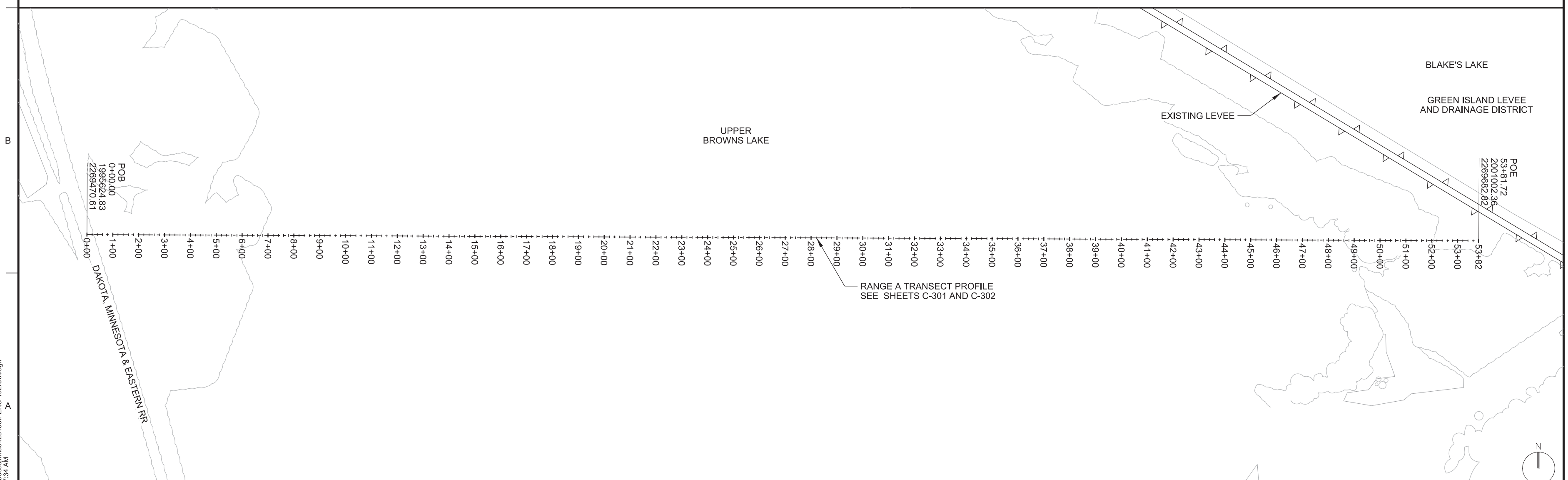

A1 PLAN 25 - 27 RANGE A - S-M545.8H

SCALE : 1"=200'-0"

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PLAN 28 - 30 RANGE B
AND 25 - 27 RANGE A

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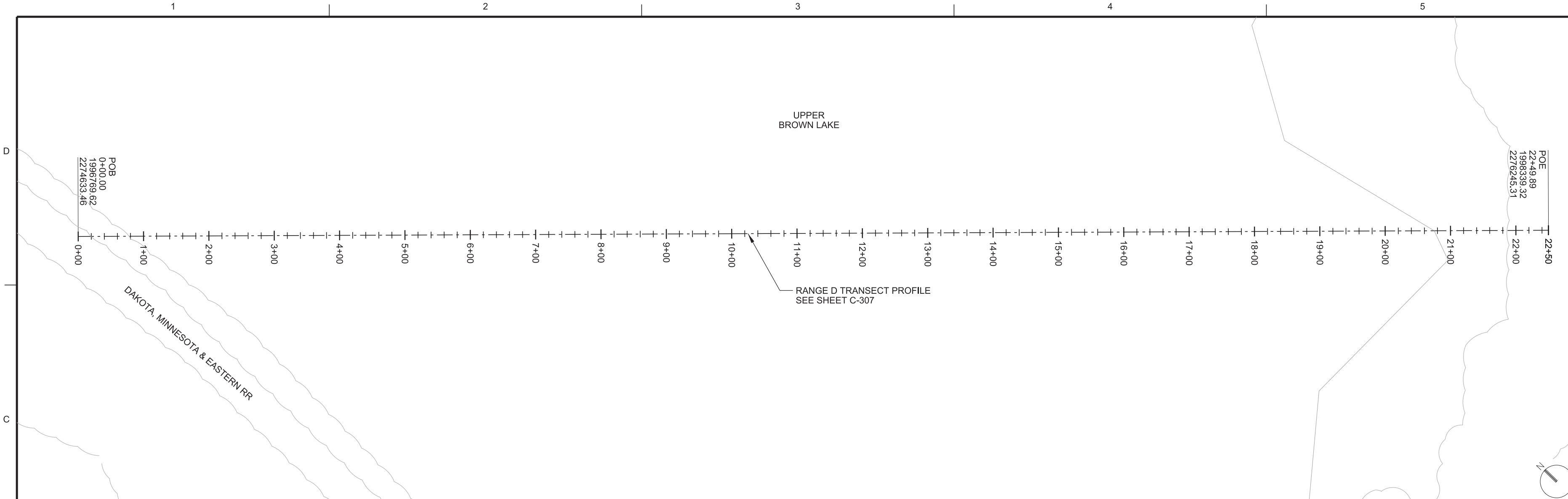

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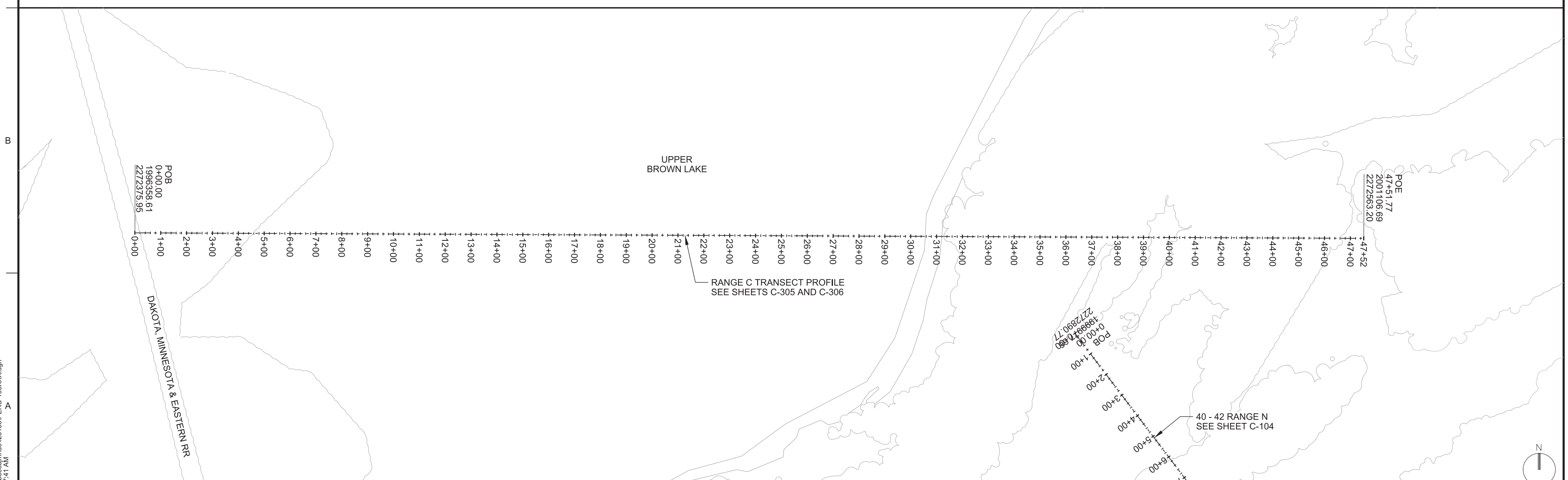

A1 PLAN 31 - 33 RANGE C - SM545.3A

SCALE : 1"=200'-0"   0   200'   400'

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BROWN'S LAKE PER

PLAN 34 - 36 RANGE D
AND 31 - 33 RANGE C

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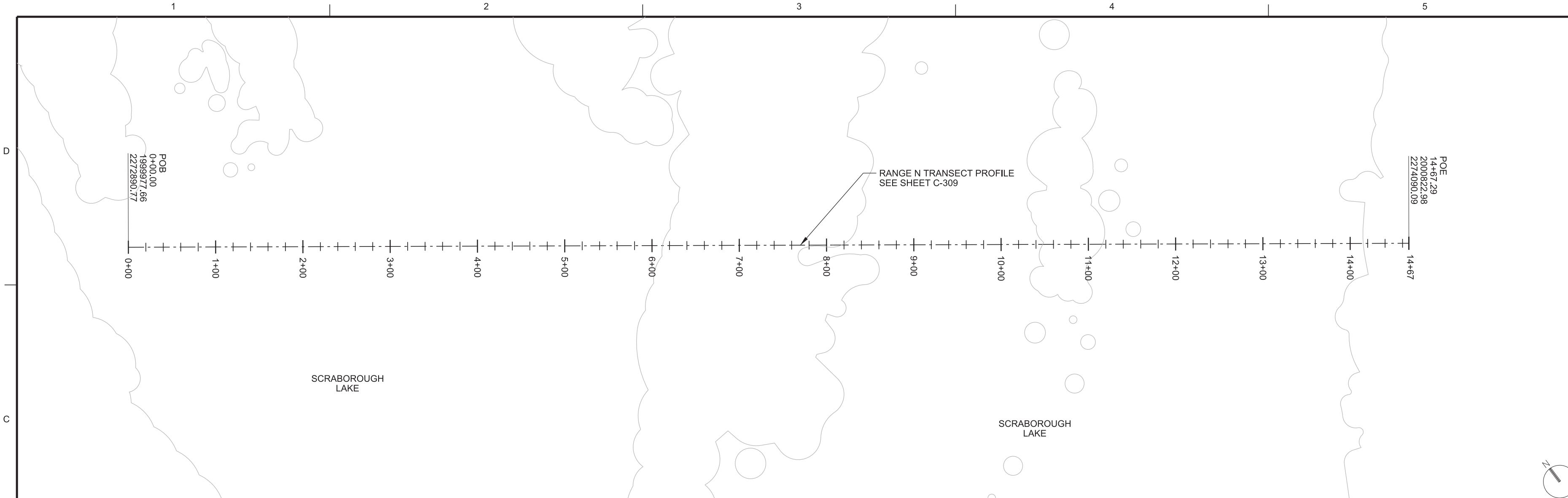

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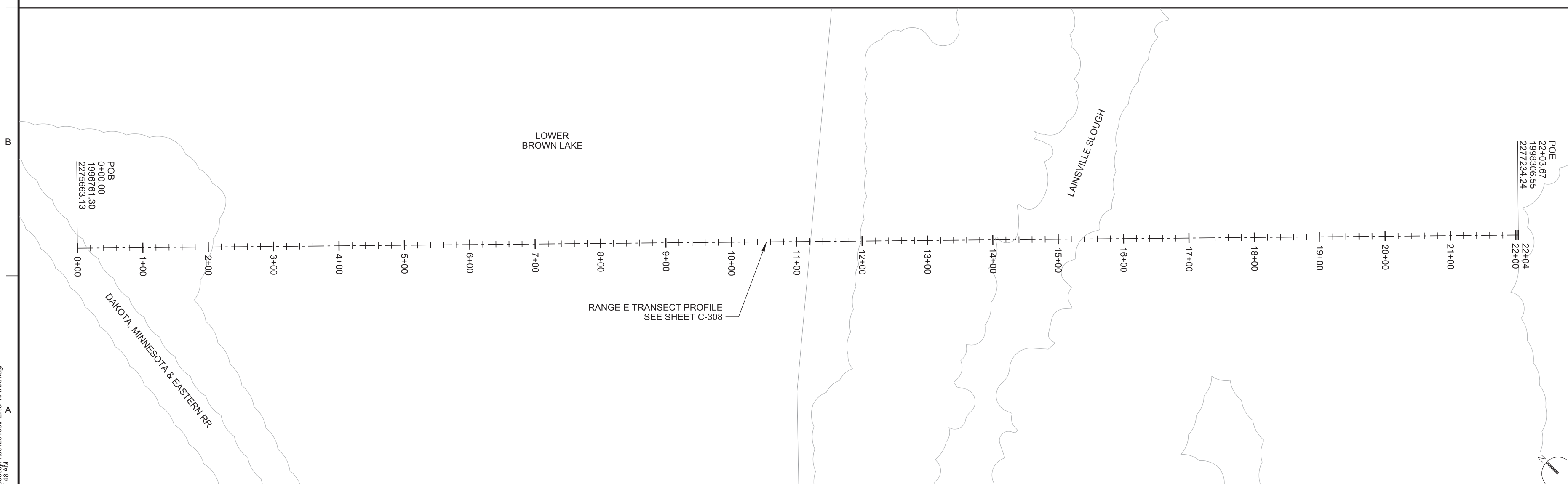

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BROWN'S LAKE PER

PLAN 40 - 42 RANGE N
AND 37- 39 RANGE E

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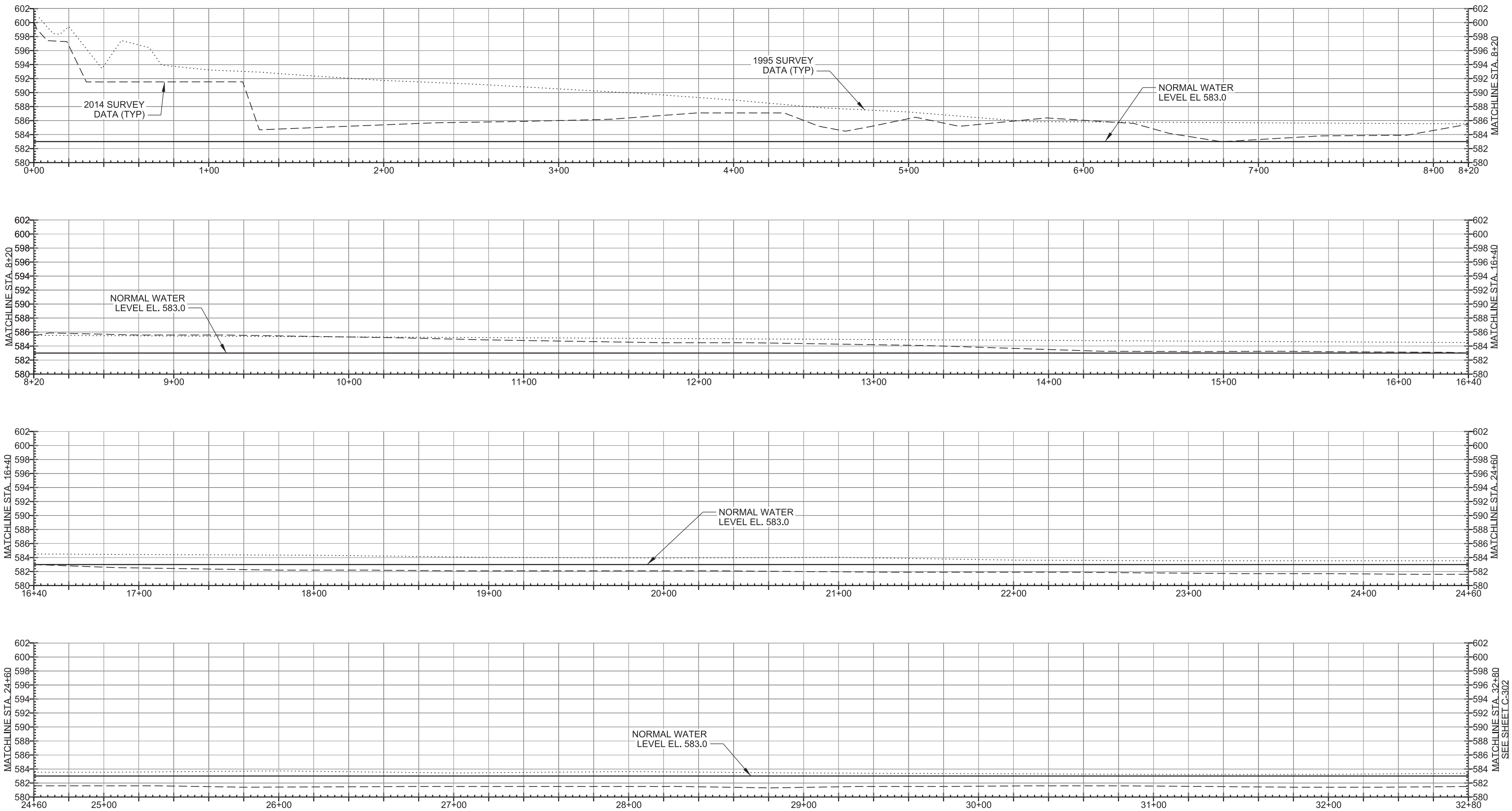

A1 PROFILE 25 - 27 RANGE A - S-M545.8H

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BROWN'S LAKE PER

PROFILE - 25 - 27 RANGE A
S-M545.8H

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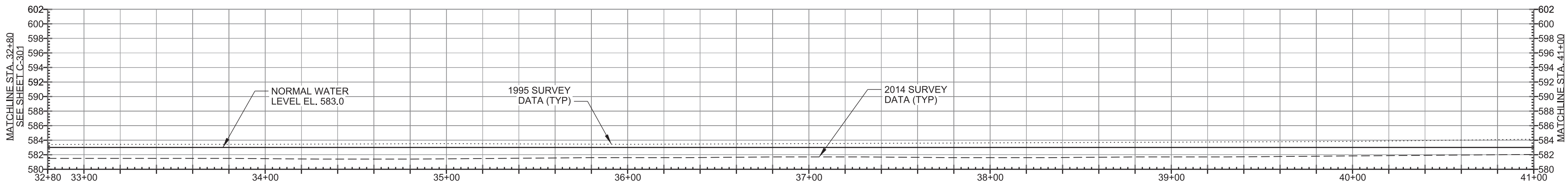

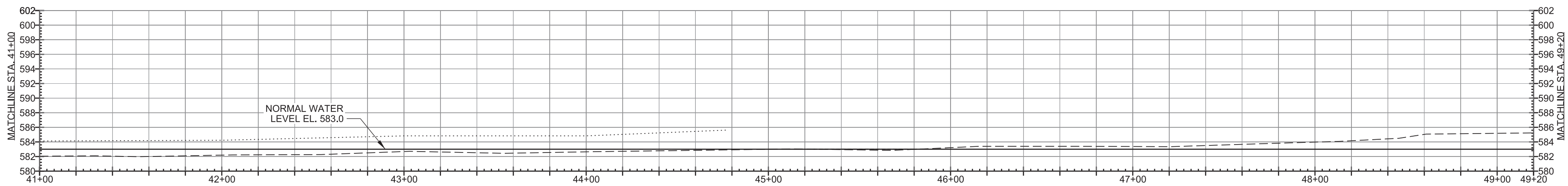

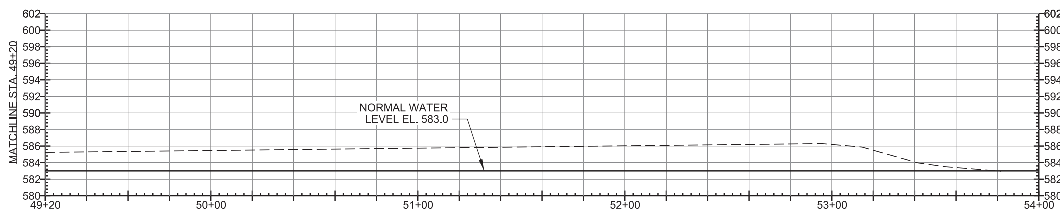

A1 PROFILE 25 - 27 RANGE A - S-M545.8H

SCALE : 1"=30'-0"

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ROCK ISLAND, ILLINOIS

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MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 25 - 27 RANGE A
S-M545.8H

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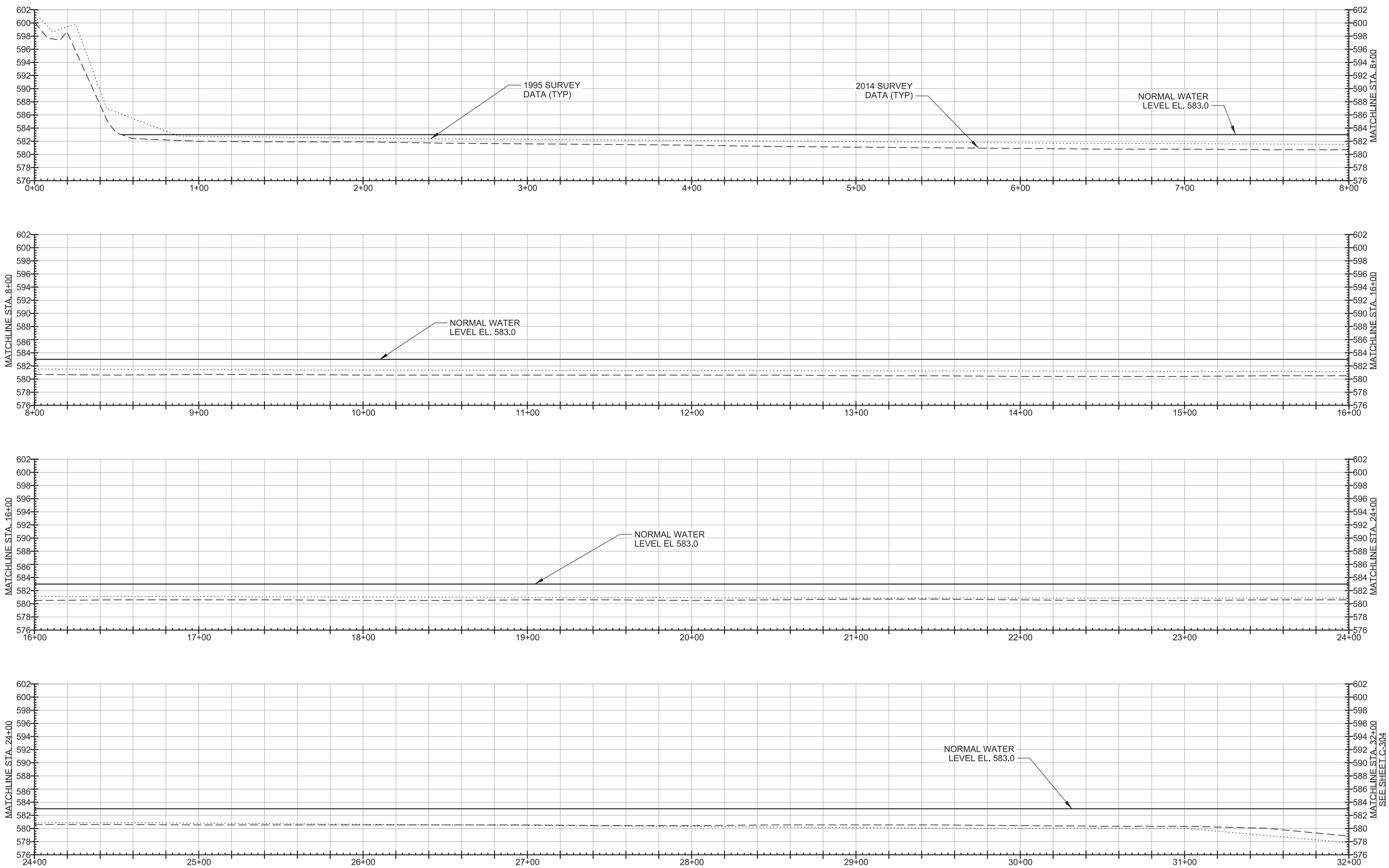

A1 PROFILE 28 - 30 RANGE B - SM-545.7H

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BROWN'S LAKE PER

PROFILE - 28 - 30 RANGE B
SM-545.7H

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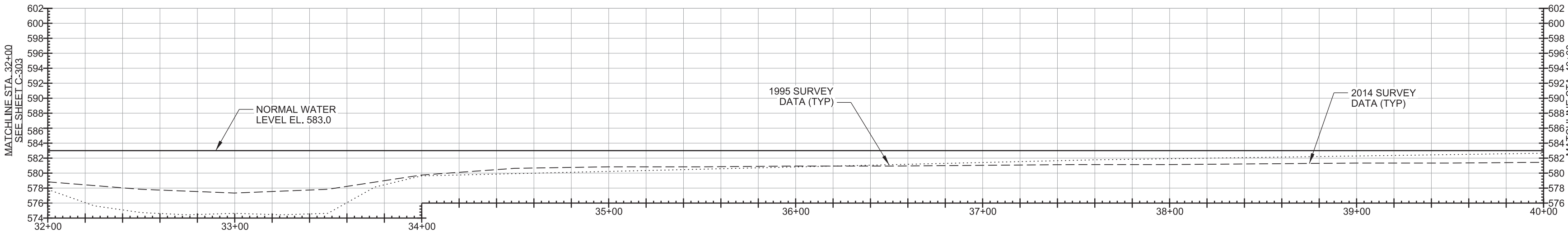

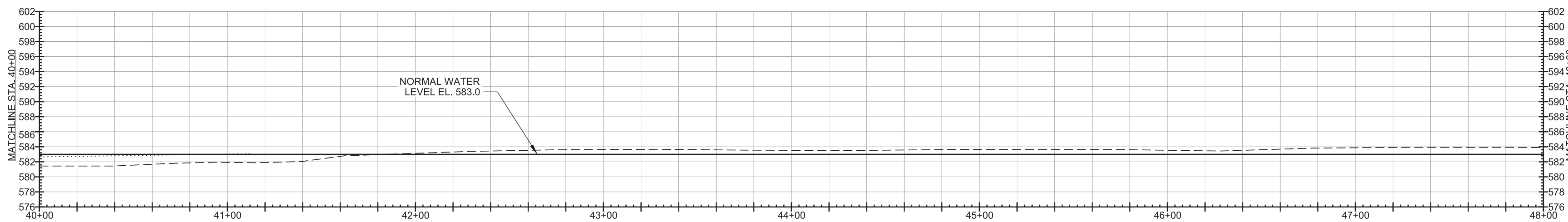

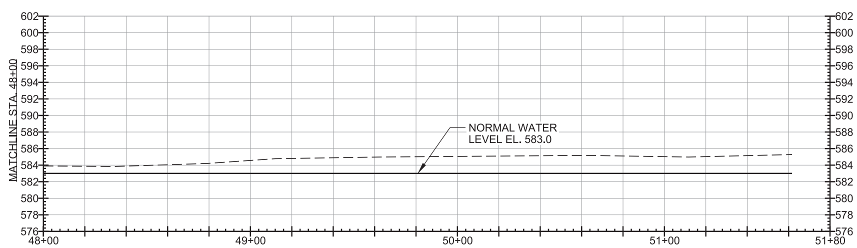

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MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 28 - 30 RANGE B
SM-545.7H

