UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL MANAGEMENT PROGRAM
POST-CONSTRUCTION
INITIAL PERFORMANCE EVALUATION REPORT

SPRING LAKE HABITAT REHABILITATION AND ENHANCEMENT PROJECT

JANUARY 2004

US Army Corps
of Engineers
Rock Island District

**POOL 13
MISSISSIPPI RIVER MILES 532 - 536
CARROLL COUNTY, ILLINOIS**

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
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UPPER MISSISSIPPI RIVER SYSTEM ENVIRONMENTAL MANAGEMENT PROGRAM POST-CONSTRUCTION INITIAL PERFORMANCE EVALUATION REPORT

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POOL 13, MISSISSIPPI RIVER MILES 532 - 536 CARROLL COUNTY, ILLINOIS

January 2004

ACRONYMS

CORPS	Corps Of Engineers
Corps	United States Army Corps of Engineers
DO	Dissolved Oxygen
DPR	Definite Project Report
EMP	Environmental Management Program
HREP	Habitat Rehabilitation and Enhancement Project
IADNR	Iowa Department of Natural Resources
IPER	Initial Performance Evaluation Report
ILDNR	Illinois Department of Natural Resources
LTRMP	Long Term Resource Monitoring Program
MSL	Mean Sea Level
O&M	Operation and Maintenance
PER	Performance Evaluation Report
RM	River Mile
UMRS	Upper Mississippi River System
USFWS	United States Fish and Wildlife Service
WWI	World War One

Additional information about the Spring Lake HREP and the UMRS-EMP is available via the Internet at the following addresses: www.mvr.usace.army.mil/EMP/default.htm or www.mvr.usace.army.mil

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Performance Evaluation
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ACKNOWLEDGMENT

Identified below are the primary staff members of the U.S. Army Corps of Engineers Rock Island District and the United States Fish and Wildlife Service who contributed to the development of this Initial Post-Construction Performance Evaluation Report for the Spring Lake Habitat Rehabilitation and Enhancement Project:

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EXECUTIVE SUMMARY

General. This is an Initial Post Construction Performance Evaluation Report (PER) for the Spring Lake Habitat Rehabilitation and Enhancement Project (HREP). The Spring Lake HREP is located in Pool 13, Upper Mississippi River, between river miles 532.5 to 536.0 in Carroll County, Illinois. Spring Lake, a 3,300-acre lake and backwater complex delimited by the natural riverbank and perimeter levee, is located approximately two miles south of Savanna, Illinois. Following World War II, the area known as Spring Lake was diked and ditched for farming. In 1938 and 1939, all project site lands were acquired in fee title by the U.S. Army Corps of Engineers as part of the 9-Foot Channel Navigation Project. Management responsibility for these lands was subsequently transferred to the U.S. Fish and Wildlife Service (USFWS). This area is now managed as a unit of the Savanna District of the Upper Mississippi River National Wildlife and Fish Refuge.

Upper and Lower Spring Lakes formerly were highly productive and heavily used sources of aquatic vegetation for migratory waterfowl. Due to breaching of the Lower Lake dike, sedimentation from river flows was degrading the aquatic habitat. Inadequate water level control capabilities and associated encroachment of woody plants and undesirable perennials were negatively affecting production of food resources preferred by migratory waterfowl in the Upper Lake. Peak waterfowl use days have decreased form 113,000 to 30,000 or less.

Project implementation is increasing the overall availability and quality of migratory bird and fish habitat at this location. Improved water level control in the Upper Lake has increased annual moist soil plant production to the benefit of dabbling ducks. Improved marsh habitat management capabilities in the Upper and Lower Lakes are providing valuable outputs to migratory waterfowl and other wetland dwelling species. The ability to distribute oxygenated water throughout the Lower Lake while minimizing sediment access is maintaining and enhancing this site's overall habitat value.

Construction was completed in three stages. Stage I was considered substantially complete on July 29, 1999. Stage II was substantially complete on May 11, 2000. Stage III was considered complete on January 10, 2002.

Purpose. The purpose of this report is to provide a summary of the observations for the performance evaluation monitoring that has been ongoing since July 1999 through December 2002.

Goals and Objectives.

1. Enhance aquatic habitat

a. Improve water quality for fish.
b. Maintain backwater lake.

2. Enhance wetland habitat

a. Provide reliable food source in Upper Lakes for migratory birds
b. Provide reliable food source in Lower Lake for migratory birds

Observations, Conclusions and Recommendations.

1. Project Goals, Objectives, and Management Plan. No formalized management plan has been developed for this project.

2. Post-Construction Evaluation and Monitoring Schedules. In general, most project monitoring efforts have been performed according to the PER Plan and the Resource Monitoring and Data Collection Summary in Appendix B, except where flood conditions or other obstacles have prevented monitoring tasks. A Post-Construction Performance Evaluation Supplement will be prepared annually. The next Post-Construction Performance Evaluation Supplement will be completed through December 2004, 5-years after construction, for distribution in March 2005.

3. Project Operation and Maintenance. Project operation and maintenance has been conducted inaccordance with the Spring Lake's Operation and Maintenance Manual, dated March 1998. Correct operation and maintenance of the stoplog structures, the gated inlet structure, the gatewell structure, and the pump station would create acceptable dissolved oxygen (DO) concentrations in Spring Lake and the Hemi-Marsh. The operation of these structure are expected to reduce the amount of suspended solids (turbidity) that enter the lake during high flows. During low flows the control structures are opened, allowing oxygenated water to enter the Lower Lake and be pumped into the Upper Lake. Maintenance for the structures includes cleaning out debris, controlling any leaks or possible vandalism and general upkeep of the pump station. Maintenance on the levees includes mowing, removal of any undesirable vegetation, repair of any rodent holes, repairing undermining of the levee due to scour holes, and repair of any levee erosion and/or sloughing due to high water events.

The water control structures as discussed above, are operated along with the pump station to control Spring Lake's water levels as the river level rises and falls during the year. A separate well structure aids in filling the Hemi-Marsh during low river flows. No major maintenance has been required since project completion.

The operation and maintenance of the control structures and levees in both the lake area and Hemi-Marsh, helps to promote the desired vegetation for consumption by migratory waterfowl.

Observations and inspections by the Site Manager will provide follow-up of the Project's operation and maintenance in the next PER, due in March 2005.

4. Project Design Enhancement.

a. Improve water quality for aquatic and wetland habitat

Water Quality Monitoring. The project has not been successful in attaining the target DO concentration (>5 mg/l). Extended periods of low DO concentrations have been observed in both the summer and winter months. The DO concentration during the summer months often fell below 5 mg/l; however, most of these excursions were short-lived. Only occasionally would the DO remain below 5 mg/l for more than two consecutive days. The gated inlet structure could be utilized during the summer months; however, close monitoring would be required in order to keep undesirable amounts of sediment from entering the lake.

A large fish kill, most likely attributable to low DO concentrations, occurred during the winter of 2000/2001. The gated inlet structure was open only 6 inches at this time. In response to the fish kill, a dye study was performed the following winter in order to determine the dispersion pattern of oxygenated Mississippi River water entering the lake through the gated inlet. The results of this study indicate that with a 10-inch gate opening, reoxygenation of the lake occurs slowly, with the dispersion pattern favoring the deeper portions of the lake north and east of Silo Island. A larger gate opening would allow for a more rapid dispersion of oxygenated water throughout the lake. One potential downside of using a larger gate opening would be an increase in water velocity in the main body of the lake. Over-wintering centrarchids prefer areas with little or no velocity. Velocity measurements could be taken at selected locations in the lake following an increase in gate opening to determine if velocity levels are acceptable.

Results from this initial monitoring and dye study indicate that a larger gate opening may be necessary in order to prevent fish kills during winters when particularly adverse conditions (early onset of snow-covered ice) occur. Opening the gate sooner may also help prevent fish kills, but this would increase the likelihood of undesirable sediment entering the lake.

b. Maintain backwater lakes.

Structures' Use and Levee Monitoring. During high flows all control structures are closed to prevent sediment-laden water from entering the Spring Lake complex. Levee monitoring has revealed some 'benching' in sandy areas of the lower perimeter levee.

c. Provide reliable food source in Upper and Lower Lakes for migratory birds.