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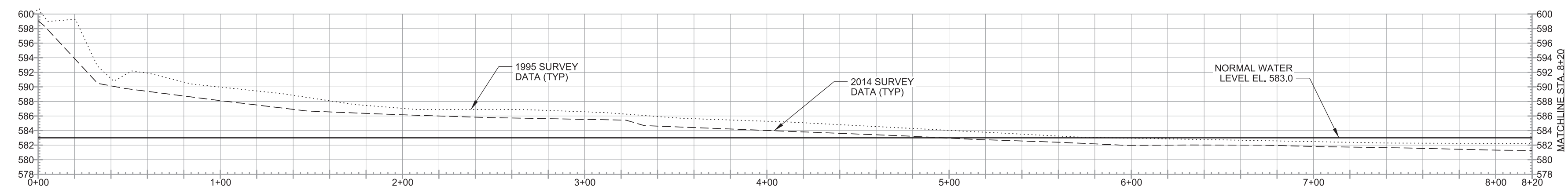
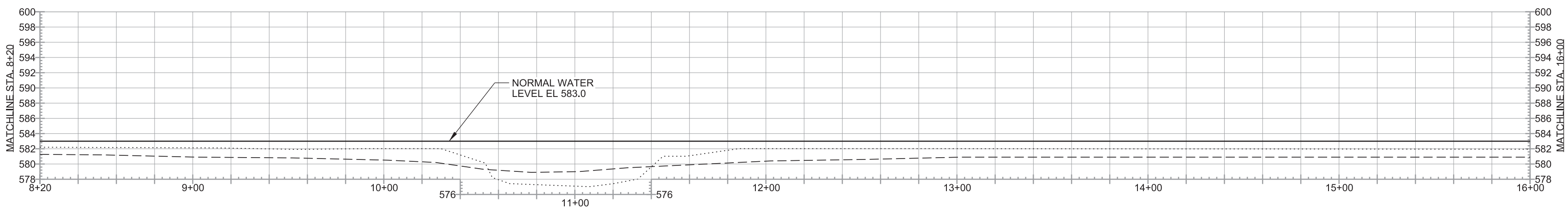
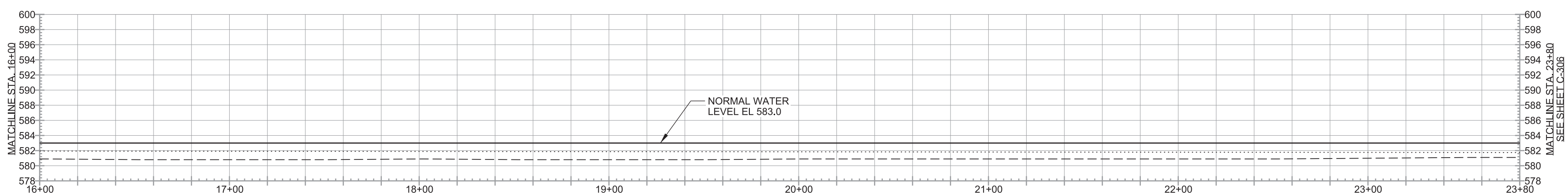
US Army Corps of Engineers







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U.S. ARMY CORPS OF ENGINEERS
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ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 31 - 33 RANGE C
SM-545.3H

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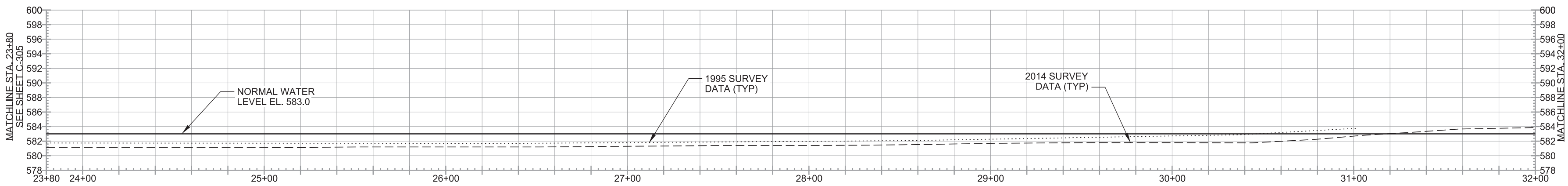

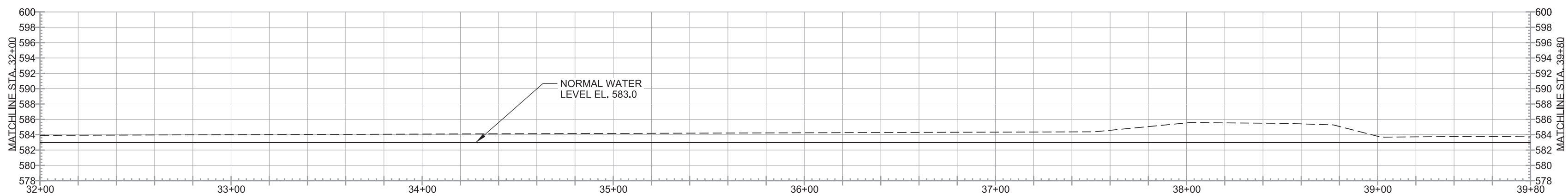

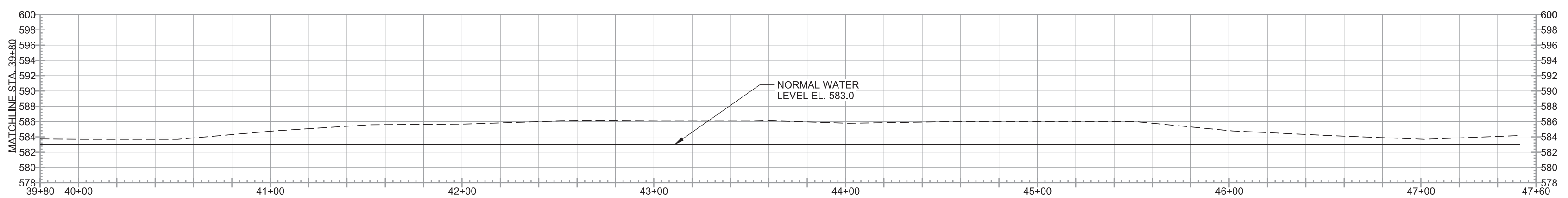

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US Army Corps of Engineers

MARK | DESCRIPTION | DATE | APPR.

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ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

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DWN BY: JMF | CKD BY: | SOLICITATION NO.:
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MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 31 - 33 RANGE C
SM-545.3H

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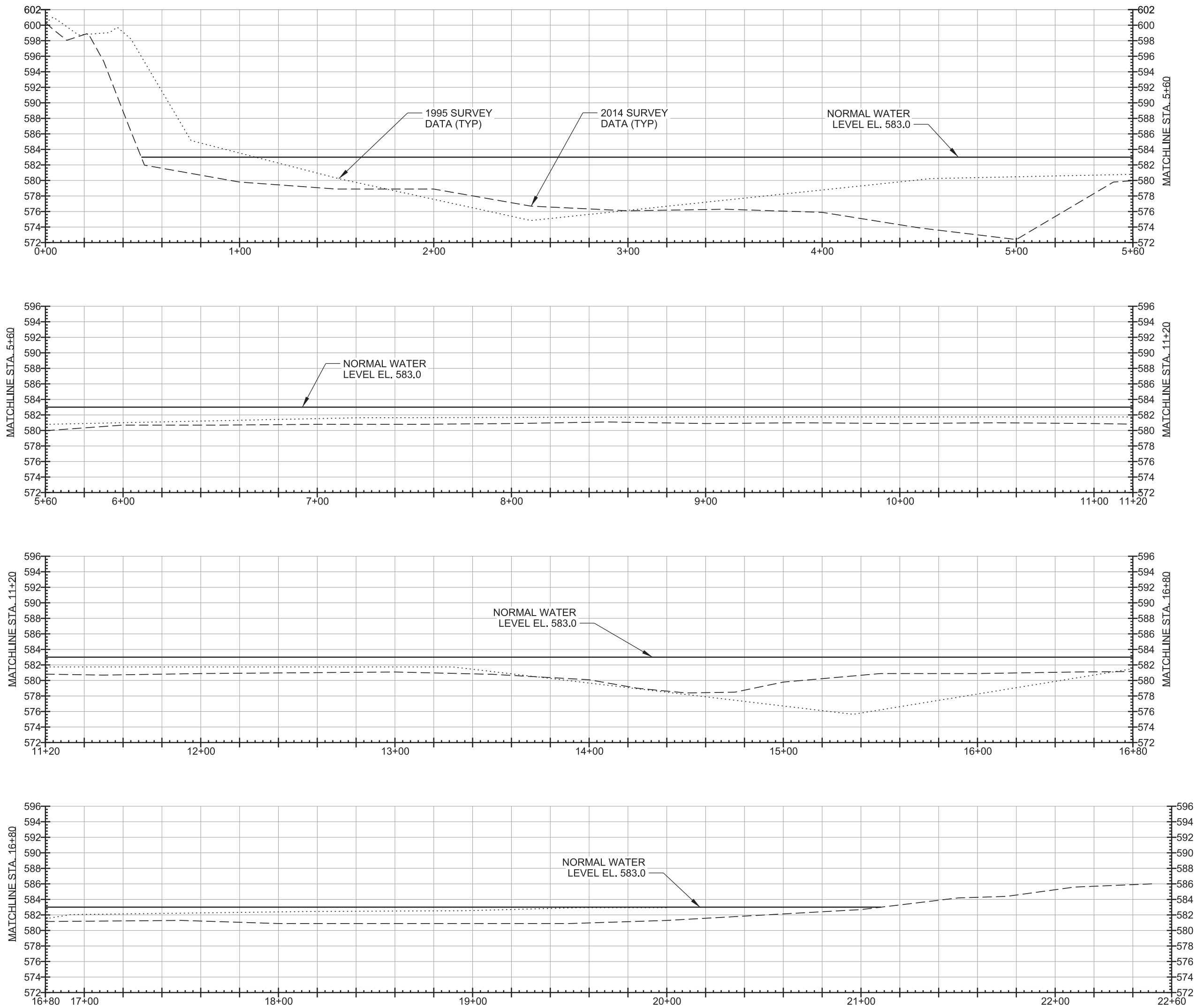


A1 PROFILE 34 - 36 RANGE D - SM-544.3A

SCALE : 1"=30'-0"

0 30' 60'

US Army Corps of Engineers

MARK	DESCRIPTION	DATE	APPR.

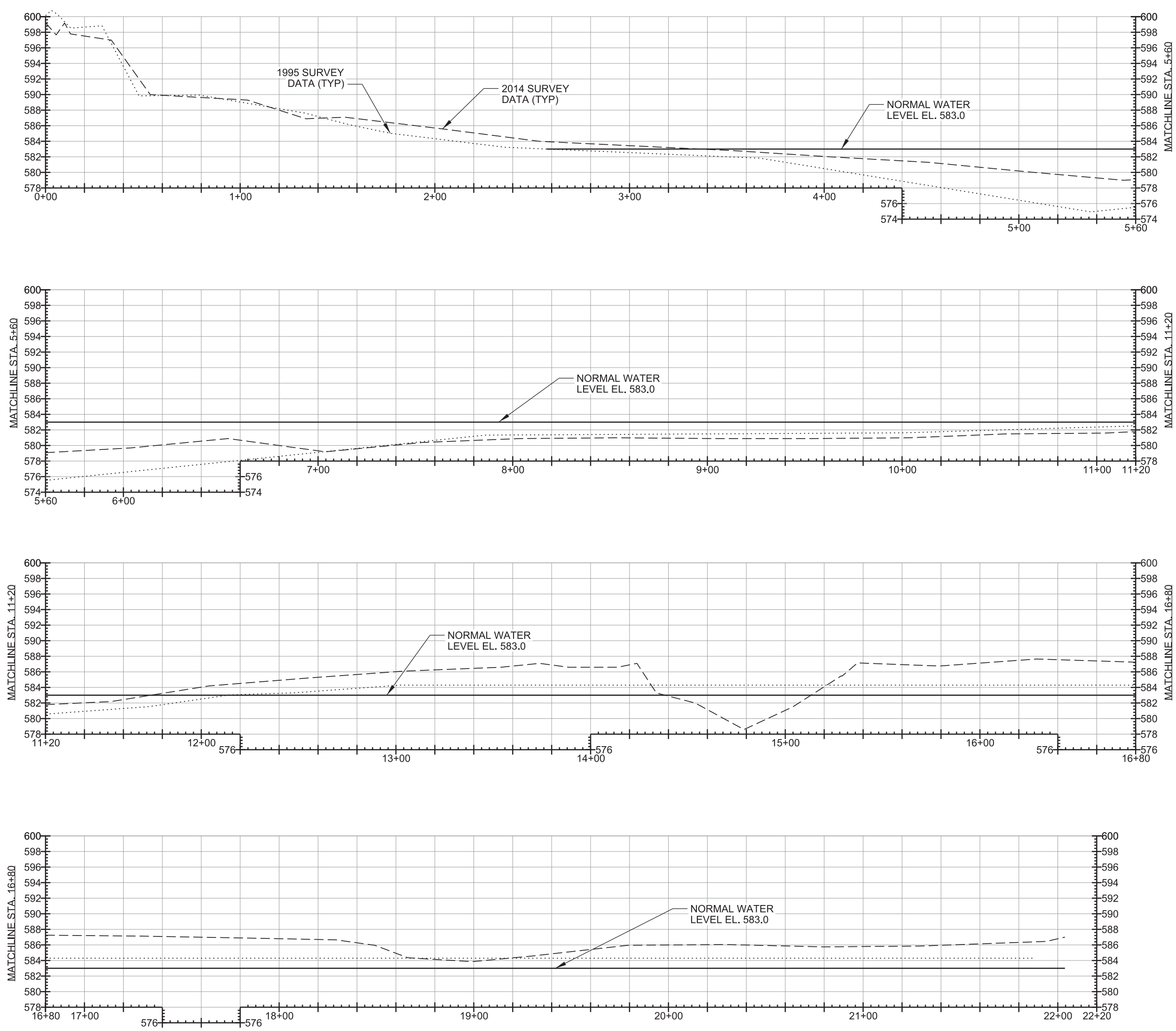
DESIGNED BY: | DATE:
DWN BY: JMF | CKD BY: | SOLICITATION NO.:
SUBMITTED BY: | CONTRACT NO.:
PLOT SCALE: AS SHOWN | PLOT DATE: | PROJECT CODE: PER
SIZE: ANSI D | FILE NAME: PERC-307XXX.dgn

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 34 - 36 RANGE D
SM-544.3A

Sheet ID
C-307



CROSS SECTIONS - 37 - 39 RANGE E - SM-544.1E

A1

SCALE : 1"=30'-0"

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US Army Corps of Engineers

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U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 37 - 39 RANGE E
SM-544.1E

Sheet ID
C-308

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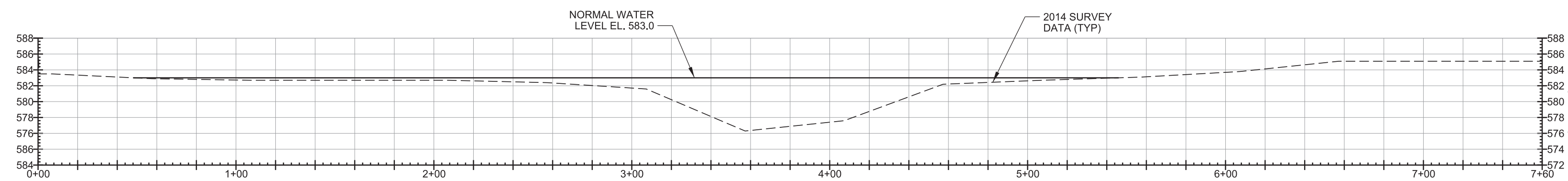
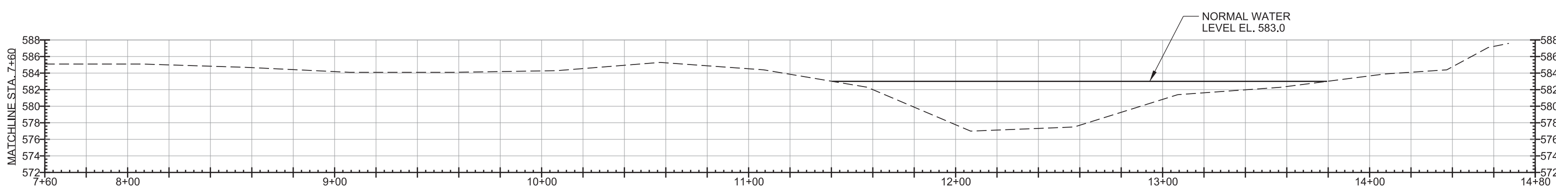
US Army Corps of Engineers

MARK	DESCRIPTION	DATE	APPR.





U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT
ROCK ISLAND, ILLINOIS

DESIGNED BY: | DATE: | SOLICITATION NO.: | CONTRACT NO.:
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MISSISSIPPI RIVER
JACKSON COUNTY, IA
GREEN ISLAND, IA
BROWN'S LAKE PER

PROFILE - 40 - 42 RANGE N
SM-544.6H

Sheet ID
C-309

A1

CROSS SECTIONS - 40 - 42 RANGE N - SM-544.6H

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POST-CONSTRUCTION
PERFORMANCE EVALUATION REPORT

BROWN'S LAKE
HABITAT REHABILITATION AND ENHANCEMENT PROJECT

APPENDIX B

WATER QUALITY REPORT

Appendix B
Water Quality Report

GOAL: Enhance Aquatic Habitat

OBJECTIVE: Improve Water Quality by Decreasing Suspended Sediment Concentrations and Increasing Winter Dissolved Oxygen Concentrations

ENHANCEMENT FEATURES: Water Control Structure, Inlet Channel and Lake Dredging, and Deflection Levee

1. Monitoring Results. The water quality objectives of the Brown's Lake project are to decrease sediment input to the lake and to increase winter dissolved oxygen (DO) concentrations. The project was designed to keep total suspended solids (TSS) concentrations at or below 50 mg/L and to maintain DO concentrations greater than 5 mg/L. No baseline water quality data were available for this project. It was presumed that fish kills observed during winters prior to project construction were likely due to low DO concentrations in conjunction with decreasing water depths due to sedimentation. In an effort to avoid future winter kills, a water control structure was constructed in the Upper Brown's Lake inlet channel. The gated structure was designed to allow oxygen rich Mississippi River water to flow into the lake, particularly during the critical winter months, while keeping sediment laden waters from the lake the remainder of the year.

This water quality performance evaluation report discusses data collected by USACE Water Quality and Sedimentation Section (EC-HQ) personnel from December 27, 2000 through March 6, 2002 and December 19, 2006 through September 10, 2013. Due to the cyclical nature of the district's Upper Mississippi River Restoration (UMRR) water quality monitoring program, sampling was not performed at the Brown's Lake Habitat Rehabilitation and Enhancement Project (HREP) from April 2002 through November 2006 and from October 2013 to the present. Water quality monitoring was also performed at one Upper Brown's Lake site by the Iowa Department of Natural Resources (IDNR) as part of the Long Term Resource Monitoring (LTRM) program. The IDNR data presented here extend from December 2000 through September 2002 and April 2004 through September 2013. Sampling was not performed by the IDNR during all of 2003 and portions of 2002 and 2004 due to budget shortfalls. During the study period, EC-HQ personnel performed water quality monitoring at three Brown's Lake sites (W-M545.8F, W-M544.2C and W-M544.6F), while IDNR personnel monitored one site (W-M545.5B). Table B-1 shows when sampling was performed by each agency.

All sites are located within dredged channels as shown in Appendix A, *Survey Transects and Cross Section Plates*. Monitoring at an Upper Brown's Lake site previously sampled by EC-HQ, W-M545.5C, was discontinued in 2001 due to sedimentation resulting in inadequate sampling depth.

Table B-1. Water Quality Sampling Performed by USACE and IDNR

		USACE Sites			IDNR Site
Year	**Season**	**W-M545.8F**	**W-M544.2C**	**W-M544.6F**	**W-M545.5B**
00/01	winter	x	x	x	x
2001	summer	x	x		x
01/02	winter	x	x	x	x
2002	summer				x
02/03	winter				
2003	summer				
03/04	winter				
2004	summer				x
04/05	winter				x
2005	summer				x
05/06	winter				x
2006	summer				x
06/07	winter	x	x	x	x
2007	summer	x	x		x
07/08	winter	x	x	x	x
2008	summer	x	x	x	x
08/09	winter	x	x	x	x
2009	summer	x	x	x	x
09/10	winter	x	x	x	x
2010	summer	x	x	x	x
10/11	winter	x	x	x	x
2011	summer	x	x	x	x
11/12	winter	x	x	x	x
2012	summer	x	x	x	x
12/13	winter	x	x	x	x
2013	summer	x	x	x	x

Corps data were obtained through a combination of periodic grab samples and the use of *in-situ* continuous monitors. Grab samples were collected near the surface at sites W-M545.8F, W-M544.2C and W-M544.6F. The three sites were usually visited twice per month from June through September and three times 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, TSS, chlorophyll (a, b and c) and pheophytin a. IDNR personnel collected grab samples approximately every other week at site W-

M545.5B during 2001, 2002 and 2004. In subsequent years, the sampling frequency generally decreased, with most samplings occurring during the months of April through June.

Grab Samples (DO). Table B-2 gives the monitoring results from grab samples collected at site W-M545.8F. This site is located downstream from the water control structure in the inlet channel. DO concentrations here ranged from 0.60 mg/l to 22.53 mg/L. Fourteen of the 88 DO measurements were below 5 mg/l; however, only two occurred during a winter month (3.18 mg/L on December 18, 2007 and 0.93 mg/L on January 21, 2009). The results from DO measurements taken at the remaining sites (W-M544.2C, W-M544.6F and W-M545.5B) are shown in Tables A-3 through A-5, respectively. The number of DO measurements below 5 mg/l at each of these sites is as follows: W-M544.2C (13), W-M544.6F (13) and W-M545.5B (10), with most occurring during the summer months. Low values that occurred during the winter months include: site W-M544.2C (4.19 mg/L on December 27, 2000), site W-M544.6F (4.92 mg/L on December 27, 2000, 4.16 mg/L on December 18, 2007, 0.67 mg/L on January 21, 2009 and 2.88 mg/L on February 7, 2011) and site W-M545.5B (2.9 mg/L on December 20, 2000 and 1.4 mg/L on January 13, 2009). The low concentrations that occurred during the month of December were due to the inlet gate not being open yet, or it was just recently opened and oxygenated water had not yet reached the sampling site. The inlet gate is typically opened by U.S. Fish and Wildlife Service (USFWS) personnel when they are notified of low DO concentrations by the IDNR. In December 2000, the inlet gate was opened 10 inches on the 21st in response to the low DO concentration (2.9 mg/L) measured by the IDNR at site W-M545.5B on the 20th.

On the 27th, the DO in the inlet channel (W-M545.8F) was 14.25 mg/L; however, sites W-M544.2C (4.19 mg/L) and W-M544.6F (4.92 mg/L) had not yet responded fully to the inflowing oxygenated water. The inlet gate was also not open yet on December 18, 2007, when low DO values were measured at sites W-M545.8F and W-M544.6F. The gate was opened 10 inches on December 26, 2007, then closed on January 7, 2008 due to snowmelt and rainfall, then reopened on January 25, 2008. The three low DO concentrations measured in January 2009 were due to a sediment blockage in the inlet channel. The blockage was removed in February 2009 and oxygenated water once again flowed into the backwater complex (an in-depth synoptic study describing this event is discussed later). Only one low winter DO concentration (2.88 mg/L on February 7, 2011 at site W-M544.6F) cannot be attributed to the inlet gates being closed or a complete sediment blockage of the inlet channel. On this date, the DO concentration at site W-M545.8F, located in the inlet channel (downstream from the water control structure), was 11.55 mg/L, which would suggest the inlet channel was not completely blocked with sediment. Since the DO concentration here was below saturation, it is possible there was a partial blockage of the inlet channel which restricted the inflow. The DO concentration further downstream at site W-M544.2C was above 5 mg/L (8.14 mg/L);

however, this site may have been influenced by water flowing in the nearby Lainsville Slough. It is likely that high water events during March/April and September/October 2010 deposited sediment in the inlet channel, thus impeding flow when the inlet gate was opened on December 22, 2010.

Table B-2. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.8F

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
12/27/2000	2.130	-	0.0	14.25	7.90	2.4	<1
1/31/2001	2.280	0.00	0.2	14.21	7.70	1.1	9.0
2/27/2001	2.410	0.00	0.9	13.48	7.40	4.4	<1
3/27/2001	2.255	0.00	4.1	22.53	8.30	18.0	11.0
5/30/2001	3.370	-	18.3	16.99	9.00	74.0	22.0
6/26/2001	3.800	2.32	27.0	16.89	9.20	114.0	13.0
7/10/2001	2.580	2.83	28.2	10.23	8.30	60.0	30.0
7/24/2001	2.200	0.00	31.5	7.64	8.20	57.0	16.0
8/7/2001	2.360	-	32.9	7.84	8.40	24.0	9.0
8/21/2001	1.880	-	23.0	9.13	8.40	59.0	31.0
9/5/2001	1.980	0.00	25.6	9.01	8.50	73.0	22.0
1/3/2002	2.010	0.00	2.2	11.06	7.30	43.0	10.0
3/6/2002	2.100	0.00	0.3	18.98	8.10	39.0	5.0
12/19/2006	1.630	0.20	2.9	9.28	7.50	29.0	15.0
1/26/2007	1.740	1.30	1.3	18.37	7.40	140.0	12.0
3/14/2007	2.140	0.16	4.4	12.54	7.20	-	-
6/5/2007	2.120	-	23.3	14.60	-	35.0	24.0
6/19/2007	1.830	-	24.9	4.61	7.80	8.7	26.0
7/3/2007	1.560	-	23.4	4.42	7.60	13.0	13.0
7/17/2007	1.480	-	24.1	4.75	7.80	18.0	22.0
7/31/2007	1.595	0.72	26.4	5.23	7.80	15.0	20.0
8/14/2007	1.530	-	26.4	2.00	7.50	9.4	13.0
8/28/2007	3.060	1.14	23.4	1.11	7.20	19.0	12.0
9/11/2007	1.820	1.40	19.9	0.60	7.30	12.0	7.0
12/18/2007	1.850	-	1.9	3.18	7.10	9.5	7.0
2/1/2008	1.900	4.71	0.0	20.32	7.70	<1	5.0
3/13/2008	2.000	0.47	1.4	10.79	7.10	2.6	19.0
6/3/2008	2.655	-	20.4	13.16	7.90	18.0	21.0
6/24/2008	3.490	2.12	23.3	5.90	7.50	26.0	9.0
7/8/2008	2.305	2.71	28.8	13.76	8.30	33.0	10.0
7/22/2008	2.220	0.64	27.0	6.04	7.70	20.0	23.0
8/5/2008	1.760	2.46	26.0	5.42	7.70	46.0	26.0
8/19/2008	1.610	1.08	24.6	6.20	7.70	32.0	30.0
9/3/2008	1.550	1.13	24.5	5.97	7.90	35.0	43.0
9/16/2008	*	*	*	*	*	*	*

* Unable to access site.