Vegetation and Waterfowl Use Monitoring. Vegetation and waterfowl use monitoring is performed through annual inspections performed by the USFWS refuge manager and joint inspections performed by the Corps and USFWS. Observation of levee vegetation indicates a mixture of voluntary grasses and weeds. Waterfowl use has increased since project completion, as noted by the USFWS through field inspections. Monitoring will continue through site inspections and site visits.

5. Project Monitoring and Evaluation.

The project has not been successful in attaining the target DO concentration (>5 mg/l). The gated inlet structure was only opened six inches during the 2000/2001fish kill. The gated inlet structure should be utilized more to prevent low DO concentration. Proper operation and maintenance of water control structures will result in enhanced wetland and aquatic habitats. Vegetation growth has been successful and waterfowl use has increased although the amount of increase has not been determined.

In general, the project features are constructed and hopefully corrective actions will allow the development of habitat objectives as expected. The next PER to assess project features and objectives is due in March 2005, covering 5-Years post-construction. Continued monitoring by the Corps and the Site Manger is needed to determine the continued development of the project’s habitat areas.

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1 INTRODUCTION

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Project implementation is increasing the overall availability and quality of migratory bird and fish habitat at this location. Improved water level control in the Upper Lake has increased annual moist soil plant production to the benefit of dabbling ducks. Improved marsh habitat management capabilities in the Upper and Lower Lakes are providing valuable outputs to migratory waterfowl and other wetland dwelling species. The ability to distribute oxygenated water throughout the Lower Lake while minimizing sediment access is maintaining and enhancing this site's overall habitat value.

Construction was essentially completed by July 1999.

1.1 Purpose

The purposes of this Initial Performance Evaluation Report (IPER) are as follows:

(1) Summarize the performance of the Spring Lake project relative to the project goals and objectives (see Table 2-1 and Appendix A, Table A-1);

(2) Review the monitoring plan for possible revisions;

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

(4) Review engineering performance of the project to aid in the design of future projects.

1.2 Scope

This report summarizes available project monitoring data, inspection records and observations made by the U.S. Army Corps of Engineers (Corps) and the U.S. Fish and Wildlife Service (USFWS) at the Spring Lake project for the period from May 1993 to December 2002. Project construction was completed in three stages. Stage I was considered substantially complete on July 29, 1999. Stage II was substantially complete on May 11, 2000. Stage III was considered complete on January 10, 2002.

2 PROJECT GOALS AND OBJECTIVES

2.1 General

The Spring Lake project was constructed to provide high quality, dependable aquatic and wetland habitat for migratory waterfowl. As stated in the Introduction, the lake is delineated by the natural riverbank to the east and a perimeter levee to the west on the Illinois side of the Upper Mississippi River navigation channel. During the 1940s dikes were built to segregate the area now known as Spring Lake for farming. By 1946 this area had become an approximate 3000-acre lake once the locks and dams generated pools of the Mississippi River. Historically, Spring Lake was a highly productive and heavily used feeding and resting area for migratory waterfowl. Over time the perimeter levee failed during flooding event causing the deposition of sediments into Spring Lake and a gradual decline in the quality and availability of aquatic vegetation. The breaks in this levee prevented proper maintenance of the perimeter levee system and allowed sediment accumulation to occur during each subsequent flood event. Areas adjacent to the breach sites had also deteriorated by forming large scour holes. The area underwent an invasion of woody vegetation and undesirable aquatic plants that were not acceptable to waterfowl. Waterfowl use in the Upper Lake clearly diminished because of the reduction in the water quality and the quantity of preferred food plant species. In addition, aquatic habitat was also negatively affected as the shallow water conditions and low flows in the Upper and Lower Lakes generated poor dissolved oxygen levels.

2.2 Goals And Objectives

Project goals and objectives were formulated during the project design phase and are summarized below in Table 2-1.

Table 2-1. Project Goals And Objectives

Goals	Objective	Features
enhance aquatic habitat	improve water quality for fish	levee & dike restoration water control structures
	maintain backwater lake	gated inlet structure excavated channel mechanical aerators Upper/Lower Lake water control
enhance wetland habitat	provide reliable food source in Upper Lake for migratory birds	levee restoration Upper Lake water control
	provide reliable food source in Lower Lake for migratory birds	Hemi-Marsh Lower Lake water control

2.3 Management Plan

No formalized management plan has been developed for this project.