Table B-2. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.8F

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
12/9/2008	1.330	0.39	1.9	18.28	8.00	-	-
1/21/2009	1.600	0.34	0.6	0.93	7.20	-	-
3/6/2009	1.635	0.25	4.9	13.83	7.40	-	-
6/4/2009	1.820	0.42	20.1	10.39	8.20	29.0	15.0
6/23/2009	2.320	-	28.5	8.83	8.71	22.0	9.0
7/7/2009	1.550	1.02	24.0	6.67	8.05	49.0	22.0
7/21/2009	1.528	0.93	21.6	7.46	8.30	26.0	24.0
8/4/2009	1.534	0.98	24.0	8.12	7.90	36.0	13.0
8/18/2009	1.704	2.58	24.6	3.74	7.40	10.0	16.0
9/1/2009	1.706	0.72	19.3	7.28	7.60	7.0	14.0
9/15/2009	1.512	0.51	22.0	4.27	7.40	17.0	23.0
12/14/2009	1.530	-	2.5	18.27	8.10	-	-
1/25/2010	2.090	0.22	0.5	11.24	7.50	-	-
3/12/2010	2.260	1.35	1.6	10.72	7.30	-	-
6/8/2010	1.880	3.40	21.7	5.93	7.90	41.0	34.0
6/23/2010	2.590	-	27.3	7.95	9.60	7.0	2.0
7/7/2010	2.865	-	27.8	9.23	9.40	4.0	1.0
7/15/2010	2.670	-	28.8	7.59	8.60	8.0	3.0
8/3/2010	2.690	-	27.0	4.33	7.40	42.0	7.0
8/17/2010	2.580	-	25.1	3.19	7.40	60.0	18.0
8/31/2010	2.240	-	24.8	5.71	7.60	52.0	26.0
9/14/2010	2.000	0.88	23.5	10.20	8.40	53.0	13.0
12/9/2010	2.210	0.75	1.7	14.32	7.80	-	-
2/7/2011	2.225	3.18	0.0	11.55	7.30	-	-
3/7/2011	2.000	0.18	1.1	10.08	7.20	-	-
6/1/2011	3.160	5.25	23.5	7.03	7.70	7.0	7.0
6/15/2011	2.390	0.58	20.7	9.30	7.70	159.0	26.0
6/28/2011	2.820	1.44	24.4	8.90	8.30	26.0	17.0
7/12/2011	2.830	1.74	28.2	8.19	8.30	40.0	12.0
7/26/2011	2.750	0.55	-	13.51	8.50	66.0	13.0
8/9/2011	2.860	-	27.2	4.64	7.60	36.0	13.0
8/23/2011	2.250	1.51	24.2	4.56	7.80	39.0	24.0
9/7/2011	1.735	-	20.8	7.32	8.10	76.0	37.0
12/13/2011	1.500	0.38	2.6	13.34	7.80	-	-
1/25/2012	1.580	2.28	0.1	13.95	8.00	-	-
3/8/2012	1.680	-	5.2	13.69	8.30	-	-
6/5/2012	2.650	1.68	25.5	14.85	8.90	26.4	13.7
6/19/2012	2.290	-	27.8	7.12	8.00	23.4	18.3
7/5/2012	2.640	0.82	32.4	8.13	8.60	12.0	6.2
7/31/2012	1.570	-	31.1	9.59	8.40	25.6	39.6

Table B-2. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.8F

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M^3)	Total Suspended Solids (Mg/L)
8/14/2012	1.390	-	24.7	-	8.50	51.0	24.1
8/28/2012	1.480	0.80	26.3	6.81	8.50	3.0	12.2
9/11/2012	1.330	-	21.3	8.56	8.50	2.3	19.5
12/19/2012	1.450	-	2.9	12.10	8.33	-	-
2/7/2013	1.510	3.54	0.1	13.14	8.13	-	-
3/13/2013	2.900	2.10	0.6	12.44	8.49	-	-
6/4/2013	3.600	3.01	21.7	6.37	7.48	1.4	-
6/18/2013	2.710	2.77	25.5	10.68	8.93	4.0	6.3
7/2/2013	3.680	8.52	25.1	5.99	7.75	<1.0	14.0
7/16/2013	2.840	2.81	30.7	15.89	8.88	3.8	7.2
7/30/2013	1.590	0.60	22.1	7.90	7.44	13.5	25.2
8/13/2013	1.470	1.26	26.6	12.12	8.60	10.3	26.5
8/27/2013	1.430	1.53	30.0	8.82	8.45	9.0	21.2
9/10/2013	1.410	0.78	28.4	12.16	8.41	14.0	24.5
MIN.	**1.330**	**0.00**	**0.0**	**0.60**	**7.10**	**<1.0**	**<1**
MAX.	**3.800**	**8.52**	**32.9**	**22.53**	**9.60**	**159.0**	**43.0**
AVG.	**2.119**	**1.42**	**18.1**	**9.62**	**-**	**30.4**	**16.6**

Table B-3. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M544.2C

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
12/27/2000	1.530	-	0.3	4.19	7.70	20.0	2.0
1/31/2001	1.680	0.00	0.1	14.34	7.80	<1	10.0
2/27/2001	1.760	0.00	0.6	16.10	7.80	14.0	3.0
3/27/2001	1.640	0.00	3.6	17.02	8.60	19.0	14.0
5/30/2001	2.810	-	17.7	8.41	7.90	14.0	29.0
6/26/2001	3.250	3.51	26.6	13.40	8.50	51.0	6.0
7/10/2001	2.160	3.69	29.5	15.81	9.20	60.0	14.0
7/24/2001	1.690	0.00	30.8	14.12	8.80	90.0	26.0
8/7/2001	1.820	-	31.1	11.80	8.70	98.0	22.0
8/21/2001	1.400	-	22.8	6.04	8.10	49.0	26.0
9/5/2001	1.390	0.00	23.9	8.62	8.30	67.0	22.0
1/3/2002	1.400	0.00	1.7	22.17	7.80	3.7	1.0
3/6/2002	1.440	0.00	1.6	22.23	8.40	48.0	16.0
12/19/2006	0.880	2.47	2.4	17.18	8.30	16.0	12.0
1/26/2007	1.060	-	0.6	14.69	7.40	3.9	6.0
3/14/2007	1.530	-	2.0	13.29	7.40	-	-
6/5/2007	1.455	-	22.7	10.38	-	10.7	15.0
6/19/2007	1.180	-	24.8	4.16	8.30	5.0	13.0
7/3/2007	0.985	-	23.6	6.38	8.80	16.0	5.0
7/17/2007	0.850	-	24.0	4.12	8.00	12.0	28.0
7/31/2007	0.950	2.64	26.6	1.69	7.60	7.1	16.0
8/14/2007	0.900	-	26.7	3.49	7.80	9.8	27.0
8/28/2007	2.440	7.98	23.5	4.20	7.50	13.0	10.0
9/11/2007	1.200	3.25	19.5	5.50	7.80	8.4	28.0
12/18/2007	1.200	-	1.2	12.45	7.70	4.9	6.0
2/1/2008	1.230	3.75	0.7	21.22	7.70	<1	6.0
3/13/2008	1.430	7.74	0.0	14.38	7.50	<1	21.0
6/3/2008	1.995	-	20.4	13.77	8.70	13.0	15.0
6/24/2008	3.450	11.25	23.0	10.23	8.40	34.0	8.0
7/8/2008	1.645	1.55	27.5	13.46	8.50	58.0	19.0
7/22/2008	1.530	7.20	27.0	3.00	7.70	20.0	16.0
8/5/2008	1.020	2.36	26.0	4.54	7.70	23.0	24.0
8/19/2008	0.850	3.58	24.8	5.35	8.20	58.0	34.0
9/3/2008	0.850	3.00	23.5	5.39	7.70	22.0	36.0
9/16/2008	0.900	5.50	21.1	8.00	-	7.5	13.0
12/9/2008	0.900	4.33	2.3	15.13	7.90	-	-
1/21/2009	0.930	0.43	0.4	5.28	7.40	-	-
3/6/2009	0.910	3.87	5.5	12.31	7.60	-	-
6/4/2009	1.060	3.82	20.7	8.23	8.10	9.0	17.0
6/23/2009	1.172	-	27.7	6.89	8.66	6.0	9.0

Table B-3. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M544.2C

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
7/7/2009	0.888	4.06	23.7	3.92	8.12	38.0	46.0
7/21/2009	0.814	3.96	22.0	7.57	8.53	52.0	43.0
8/4/2009	0.854	6.74	24.2	5.65	8.60	19.0	65.0
8/18/2009	0.950	4.92	24.2	4.51	8.20	14.0	31.0
9/1/2009	1.006	15.35	19.8	8.01	8.80	8.0	21.0
9/15/2009	0.798	5.42	21.9	3.15	8.90	14.0	94.0
12/14/2009	0.900	-	1.1	16.53	7.90	-	-
1/25/2010	1.510	10.20	-0.1	12.59	7.70	-	-
3/12/2010	1.590	10.91	2.6	12.68	7.70	-	-
6/8/2010	1.035	-	22.2	6.02	7.90	2.0	53.0
6/23/2010	1.730	-	25.3	6.54	7.90	2.0	20.0
7/7/2010	2.240	-	25.7	7.24	9.00	3.0	4.0
7/15/2010	1.825	-	28.4	7.20	8.20	16.0	1.0
8/3/2010	2.030	-	27.7	4.88	7.50	50.0	10.0
8/17/2010	1.860	-	25.1	7.45	8.00	22.0	26.0
8/31/2010	1.440	-	26.2	10.12	8.30	90.0	22.0
9/14/2010	1.370	3.41	24.5	15.05	8.80	54.0	20.0
12/9/2010	1.480	0.10	0.1	14.76	8.10	-	-
2/7/2011	1.610	2.47	0.0	8.14	7.20	-	-
3/7/2011	1.660	0.88	0.9	9.23	7.60	-	-
6/1/2011	2.400	8.03	21.4	13.93	8.70	53.0	18.0
6/15/2011	2.120	2.20	20.8	8.12	7.70	41.0	16.0
6/28/2011	2.110	0.79	23.7	10.82	8.40	27.0	17.0
7/12/2011	1.880	2.43	29.8	16.24	8.90	96.0	12.0
7/26/2011	1.900	4.46	30.0	26.63	9.10	130.0	19.0
8/9/2011	2.100	-	26.5	6.68	8.10	37.0	32.0
8/23/2011	1.480	-	24.6	3.66	7.90	50.0	37.0
9/7/2011	1.055	-	23.0	15.50	8.90	97.0	51.0
12/13/2011	0.700	2.60	3.0	19.14	8.50	-	-
1/25/2012	0.900	0.81	1.2	12.26	7.80	-	-
3/8/2012	0.860	-	7.3	12.93	8.50	-	-
6/5/2012	1.840	4.04	21.7	8.81	8.40	32.9	30.8
6/19/2012	1.460	-	29.6	10.58	8.50	45.1	29.2
7/5/2012	1.970	3.82	33.7	17.17	9.10	18.6	6.2
7/17/2012	1.000	-	32.1	8.52	8.30	25.8	15.1
7/31/2012	0.780	-	30.8	8.72	8.40	25.6	35.6
8/14/2012	0.620	-	26.2	-	8.40	18.4	20.0
8/28/2012	0.720	-	28.5	6.21	8.00	<1.0	7.5
9/11/2012	0.420	-	23.2	8.59	8.60	<1.0	8.3
12/19/2012	0.680	-	3.0	11.32	8.24	-	-

Table B-3. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M544.2C

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M^3)	Total Suspended Solids (Mg/L)
2/7/2013	0.725	7.19	0.2	11.55	8.04	-	-
3/13/2013	2.110	10.92	0.3	12.05	6.79	-	-
6/4/2013	3.000	9.23	19.3	6.93	7.49	1.2	19.0
6/18/2013	2.240	4.90	24.5	10.20	8.62	7.1	14.8
7/2/2013	3.110	13.18	25.7	7.19	7.70	1.6	14.7
7/16/2013	1.910	2.37	29.5	18.78	9.06	12.0	12.0
7/30/2013	0.710	8.83	21.2	8.44	7.81	12.0	23.7
8/13/2013	0.550	2.65	28.0	11.54	8.60	2.7	21.6
8/27/2013	0.740	3.94	30.5	8.43	8.42	3.2	20.3
9/10/2013	0.650	1.45	28.1	9.28	8.55	5.3	22.0
MIN.	**0.420**	**0.00**	**-0.1**	**1.69**	**6.79**	**<1.0**	**1.0**
MAX.	**3.450**	**15.35**	**33.7**	**26.63**	**9.20**	**130.0**	**94.0**
AVG.	**1.431**	**4.28**	**18.1**	**10.34**	**-**	**27.3**	**20.7**

Table B-4. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M544.6F

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
12/27/2000	2.100	-	0.9	4.92	7.70	21.0	2.0
1/31/2001	2.230	0.00	1.0	13.18	7.40	<1	5.0
2/27/2001	2.400	0.00	0.9	15.89	7.60	21.0	21.0
3/27/2001	2.160	0.00	5.5	17.05	8.70	21.0	33.0
1/3/2002	1.830	0.00	2.1	26.48	8.50	77.0	12.0
3/6/2002	1.940	0.00	1.8	22.53	8.40	55.0	14.0
12/19/2006	1.570	0.45	2.8	15.15	8.10	22.0	10.0
1/26/2007	1.670	0.42	0.8	12.90	7.60	19.0	2.0
3/14/2007	2.090	1.07	3.5	12.82	7.30	-	-
12/18/2007	1.800	-	1.8	4.16	7.40	4.3	6.0
2/1/2008	1.800	0.23	0.7	12.02	7.50	3.5	4.0
3/13/2008	1.800	1.14	1.0	14.68	7.50	1.1	7.0
6/3/2008	1.868	-	20.4	11.10	7.90	10.0	25.0
6/24/2008	2.780	7.31	22.5	6.64	7.80	9.1	26.0
7/8/2008	1.750	2.71	28.1	16.55	8.70	123.0	28.0
7/22/2008	1.405	0.40	27.0	3.37	7.80	83.0	40.0
8/5/2008	1.640	5.39	25.8	4.21	7.80	37.0	38.0
8/19/2008	1.540	1.19	25.2	4.30	8.00	45.0	32.0
9/3/2008	1.410	2.37	23.9	4.48	7.70	29.0	33.0
9/16/2008	1.490	1.40	20.7	8.94	-	15.0	21.0
12/9/2008	1.540	0.08	1.6	16.44	8.10	-	-
1/21/2009	1.550	0.24	0.8	0.67	7.20	-	-
3/6/2009	1.520	1.35	5.8	24.40	8.90	-	-
6/4/2009	1.690	1.32	20.4	9.53	7.90	46.0	26.0
6/23/2009	1.960	-	28.2	9.44	8.18	47.0	14.0
7/7/2009	1.460	1.01	24.6	7.59	8.91	43.0	17.0
7/21/2009	1.356	0.48	22.2	7.86	8.78	19.0	17.0
8/4/2009	1.428	0.34	24.7	6.58	8.10	32.0	15.0
8/18/2009	1.482	0.48	24.8	3.68	8.00	14.0	13.0
9/1/2009	1.480	1.33	19.5	5.03	7.60	10.0	9.0
9/15/2009	1.290	0.94	22.2	3.74	7.60	20.0	28.0
12/14/2009	1.400	-	1.3	10.10	7.50	-	-
1/25/2010	1.960	2.76	0.0	11.76	7.70	-	-
3/12/2010	2.130	0.99	1.6	11.67	7.60	-	-
6/8/2010	1.720	-	21.6	4.87	8.00	17.0	31.0
6/23/2010	2.450	-	26.1	8.17	8.70	15.0	4.0
7/7/2010	2.675	-	27.0	8.38	8.60	6.0	4.0
7/15/2010	2.355	-	27.8	3.63	8.00	9.0	2.0
8/3/2010	2.330	-	27.4	12.76	8.40	57.0	10.0
8/17/2010	2.360	-	25.2	9.37	8.40	107.0	17.0

Table B-4. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M544.6F

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
8/31/2010	2.060	-	25.6	6.69	7.80	35.0	13.0
9/14/2010	1.750	0.10	22.8	7.94	8.40	28.0	26.0
12/9/2010	1.880	0.56	0.8	14.56	8.20	-	-
2/7/2011	1.900	0.45	1.5	2.88	7.10	-	-
3/7/2011	2.010	0.19	1.1	7.23	7.40	-	-
6/1/2011	2.900	7.37	22.3	14.14	8.70	71.0	13.0
6/15/2011	2.700	1.16	20.7	9.52	7.70	121.0	19.0
6/28/2011	2.725	2.92	24.9	11.43	8.40	32.0	11.0
7/12/2011	2.630	3.25	29.3	11.71	8.60	47.0	11.0
7/26/2011	2.610	1.62	29.9	20.89	8.90	79.0	12.0
8/9/2011	2.650	-	26.7	6.10	8.00	43.0	24.0
8/23/2011	2.050	-	24.6	4.83	7.90	34.0	46.0
9/7/2011	1.745	-	21.5	7.84	8.10	56.0	43.0
12/13/2011	1.280	0.58	2.4	12.50	8.00	-	-
1/25/2012	1.390	0.66	0.4	9.53	7.50	-	-
3/8/2012	1.530	-	7.8	14.62	8.60	-	-
6/5/2012	2.490	3.02	24.7	15.80	9.00	65.2	21.2
6/19/2012	2.050	-	28.3	8.70	8.20	38.1	27.2
7/5/2012	2.610	0.31	33.0	12.23	8.70	11.8	5.6
7/17/2012	1.600	-	32.6	7.31	8.30	12.4	9.3
7/31/2012	1.450	-	30.7	10.02	8.40	18.8	20.0
8/14/20112	1.210	-	25.0	-	-	58.1	22.5
8/28/2012	1.320	-	27.4	8.33	8.50	5.9	18.6
9/11/2012	1.050	-	21.9	7.77	8.30	3.7	14.5
12/19/2012	1.330	-	2.7	10.95	8.19	-	-
2/7/2013	1.400	0.50	0.4	9.89	7.94	-	-
3/13/2013	2.780	2.48	0.5	11.53	6.56	-	-
6/4/2013	3.680	3.01	19.9	7.42	7.54	1.5	20.0
6/18/2013	3.000	2.63	25.4	9.60	8.62	3.9	12.2
7/2/2013	3.750	8.73	24.5	6.40	7.77	<1.0	21.8
7/16/2013	2.710	1.24	31.0	16.82	9.07	5.9	8.0
7/30/2013	1.420	1.37	21.6	5.70	7.28	7.2	21.1
8/13/2013	1.340	1.81	26.9	10.41	8.58	7.6	24.0
8/27/2013	1.340	1.06	30.1	7.43	8.34	7.2	21.7
9/10/2013	1.300	1.22	28.3	9.26	8.44	5.1	28.8
MIN.	**1.050**	**0.00**	**0.0**	**0.67**	**6.56**	**<1.0**	**2.0**
MAX.	**3.750**	**8.73**	**33.0**	**26.48**	**9.07**	**123.0**	**46.0**
AVG.	**1.934**	**1.57**	**16.9**	**10.07**	**-**	**31.1**	**18.3**

Table B-5. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.5B by IDNR Personnel

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
12/13/2000	1.8	0	1.6	8.2	7.6	-	6.3
12/20/2000	1.5	0	1.7	2.9	6.9	-	-
12/27/2000	1.9	0	0.8	5.7	7.5	-	3.9
1/11/2001	1.9	0	0.5	11.4	7.6	-	2.0
1/23/2001	1.9	0	0.3	12.4	7.8	-	3.6
2/7/2001	1.9	0	0.2	12.8	7.9	-	3.1
2/19/2001	1.8	0	0.1	13.6	7.8	-	4.4
3/2/2001	1.8	0	1.8	14.9	7.3	-	-
3/6/2001	1.9	0	2.1	14.9	7.9	-	6.6
4/4/2001	2.1	0	8.6	16.1	9.1	-	42.1
4/18/2001	6.2	0	8.5	10.2	7.7	-	15.6
4/30/2001	5.5	5	14.3	4.4	7.8	-	35.8
5/15/2001	5.1	15	19.1	8.6	7.5	-	11.4
5/28/2001	3.2	0	17.4	13.2	8.8	-	13.2
6/15/2001	2.6	0	24.8	9.7	8.7	-	20.1
6/27/2001	3.3	0	27.5	>20.0	9.5	-	19.1
7/11/2001	2.0	0	26.6	9.5	8.6	-	22.4
7/26/2001	1.9	0	25.1	6.2	8.1	-	19.7
8/7/2001	1.9	1	29.9	6.5	8.1	-	19.6
8/21/2001	1.7	0	22.6	8.0	8.2	38.19	30.3
9/4/2001	1.7	0	26.3	10.1	8.4	-	35.6
9/20/2001	1.7	0	17.0	6.2	7.7	-	32.2
10/1/2001	1.6	0	17.8	9.0	8.7	29.00	25.3
10/16/2001	1.8	1	9.2	11.8	8.3	-	25.8
10/29/2001	1.5	0	7.5	12.4	8.1	-	34.3
11/15/2001	1.6	0	13.2	10.8	8.3	-	25.9
11/28/2001	1.7	0	4.8	11.8	8.3	-	25.7
12/10/2001	2.0	0	2.8	15.0	8.7	-	15.6
12/28/2001	1.6	0	1.9	17.7	8.6	52.93	19.0
1/8/2002	1.8	0	3.5	>20.0	8.4	-	10.3
1/17/2002	1.8	0	3.3	19.5	-	-	-
1/24/2002	1.8	0	0.8	14.8	8.0	-	2.7
2/4/2002	1.7	0	2.2	15.3	8.1	-	-
3/7/2002	1.7	0	2.2	14.5	8.6	42.38	12.0
3/18/2002	1.8	0	5.9	>20.0	9.0	-	35.1
4/4/2002	1.8	0	3.5	16.8	9.1	-	51.5
4/17/2002	2.4	0	21.5	10.4	8.5	-	14.7
4/30/2002	2.7	0	12.4	12.5	8.5	-	6.8
5/14/2002	2.6	0	14.3	12.8	8.9	54.59	19.1

Table B-5. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.5B by IDNR Personnel

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
5/28/2002	2.1	0	21.0	10.8	8.7	-	14.8
6/12/2002	2.7	0	25.9	12.8	8.9	-	17.6
6/25/2002	2.2	0	28.4	8.2	8.4	-	17.7
7/9/2002	2.8	0	28.0	7.8	8.1	-	11.6
7/23/2002	2.5	0	27.9	7.5	8.1	55.46	16.6
8/6/2002	2.0	0	26.1	6.8	7.9	-	22.5
8/20/2002	2.1	0	24.1	6.1	7.9	63.46	23.1
9/3/2002	2.1	0	25.0	5.6	7.7	-	12.4
9/16/2002	2.4	0	22.1	6.8	8.0	27.67	17.1
4/5/2004	2.1	0	11.6	16.6	8.8	-	28.4
4/21/2004	1.7	0	13.8	8.7	8.1	-	123.8
5/5/2004	2.0	0	16.8	10.6	9.0	-	23.9
5/18/2004	1.9	0	20.5	5.9	8.3	-	26.9
6/3/2004	3.3	0	20.3	17.1	9.0	48.11	18.0
6/15/2004	3.5	0	25.9	15.0	9.0	-	15.1
6/30/2004	2.1	0	24.9	18.8	9.1	-	13.0
7/15/2004	2.0	0	27.5	12.5	9.0	-	26.1
7/26/2004	1.6	0	25.4	10.2	8.3	-	33.7
8/11/2004	1.6	0	17.6	6.3	8.0	-	41.9
8/26/2004	1.5	0	23.7	6.3	7.8	-	21.4
9/9/2004	1.5	0	20.2	4.2	7.6	-	28.3
9/23/2004	2.0	0	21.0	7.6	8.3	39.58	15.2
10/6/2004	1.8	0	13.6	9.8	8.2	-	10.6
11/5/2004	1.9	0	8.3	11.6	8.4	-	10.2
1/13/2005	1.4	0	1.6	6.7	7.2	-	1.5
4/4/2005	2.5	0	13.5	19.2	9.0	73.56	23.2
4/18/2005	2.1	0	18.1	16.9	9.2	-	17.3
5/4/2005	2.1	0	13.1	11.2	8.7	-	16.7
5/16/2005	1.9	0	13.3	10.9	8.5	41.78	15.3
5/31/2005	2.1	0	21.6	8.3	8.3	-	15.9
6/15/2005	2.3	0	23.9	6.9	8.1	-	26.8
6/27/2005	2.4	0	27.3	5.0	7.8	-	5.1
7/14/2005	1.7	0	27.0	4.0	7.5	19.17	8.7
8/8/2005	1.5	0	28.7	9.9	8.4	-	21.7
9/6/2005	1.3	0	23.6	7.0	7.7	13.30	6.3
10/4/2005	1.8	0	21.4	9.3	8.0	-	7.6
11/7/2005	1.6	0	10.2	9.8	8.0	-	6.6
1/10/2006	2.0	0	1.7	11.0	7.4	-	3.2
3/7/2006	1.5	0	0.9	17.0	8.4	-	8.5

Table B-5. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.5B by IDNR Personnel

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
4/4/2006	2.5	0	9.0	15.4	8.8	-	21.7
4/19/2006	2.7	0	14.8	9.7	8.1	45.74	9.8
5/2/2006	2.3	0	15.7	12.6	8.7	-	14.9
6/1/2006	2.1	0	27.5	9.3	8.5	-	13.4
6/15/2006	1.6	0	22.7	7.0	7.8	-	16.7
6/29/2006	1.6	0	25.3	6.2	7.8	-	13.9
8/7/2006	1.5	0	27.1	6.2	7.7	-	11.5
1/11/2007	1.6	0	1.4	14.2	8.2	-	8.9
4/6/2007	3.1	0	6.0	10.4	7.8	21.50	12.8
4/19/2007	2.2	0	11.2	19.3	9.0	-	24.6
5/3/2007	2.2	0	18.6	8.3	8.3	-	11.2
5/16/2007	1.8	0	19.0	7.7	8.1	-	9.9
5/30/2007	1.8	0	24.1	8.9	8.1	-	10.7
6/11/2007	1.8	0	25.5	10.8	8.5	-	8.4
6/25/2007	1.7	0	22.9	10.0	8.5	30.26	7.0
8/10/2007	1.4	0	29.6	6.6	8.7	-	6.7
9/5/2007	1.6	0	26.9	3.7	8.1	-	1.9
10/1/2007	1.7	0	18.8	7.9	8.8	-	2.8
11/7/2007	2.0	0	5.7	11.0	8.2	-	3.4
3/6/2008	1.5	0	0.3	10.6	7.3	-	25.0
4/2/2008	2.2	0	6.3	13.1	7.5	26.38	11.0
4/14/2008	2.3	0	9.3	15.2	8.4	43.93	12.9
5/1/2008	3.7	0	11.9	9.1	7.7	-	15.6
5/15/2008	3.0	0	15.6	12.1	8.3	-	12.3
5/28/2008	2.7	0	19.2	13.3	8.7	-	19.7
6/10/2008	3.8	0	23.5	9.0	8.6	-	8.4
6/23/2008	2.7	0	25.1	11.1	8.4	51.44	15.4
7/8/2008	2.0	0	26.2	6.3	7.7	91.44	16.1
8/5/2008	1.7	0	26.6	3.5	7.5	12.79	8.0
9/3/2008	1.4	0	23.0	1.9	7.7	-	8.8
10/8/2008	1.4	0	14.3	8.4	8.1	-	7.4
11/10/2008	1.6	0	2.0	11.6	8.3	7.47	16.1
1/13/2009	0.9	0	0.5	1.4	6.1	-	13.0
4/9/2009	2.8	0	10.2	16.6	9.2	78.18	23.3
4/21/2009	2.1	0	10.6	9.0	8.3	-	12.8
5/4/2009	2.4	0	19.4	12.9	8.8	21.71	11.8
5/21/2009	1.5	0	20.9	8.9	8.1	-	61.0
6/4/2009	1.6	0	25.2	10.1	8.5	-	7.5
6/15/2009	1.7	0	24.3	10.2	8.9	-	9.7

Table B-5. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.5B by IDNR Personnel

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
7/2/2009	1.5	-	20.1	7.0	8.9	-	7.6
7/16/2009	1.5	0	24.7	9.7	9.2	16.46	9.1
8/11/2009	1.6	0	26.0	6.3	8.5	6.02	5.7
11/9/2009	1.9	0	12.8	13.7	8.6	-	5.1
1/14/2010	1.1	3	0.2	12.2	7.7	-	3.1
3/8/2010	1.2	0	0.4	11.7	7.5	-	4.8
4/9/2010	3.2	0	12.7	9.5	8.3	-	11.0
4/20/2010	2.2	0	17.2	14.6	8.9	-	8.4
5/3/2010	1.8	0	19.4	12.9	8.8	-	9.4
5/20/2010	2.2	0	20.8	19.2	9.4	-	8.4
6/1/2010	1.7	0	27.0	5.4	9.2	-	3.1
6/16/2010	1.9	0	22.6	6.5	8.6	-	3.1
6/29/2010	2.7	0	26.9	9.4	8.9	-	5.2
7/15/2010	1.8	0	29.5	7.4	8.5	-	6.3
8/12/2010	2.1	0	28.6	4.7	7.4	-	13.5
9/8/2010	1.9	0	20.1	9.9	8.4	-	18.1
10/5/2010	4.7	0	18.1	6.5	7.6	4.98	5.5
11/8/2010	2.7	0	7.4	9.7	7.8	-	5.1
1/10/2011	1.5	-	1.1	10.4	7.5	-	2.3
3/7/2011	1.6	0	4.2	6.5	7.5	-	3.8
4/7/2011	3.9	0	7.2	10.5	7.6	-	9.1
4/21/2011	4.5	0	7.8	10.9	7.9	16.35	14.0
5/2/2011	4.0	0	11.4	12.4	8.5	-	11.6
5/17/2011	2.7	0	16.6	12.3	8.6	-	13.4
6/1/2011	3.0	0	21.7	11.6	8.4	-	16.8
6/13/2011	2.6	0	21.8	7.0	7.9	-	14.9
6/29/2011	3.0	0	27.0	19.0	8.9	-	14.8
7/15/2011	2.2	0	27.0	9.4	8.4	-	18.3
8/9/2011	2.1	0	26.5	5.3	8.1	-	19.8
9/7/2011	1.5	0	21.5	10.6	8.5	-	41.9
10/3/2011	1.4	0	15.8	10.2	8.5	-	11.5
11/7/2011	1.5	0	9.4	9.7	8.3	-	6.7
1/9/2012	0.9	0	3.9	14.0	8.0	-	12.9
3/9/2012	1.5	0	4.4	12.8	8.3	-	57.2
4/4/2012	1.6	0	15.4	8.8	8.8	-	36.7
4/17/2012	1.5	0	15.8	12.6	8.7	-	30.0
5/3/2012	1.8	0	19.0	9.1	8.2	-	17.7
5/16/2012	2.3	0	22.1	11.2	8.7	61.00	12.1
5/30/2012	1.9	0	21.6	7.6	8.3	-	23.3

Table B-5. Post-Project Water Quality Monitoring Results From Surface Samples Collected at Site W-M545.5B by IDNR Personnel

Date	Water Depth (M)	Velocity (cm/sec)	Water Temp. (°C)	Dissolved Oxygen (Mg/L)	PH (SU)	Chlorophyll A (Mg/M³)	Total Suspended Solids (Mg/L)
6/12/2012	2.7	0	24.7	7.4	8.4	-	17.6
6/25/2012	2.2	0	26.0	8.2	8.3	-	17.9
7/10/2012	1.8	0	27.9	4.1	8.0	-	10.8
9/4/2012	1.5	0	27.3	5.5	8.2	-	9.1
10/1/2012	1.2	0	17.6	14.7	9.4	-	10.6
1/7/2013	1.2	0	1.8	13.8	7.8	-	10.5
3/6/2013	1.0	0	0.1	13.1	7.8	-	4.6
4/2/2013	1.8	0	5.8	13.3	8.1	-	28.9
4/16/2013	3.1	0	9.8	13.5	8.7	-	19.4
5/2/2013	2.9	0	16.1	17.1	9.2	-	28.6
5/13/2013	3.3	0	17.2	11.4	8.3	-	6.6
5/29/2013	3.0	0	20.6	14.2	8.9	-	10.4
6/11/2013	3.1	0	22.6	18.8	9.0	-	11.7
6/25/2013	3.8	0	24.4	8.2	8.3	-	10.5
7/8/2013	3.2	0	26.3	14.3	8.9	-	12.5
8/6/2013	1.3	0	23.1	6.1	8.1	81.69	20.0
9/3/2013	1.3	0	23.2	6.8	8.2	86.76	25.0
MIN.	**0.9**	**0**	**0.1**	**1.4**	**6.1**	**4.98**	**1.5**
MAX.	**6.2**	**15**	**29.9**	**>20.0**	**9.5**	**91.44**	**123.8**
AVG.	**2.1**	**0**	**16.2**	**10.6**	**-**	**40.73**	**16.3**

Continuous Monitoring (DO). In addition to grab samples, *in-situ* water quality monitors (YSI model 6000 or 6600 series sondes) were deployed by EC-HQ personnel on 59 occasions at site W-M544.6F, 8 occasions at site W-M544.2C and 7 occasions at site W-M545.8F. For most deployments the sondes were positioned 3' (0.9 m) above the bottom. Deployments were typically for a period of two weeks during the summer months and approximately six weeks during the winter months. The sondes were usually equipped to measure DO, temperature, pH, specific conductance, depth, and occasionally turbidity.

It was common for supersaturated DO concentrations to be measured by sondes deployed during the winter months. The results from a typical winter deployment are shown in Figure B-1, where DO concentrations at site W-M544.6F exceeded 15 mg/L for the majority of the February 27 through March 27, 2001 deployment. The DO concentration was well above the target level and supersaturated conditions were observed for most of the deployment. The benefit of utilizing the inlet gate was clearly demonstrated during the January 3 through March 6, 2002 deployment at site

W-M545.8F (Figure B-2). The DO concentration was declining rapidly during mid-January and fell below the target level of 5 mg/L. The inlet gate was opened 10 inches (25 cm) on January 18 and the DO concentration responded quickly, increasing to levels above saturation within three days.

Extended periods of low winter DO concentrations were occasionally recorded; however, most of these occurred during a time when the inlet gate was not open or inflowing water had not reached the site yet. As shown in Figure B-3, the DO concentration at site W-M544.6F was below the target level for nearly the entire December 27, 2000 through January 31, 2001 deployment. The inlet gate was opened 10 inches on December 21, 2000 in response to a low DO measurement (2.90 mg/L) recorded by IDNR personnel on December 20, 2000 at site W-M545.5B. By December 27, the DO concentration was above 5 mg/L at sites W-M545.8F (14.25 mg/L) and W-M545.5B (5.7 mg/L); however, further downstream at sites W-M544.2C (4.19 mg/L) and W-M544.6F (4.92 mg/L), the DO was still below 5 mg/L. Figure B-3 indicates the DO did not start to increase at site W-M544.6F until January 14, 2001 (24 days after opening the inlet gate). This was in contrast to the results of a 1991 IDNR study which showed an increase in surface DO concentrations throughout the complex within seven days of opening the inlet gate (Gent et. al. 1995). In an effort to determine why inflowing water took considerably longer to circulate throughout the backwater complex in 2000/2001 compared to 1991, three factors were considered: inlet gate opening, river stage and inlet channel sedimentation. In 1991, the inlet gate was opened 12 inches (31 cm); whereas, in 2000, it was opened only 10 inches (25 cm). The Mississippi River stage at L/D 13 on January 17, 1991 was 4.57' (1.39 m) and it fell to 4.32' (1.32 m) by January 31. On December 21, 2000, the river stage at L/D 13 was 5.18' (1.58 m) and it remained relatively stable over the next two weeks. It is possible that accretion of sediment in the inlet channel may have caused a reduction in inflow during 2000/2001. A sediment survey performed in October 2002 showed an accretion of about 5' (1.5 m) of sediment in the inlet channel (sediment range S-M546.3H) relative to the designed dredging depth. Much of this accretion could have occurred during a flood event in 1997 (15 days over the flood stage at the L/D 12 gage) which took place relatively soon after the inlet channel was dredged in 1996; thus, side cast material may have been fairly susceptible to erosion. Of the three factors considered, inlet gate opening and inlet channel sedimentation may have contributed to the relatively slow rate of inflow circulation during the winter of 2000/2001.

FIGURE B-1. POST-PROJECT DISSOLVED OXYGEN AND TEMPERATURE VALUES COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M544.6F

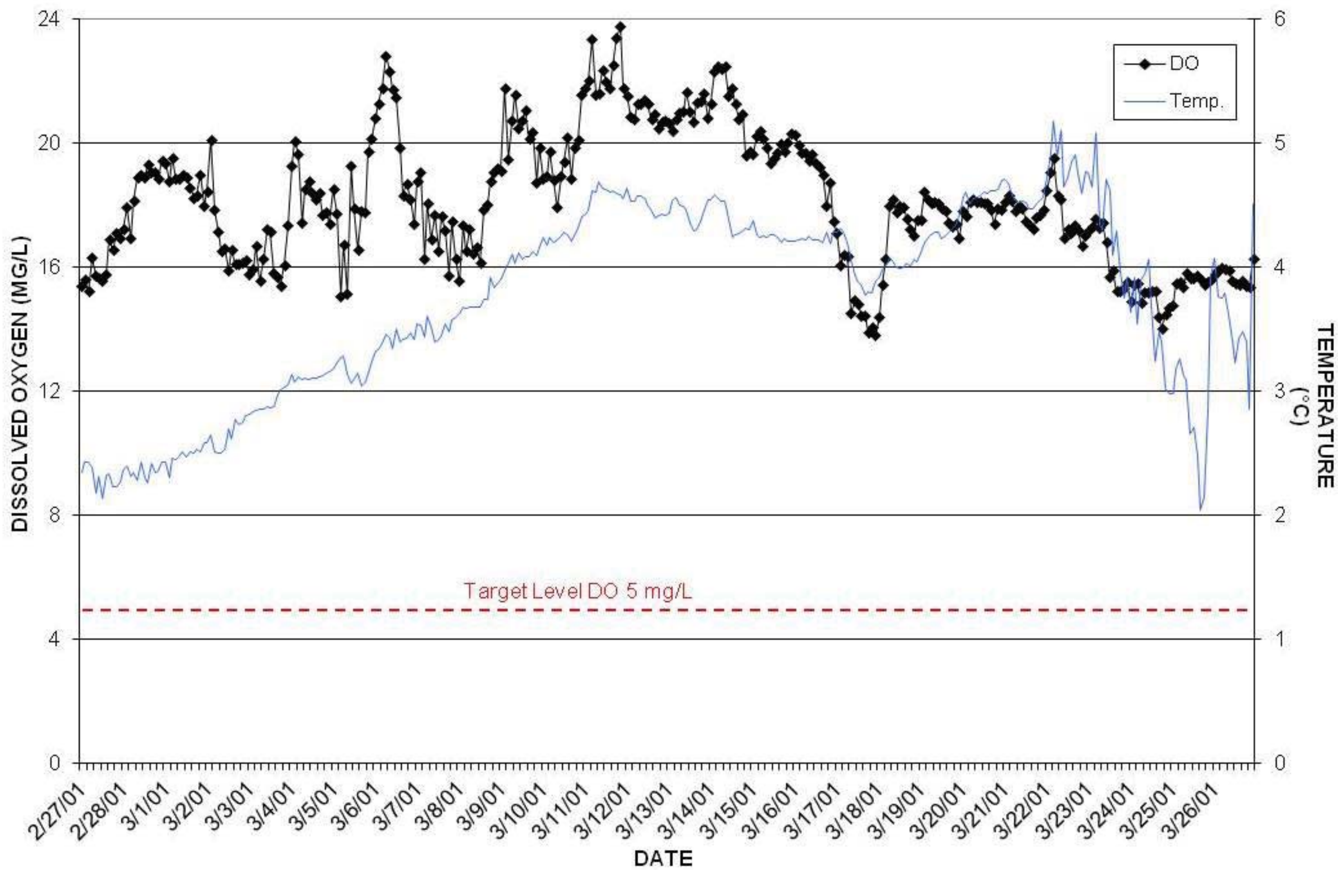


FIGURE B-3.

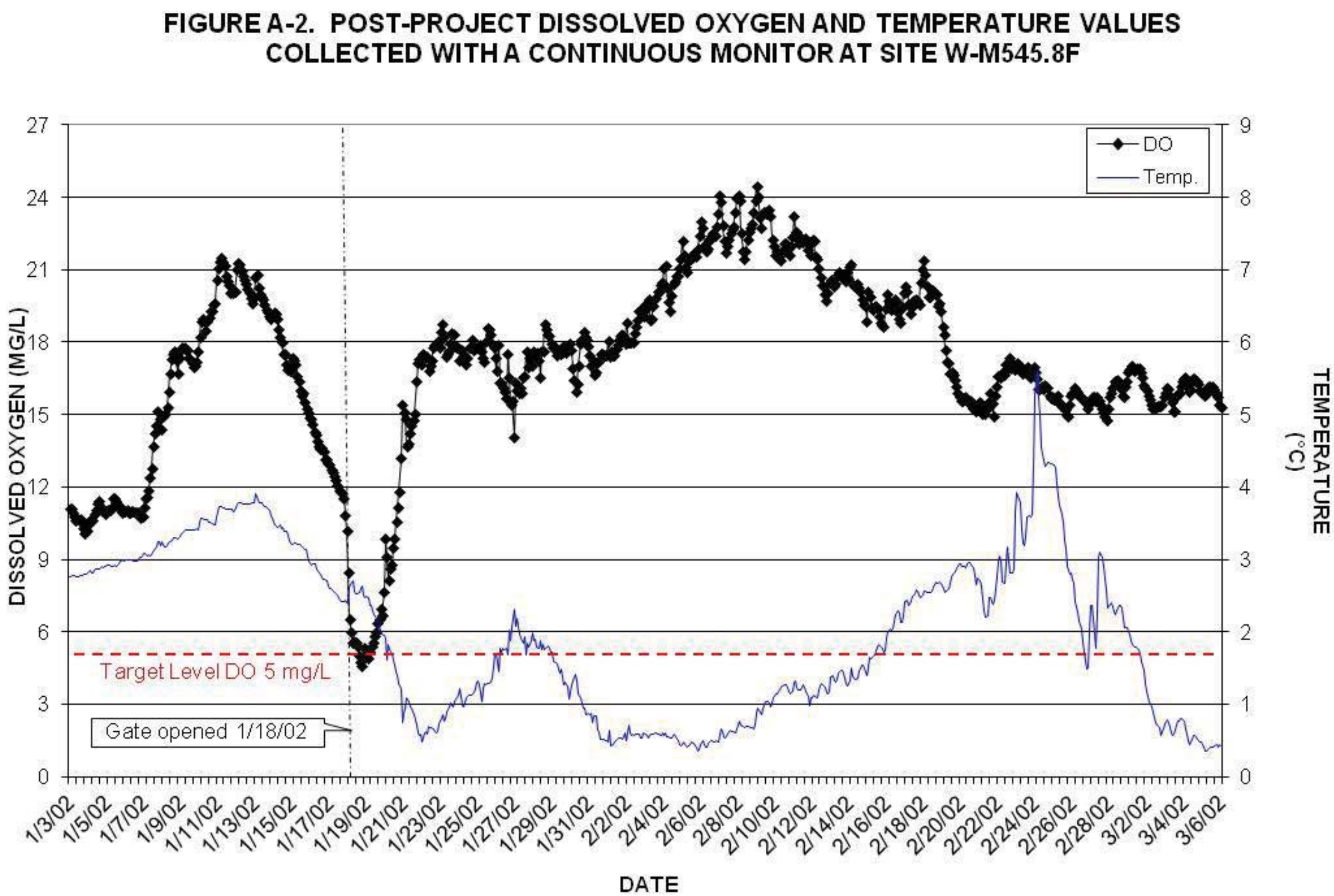
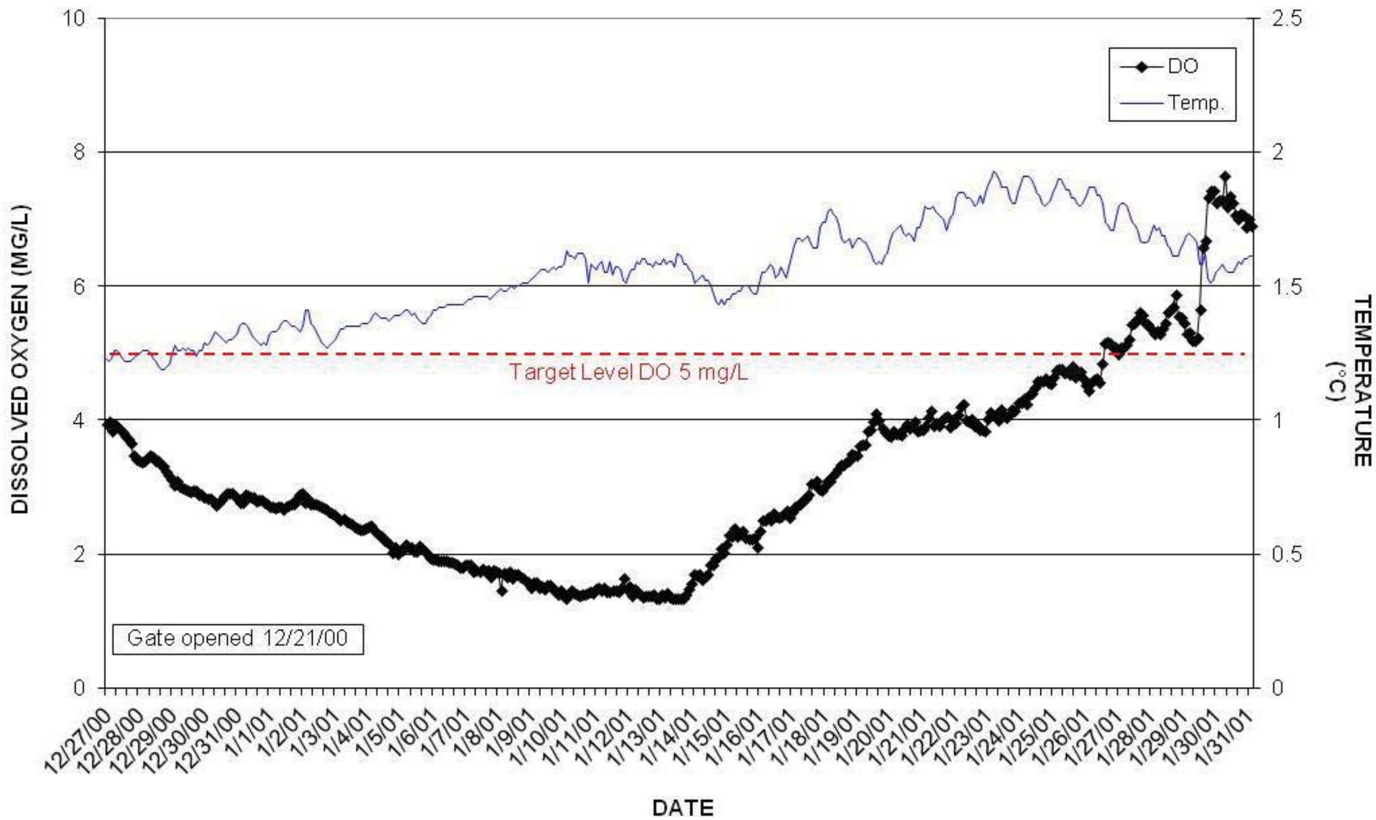


FIGURE A-2. POST-PROJECT DISSOLVED OXYGEN AND TEMPERATURE VALUES COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M545.8F
DO
Temp.
DISSOLVED OXYGEN (MG/L)
TEMPERATURE (°C)
Target Level DO 5 mg/L
Gate opened 1/18/02
DATE
0
3
6
9
12
15
18
21
24
27
1
2
4
5
7
8
1/3/02
1/5/02
1/7/02
1/9/02
1/11/02
1/13/02
1/15/02
1/17/02
1/19/02
1/21/02
1/23/02
1/25/02
1/27/02
1/29/02
1/31/02
2/2/02
2/4/02
2/6/02
2/8/02
2/10/02
2/12/02
2/14/02
2/16/02
2/18/02
2/20/02
2/22/02
2/24/02
2/26/02
2/28/02
3/2/02
3/4/02
3/6/02

FIGURE B-3. **POST-PROJECT DISSOLVED OXYGEN AND TEMPERATURE VALUES COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M544.6F**



Periods of low winter DO concentrations were also recorded during the following deployments: December 9, 2010 - February 7, 2011 at both sites W-M545.8F and W-M544.6F; February 7 – March 7, 2011 at site W-M545.8F; and December 19, 2012 – February 7, 2013 at site W-M544.6F. The low DO concentrations were primarily due to the timing of opening/closing the inlet gate: December 22/February 18 in 2010/2011 and January 8/March 7 in 2013. During the December 19, 2012 – February 7, 2013 deployment at site W-M544.6F, the DO concentration fell below 5 mg/L for several days in mid-January and a few days in late January 2013 (Figure B-4). The low mid-January concentrations were likely due to the inflow not reaching the site yet following opening of the inlet gate on January 8. Once DO concentrations started to increase, there appeared to be a correlation with river stage (although offset by a few days); however, the offset shortened as the deployment progressed. A sharp rise in river stage from January 30 – February 1 was accompanied by an immediate sharp increase in DO concentrations. As the stage generally fell late in the deployment, DO concentrations also generally fell. It is possible that a partial sediment blockage of the inlet channel may have been responsible for the initial delay of oxygenated main channel water reaching site W-M544.6F. DO concentrations may have been related to river stage; however, it is difficult to explain why the offset between stage and DO concentration narrowed as the deployment progressed.

During the summer months, nighttime DO concentrations frequently fell below the 5 mg/L target level; however, they often recovered the following day. The results from a typical summer deployment are shown in Figure B-5 for the July 17-31, 2007 deployment at site W-M544.2C. Although DO concentrations often fell below 5 mg/L during the night, they recovered the following day, often to supersaturated levels. Perhaps the worst-case conditions occurred during the July 12 - 26, 2011 deployment at site W-M544.6F. As shown in Figure B-6, the DO concentration was below the target level for nearly the entire deployment. Nearby main channel DO concentrations were also relatively low during this deployment, as evidenced by grab sample values below saturation (~ 8 mg/L) on July 12, 2011 (6.19 mg/L) and July 26, 2011 (6.18 mg/L).

FIGURE B-4.

FIGURE A-4. POST-PROJECT DISSOLVED OXYGEN COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M544.6F AND L/D 12 (BELLEVUE) RIVER STAGE

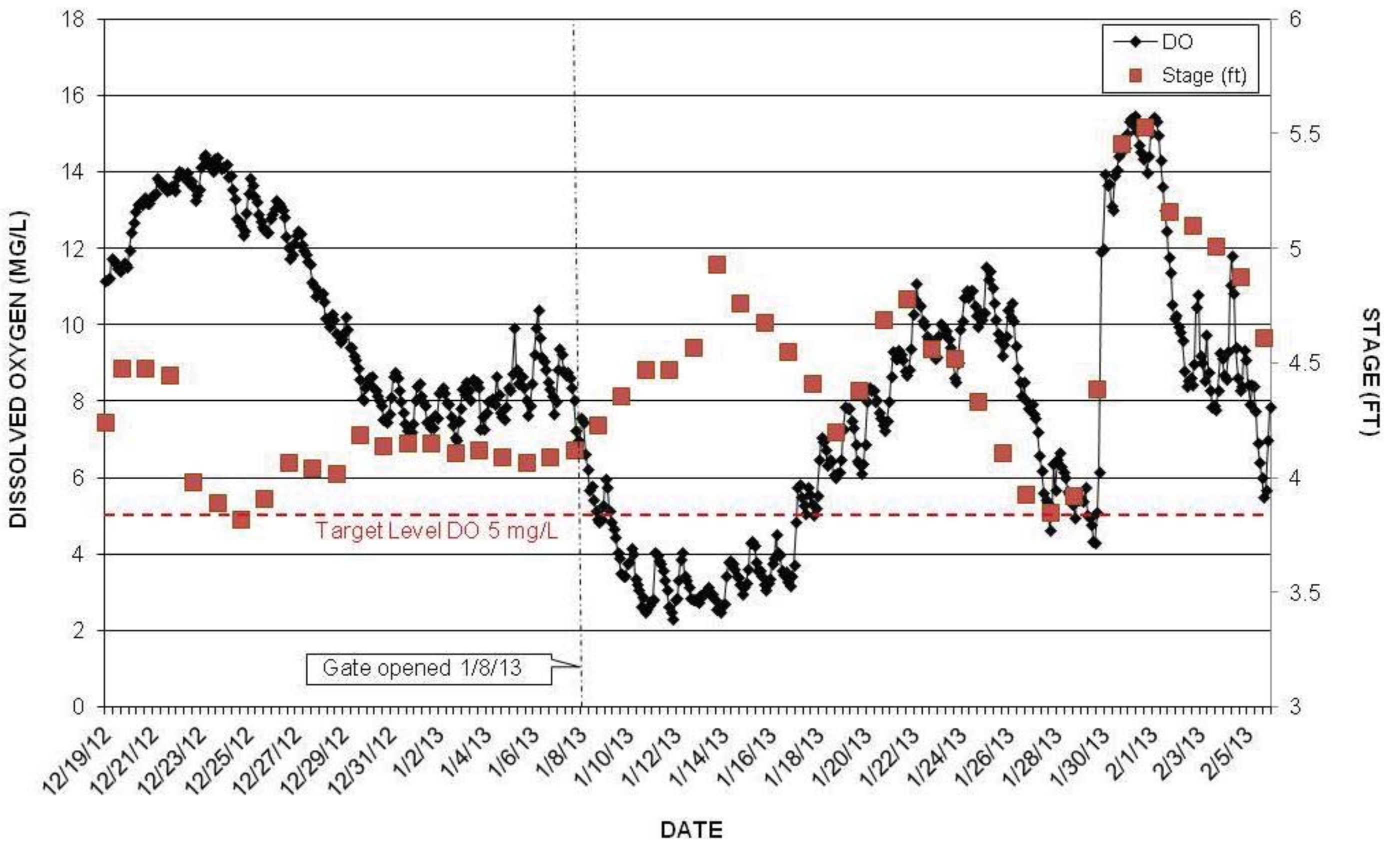


FIGURE B-5. POST-PROJECT DISSOLVED OXYGEN AND pH VALUES COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M544.2C

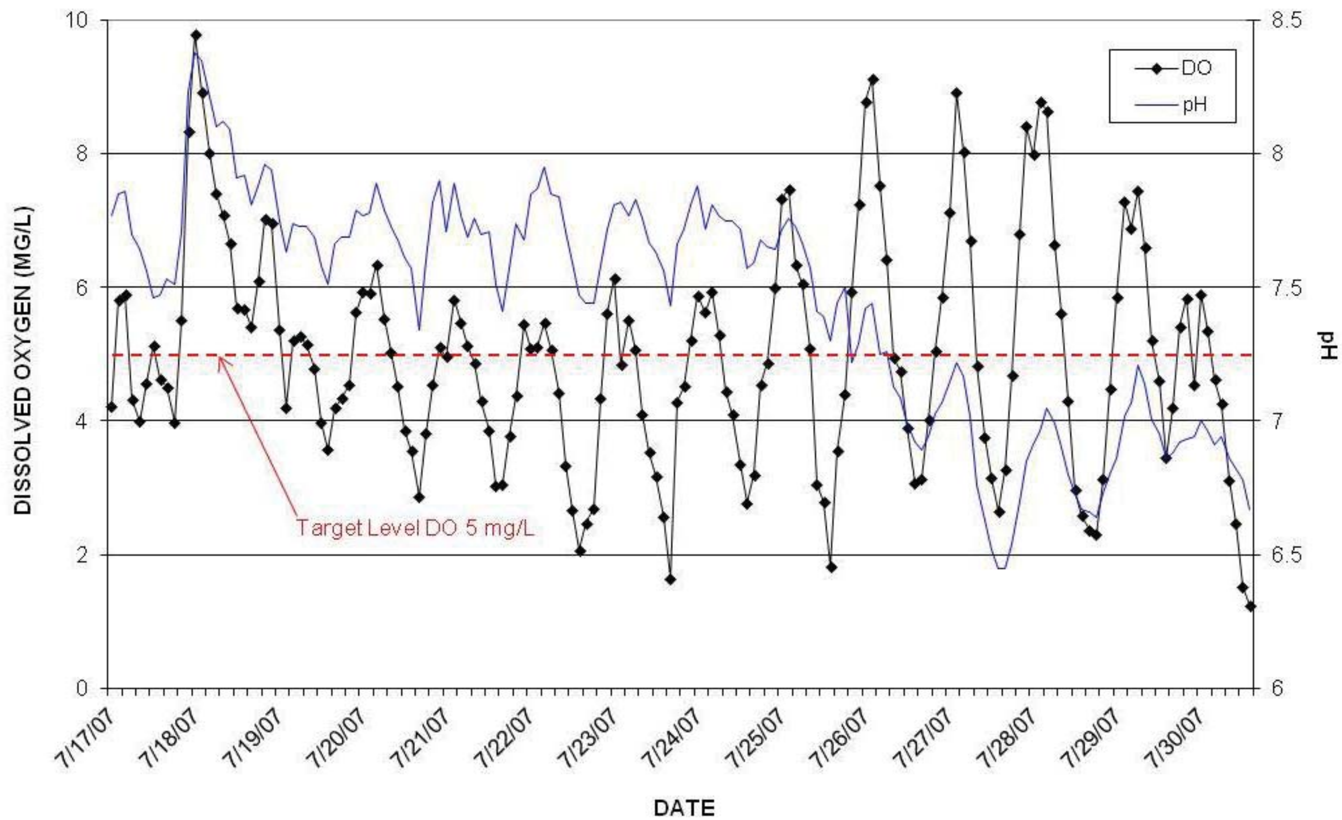
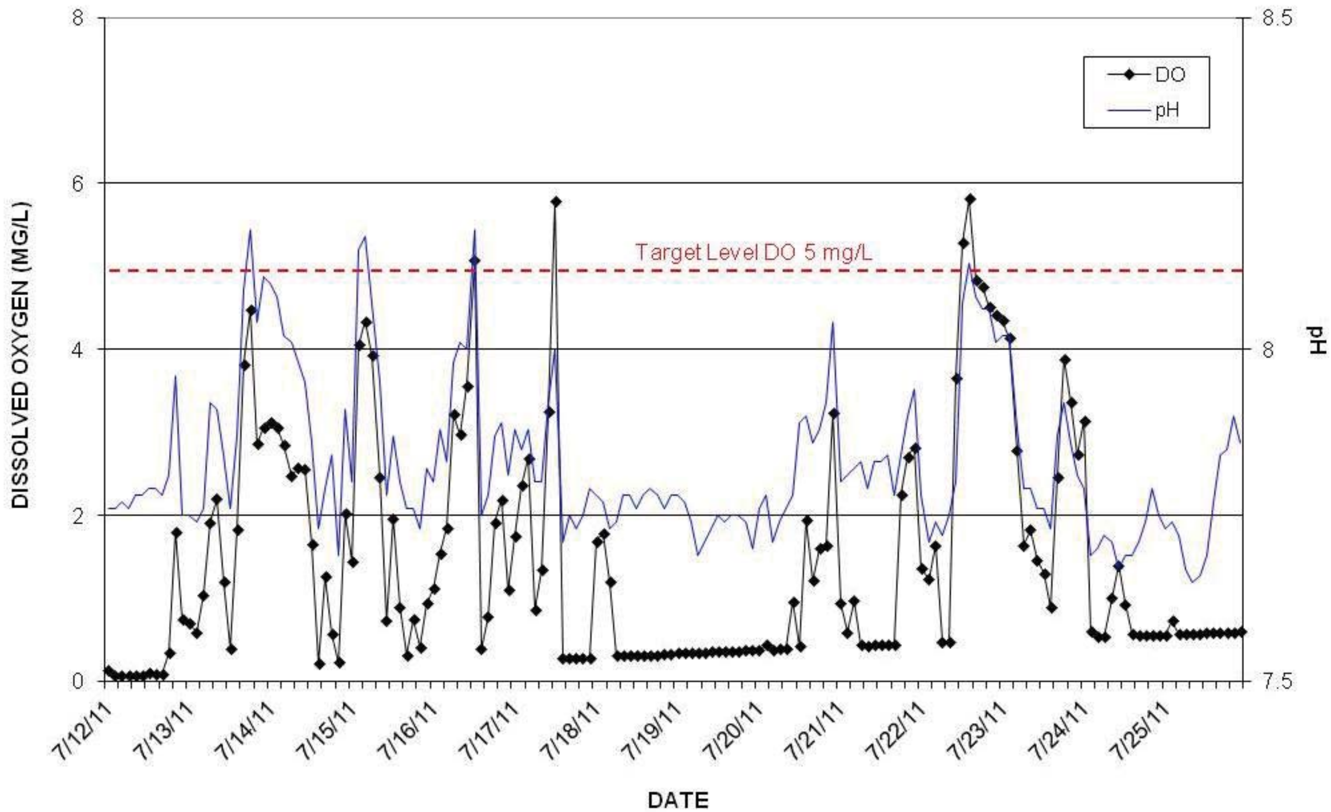