3 PROJECT DESCRIPTION

3.1 Project Features

The Spring Lake project promotes aquatic habitat enhancement through levee restoration and the construction of several water control structures. The project promotes wetland habitat enhancement with the creation of a managed 3-cell moist soil unit with water control structures in the Upper Lake and a Hemi-Marsh in the Lower Lake. A constructed pump station can pump water from the Lower Lake to the Upper Lake, during low water levels, as well as pump water from the Upper Lake, to the Lower Lake, during desired drawdown periods. Water for the Hemi-Marsh is provided by a well located at the northeast corner of the Hemi-Marsh levee. The perimeter levee provides protection from sediment-laden floodwater for the whole complex, while water control structures allow fresh water flow through the Lower Lake during low flow periods. A general view of these project features is illustrated on Plate 1 in Appendix F and summarized in the Operation and Maintenance Manual.

3.2 Construction

The Stage I construction contract was awarded on January 25,1995 to the Illinois Constructors Corporation under Contract No. DACW25-95-C-0020. This contract consisted of levee construction, water control structures, and pump station. Stage II – Hemi-Marsh Well contract was awarded on May 21, 1999 to Langman Construction, Inc. under Contract No. DACW25-99-C-0021. This contract consisted of construction of a new water well and outlet channel. The contract was also modified to place offshore revetment in high-erosion areas of the Hemi-Marsh levee. Stage III, Structural Modifications contract, was awarded on September 8, 2000 to Del-Jen under the Regional Job Order Contract. This contract consisted of minor modifications to the structures built during Stage I, to make them better adapted, for easy use by Refuge personnel. Stage I was considered substantially complete on July 29, 1999. Stage II was substantially complete on May 11, 2000. Stage III was considered complete on January 10, 2002.

3.3 Operation And Maintenance

Project operation and maintenance generally consists of operating the water control structures and maintaining the levees' integrity to control the water levels in Spring Lake. Operation and maintenance of the project includes (1) mowing and maintaining the perimeter levee to reduce erosion effects and eliminate rodent holes; (2) operating the pump station and water control structures, such as removing the stoplogs in the stoplog structures and raising/lowering the structures' gates, to achieve desired water elevations and minimize overtopping erosion during high flows; (3) maintaining the interior drainage and outlet and inlet channels (e.g., removal of silt, debris, and undesirable vegetation); and (4) controlling undesired vegetation between planted trees. For a more in-depth guide on the operation and maintenance of the Spring Lake project, please reference: *Draft Operation and Maintenance Manual, Spring Lake Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 13, River Miles 532-536, Carroll County, Illinois,* March 1998.

4 PROJECT PERFORMANCE MONITORING AND EVALUATION

4.1 General

The relative success of the project as related to original project objectives will be measured using these data, along with other project data, field observations and project inspections performed by the USFWS. The U.S. Army Corps of Engineers, Rock Island District (Corps) has overall responsibility to measure and document project performance.

Appendix A presents the Post-Construction Performance Evaluation Plan. This plan was developed during the project design phase and serves as a guide to measure and document project performance. Appendix A also contains the Monitoring and Performance Evaluation Matrix and Resource Monitoring and Data Collection Summary. The latter presents the types and frequency of data that is collected to meet the requirements of the Post-Construction Performance Evaluation Plan.

4.2 Corps Of Engineers.

The Corps has the overall responsibility to perform data collection for design and maintenance, construction monitoring, performance evaluation monitoring, and biological response monitoring in order to present this information and data in a Performance Evaluation Report (PER) of the Spring Lake project. Completion of the PER will ensure that the site is being maintained according to the Operation and Maintenance (O&M) manual.

4.3 U.S. Fish And Wildlife Service

The USFWS is responsible for maintaining the Spring Lake Habitat Rehabilitation and Enhancement Project. The USFWS does not have project-specific monitoring responsibilities. The Savanna District Manger is required to conduct annual inspections of the project and participating in periodic joint inspections of the project with the Corps. On-site qualitative observations are a valuable component of assessing the performance of the project.