FIGURE B-6. **POST-PROJECT DISSOLVED OXYGEN AND pH VALUES COLLECTED WITH A CONTINUOUS MONITOR AT SITE W-M544.6F**



Grab Samples (TSS). The project was designed to keep TSS concentrations at or below 50 mg/L by incorporating a water control structure and a deflection levee. TSS samples collected at sites W-M545.8F, W-M544.2C, W-M544.6F and W-M545.5B were less than or equal to the 50 mg/L objective the majority of the time (Tables A-2 through A-5). All TSS concentrations at sites W-M545.8F and W-M544.6F were below 50 mg/L, with values ranging from <1 mg/L to 43.0 mg/L and 2.0 mg/L to 46.0 mg/L, respectively. The TSS concentration exceeded 50 mg/L on four occasions at both sites W-M544.2C (65.0 mg/L on August 4, 2009, 94.0 mg/L on September 15, 2009, 53.0 mg/L on June 8, 2010 and 51.0 mg/L on September 7, 2011) and W-M545.5B (51.5 mg/L on April 4, 2002, 123.8 mg/L on April 21, 2004, 61.0 mg/L on May 21, 2009 and 57.2 mg/L on March 9, 2012). The April 4, 2002 and September 7, 2011 exceedances were likely due to an algal bloom, as they were both accompanied by supersaturated DO concentrations (16.8 and 15.5 mg/L, respectively) and high pH values (9.1 and 8.9, respectively). The April 21, 2004 exceedance was likely due to wind generated waves that caused resuspension of bottom sediments. The site W-M544.2C exceedances on August 4 and September 15, 2009 may have been due to a "backwater" effect from Lainsville Slough, as high velocities were measured on these two dates. There is no obvious explanation for the remaining three exceedances. The period average TSS concentrations at sites W-M545.8F, W-M544.2C, W-M544.6F and W-M545.5B were similar to those observed in the previous performance evaluation report that covered the period December 1996 through September 2000 (in parentheses): 16.6 mg/L (18.1 mg/L), 20.7 mg/L (22.8 mg/L), 18.3 mg/L (17.8 mg/L) and 16.3 mg/L (17.7 mg/L), respectively.

2 Synoptic DO Study – February 2009. On January 13, 2009, IDNR personnel were performing water quality monitoring within Brown's Lake as part of the UMRR LTRM Program. A DO concentration of 1.4 mg/L was measured at site W-M545.5B and USFWS personnel were immediately notified. The inlet gate was opened later that day; however, water did not flow into the lake due to sedimentation in the inlet channel. USACE was notified and Mississippi River Project Maintenance personnel mobilized to the scene on February 3rd and removed the sediment blockage with a track hoe excavator. Water started flowing into Brown's Lake shortly thereafter. These conditions presented an opportunity to revisit the water quality portion of a study performed by the IDNR in 1991 that investigated largemouth bass response to varying water quality conditions within Brown's Lake (Gent et al., 1995). The IDNR researchers observed that following a decrease in DO concentration to below 3 mg/L, a 12 in (30 cm) inlet gate opening resulted in DO levels as high as 10 mg/L in the top strata of most of the backwater complex within six days. Since this study was performed, sediment has accumulated within the dredge cuts; thus, decreasing the volume of the lake and the efficiency of the inlet channel to convey water from the main channel of the Mississippi River to the lake. Sediment transect studies performed from 1997 to 2001 showed an average deposition rate of 3.52 in (8.94cm)/year (USACE, 2003). In an effort to determine if the project was still effective in reoxygenating the backwater complex, despite the reduced lake volume, a synoptic study was performed in February 2009 that included performing water quality measurements on five occasions, at several locations, under various operating scenarios. The results from water quality measurements taken on February 6th, 9th, 20th, 24th and 27th indicated the project was still effective in oxygenating the backwater complex when low DO concentrations were encountered. In addition, the results of the February 27th monitoring event indicated that even with the inlet gate closed, oxygen (and sediment) may enter the downstream portion of the backwater complex under certain environmental conditions. On this date, flow in the upstream direction was measured at several sites. It is possible that downstream ice jams produced a backwater effect that caused a flow reversal into Brown's Lake. A detailed description of the synoptic study can be found in Bierl (2009).

3. Discussion and Conclusions. The water quality objectives of the Brown's Lake project are to decrease sediment input to the lake and to increase winter DO concentrations. The project was designed to maintain DO concentrations above 5 mg/L and to keep suspended solids concentrations at or below 50 mg/L. Results from the current evaluation period show that the Brown's Lake project continues to have a positive impact on water quality as long as the inlet gate is opened at the proper time and sediment is not allowed to accumulate in the inlet channel. During the critical winter months, nine grab sample DO concentrations were below the 5 mg/L objective; however, nearly all were attributed to either the inlet gate was not open, inflowing oxygenated water had not yet reached the sampling sites, or sediment had blocked the inlet channel. Most low winter DO concentrations could be avoided by opening the inlet gate by the second week of December, rather than waiting for low DO concentrations to be measured first before opening the gate, as is the current protocol. Should the extended forecast call for heavy rainfall, or a warming trend which would delay freeze-up, the gate opening could be delayed a few days. Accretion of sediment in the inlet channel is an ongoing problem with the project. It is critical that the inlet channel be surveyed more frequently in order to determine when dredging may be necessary to allow a sufficient volume of oxygenated water to be delivered to the backwater complex.

Most of the low DO concentrations observed during the evaluation period occurred during the summer months. Recovery of low nighttime DO concentrations typically occurred during the following day; although, there were occasions when extended periods of low DO were observed. However, no fish kills were reported according to Mike Steuck, former IDNR fisheries research biologist at the Bellevue Fisheries Management Office and Mel Bowler, fisheries technician at the IDNR Mississippi River Monitoring Station, also in Bellevue, Iowa.

Closure of the water control structure during the spring through fall, coupled with the additional protection provided by the deflection levee effectively shielded the lake from high main channel TSS loads the majority of the time. The few instances when the TSS concentration exceeded 50 mg/L were primarily caused by resuspension of bottom sediments due to high winds, high velocities keeping sediment in suspension or high algal concentrations.

Comparisons of periodic grab sample data collected at the four Brown's Lake monitoring sites during the current and most recent past performance evaluation periods are summarized in Tables A-6 through A-9. The tables indicate that during both post-project evaluation periods, DO concentrations below the target level occurred primarily during the summer months and were relatively rare during the winter months. In general, minimum DO concentrations were lower and maximum DO concentrations were higher for the most recent evaluation period. This is most likely a function of sedimentation resulting in a decrease in water volume, causing the effects of photosynthesis (oxygen production) and respiration (oxygen consumption) to be more pronounced.

Table B-6. Summary of Grab Sample Data from Site W-M545.8F

Site W-M545.8F	Post-Project 1/25/94–9/26/00	Post-Project 12/27/00–9/10/13
Number of Samples	82	88
Oct – Mar Samples	28	27
April - September Samples	54	61
DO Concentrations < 5 mg/L	20 (24.4%)	14 (15.9%)
DO Concentrations < 5 mg/L (Oct – Mar Samples)	1 (3.6%)	2 (2.3%)
DO Concentrations < 5 MG/L Apr - Sep Samples	19 (35.2%)	12 (13.6%)
Minimum DO Concentration (mg/L)	1.61	0.60
Maximum DO Concentration (mg/L)	21.40	22.53
Average DO Concentration (mg/L)	8.32	9.62

Table B-7. Summary of Grab Sample Data from Site W-M544.2C

Site W- M544.2C	Post-Project 1/25/94–9/26/00	Post-Project 12/27/00–9/10/13
Number of Samples	82	89
Oct – Mar Samples	28	27
April - September Samples	54	62
DO Concentrations < 5 mg/L	9 (11.0%)	13 (14.6%)
DO Concentrations < 5 mg/L (Oct – Mar Samples)	1 (3.6%)	1 (1.1%)
DO Concentrations < 5 MG/L Apr - Sep Samples	8 (14.8%)	12 (13.5%)
Minimum DO Concentration (mg/L)	2.18	1.69
Maximum DO Concentration (mg/L)	21.30	26.63
Average DO Concentration (mg/L)	9.65	10.34

Table B-8. Summary of Grab Sample Data from Site W-M544.6F

Site W- M544.6F	Post-Project 1/25/94–9/26/00	Post-Project 12/27/00–9/10/13
Number of Samples	21	74
Oct – Mar Samples	21	27
April - September Samples	0	47
DO Concentrations < 5 mg/L	2 (9.5%)	13 (17.6%)
DO Concentrations < 5 mg/L (Oct – Mar Samples)	2 (9.5%)	4 (5.4%)
Do Concentrations < 5 MG/L Apr - Sep Samples	0 (0.0%)	9 (12.2%)
Minimum DO Concentration (mg/L)	3.42	0.67
Maximum DO Concentration (mg/L)	21.87	26.48
Average DO Concentration (mg/L)	12.50	10.07

Table B-9. Summary of Grab Sample Data from Site W-M545.5B

Site W- M545.5B	Post-Project 1/25/94–9/26/00	Post-Project 12/27/00–9/10/13
Number of Samples	171	173
Oct – Mar Samples	82	50
April - September Samples	89	123
DO Concentrations < 5 mg/L	5 (2.9%)	10 (5.8%)
DO Concentrations < 5 mg/L (Oct – Mar Samples)	0 (0.0%)	2 (1.2%)
Do Concentrations < 5 MG/L Apr - Sep Samples	5 (2.9%)	8 (4.6%)
Minimum DO Concentration (mg/L)	3.0	1.4
Maximum DO Concentration (mg/L)	25.0	>20.0
Average DO Concentration (mg/L)	11.7	10.6

Results from the current evaluation period indicate the ability to introduce oxygenated water into, and exclude sediment laden water from, the Brown's Lake HREP continue to be key elements of the project's success.

4. References

Bierl, D.P. 2009. *Water Quality in Brown's Lake, a Backwater of the Mississippi River near Green Island, Iowa, under Various Operating Scenarios during February 2009*. Internal Report, U.S. Army Corps of Engineers, Rock Island District.

Gent, R., J. Pitlo, and T. Boland. 1995. *Largemouth Bass Response to Habitat and Water Quality Rehabilitation in a Backwater of the Upper Mississippi River*. North American Journal of Fisheries Management 15:784-7.

U.S. Army Corps of Engineers, Rock Island District. 2003. *Upper Mississippi River System Environmental Management Program Post-Construction Performance Evaluation Report Supplement (12-Years Post Construction), Brown's Lake Habitat Rehabilitation And Enhancement Project, Pool 13, Mississippi River Miles 544.0 – 546.0, Jackson County, Iowa*.

U.S. Army Corps of Engineers, Rock Island District. 1987. *Upper Mississippi River System Environmental Management Program Definite Project Report (R-2), Brown's Lake Rehabilitation and Enhancement, Pool 13, River Mile 545.8, Upper Mississippi River, Jackson County, Iowa, with Environmental Assessment.*

POST-CONSTRUCTION
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BROWN'S LAKE
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APPENDIX C

BOTTOMLAND HARDWOOD DIVERSITY SUPPORTING DOCUMENTS

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Bottomland Hardwood Diversity Supporting Documents

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING - P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF

http://www.mvr.usace.army.mil

CEMVR-OD-MN 31 December 2008

MEMORANDUM FOR RECORD

SUBJECT: Brown's Lake EMP inventory

1. Jon Schultz and Ben Vandermyde visited the site on the 5th and 10th of December 2008.

2. Inventory data stored in Natural Resource Team Drive:
   T:\ODMN-Forest\Forestry\Memos-Letters\2008
   Tree and herbaceous codes included in excel file for all species referenced.

3. Entire site includes 28 fixed plots. 23 of the fixed plots contain prism plots(10 BAF); the remaining 5 fixed plots had no count trees within the plot. 4 fixed plots had no regeneration; 3 of those plots were in the west cell.

4. East Cell management area - Contains 20 fixed plots. Transects laid out on a 110 degree bearing. Fixed plots have a spacing of 5 chains by 5 chains. Tree species tallied in the 18 prism plots included: Dominant - *Populus deltoides, L. tulipifera, Salix interior, Betula nigra, Fraxinus pennsylvanica*; Co-Dominant - *Salix interior, Salix nigra, Quercus rubra, Populus deltoides,* and *Quercus palustris*; Intermediate – *Salix interior, L. tulipifera, Populus deltoides, Salix nigra, Quercus rubra,* and *Quercus macrocarpa* - respectively by most frequent occurrence. Coverage of the site is well representative from data collected from prism plot inventory. Overstory closure ranges from 0% to 90%; the average overstory closure across the site is 33%. Tree height across the site ranges from 20' to 90'; the average tree height is 43'. Understory tree height ranges from 2'to 5' and 35'to 40'; 42% of the understory height is 15' to 10'. Tree regeneration cover, trees less than 4" dbh is based on a 0 (no trees) to 5 (complete tree coverage in the fixed plot) scale, is rated a 4 on average across the site.

5. West Cell management area – Contains 8 fixed plots. Transects at north and south end of cell are laid out on a 110 degree bearing. Fixed plots have a spacing of 5 chains by 5 chains. Tree species tallied in the 5 prism plots included: Dominant – *Salix interior*; Co-Dominant – *Salix nigra*; Intermediate – *Salix interior, Salix nigra, Populus deltoides* – respectively by most frequent occurrence. Coverage of the site is well representative from data collected from prism plot inventory. Overstory closure ranges from 0% to 50%; the average overstory closure across the site is 16%. Tree height across the site ranges from 1' to 35'; the average tree height is 17'. Understory

tree height ranges from 0' and 15' to 20'; 57%(4 plots) of the understory height is 0'. Tree regeneration cover, trees less than 4"dbh is based on a 0 (no trees) to 5 (complete tree coverage in the fixed plot) scale, is rated a 3 on average across the site.

6. East Cell: Prism plot inventory data conducted by using a 10 BAF prism. An estimated 1148 trees per acre were recorded. *S. interior, S. nigra*, and *P. deltoids* comprise of 83% of total stem density. The stocking of hard mast trees only includes *Q. macrocarpa, Q. palustris*, and *Q. rubra*; these oak species occur at a rate of 151 trees per acre. The oak is mostly of healthy, vigorously developing trees; only in the co-dominant and intermediate classifications. *Q. rubra* ranges from 3" to 10" dbh; majority of the stems are 3" dbh. *Q. macrocarpa* and *Q. palustris* are of the 1" and 3" dbh size class, respectively.

7. West Cell: Prism plot inventory data conducted by using a 10 BAF prism. An estimated 3147 trees per acre were recorded. *S. interior, S. nigra*, and *P. deltoids* comprise of 100% of total stem density.

8. Understory cover noted in fixed plots – Tree and woody species inventoried: *Acer saccharinum, Cephalanthus occidentalis, Cornus racemosa, Cornus, Cornus sericea, Elaeagnus umbellata, Fraxinus pennsylvanica, Juniperus virginiana, Populus deltoides, L. tulipifera, Quercus bicolor, Quercus macrocarpa, Quercus rubra, Salix interior, Salix spp., Salix nigra*, and *Ulmus Americana*.

9. Notable species - Specie within parameter of fixed plot that was not already mentioned previously: *Celtis occidentalis*; noted only once. Within the east cell management area, some planted *Taxodium distichum* (bald cypress) are healthy and appear to have vigorous growth.

10. Herbaceous cover noted in fixed plots – Time of inventory was well into dormant period of the year and the ground was blanked in snow; thus limited ability to capture complete data on herbaceous growth. Clearly apparent species that were noted included: *Phragmites australis, Thypha spp., Panicum virgatum,* and *Achnatherum spp.*

11. Invasive Concerns – *Elaeagnus umbellata* noted in three separate fixed plots. All three plots located at eastern end of the East Cell management area. *E. umbellata* is at an easily manageable state; few stems and sparsely scattered. Control/monitoring should be done as soon as possible.

12. *Q. palustris* helicopter broadcast planting of 1990 had no evidence of any survival. This planting was in the west cell. The only occurring tree cover is willow. Failure for survival is due to water being unable to recede after the 1993 flood. Beavers damned up the drainage point and water remained within the cell for the entire summer. The west cell currently represents little to no ability for oak propagation to occur because of poor water drainage; sustained periods of site being under water and very hydric soil conditions.

13. Elevation height of the management area has been elevated between 6' and 8' above the surrounding flood plain. Dredge material was unevenly placed into containment basin; material was pumped into the east cell, only at the east end. The divisional interior levee permitted only silt and clay to be deposited in the west cell. The west cell remains lower in elevation change with high levee construction around the parameter; holds water and remains moist year round. The east cell has a much higher settlement of sediment; highest point is to the eastern end of the cell. The management cell changes dramatically in composition of clay, silt, sand, and gravel from the west to the east respectively. The higher elevation is mostly composed of sand and is better drained. Tree survival is more prevalent on the sandier soil of the entire management area; however, those sandier areas are micro-topographical locations that either will not become flooded or flood water recedes from efficiently.

14. Further inventory needed to fully encompass ratio of tree specie survivability from planted stock. Prism plot data is limited to representative totals of stems on site; due to small diameter of trees in interest. Additional fixed plot data would better to determine stocking densities.

15. Volunteer native species are a large component of the current site canopy closer. The site encompasses a large component of *S. interior*, *S. nigra*, and *P. deltoides*; especially in the west cell.

16. Desirable trees on site will need opening and releasing from surrounding nurse trees and volunteer tree pressure. Crop tree release cutting by personal on the ground would be most effective means of timber stand improvement. Crop tree release should be done within three to five years before desirable trees begin to become suppressed. Thick pockets of desirable tree growth will need thinning within five to eight years. Without moderate thinning, desirable trees will most likely be stressed from overstocking complications.

Trees per acre determined by 8 plots, 3 plots had no count trees in prism plot
West Cell

DBH	PODE3	SAIN3	SANI	Total
1	0	2979.381	0	2979
2	0	57.29578	0	57
3	0	0	0	0
4	42.97183	0	28.64789	72
5	0	0	18.33465	18
6	0	0	6.366198	6
7	0	0	4.677206	5
8	3.580986	0	0	4
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	1.169302	0	0	1
15	1.018592	0	0	1
16	3.580986	0	0	4
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0.473519	0	0	0
Total	53	3037	58	3147

Trees per acre determined by 20 plots, 2 plot had no count trees in prism plot

East Cell

DBH	BENI	FRPE	PODE3	LITU	QUMA2	QUPA2	QURU	SAIN3	SANI	Snag	Total
1	0	0	275.0197	0	91.67325	0	0	366.693	0	0	733
2	0	0	22.91831	0	0	0	0	114.5916	22.91831	22.91831	183
3	0	0	0	0	0	10.18592	30.55775	81.48733	30.55775	0	153
4	5.729578	0	0	0	0	0	11.45916	17.18873	5.729578	0	40
5	3.66693	3.66693	3.66693	0	0	0	0	0	0	0	11
6	0	0	2.546479	0	0	0	5.092958	0	0	2.546479	10
7	0	0	1.870883	0	0	0	0	0	0	0	2
8	0	0	1.432394	1.432394	0	0	1.432394	0	0	0	4
9	0	0	0	1.131768	0	0	0	0	0	0	1
10	0	0	1.833465	2.750197	0	0	0.916732	0	0	0	6
11	0	0	1.51526	0	0	0	0	0	0	0	2
12	0	0	1.27324	0	0	0	0	0	0	0	1
13	0	0	0	0.542445	0	0	0	0	0	0	1
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0.716197	0	0	0	0	0	0	0	1
17	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0.282942	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
Total	9	4	313	6	92	10	49	580	59	25	1148

Hard Mast Trees per Acre Total:	151
Soft Mast Trees per Acre Total:	971
Snags per Acre Total:	25

Post-Construction
Performance Evaluation Report

Brown's Lake
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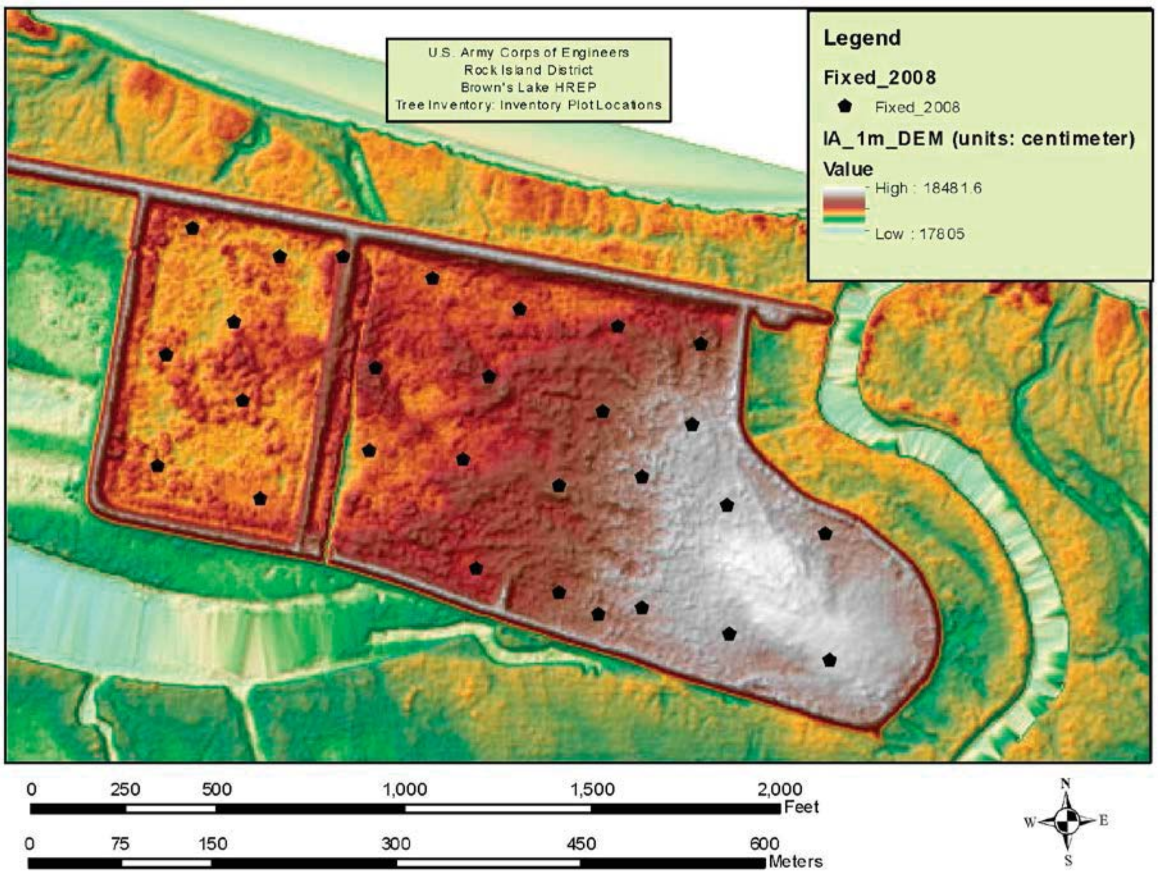
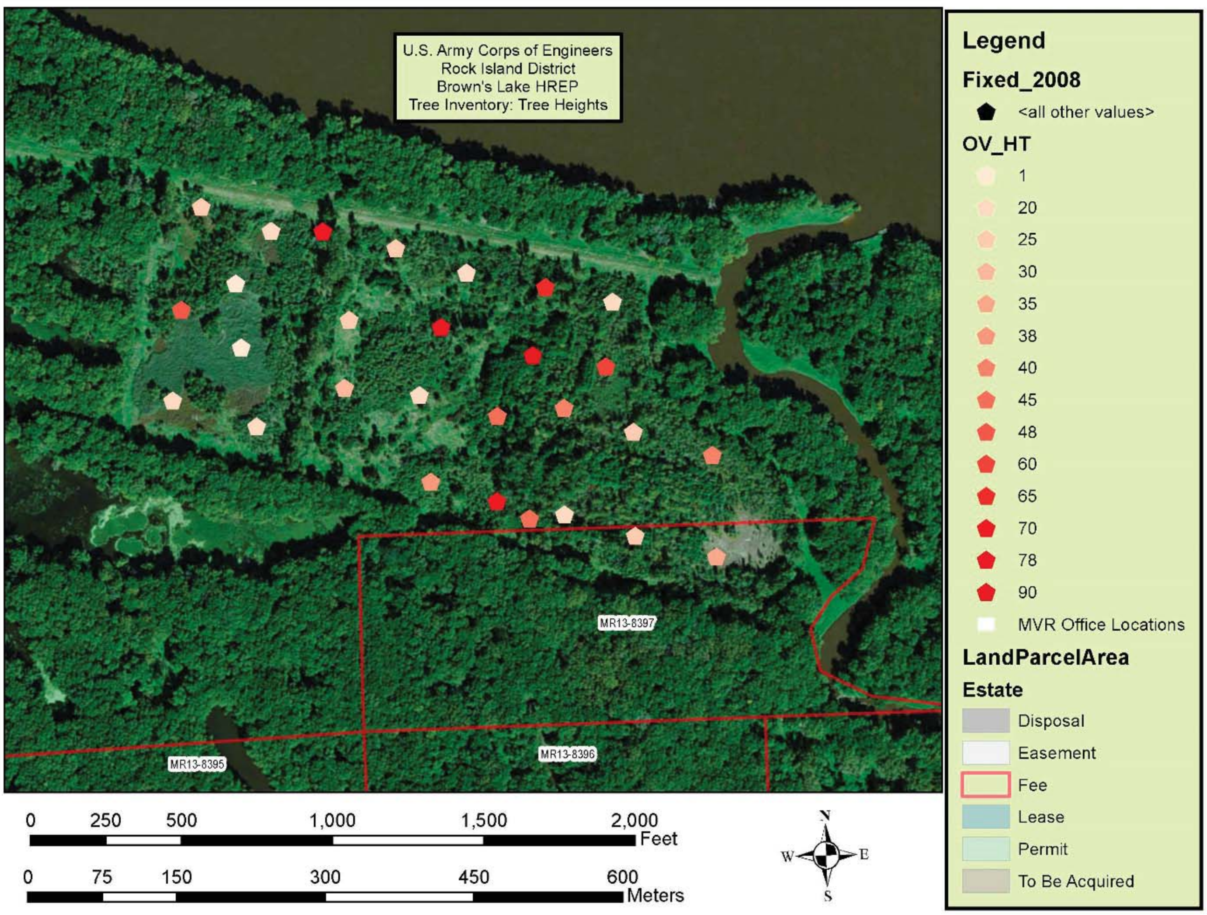
Appendix C
Bottomland Hardwood Diversity Supporting Documents




U.S. Army Corps of Engineers
Rock Island District
Brown's Lake HREP
Tree Inventory: Tree Heights
MR13-8397
MR13-8395
MR13-8396
Legend
Fixed_2008
<all other values>
OV_HT
1
20
25
30
35
38
40
45
48
60
65
70
78
90
MVR Office Locations
LandParcelArea
Estate
Disposal
Easement
Fee
Lease
Permit
To Be Acquired
0 250 500 1,000 1,500 2,000
Feet
0 75 150 300 450 600
Meters
N
W
E
S

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BROWN'S LAKE
HABITAT REHABILITATION AND ENHANCEMENT PROJECT

APPENDIX D

BROWN'S LAKE SEDIMENT DEPOSITION RATE EVALUATION

Browns Lake Sediment Deposition Rate Evaluation 20160407

Four sediment ranges (surveyed by CEMVR-EC-TS) were used to evaluate sediment deposition rates in the Brown's Lake HREP between 1995 and 2014. Figure D-1 shows the location of the ranges. Survey data for Range A was available for 2014, but not 1995. The extent surveyed along range N was not consistent for 1995 and 2014, so this range was not used to evaluate sedimentation rates. Figures D-2 through 7 show plots of the 1995 and 2014 survey points along each range.