5 EVALUATION OF PROJECT OBJECTIVES

Observations by USFWS personnel indicate that waterfowl usage at Spring Lake has increased substantially since project completion. Fishermen at Spring Lake indicate better fishing conditions overall. Aquatic and wetland habitats are evaluated according to the project goals and objectives as stated in Table 5-1, below. Based on data and observations collected since project completion, the stated project goals and objectives are for the most part, being met. However, certain issues still need to be addressed to enhance project features and minimize operation and maintenance needs and requirements. These are discussed in the paragraphs that follow.

Table 5-1 Project Goals And Objectives

Goals	Objective	Features	Status
enhance aquatic habitat	improve water quality for fish	levee & dike restoration water control structures	partially met
	maintain backwater lake	gated inlet structure excavated channel Upper/Lower Lake water control	being met
enhance wetland habitat	provide reliable food source in Upper Lake for migratory birds	levee restoration upper Lake water control	in progress
	provide reliable food source in Lower Lake for migratory birds	Hemi-Marsh Lower Lake water control	in progress

5.1 Improve Water Quality To Enhance Aquatic Habitat

5.1.1 Water quality overview. A gated inlet was constructed in Lower Spring Lake for the purpose of allowing oxygenated water into the lake during periods when low dissolved oxygen (DO) concentrations are present. The ability to distribute oxygenated water throughout the lake, especially during periods of ice cover, is essential for the prevention of fish kills. The water quality objective of the Spring Lake project is to improve water quality for fish by maintaining a minimum DO concentration. As shown in Appendix A, Table A-1, the Year 50 Target of the project is to maintain a DO concentration greater than 5 mg/l at all times. In order to determine the effectiveness of the project in attaining this goal, post-project water quality monitoring commenced on December 17, 1998 at three sites: W-M532.6Q, W-M534.8R and W-M534.6V (see Plate 3 in Appendix F for site locations). This monitoring was performed by Corps personnel. Samples were also collected at site W-M532.3T by ILDNR personnel as part of the LTRM program and compiled into a water quality report. This report discusses post-project data collected through 2002 by Corps personnel and through 2001 by ILDNR personnel. The results from a special dye tracer study performed by Corps personnel during February 2002 are also included. The full water quality report is in Appendix C. A summary of the monitoring report is in the next section.

5.1.2 Water quality monitoring summary. The project has not been successful in attaining the target DO concentration (>5 mg/l). Extended periods of low DO concentrations have been observed in both the summer and winter months. The DO concentration during the summer months often fell below 5 mg/l; however, most of these excursions were short-lived. Only occasionally would the DO remain below 5 mg/l for more than two consecutive days. The gated inlet structure could be utilized during the summer months; however, close monitoring would be required in order to keep undesirable amounts of sediment from entering the lake.

A large fish kill, most likely attributable to low DO concentrations, occurred during the winter of 2000/2001. The gated inlet structure was open only 6 inches at this time. In response to the fish kill, a dye study was performed the following winter in order to determine the dispersion pattern of oxygenated Mississippi River water entering the lake through the gated inlet. The results of this study indicate that with a 10-inch gate opening, reoxygenation of the lake occurs slowly, with the dispersion pattern favoring the deeper portions of the lake north and east of Silo Island. A larger gate opening would allow for a more rapid dispersion of oxygenated water throughout the lake. One potential downside of using a larger gate opening would be an increase in water velocity in the main body of the lake. Over-wintering centrarchids prefer areas with little or no velocity. Velocity measurements could be taken at selected locations in the lake following an increase in gate opening to determine if velocity levels are acceptable.

Results from this initial performance evaluation indicate that a larger gate opening may be necessary in order to prevent fish kills during winters when particularly adverse conditions (early onset of snow-covered ice) occur. Opening the gate sooner may also help prevent fish kills, but this would increase the likelihood of undesirable sediment entering the lake.

Water quality monitoring will continue at Spring Lake but will be modified to reflect lessons learned. Current sampling frequencies are different than what is presented in Table A-3 Resource Monitoring and Data Collection Summary. Winter sampling occurs three times between December to March. Summer sampling occurs every two weeks between June and September. Further special studies are needed to determine how the inlet structure should be operated in order to maximize fishery benefits and further discussion regarding this effort will be included in the next performance evaluation report.