The sediment deposition rates between 1995 and 2014 were calculated by determining the difference in cross-sectional area below elevation 605' MSL 1912. These rates were determined between certain offset distances along each transect. These offset distances are listed in Table D-2. Offsets were chosen based on consistent data between the two sets.

The sediment deposition rates between 1995 and 2014 were compared to values listed in several tables from the 1996 PER for Brown's Lake, including the Sediment Reduction Tables (Tables D-1 and 2); the Dredge Cut Depth Tables (Tables D-3 and 4); the Sediment Deposition Tables (Tables D-5 and 6); and the Average Annual Sediment Accretion Tables-(Tables D-7 and 8).

The Sediment Reduction Table from the 1996 PER (Table D-1) shows the calculated with-project annual sediment deposition rate and a comparison of the actual acre-feet of annual sediment reduction to the design acre-feet of annual sediment reduction, established in the 1987 Definite Project Report Appendix A, *Hydrology and Hydraulics*. The design acre-feet of annual sediment reduction for Brown's Lake was 21.6 acre-feet per year. The 1996 PER table shows a with-project annual sediment deposition rate of 19.4 acre-feet per year and an actual acre-feet of annual sediment reduction of 11.4 acre-feet per year.

The Updated Table based on the 2014 and 1995 data (Table D-2) shows a with-project annual sediment deposition rate of 23.7 acre-feet per year and an actual acre-feet of annual sediment reduction of 7.1 acre-feet per year.

The Dredge Cut Sediment Deposition Table from the 1996 PER (Table 3) shows a sediment deposition rate of 4.6 inches per year in the dredge cuts. The updated table based on the 2014 and 1995 data (Table D-4) shows a sediment deposition rate of 1.8 inches per year in the dredge cuts.

The Sediment Deposition Table from the 1996 PER (Table D-5) and the updated table from 2014 and 1995 data (Table D-6) summarize the deposition rates along the ranges.

The Average Annual Sediment Accretion Table calculates additional lake volume available from the dredge cuts. The 1996 PER table (Table D-7) shows a calculated additional volume value of 169 acre-feet at Year 6 based on a sediment deposition rate of 4.6 inches per year in the dredge cuts at 1995. The updated table based on 2014 and 1995 data (Table D-8) shows a calculated additional volume value of 92 acre-feet based on a sediment deposition rate of 1.8 inches per year (0.15 foot /year) between 1995 and 2014.

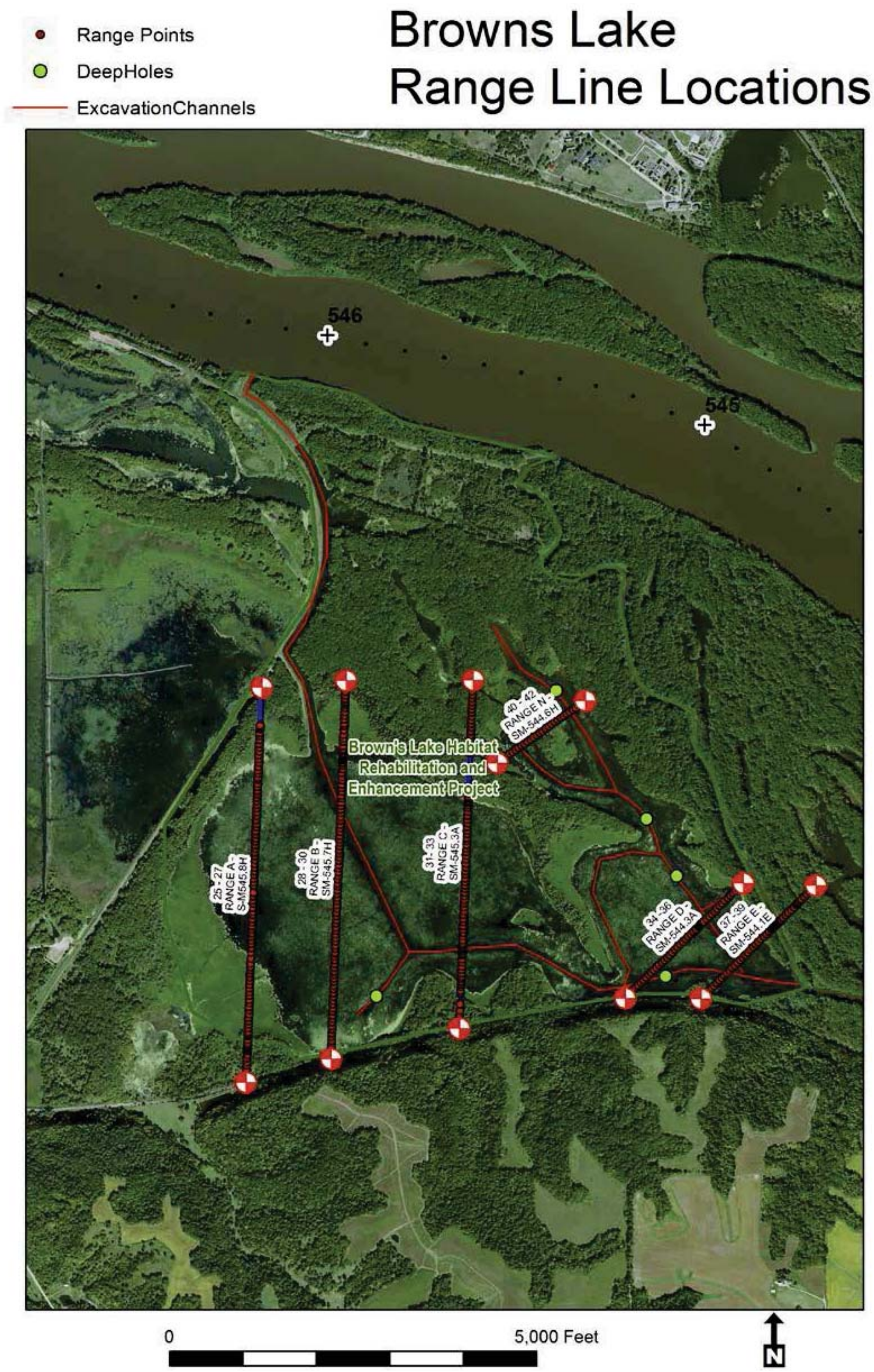

Figure D-1. Location of Browns Lake Sediment Ranges

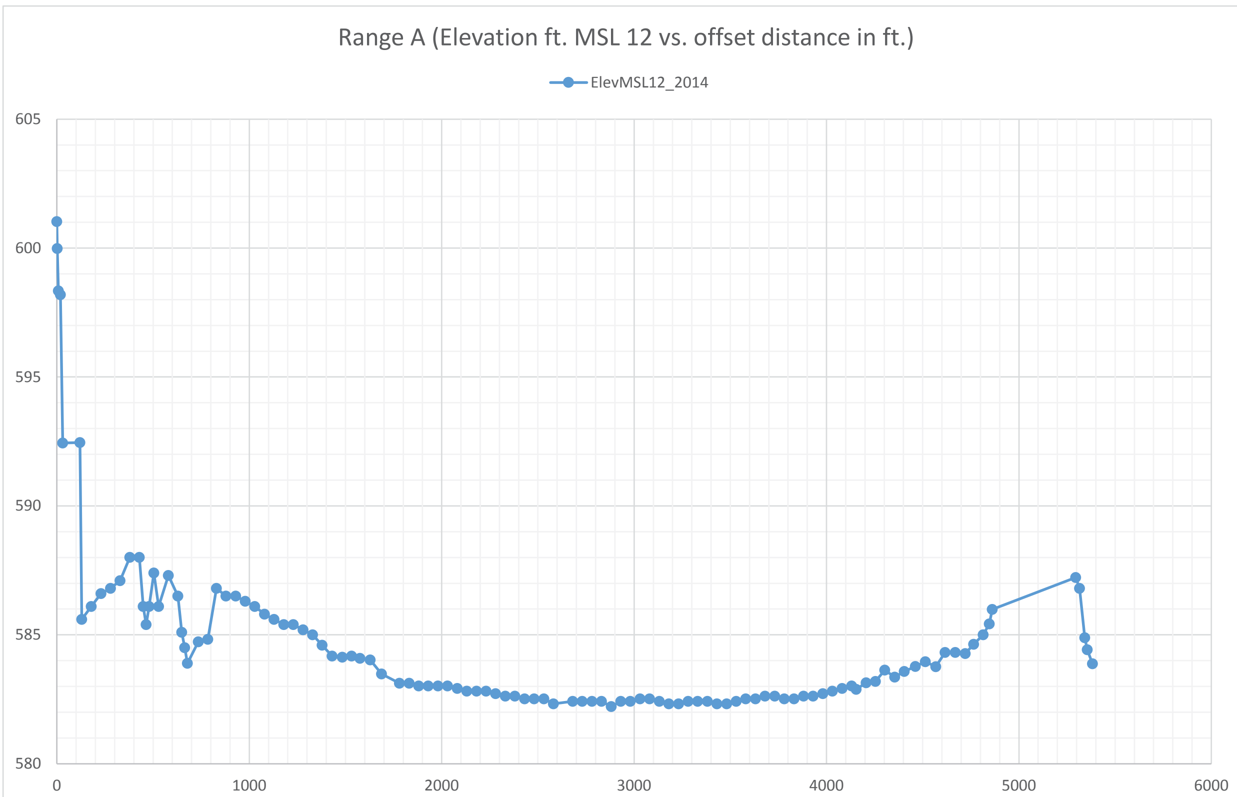

Figure D-2. Range A. No 1995 Data

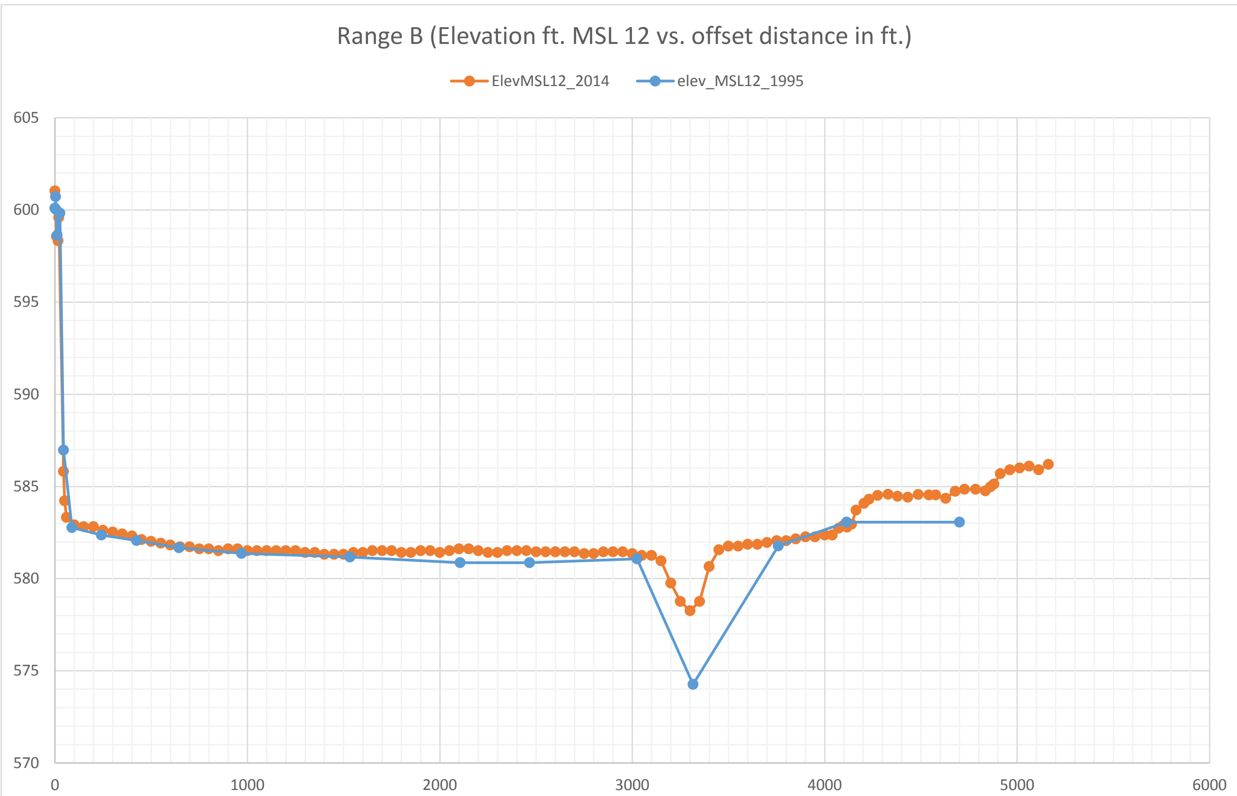

Figure D-3. Range B

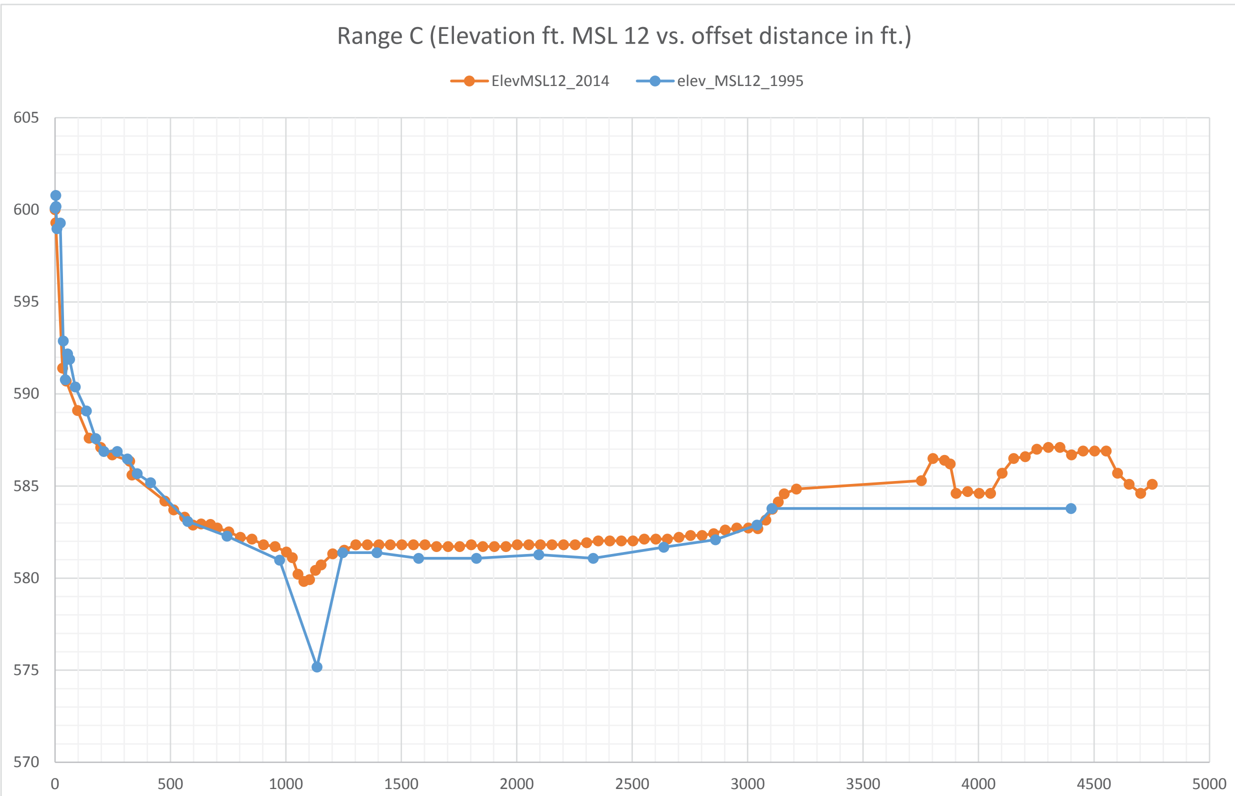

Figure D-4. Range C

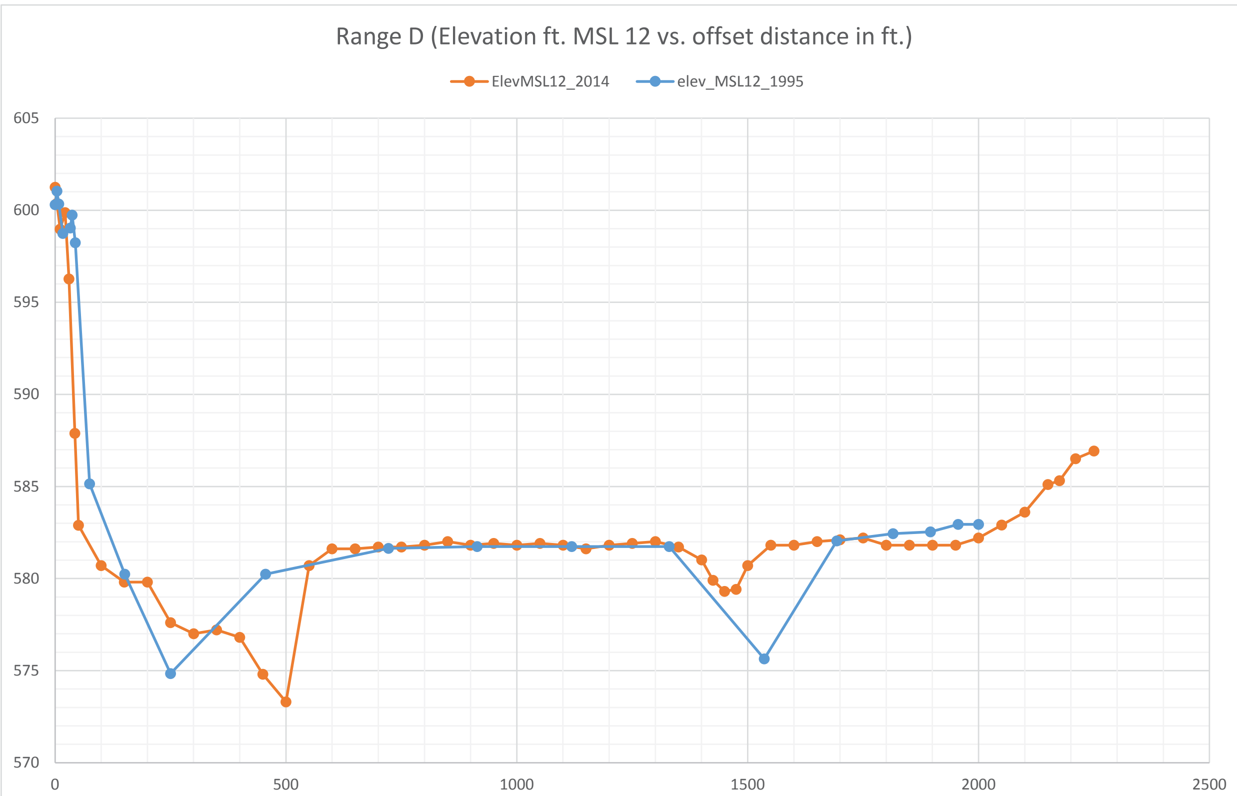

Figure D-5. Range D

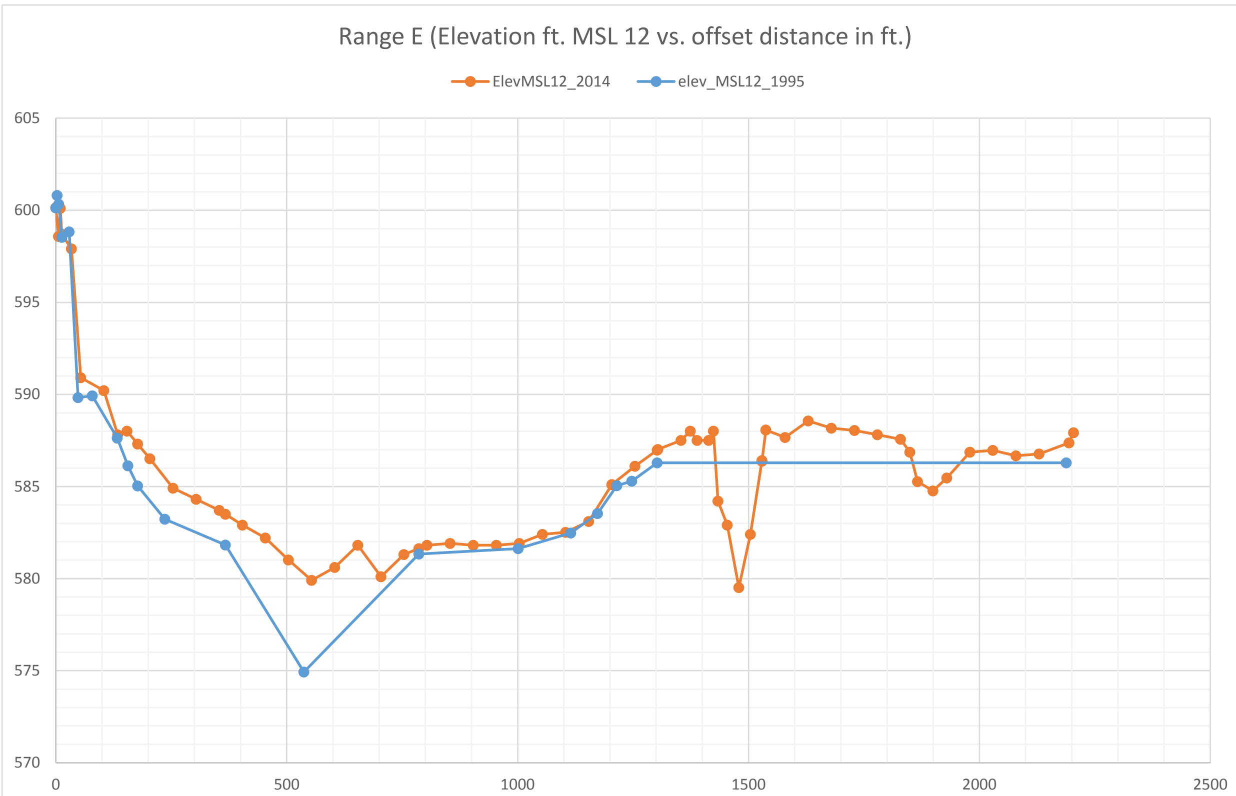

Figure D-6. Range E

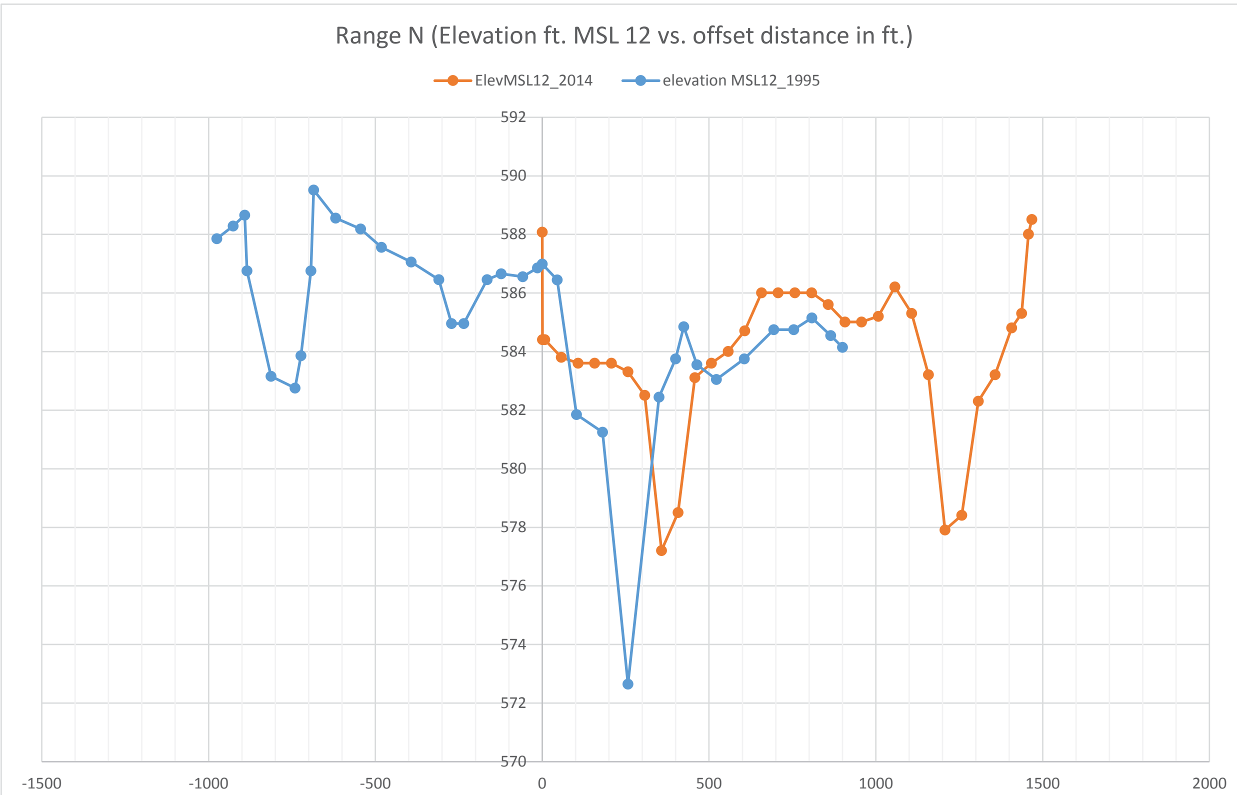

Figure D-7. Range N

Appendix D
Brown's Lake Sediment Deposition Rate Evaluation

Table D-1. Sediment Reduction Table from the 1996 PER

1996 PER Table

Sediment Transect	Period	Years	Section Length, Ft[1/]	Scour, SF[1/]	Deposition, SF	Total Scour(-)/ Deposition, SF	Total Scour(-)/ Deposition, Ft	Total Scour(-)/ Deposition, In/Year
Corps								
545.8H (Upper Brown's Lake)	29/30-95	65.5	4478.0		11894.0	11894.0	2.66	0.5
545.7H (Upper Brown's Lake)	29/30-95	65.5	3813.0	-707.0	7498.0	8205.0	2.15	0.4
545.3H (Upper Brown's Lake)	29/30-95	65.5	2955.0	-211.0	6221.0	6432.0	2.18	0.4
544.3H (Lower Brown's Lake)	38/39-95	56.5	1455.0	-1019.1	1236.0	2255.1	1.55	0.3
							Corps Average	0.4
USFWS								
545.5A (Upper Brown's Lake)	90-95	5.0	1025.0	21.6	312.3	290.7	0.28	0.7
545.4A (Upper Brown's Lake)	90-95	5.0	775.0		226.5	226.5	0.29	0.7
544.2A (Lower Brown's Lake)	89-95	6.0	400.0	110.5	449.8	339.3	0.85	1.7
							USFWS Average	1.0
IADNR								
545.8E (Upper Brown's Lake)	84-94	10.0	250.0		53.0	53.0	0.21	0.3
545.6B (Upper Brown's Lake)	89-94	10.0	100.0		5.5	5.5	0.06	0.1
544.9E (Lower Brown's Lake)	84-94	10.0	190.0		29.7	29.7	0.16	0.2
							IADNR Average	0.2
						Weighted Average[2/]		0.3
						With-Project Annual Sediment Deposition, Acre-Feet		19.4
						Actual Acre-Feet of Annual Sediment Reduction [3/]		11.4
						Design Acre-Feet of Annual Sediment Reduction [3/,4/]		21.6

[1/] Corps section lengths and scour adjusted to exclude dredge cut areas.
[2/] Based on % undisturbed project area (IADNR and Corps transects) and % project area dredged channels (USFWS transects)
Project Area = 740 acres
Dredged Channel Area = (19,520*60)/43560 = 27 acres
% Project Area Dredged Channels = 27/740 = 4%
[3/] Without project annual sediment volume = 30.8 Acre-Feet (ref DPR A-2, 3).
[4/] Based on with-project annual sediment deposition = 0.15" (.0125') (ref DPR, pg A-4,5)

Appendix D
Brown's Lake Sediment Deposition Rate Evaluation

Table D-2. Updated Sediment Reduction Table Calculated with 2014 and 1995 Data

Update with 2014 Data

Sediment Transect	Period	Years	offset zone[5]	Section Length, Ft[6/]		% Brown's Lake Area (in each lake section)[7]	Total Scour(-)/ Deposition, SF	Total Scour(-)/ Deposition, Ft	Total Scour(-)/ Deposition, In/Year	Total Scour(-)/ Deposition, In/Year (in lake section)[8]
Corps from 95 - 2014										
545.7H (Upper Brown's Lake) - Range B	95-2014	19.0	0 - 4113	4113.0		77.0	2993.9	0.73	0.460	0.392
545.3H (Upper Brown's Lake) - Range C	95-2014	19.0	0 - 3105	3105.0			1489.6	0.48	0.303	
544.3H (Lower Brown's Lake) - Range D	95-2014	19.0	0 - 2000	2000.0		23.0	-163.0	-0.08	-0.051	0.355
5441H (Lower Brown's Lake) - Range E	95-2014	19.0	0 - 1302	1302.0			2019.9	1.55	0.980	
							Area Weighted Average[9/]		0.384	
							With-Project Annual Sediment Deposition, Acre-Feet		23.7	
							Actual Acre-Feet of Annual Sediment Reduction [3/]		7.1	
							Design Acre-Feet of Annual Sediment Reduction [3/,4/]		21.6	

[5/] Offsets from 0 on each range
[6/] Section length calculated from offsets shown in offset zone column
[7/] Approximate percent area of each lake section in the total Brown's Lake Area
[8/] Scour(-)/Deposition in each lake section (Upper and Lower)
[9/] Average Total Scour/Deposition (in lake section) weighted by % Brown's Lake Area (in each lake section).

Table D-3. Dredge Cut Sediment Deposition Depth Table from the 1996 PER.

1996 PER Table

	Year															
	1989		1990		1991	1992	1993	1994	1995		1996					
Sediment Transect[1/]	Area[2/] SF	Depth Ft	Area SF	Depth Ft	Area SF	Area SF	Area SF	Area SF	Area SF	Depth Ft	Area SF	Depth Ft	Dredge Cut Deposition, SF	Dredge Cut Deposition, Ft (Depth - Depth)	Dredge Cut Deposition, Ft/Year (Depth - Depth)	Dredge Cut Deposition, In/Year (Depth - Depth)
Corps																
545.7H (Upper Brown's Lake)	702	9							1294.5	8.4				0.60	0.10	1.2
545.3H (Upper Brown's Lake)	702	9							424.9	6			277.10	3.00	0.50	6.0
545.6H (Lower Brown's Lake)	702	9							876.7	8.1				0.90	0.15	1.8
544.3HL (Lower Brown's Lake)	702	9							523.4	7.5			178.60	1.50	0.25	3.0
544.3HR (Lower Brown's Lake)	702	9							1976.1	8				1.00	0.17	2.0
544.1EL (Lower Brown's Lake)	702	9							642.2	7.1			59.80	1.90	0.32	3.8
544.1ER (Lower Brown's Lake)	702	9							446.9	6.7			255.10	2.30	0.38	4.6
														Corps Average	0.27	3.2
546.3H (Inlet Channel)	432	9							156.1	3.2	408.5	7.7	275.90	5.80	0.97	11.6
545.9H (Access Channel)	432	9							803.5	11.1						
USFWS																
545.5A (Upper Brown's Lake)			740.4	9	716.3		651.9	659.3	659.5	6.8			80.90	2.20	0.55	6.6
545.4A (Upper Brown's Lake)			728.8	8.8	652.9	600	544.8	539.5	497.0	6.4			231.80	2.40	0.60	7.2
544.2A (Lower Brown's Lake)	822.7	11	695.5				692.2	661	595.0	7.1			227.70	3.90	0.78	9.4
														USFWS Average	0.58	6.9
							Average Dredge Cut Depth			7.21				Average	0.38	4.6
														Additional Lake Volume at Year 6, Acre-Feet3/	169	

[1/] Dredge Cut (or portions thereof) Area Only, SF (Deep Hole Dredging excluded)
[2/] 1989 Areas for Corps sediment transects are design only--no as-built information is available.
[3/] Additional Lake Volume=230-((L*W*S)*Y/43560) L=19,520'; W=60', S=0.38', Y=6

Table D-4. Dredge Cut Sediment Deposition Depth Table Calculated with 2014 and 1995 Data

Update with 2014 Data

			Year										
			1995		2014								
Sediment Range[4/]	offset zone	width	Area SF[5/]	Depth Ft	Area SF[5/]	Depth Ft	Dredge Cut Deposition, SF	Dredge Cut Deposition, Ft (Depth - Depth)	Dredge Cut Deposition, Ft/Year (Depth - Depth)	Dredge Cut Deposition, In/Year (Depth - Depth)	Lake Area	% Brown's Lake Area (in each lake section) [6/]	Total Scour(-)/ Deposition, In/Year (in lake section)[7]
28 - 30 RANGE B - SM-545.7H	3025 - 3759	734	7427	10.1	5279	7.2	2148	2.93	0.15	1.85	Upper Brown's	77.0	1.80
31- 33 RANGE C - SM-545.3A	972 - 1245	273	2686	9.8	1962.9	7.2	723	2.65	0.14	1.67			
34 -36 RANGE D - SM-544.3A	1330 - 1693	363	3356	9.2	2476.1	6.8	880	2.42	0.13	1.53	Lower Brown's	23.0	1.76
37 -39 RANGE E - SM-544.1E	367 - 786	419	4093	9.8	2798.2	6.7	1295	3.09	0.16	1.95			
								Area Weighted Average	0.15	1.79			
								Additional Lake Volume at Year 25, Acre-Feet3/	92				

[4/] Dredge Cut (or portions thereof) Area Only. Areas considered dredge cut are listed in the offset zone column. Offsets from 0 on each range.
[5/] Cross sectional area calculated below elevation 588' MSL 12
[6/] Approximate percent area of each lake section in the total Brown's Lake Area
[7/] Scour(-)/Deposition in each lake section (Upper and Lower)

Table D-5. Sediment Deposition Table Calculated with 2014 and 1995 Data

Original Table 1996 PER		
Sediment Transect	Total Deposition, In/Year	Dredge Cut Deposition, In/Year
Corps		
545.8H (Upper Brown's Lake)	0.5	
545.7H (Upper Brown's Lake)	0.4	1.2
545.3H (Upper Brown's Lake)	0.4	6.0
545.6H (Lower Brown's Lake)		1.8
544.3HL (Lower Brown's Lake)	0.3	3.0
544.3HR (Lower Brown's Lake)		2.0
544.1EL (Lower Brown's Lake)		3.8
544.1ER (Lower Brown's Lake)		4.6
545.9H (Access Channel)	N/A	N/A
546.3H (Inlet Channel)	N/A	N/A
Corps Average	0.4	3.2
USFWS		
545.5A (Upper Brown's Lake)	0.7	6.6
545.4A (Upper Brown's Lake)	0.7	7.2
544.2A (Lower Brown's Lake)	1.7	9.4
USFWS Average	1.0	7.7
IADNR		
545.8E (Upper Brown's Lake)	0.3	
545.6B (Upper Brown's Lake)	0.1	
544.9E (Lower Brown's Lake)	0.2	
IADNR Average	0.2	
Total Average	0.3	4.6

Table D-6. Sediment Deposition Table Calculated with 2014 and 1995 Data

Update with 2014 Data (1995 - 2014)		
Sediment Transect	Total Deposition, In/Year	Dredge Cut Deposition, In/Year
Corps		
545.8H (Upper Brown's Lake)	N/A	N/A
545.7H (Upper Brown's Lake)	0.5	1.8
545.3H (Upper Brown's Lake)	0.3	1.7
545.6H (Lower Brown's Lake)	N/A	N/A
544.3A (Lower Brown's Lake)	-0.1	1.5
544.3HR (Lower Brown's Lake)	N/A	N/A
544.1E (Lower Brown's Lake)	1.0	2.0
544.1ER (Lower Brown's Lake)	N/A	N/A
545.9H (Access Channel)	N/A	N/A
546.3H (Inlet Channel)	N/A	N/A

Table D-7. Average Annual Sediment Accretion Table from the 1995 PER

Original Table 1996 PER

Year	Additional Lake Volume, Acre-Feet[1/, 2/]	
	Design	Actual
0	230	230
1	230	220
2	229	210
3	229	199
4	229	189
5	229	179
6	228	169
7	228	158
8	228	148
9	228	138
10	227	128
11	227	118
12	227	107
13	227	97
14	226	87
15	226	77
16	226	67
17	225	56
18	225	46
19	225	36
20	225	26
21	224	15
22	224	5
50	217	

[1/] Assumes an annual sedimentation rate:
Design: S = 0.15 inches (0.01 foot)/year. Ref. DPR A-5.
Actual: S = 4.6 inches (0.38 foot)/year. See Table E-2.
[2/]Additional Lake Volume = 230-((L*W*S)*Y/43560)L = 19,520'; W =60'S =See [1/],Y = Year column

Table D-8. Average Annual Sediment Accretion Table Calculated with 2014 and 1995 Data

Update with 2014 Data (1995 - 2014)

Year	Additional Lake Volume, Acre-Feet[1/, 2/]		
	Design	Actual	
0	230	230	0.38 foot /year
1	230	220	0.38 foot /year
2	229	210	0.38 foot /year
3	229	199	0.38 foot /year
4	229	189	0.38 foot /year
5	229	179	0.38 foot /year
6	228	169	0.38 foot /year
7	228	165	0.15 foot/ year
8	228	161	0.15 foot/ year
9	228	157	0.15 foot/ year
10	227	153	0.15 foot/ year
11	227	149	0.15 foot/ year
12	227	144	0.15 foot/ year
13	227	140	0.15 foot/ year
14	226	136	0.15 foot/ year
15	226	132	0.15 foot/ year
16	226	128	0.15 foot/ year
17	225	124	0.15 foot/ year
18	225	120	0.15 foot/ year
19	225	116	0.15 foot/ year
20	225	112	0.15 foot/ year
21	224	108	0.15 foot/ year
22	224	104	0.15 foot/ year
23	224	100	0.15 foot/ year
24	224	96	0.15 foot/ year
25	223	92	0.15 foot/ year
50	217		

[1/] Assumes an annual sedimentation rate:
Design: S = 0.15 inches (0.01 foot)/year. Ref. DPR A-5.
Actual through 1995: S1 = 4.6 inches (0.38 foot)/year. See Table E-2.
Actual 1995 - 2014: S2 = 1.8 inches (0.15 foot)/year. See Table E-2.
[2/] Additional Lake Volume = 230-((L*W*S1)*6/43560)-((L*W*S2)*19/43560); L = 19,520'; W =60'S =See [1/],Y = Year column

Table D-9. Transect Data from EC-S
File Last Modified 18 SEP 1995

Brown's Lake Sed. Plot Data 9/18/95 rhd

Locate sections/ranges for 1995 data : FC-92-16/pp.70-71,75

drwg.: data from "Brown's Lake, Monitoring Ranges", Plates 18,19,20,21

Range	S-M	Station	1995	1987	1938/39	1929/30
A	545.8H	30+00.45	----	FC-87-3 pp.2-5	drwg.	drwg.
B	545.7H	42+00.19	FC-95-5 pp.11	FC-87-3 pp.8-9	drwg.	drwg.
C	545.3H	59+98.14	FC-92-16 pp.79	FC-87-3 pp.14-15	drwg.	drwg.
D	544.3H	82+95.00	FC-92-16 pp.78	drwg.	drwg.	drwg.
E	544.1E	93+30.00	FC-92-16 pp.77	drwg.	drwg.	drwg.
F	545.68	SMITH'S CRK THALWEG	----	drwg.	drwg.	drwg.
H	545.9H	86+95.40	FC-92-16 pp.76	FC-87-3/24 FC-87-5/13	drwg.	
I	546.3H	109+00.00	FC-92-16 pp.58,60	*FC-87-3 pp.26	drwg.	
N	544.6H	30+00.00	FC-95-5 pp.12-13	drwg.	drwg.	drwg.

* STA 107+98.45 used for 109+00

OOOOOO, LLLLLL, SSSSSSSS, RRRRRR, IIIIII
SECTION 1995 SOURCE

OFFSET,	ELEV,	STATION,	SOURCE	ROD,	HI
0.0000,	600.00,	5+45.68,	DUMMY	0.0000,	600.000
4925.0,	600.00,	5+45.68,	DUMMY	0.0000,	600.000
-975.0,	587.86,	30+00.00,		0.0000,	587.860
-926.0,	588.29,	30+00.00,		-.4300,	587.860
-892.0,	588.66,	30+00.00,		-.8000,	587.860

-885.0,	586.76,	30+00.00,	1.1000,	587.860
-813.0,	583.16,	30+00.00,	3.6000,	586.760
-741.0,	582.76,	30+00.00,	4.0000,	586.760
-723.0,	583.86,	30+00.00,	2.9000,	586.760
-693.0,	586.76,	30+00.00,	1.1000,	587.860
-685.0,	589.52,	30+00.00,	-1.660,	587.860
-619.0,	588.56,	30+00.00,	-.7000,	587.860
-544.0,	588.19,	30+00.00,	-.3300,	587.860
-482.0,	587.56,	30+00.00,	.29999,	587.860
-393.0,	587.06,	30+00.00,	.79999,	587.860
-310.0,	586.46,	30+00.00,	1.4000,	587.860
-272.0,	584.96,	30+00.00,	2.9000,	587.860
-235.0,	584.96,	30+00.00,	2.9000,	587.860
-165.0,	586.46,	30+00.00,	1.4000,	587.860
-123.0,	586.66,	30+00.00,	1.2000,	587.860
-58.00,	586.56,	30+00.00,	1.3000,	587.860
-14.00,	586.86,	30+00.00,	1.0000,	587.860
0.0000,	586.99,	30+00.00,	0.0000,	586.990
45.000,	586.45,	30+00.00,	.53998,	586.990
103.00,	581.85,	30+00.00,	4.6000,	586.450
181.00,	581.25,	30+00.00,	5.2000,	586.450
257.00,	572.65,	30+00.00,	13.800,	586.450
350.00,	582.45,	30+00.00,	4.0000,	586.450
400.00,	583.75,	30+00.00,	2.7000,	586.450
424.00,	584.85,	30+00.00,	1.6000,	586.450
464.00,	583.55,	30+00.00,	2.9000,	586.450
522.00,	583.05,	30+00.00,	3.4000,	586.450
606.00,	583.75,	30+00.00,	2.7000,	586.450
694.00,	584.75,	30+00.00,	1.7000,	586.450
754.00,	584.75,	30+00.00,	1.7000,	586.450
808.00,	585.15,	30+00.00,	1.3000,	586.450
865.00,	584.55,	30+00.00,	1.9000,	586.450
900.00,	584.15,	30+00.00,	2.3000,	586.450

0.0000,	600.12,	30+00.45,	.90002,	601.020
5381.0,	596.55,	30+00.45,	4.9000,	601.450

0.0000,	600.10,	42+00.19,	-1.270,	598.830
3.0000,	600.73,	42+00.19,	-1.900,	598.830
6.0000,	600.03,	42+00.19,	-1.200,	598.830
11.000,	598.63,	42+00.19,	.20001,	598.830
25.000,	599.83,	42+00.19,	-1.000,	598.830
44.000,	586.97,	42+00.19,	11.860,	598.830

88.000,	582.77,	42+00.19,	4.2000,	586.970
241.00,	582.37,	42+00.19,	4.6000,	586.970
424.00,	582.07,	42+00.19,	4.9000,	586.970
644.00,	581.67,	42+00.19,	5.3000,	586.970
969.00,	581.37,	42+00.19,	5.6000,	586.970
1533.0,	581.17,	42+00.19,	5.8000,	586.970
2105.0,	580.87,	42+00.19,	6.1000,	586.970
2466.0,	580.87,	42+00.19,	6.1000,	586.970
3025.0,	581.07,	42+00.19,	5.9000,	586.970
3316.0,	574.27,	42+00.19,	12.700,	586.970
3759.0,	581.77,	42+00.19,	5.2000,	586.970
4113.0,	583.07,	42+00.19,	3.9000,	586.970
4700.0,	583.07,	42+00.19,	3.9000,	586.970

0.0000,	600.10,	59+94.44,	-13.22,	586.880
3.0000,	600.78,	59+94.44,	-13.90,	586.880
4.0000,	600.18,	59+94.44,	-13.30,	586.880
8.0000,	598.98,	59+94.44,	-12.10,	586.880
23.000,	599.28,	59+94.44,	-12.40,	586.880
35.000,	592.88,	59+94.44,	-6.000,	586.880
44.000,	590.78,	59+94.44,	-3.900,	586.880
54.000,	592.18,	59+94.44,	-5.300,	586.880
63.000,	591.88,	59+94.44,	-5.000,	586.880
87.000,	590.38,	59+94.44,	-3.500,	586.880
136.00,	589.08,	59+94.44,	-2.200,	586.880
176.00,	587.58,	59+94.44,	-.7000,	586.880
211.00,	586.88,	59+94.44,	0.0000,	586.880
269.00,	586.88,	59+94.44,	0.0000,	586.880
313.00,	586.48,	59+94.44,	.40002,	586.880
356.00,	585.68,	59+94.44,	1.2000,	586.880
414.00,	585.18,	59+94.44,	1.7000,	586.880
575.00,	583.08,	59+94.44,	3.8000,	586.880
745.00,	582.28,	59+94.44,	4.6000,	586.880
972.00,	580.98,	59+94.44,	5.9000,	586.880
1134.0,	575.18,	59+94.44,	11.700,	586.880
1245.0,	581.38,	59+94.44,	5.5000,	586.880
1394.0,	581.38,	59+94.44,	5.5000,	586.880
1574.0,	581.08,	59+94.44,	5.8000,	586.880
1825.0,	581.08,	59+94.44,	5.8000,	586.880
2095.0,	581.28,	59+94.44,	5.6000,	586.880
2331.0,	581.08,	59+94.44,	5.8000,	586.880
2636.0,	581.68,	59+94.44,	5.2000,	586.880
2860.0,	582.08,	59+94.44,	4.8000,	586.880

3040.0,	582.88,	59+94.44,	4.0000,	586.880
3105.0,	583.78,	59+94.44,	3.1000,	586.880
4400.0,	583.78,	59+94.44,	3.1000,	586.880
0.0000,	600.30,	82+95.00,	-1.260,	599.040
4.0000,	601.04,	82+95.00,	-2.000,	599.040
8.0000,	600.34,	82+95.00,	-1.300,	599.040
17.000,	598.74,	82+95.00,	.29999,	599.040
33.000,	599.04,	82+95.00,	0.0000,	599.040
37.000,	599.74,	82+95.00,	-.7000,	599.040
44.000,	598.24,	82+95.00,	.79999,	599.040
75.000,	585.14,	82+95.00,	13.900,	599.040
151.00,	580.24,	82+95.00,	4.9000,	585.140
250.00,	574.84,	82+95.00,	10.300,	585.140
456.00,	580.24,	82+95.00,	4.9000,	585.140
722.00,	581.64,	82+95.00,	3.5000,	585.140
914.00,	581.74,	82+95.00,	3.4000,	585.140
1119.0,	581.74,	82+95.00,	3.4000,	585.140
1330.0,	581.74,	82+95.00,	3.4000,	585.140
1536.0,	575.64,	82+95.00,	9.5000,	585.140
1693.0,	582.04,	82+95.00,	3.1000,	585.140
1815.0,	582.44,	82+95.00,	2.7000,	585.140
1896.0,	582.54,	82+95.00,	2.6000,	585.140
1956.0,	582.94,	82+95.00,	2.2000,	585.140
2000.0,	582.94,	82+95.00,	2.2000,	585.140
-121.0,	587.20,	86+95.40,	18.100,	605.300
-99.00,	585.90,	86+95.40,	19.400,	605.300
-90.00,	585.10,	86+95.40,	20.200,	605.300
-81.00,	585.90,	86+95.40,	19.400,	605.300
-59.00,	589.50,	86+95.40,	15.800,	605.300
-41.00,	591.40,	86+95.40,	13.900,	605.300
-31.00,	592.80,	86+95.40,	12.500,	605.300
-17.00,	597.30,	86+95.40,	8.0000,	605.300
-8.000,	599.90,	86+95.40,	5.4000,	605.300
0.0000,	600.00,	86+95.40,	5.3000,	605.300
8.0000,	599.70,	86+95.40,	5.6000,	605.300
20.000,	598.70,	86+95.40,	6.6000,	605.300
36.000,	594.30,	86+95.40,	11.000,	605.300
54.000,	588.60,	86+95.40,	16.700,	605.300
70.000,	579.30,	86+95.40,	26.000,	605.300
86.000,	574.70,	86+95.40,	30.600,	605.300
110.00,	571.90,	86+95.40,	33.400,	605.300

135.00,	571.90,	86+95.40,	33.400,	605.300
160.00,	579.30,	86+95.40,	26.000,	605.300
165.00,	589.20,	86+95.40,	16.100,	605.300
193.00,	589.40,	86+95.40,	15.900,	605.300
221.00,	590.10,	86+95.40,	15.200,	605.300

0.0000,	600.13,	93+30.00,	-14.50,	585.630
3.0000,	600.81,	93+30.00,	-15.18,	585.630
6.0000,	600.33,	93+30.00,	-14.70,	585.630
13.000,	598.53,	93+30.00,	-12.90,	585.630
29.000,	598.83,	93+30.00,	-13.20,	585.630
48.000,	589.83,	93+30.00,	-4.200,	585.630
79.000,	589.93,	93+30.00,	-4.300,	585.630
133.00,	587.63,	93+30.00,	-2.000,	585.630
156.00,	586.13,	93+30.00,	-.5000,	585.630
177.00,	585.03,	93+30.00,	.59998,	585.630
236.00,	583.23,	93+30.00,	1.8000,	585.030
367.00,	581.83,	93+30.00,	3.2000,	585.030
537.00,	574.93,	93+30.00,	10.100,	585.030
786.00,	581.33,	93+30.00,	3.7000,	585.030
1001.0,	581.63,	93+30.00,	3.4000,	585.030
1115.0,	582.48,	93+30.00,	2.5500,	585.030
1173.0,	583.53,	93+30.00,	1.5000,	585.030
1215.0,	585.05,	93+30.00,	.58002,	585.630
1247.0,	585.29,	93+30.00,	.34003,	585.630
1302.0,	586.29,	93+30.00,	-.6600,	585.630
2188.0,	586.29,	93+30.00,	-.6600,	585.630

-76.00,	587.20,	109+00.00,	14.600,	601.800
-56.00,	588.20,	109+00.00,	13.600,	601.800
-47.00,	590.60,	109+00.00,	11.200,	601.800
-18.00,	596.40,	109+00.00,	5.4000,	601.800
-7.000,	598.40,	109+00.00,	3.4000,	601.800
0.0000,	598.70,	109+00.00,	3.1000,	601.800
7.0000,	598.60,	109+00.00,	3.2000,	601.800
12.000,	597.20,	109+00.00,	4.6000,	601.800
31.000,	595.40,	109+00.00,	6.4000,	601.800
57.000,	588.00,	109+00.00,	13.800,	601.800
70.000,	584.00,	109+00.00,	17.800,	601.800
100.00,	579.90,	109+00.00,	21.900,	601.800
150.00,	581.40,	109+00.00,	20.400,	601.800
165.00,	588.00,	109+00.00,	13.800,	601.800
167.00,	589.00,	109+00.00,	12.800,	601.800

185.00, 591.20, 109+00.00, 10.600, 601.800
225.00, 593.60, 109+00.00, 8.2000, 601.800
245.00, 591.60, 109+00.00, 10.200, 601.800
350.00, 591.60, 109+00.00, 10.200, 601.800

SECTION 1930 SOURCE
OFFSET, ELEV, STATION, ROD, HI
89.999, 600.06, 30+00.45, -600.1, 0.00000
90.000, 593.00, 30+00.45, -593.0, 0.00000
400.00, 585.00, 30+00.45, -585.0, 0.00000
2920.0, 580.00, 30+00.45, -580.0, 0.00000
4500.0, 580.00, 30+00.45, -580.0, 0.00000
5090.0, 584.00, 30+00.45, -584.0, 0.00000
5320.0, 586.50, 30+00.45, -586.5, 0.00000
5325.0, 586.70, 30+00.45, -586.7, 0.00000
5325.0, 596.59, 30+00.45, -596.6, 0.00000

0.0000, 600.10, 42+00.19, -600.1, 0.00000
0.0010, 585.00, 42+00.19, -585.0, 0.00000
50.000, 583.20, 42+00.19, -583.2, 0.00000
500.00, 580.00, 42+00.19, -580.0, 0.00000
3800.0, 580.00, 42+00.19, -580.0, 0.00000
4000.0, 581.10, 42+00.19, -581.1, 0.00000
4100.0, 581.77, 42+00.19, -581.8, 0.00000
4100.0, 583.02, 42+00.19, -583.0, 0.00000
4700.0, 585.00, 42+00.19, -585.0, 0.00000
4700.0, 583.07, 42+00.19, -583.1, 0.00000

180.00, 587.50, 59+94.44, -587.5, 0.00000
180.00, 585.00, 59+94.44, -585.0, 0.00000
600.00, 580.00, 59+94.44, -580.0, 0.00000
3200.0, 580.00, 59+94.44, -580.0, 0.00000
4400.0, 585.00, 59+94.44, -585.0, 0.00000
4400.0, 583.78, 59+94.44, -583.8, 0.00000
SECTION 1938 SOURCE
OFFSET, ELEV, STATION, ROD, HI
-900.0, 581.80, 30+00.00, -581.8, 0.00000
-833.0, 580.60, 30+00.00, -580.6, 0.00000
-764.0, 582.00, 30+00.00, -582.0, 0.00000
-752.0, 583.80, 30+00.00, -583.8, 0.00000
-743.0, 587.90, 30+00.00, -587.9, 0.00000
-727.0, 588.20, 30+00.00, -588.2, 0.00000
-708.0, 587.90, 30+00.00, -587.9, 0.00000

-539.0,	586.90,	30+00.00,	-586.9,	0.00000
-500.0,	586.90,	30+00.00,	-586.9,	0.00000
-350.0,	586.00,	30+00.00,	-586.0,	0.00000
-308.0,	583.90,	30+00.00,	-583.9,	0.00000
-217.0,	585.00,	30+00.00,	-585.0,	0.00000
-30.00,	586.30,	30+00.00,	-586.3,	0.00000
25.000,	585.90,	30+00.00,	-585.9,	0.00000
59.000,	581.80,	30+00.00,	-581.8,	0.00000
282.00,	581.75,	30+00.00,	-581.8,	0.00000

30.001,	600.10,	30+00.45,	-600.1,	0.00000
30.002,	594.00,	30+00.45,	-594.0,	0.00000
60.000,	594.50,	30+00.45,	-594.5,	0.00000
110.00,	593.30,	30+00.45,	-593.3,	0.00000
230.00,	591.80,	30+00.45,	-591.8,	0.00000
380.00,	589.50,	30+00.45,	-589.5,	0.00000
450.00,	588.00,	30+00.45,	-588.0,	0.00000
790.00,	584.00,	30+00.45,	-584.0,	0.00000
1270.0,	582.80,	30+00.45,	-582.8,	0.00000
1550.0,	583.50,	30+00.45,	-583.5,	0.00000
1700.0,	582.80,	30+00.45,	-582.8,	0.00000
1850.0,	583.50,	30+00.45,	-583.5,	0.00000
2035.0,	582.10,	30+00.45,	-582.1,	0.00000
2910.0,	581.60,	30+00.45,	-581.6,	0.00000
3740.0,	582.00,	30+00.45,	-582.0,	0.00000
3880.0,	582.30,	30+00.45,	-582.3,	0.00000
4100.0,	581.90,	30+00.45,	-581.9,	0.00000
4240.0,	582.20,	30+00.45,	-582.2,	0.00000
4400.0,	583.00,	30+00.45,	-583.0,	0.00000
4655.0,	583.50,	30+00.45,	-583.5,	0.00000
4860.0,	583.00,	30+00.45,	-583.0,	0.00000
4970.0,	581.90,	30+00.45,	-581.9,	0.00000
5015.0,	583.00,	30+00.45,	-583.0,	0.00000
5085.0,	583.50,	30+00.45,	-583.5,	0.00000
5180.0,	582.80,	30+00.45,	-582.8,	0.00000
5375.0,	584.20,	30+00.45,	-584.2,	0.00000
5375.0,	596.55,	30+00.45,	-596.6,	0.00000

40.001,	583.56,	42+00.19,	-583.6,	0.00000
40.002,	585.10,	42+00.19,	-585.1,	0.00000
50.000,	583.60,	42+00.19,	-583.6,	0.00000
90.000,	581.70,	42+00.19,	-581.7,	0.00000
500.00,	582.00,	42+00.19,	-582.0,	0.00000

1500.0,	582.40,	42+00.19,	-582.4,	0.00000
1700.0,	582.30,	42+00.19,	-582.3,	0.00000
3400.0,	581.30,	42+00.19,	-581.3,	0.00000
4100.0,	583.60,	42+00.19,	-583.6,	0.00000
4100.0,	583.02,	42+00.19,	-583.0,	0.00000
4400.0,	583.50,	42+00.19,	-583.5,	0.00000
4400.0,	584.01,	42+00.19,	-584.0,	0.00000
20.001,	599.22,	59+94.44,	-599.2,	0.00000
20.002,	598.00,	59+94.44,	-598.0,	0.00000
60.000,	593.00,	59+94.44,	-593.0,	0.00000
140.00,	589.50,	59+94.44,	-589.5,	0.00000
200.00,	588.00,	59+94.44,	-588.0,	0.00000
300.00,	587.20,	59+94.44,	-587.2,	0.00000
520.00,	585.90,	59+94.44,	-585.9,	0.00000
640.00,	582.80,	59+94.44,	-582.8,	0.00000
730.00,	581.30,	59+94.44,	-581.3,	0.00000
920.00,	581.20,	59+94.44,	-581.2,	0.00000
1120.0,	581.30,	59+94.44,	-581.3,	0.00000
1180.0,	582.10,	59+94.44,	-582.1,	0.00000
1485.0,	583.40,	59+94.44,	-583.4,	0.00000
1540.0,	583.00,	59+94.44,	-583.0,	0.00000
1640.0,	582.00,	59+94.44,	-582.0,	0.00000
1670.0,	581.40,	59+94.44,	-581.4,	0.00000
1890.0,	581.00,	59+94.44,	-581.0,	0.00000
2150.0,	581.50,	59+94.44,	-581.5,	0.00000
2155.0,	582.00,	59+94.44,	-582.0,	0.00000
3200.0,	584.00,	59+94.44,	-584.0,	0.00000
3700.0,	584.60,	59+94.44,	-584.6,	0.00000
3700.0,	582.08,	59+94.44,	-582.1,	0.00000
20.000,	595.40,	82+95.00,	-595.4,	0.00000
40.000,	590.00,	82+95.00,	-590.0,	0.00000
90.000,	579.00,	82+95.00,	-579.0,	0.00000
320.00,	578.70,	82+95.00,	-578.7,	0.00000
540.00,	579.10,	82+95.00,	-579.1,	0.00000
560.00,	580.00,	82+95.00,	-580.0,	0.00000
580.00,	582.00,	82+95.00,	-582.0,	0.00000
600.00,	582.10,	82+95.00,	-582.1,	0.00000
740.00,	580.90,	82+95.00,	-580.9,	0.00000
775.00,	580.00,	82+95.00,	-580.0,	0.00000
830.00,	580.90,	82+95.00,	-580.9,	0.00000
1630.0,	583.20,	82+95.00,	-583.2,	0.00000

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1800.0,   582.40,   82+95.00,          -582.4,   0.00000
1920.0,   582.90,   82+95.00,          -582.9,   0.00000
2000.0,   583.60,   82+95.00,          -583.6,   0.00000
7.0000,   590.00,   86+95.40,          -590.0,   0.00000
14.000,   589.30,   86+95.40,          -589.3,   0.00000
36.500,   585.00,   86+95.40,          -585.0,   0.00000
42.000,   580.90,   86+95.40,          -580.9,   0.00000
54.000,   579.40,   86+95.40,          -579.4,   0.00000
70.000,   581.00,   86+95.40,          -581.0,   0.00000
81.000,   585.00,   86+95.40,          -585.0,   0.00000
90.000,   585.60,   86+95.40,          -585.6,   0.00000
98.000,   585.00,   86+95.40,          -585.0,   0.00000
111.00,   587.20,   86+95.40,          -587.2,   0.00000
192.00,   587.50,   86+95.40,          -587.5,   0.00000
200.00,   587.45,   86+95.40,          -587.5,   0.00000

10.000,   596.20,   93+30.00,          -596.2,   0.00000
55.000,   586.00,   93+30.00,          -586.0,   0.00000
95.000,   587.40,   93+30.00,          -587.4,   0.00000
138.00,   585.20,   93+30.00,          -585.2,   0.00000
170.00,   580.00,   93+30.00,          -580.0,   0.00000
465.00,   579.00,   93+30.00,          -579.0,   0.00000
523.00,   578.60,   93+30.00,          -578.6,   0.00000
555.00,   579.00,   93+30.00,          -579.0,   0.00000
570.00,   580.00,   93+30.00,          -580.0,   0.00000
865.00,   580.90,   93+30.00,          -580.9,   0.00000
920.00,   582.80,   93+30.00,          -582.8,   0.00000
999.00,   582.80,   93+30.00,          -582.8,   0.00000
1160.0,   585.00,   93+30.00,          -585.0,   0.00000
1176.0,   585.00,   93+30.00,          -585.0,   0.00000
1225.0,   580.00,   93+30.00,          -580.0,   0.00000
1280.0,   579.10,   93+30.00,          -579.1,   0.00000
1386.0,   580.00,   93+30.00,          -580.0,   0.00000
1410.0,   585.00,   93+30.00,          -585.0,   0.00000
1440.0,   585.50,   93+30.00,          -585.5,   0.00000
1470.0,   585.00,   93+30.00,          -585.0,   0.00000
1485.0,   584.30,   93+30.00,          -584.3,   0.00000
1500.0,   585.00,   93+30.00,          -585.0,   0.00000
1536.0,   585.50,   93+30.00,          -585.5,   0.00000
1580.0,   585.00,   93+30.00,          -585.0,   0.00000
1615.0,   581.80,   93+30.00,          -581.8,   0.00000
1665.0,   579.50,   93+30.00,          -579.5,   0.00000
1690.0,   580.70,   93+30.00,          -580.7,   0.00000
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1720.0,	585.20,	93+30.00,	-585.2,	0.00000
1750.0,	581.00,	93+30.00,	-581.0,	0.00000
1765.0,	579.80,	93+30.00,	-579.8,	0.00000
1778.0,	580.90,	93+30.00,	-580.9,	0.00000
1790.0,	585.00,	93+30.00,	-585.0,	0.00000
1835.0,	586.00,	93+30.00,	-586.0,	0.00000
1895.0,	586.00,	93+30.00,	-586.0,	0.00000
1950.0,	585.90,	93+30.00,	-585.9,	0.00000
2100.0,	583.80,	93+30.00,	-583.8,	0.00000
2150.0,	582.90,	93+30.00,	-582.9,	0.00000
2188.0,	580.00,	93+30.00,	-580.0,	0.00000

25.000,	592.30,	109+00.00,	-592.3,	0.00000
35.000,	591.10,	109+00.00,	-591.1,	0.00000
40.000,	590.10,	109+00.00,	-590.1,	0.00000
43.000,	588.90,	109+00.00,	-588.9,	0.00000
90.000,	586.10,	109+00.00,	-586.1,	0.00000
94.500,	585.20,	109+00.00,	-585.2,	0.00000
98.500,	580.00,	109+00.00,	-580.0,	0.00000
103.00,	579.00,	109+00.00,	-579.0,	0.00000
113.00,	579.80,	109+00.00,	-579.8,	0.00000
115.00,	581.20,	109+00.00,	-581.2,	0.00000
130.00,	586.00,	109+00.00,	-586.0,	0.00000
141.00,	588.00,	109+00.00,	-588.0,	0.00000
150.00,	589.00,	109+00.00,	-589.0,	0.00000
167.00,	589.25,	109+00.00,	-589.3,	0.00000
215.00,	588.00,	109+00.00,	-588.0,	0.00000
229.00,	586.00,	109+00.00,	-586.0,	0.00000
244.00,	585.00,	109+00.00,	-585.0,	0.00000
277.00,	584.00,	109+00.00,	-584.0,	0.00000
281.00,	582.80,	109+00.00,	-582.8,	0.00000
295.00,	581.00,	109+00.00,	-581.0,	0.00000
310.00,	578.70,	109+00.00,	-578.7,	0.00000
318.50,	579.90,	109+00.00,	-579.9,	0.00000
337.00,	584.70,	109+00.00,	-584.7,	0.00000
343.50,	585.80,	109+00.00,	-585.8,	0.00000
350.00,	586.50,	109+00.00,	-586.5,	0.00000

SECTION 1987 SOURCE

OFFSET,	ELEV,	STATION,	ROD,	HI
0.0000,	599.00,	5+45.68,	-599.0,	0.00000
1080.0,	598.00,	5+45.68,	-598.0,	0.00000
1235.0,	596.10,	5+45.68,	-596.1,	0.00000
1580.0,	595.00,	5+45.68,	-595.0,	0.00000

1745.0,	594.00,	5+45.68,	-594.0,	0.00000
1840.0,	593.90,	5+45.68,	-593.9,	0.00000
1960.0,	593.00,	5+45.68,	-593.0,	0.00000
2175.0,	592.10,	5+45.68,	-592.1,	0.00000
2850.0,	590.00,	5+45.68,	-590.0,	0.00000
3000.0,	389.20,	5+45.68,	-389.2,	0.00000
3245.0,	588.10,	5+45.68,	-588.1,	0.00000
3480.0,	588.00,	5+45.68,	-588.0,	0.00000
3690.0,	587.10,	5+45.68,	-587.1,	0.00000
3870.0,	586.70,	5+45.68,	-586.7,	0.00000
4270.0,	585.60,	5+45.68,	-585.6,	0.00000
4730.0,	584.00,	5+45.68,	-584.0,	0.00000
4925.0,	583.70,	5+45.68,	-583.7,	0.00000

-686.0,	583.50,	30+00.00,	-583.5,	0.00000
-669.0,	585.40,	30+00.00,	-585.4,	0.00000
-658.0,	589.50,	30+00.00,	-589.5,	0.00000
-600.0,	589.10,	30+00.00,	-589.1,	0.00000
-500.0,	588.80,	30+00.00,	-588.8,	0.00000
-400.0,	587.90,	30+00.00,	-587.9,	0.00000
-300.0,	587.10,	30+00.00,	-587.1,	0.00000
-200.0,	586.00,	30+00.00,	-586.0,	0.00000
-100.0,	586.00,	30+00.00,	-586.0,	0.00000
-43.00,	585.90,	30+00.00,	-585.9,	0.00000
-30.00,	583.60,	30+00.00,	-583.6,	0.00000

0.0000,	600.12,	30+00.45,	.90002,	601.020
5.0000,	600.02,	30+00.45,	1.0000,	601.020
10.000,	598.52,	30+00.45,	2.5000,	601.020
23.000,	598.12,	30+00.45,	2.9000,	601.020
32.000,	593.22,	30+00.45,	7.8000,	601.020
35.000,	591.92,	30+00.45,	9.1000,	601.020
42.000,	593.22,	30+00.45,	7.8000,	601.020
48.000,	597.32,	30+00.45,	3.7000,	601.020
65.000,	596.42,	30+00.45,	4.6000,	601.020
76.000,	593.82,	30+00.45,	7.2000,	601.020
100.00,	593.22,	30+00.45,	7.8000,	601.020
200.00,	591.72,	30+00.45,	9.3000,	601.020
300.00,	590.52,	30+00.45,	10.500,	601.020
400.00,	588.83,	30+00.45,	4.1000,	592.930
500.00,	587.53,	30+00.45,	5.4000,	592.930
600.00,	586.23,	30+00.45,	6.7000,	592.930
700.00,	585.43,	30+00.45,	7.5000,	592.930

800.00,	585.06,	30+00.45,	5.1000,	590.160
900.00,	585.16,	30+00.45,	5.0000,	590.160
1000.0,	584.86,	30+00.45,	5.3000,	590.160
1100.0,	584.76,	30+00.45,	5.4000,	590.160
1200.0,	584.56,	30+00.45,	5.6000,	590.160
1300.0,	584.36,	30+00.45,	5.8000,	590.160
1336.0,	583.76,	30+00.45,	6.4000,	590.160
1400.0,	584.76,	30+00.45,	5.4000,	590.160
1500.0,	584.36,	30+00.45,	5.8000,	590.160
1600.0,	584.56,	30+00.45,	5.6000,	590.160
1700.0,	584.06,	30+00.45,	6.1000,	590.160
1800.0,	582.86,	30+00.45,	7.3000,	590.160
2000.0,	582.66,	30+00.45,	7.5000,	590.160
2300.0,	582.36,	30+00.45,	7.5000,	589.860
2400.0,	582.26,	30+00.45,	7.6000,	589.860
2500.0,	582.26,	30+00.45,	7.6000,	589.860
2600.0,	582.06,	30+00.45,	7.8000,	589.860
2900.0,	582.06,	30+00.45,	7.8000,	589.860
3000.0,	581.86,	30+00.45,	8.0000,	589.860
3100.0,	582.06,	30+00.45,	7.8000,	589.860
3200.0,	582.06,	30+00.45,	7.8000,	589.860
3400.0,	582.36,	30+00.45,	7.5000,	589.860
3500.0,	582.43,	30+00.45,	7.4000,	589.830
3600.0,	582.43,	30+00.45,	7.4000,	589.830
3700.0,	582.53,	30+00.45,	7.3000,	589.830
3800.0,	582.83,	30+00.45,	7.0000,	589.830
3900.0,	582.83,	30+00.45,	7.0000,	589.830
4000.0,	583.03,	30+00.45,	6.8000,	589.830
4200.0,	583.33,	30+00.45,	6.5000,	589.830
4300.0,	584.23,	30+00.45,	5.6000,	589.830
4400.0,	584.33,	30+00.45,	5.5000,	589.830
4500.0,	584.83,	30+00.45,	5.0000,	589.830
4590.0,	585.43,	30+00.45,	4.4000,	589.830
4600.0,	585.63,	30+00.45,	4.2000,	589.830
4700.0,	586.61,	30+00.45,	5.8000,	592.410
4800.0,	587.31,	30+00.45,	5.1000,	592.410
4900.0,	587.71,	30+00.45,	4.7000,	592.410
5000.0,	587.71,	30+00.45,	4.7000,	592.410
5055.0,	588.05,	30+00.45,	13.400,	601.450
5065.0,	585.85,	30+00.45,	15.600,	601.450
5071.0,	584.55,	30+00.45,	16.900,	601.450
5088.0,	586.25,	30+00.45,	15.200,	601.450
5100.0,	586.25,	30+00.45,	15.200,	601.450

5114.0,	585.95,	30+00.45,	15.500,	601.450
5119.0,	585.75,	30+00.45,	15.700,	601.450
5170.0,	585.75,	30+00.45,	15.700,	601.450
5180.0,	586.05,	30+00.45,	15.400,	601.450
5200.0,	586.25,	30+00.45,	15.200,	601.450
5231.0,	588.15,	30+00.45,	13.300,	601.450
5300.0,	589.15,	30+00.45,	12.300,	601.450
5310.0,	588.95,	30+00.45,	12.500,	601.450
5363.0,	596.15,	30+00.45,	5.3000,	601.450
5381.0,	596.55,	30+00.45,	4.9000,	601.450

0.0000,	600.10,	42+00.19,	1.1500,	601.250
0.0010,	600.15,	42+00.19,	1.1000,	601.250
5.0000,	600.05,	42+00.19,	1.2000,	601.250
10.000,	598.85,	42+00.19,	2.4000,	601.250
21.000,	598.85,	42+00.19,	2.4000,	601.250
25.000,	600.15,	42+00.19,	1.1000,	601.250
53.000,	584.95,	42+00.19,	16.300,	601.250
53.100,	583.65,	42+00.19,	17.600,	601.250
100.00,	583.05,	42+00.19,	18.200,	601.250
200.00,	582.95,	42+00.19,	18.300,	601.250
300.00,	582.75,	42+00.19,	6.2700,	589.020
400.00,	582.22,	42+00.19,	6.8000,	589.020
500.00,	582.22,	42+00.19,	6.8000,	589.020
600.00,	582.52,	42+00.19,	6.5000,	589.020
700.00,	582.72,	42+00.19,	6.3000,	589.020
900.00,	582.12,	42+00.19,	6.9000,	589.020
1100.0,	581.92,	42+00.19,	7.1000,	589.020
1300.0,	582.02,	42+00.19,	7.0000,	589.020
1500.0,	582.02,	42+00.19,	7.0000,	589.020
1700.0,	581.82,	42+00.19,	7.2000,	589.020
1900.0,	581.82,	42+00.19,	7.2000,	589.020
2100.0,	581.82,	42+00.19,	7.2000,	589.020
2300.0,	581.72,	42+00.19,	7.3000,	589.020
2500.0,	581.72,	42+00.19,	7.3000,	589.020
2700.0,	581.82,	42+00.19,	7.2000,	589.020
2900.0,	581.92,	42+00.19,	7.1000,	589.020
3100.0,	581.92,	42+00.19,	7.1000,	589.020
3300.0,	582.12,	42+00.19,	6.9000,	589.020
3500.0,	582.22,	42+00.19,	6.8000,	589.020
3700.0,	582.52,	42+00.19,	6.5000,	589.020
3800.0,	582.72,	42+00.19,	6.3000,	589.020
3900.0,	583.02,	42+00.19,	6.0000,	589.020

4000.0,	583.22,	42+00.19,	5.8000,	589.020
4100.0,	583.62,	42+00.19,	-583.6,	0.00000
4130.0,	584.90,	42+00.19,	-584.9,	0.00000
4200.0,	585.20,	42+00.19,	-585.2,	0.00000
4200.0,	583.18,	42+00.19,	-583.2,	0.00000
0.0000,	600.10,	59+94.44,	3.5500,	603.650
0.0010,	600.17,	59+94.44,	3.4800,	603.650
5.0000,	600.15,	59+94.44,	3.5000,	603.650
10.000,	599.15,	59+94.44,	4.5000,	603.650
21.000,	599.05,	59+94.44,	4.6000,	603.650
23.000,	600.45,	59+94.44,	3.2000,	603.650
46.000,	591.25,	59+94.44,	12.400,	603.650
54.000,	592.45,	59+94.44,	11.200,	603.650
100.00,	590.45,	59+94.44,	13.200,	603.650
200.00,	587.55,	59+94.44,	2.4000,	589.950
300.00,	586.85,	59+94.44,	3.1000,	589.950
400.00,	585.45,	59+94.44,	4.5000,	589.950
500.00,	584.15,	59+94.44,	.75000,	584.900
600.00,	582.90,	59+94.44,	2.0000,	584.900
700.00,	582.80,	59+94.44,	2.1000,	584.900
800.00,	582.50,	59+94.44,	2.4000,	584.900
900.00,	582.20,	59+94.44,	2.7000,	584.900
1000.0,	582.00,	59+94.44,	2.9000,	584.900
1100.0,	582.00,	59+94.44,	2.9000,	584.900
1600.0,	582.00,	59+94.44,	2.9000,	584.900
1800.0,	582.00,	59+94.44,	2.9000,	584.900
2000.0,	581.90,	59+94.44,	3.0000,	584.900
2200.0,	582.00,	59+94.44,	2.9000,	584.900
2400.0,	582.00,	59+94.44,	2.9000,	584.900
2600.0,	582.10,	59+94.44,	2.8000,	584.900
2800.0,	582.10,	59+94.44,	2.8000,	584.900
2900.0,	582.10,	59+94.44,	2.8000,	584.900
3000.0,	582.20,	59+94.44,	2.7000,	584.900
3100.0,	582.80,	59+94.44,	2.1000,	584.900
3200.0,	583.40,	59+94.44,	6.5500,	589.950
3298.0,	584.85,	59+94.44,	-584.9,	0.00000
3298.0,	584.12,	59+94.44,	-584.1,	0.00000
0.0000,	600.30,	82+95.00,	-600.3,	0.00000
10.000,	600.30,	82+95.00,	-600.3,	0.00000
11.000,	599.50,	82+95.00,	-599.5,	0.00000
20.000,	598.70,	82+95.00,	-598.7,	0.00000

35.000,	600.00,	82+95.00,	-600.0,	0.00000
90.000,	583.20,	82+95.00,	-583.2,	0.00000
175.00,	583.00,	82+95.00,	-583.0,	0.00000
300.00,	582.00,	82+95.00,	-582.0,	0.00000
880.00,	581.00,	82+95.00,	-581.0,	0.00000
1980.0,	583.30,	82+95.00,	-583.3,	0.00000
0.0000,	599.39,	86+95.40,	4.8000,	604.190
3.0000,	599.19,	86+95.40,	5.0000,	604.190
28.000,	589.79,	86+95.40,	14.400,	604.190
49.000,	590.19,	86+95.40,	14.000,	604.190
57.000,	585.39,	86+95.40,	18.800,	604.190
61.000,	584.79,	86+95.40,	19.400,	604.190
61.100,	583.79,	86+95.40,	20.400,	604.190
100.00,	579.60,	86+95.40,	5.2000,	584.800
132.00,	582.40,	86+95.40,	2.4000,	584.800
141.00,	585.59,	86+95.40,	18.600,	604.190
146.00,	589.39,	86+95.40,	14.800,	604.190
200.00,	589.29,	86+95.40,	14.900,	604.190
0.0000,	600.50,	93+30.00,	-600.5,	0.00000
10.000,	600.50,	93+30.00,	-600.5,	0.00000
18.000,	598.10,	93+30.00,	-598.1,	0.00000
30.000,	600.00,	93+30.00,	-600.0,	0.00000
97.000,	586.00,	93+30.00,	-586.0,	0.00000
160.00,	583.40,	93+30.00,	-583.4,	0.00000
190.00,	583.00,	93+30.00,	-583.0,	0.00000
330.00,	581.90,	93+30.00,	-581.9,	0.00000
628.00,	581.70,	93+30.00,	-581.7,	0.00000
850.00,	583.00,	93+30.00,	-583.0,	0.00000
960.00,	583.40,	93+30.00,	-583.4,	0.00000
1000.0,	586.50,	93+30.00,	-586.5,	0.00000
1078.0,	586.80,	93+30.00,	-586.8,	0.00000
1155.0,	586.50,	93+30.00,	-586.5,	0.00000
1178.5,	584.40,	93+30.00,	-584.4,	0.00000
1280.0,	582.80,	93+30.00,	-582.8,	0.00000
1370.0,	584.40,	93+30.00,	-584.4,	0.00000
1430.0,	586.50,	93+30.00,	-586.5,	0.00000
1880.0,	587.10,	93+30.00,	-587.1,	0.00000
2165.0,	587.20,	93+30.00,	-587.2,	0.00000
0.0000,	597.80,	109+00.00,	5.0000,	602.800
3.0000,	597.60,	109+00.00,	5.2000,	602.800

33.000,	588.80,	109+00.00,	14.000,	602.800
56.000,	590.30,	109+00.00,	12.500,	602.800
63.000,	586.60,	109+00.00,	16.200,	602.800
75.000,	584.80,	109+00.00,	18.000,	602.800
75.100,	583.00,	109+00.00,	1.8000,	584.800
100.00,	580.90,	109+00.00,	3.9000,	584.800
134.00,	583.60,	109+00.00,	1.2000,	584.800
142.00,	584.90,	109+00.00,	17.900,	602.800
147.00,	588.20,	109+00.00,	14.600,	602.800
200.00,	587.20,	109+00.00,	15.600,	602.800
250.00,	587.50,	109+00.00,	15.300,	602.800
300.00,	587.40,	109+00.00,	15.400,	602.800