5.2 Maintain Backwater Lakes To Enhance Aquatic Habitat

The appropriate operation of the water control structures, well, and pump station will help to maintain a good supply of oxygenated water while reducing the flow of sedimentation into the lake area. This should promote better vegetative response and waterfowl use.

The water control structures, such as the gated inlet structure and gatewell, are opened to allow oxygenated water to enter the Lower Lake when flows along the main river channel are low and sediment movement is relatively small. As flows increase along the main channel, control structures along the perimeter levee are closed to reduce the inflow of sediment.

5.3 Provide Reliable Wetland Vegetation

Proper operation and maintenance of water control structures will result in an enhanced wetland habitat, which will in turn be a reliable food source for migrating birds. An estimate of the acres of emergent/submergent vegetation will be established every 5 years by completing vegetation transects that are scheduled for completion during FY2005. This assessment will be provided in the 6-year post construction performance evaluation report schedule in FY 2005.

6 EVALUATION OF PROJECT OPERATION AND MAINTENANCE

6.1 Operation Evaluation

This section focuses on challenges and difficulties experienced through operation of the project. The Upper Lake was not managed in 2002 due to the breach in the cross dike during the 2001 Flood.

6.1.1 Perimeter levee, interior levee, and cross dike

Challenges or Difficulties. Since construction has been completed, muskrat burrowing has caused extensive damage. As a result, severe erosion on side slopes and large sinkholes on the levee crown are occurring. Also, water is flowing between the impoundment due to the continuous muskrat tunnels. This has caused the refuge manger to be unable to manipulate water levels within individual impoundments as desired. Costs to inspect and repair the damage have become very large. The problem has also become a safety hazard to vehicles traveling on the levee crowns due to large holes that develop. Muskrat populations are not likely to decrease.

Actions and Recommendations. Annual inspection and maintenance will continue as outlined in the O&M Manual for Spring Lake, dated March 1998. The muskrat damage needs to be addressed. Currently, the cost of eradicating muskrats and repairing subsequent damage exceeds the budget for operating the upper unit. Thus, Habitat Rehabilitation and Enhancement Project (HREP) project goals cannot be realized if no action is taken. One possible solution would be to lay chain link fence fabric on the levee slope, providing a physical barrier to the muskrats. Another possible solution would be to establish an aggressive eradication program. Trapping would be the most likely method of eradication; however, due to a poor market for pelts, it may be necessary to subsidize the trapping.

6.1.2 Pump station

Challenges or Difficulties. Pump No. 1 will not run on auto and the service company does not know the reason.

Actions and Recommendations. The pump should be repaired so that it is fully operational. Other pump service companies or the pump manufacture should be contacted for information on why the pump is not operating correctly.

6.1.3 Stoplog structures

Challenges or Difficulties. Removal of the stoplogs underwater has proven to be difficult. Locating the lifting lugs with the lifting device is a hit-and-miss operation. Stoplogs also do not seal well, allowing seepage between cells.

Actions and Recommendations. Stoplog lifting device should be modified to make locating the lugs easier. This has been undertaken by refuge personnel. The stoplogs will eventually seal after several days due to fine sediment build-up between the gaps. It is recommended that the stoplog settings not be changed frequently to avoid breaking this seal. If a more immediate seal is needed, cinders may be utilized on the upstream side of the stoplogs.

6.1.4 Gated inlet structure and 24-in. gatewell

Challenges or Difficulties. The gate position is difficult to read. Stoplogs are used in the gated inlet structure during maintenance of the structure. The stoplogs are difficult to remove with a head against them.

Actions and Recommendations. Refuge personnel have painted the top of the gate stem bright orange to make its position easier to read. To ease removal of the stoplogs, the respective gate should be closed temporarily and water levels allowed to equalize on either side of the stoplogs.

6.1.5 Well

Challenges or Difficulties. The pump's motor minder and transformer burned out. The pump works if the motor minder and transformer are by-passed.

Actions and Recommendations. The motor minder and transformer are at the pump service shop being repaired. Operating the pump without the motor minder should be avoided, as the pump will have no overload or fault protection. Once the repairs are complete the system's operation should return to normal.

6.2 Maintenance Evaluation

The following paragraphs identify maintenance items that the USFWS and the Corps have observed during operation and inspection of the Spring Lake project.

6.2.1 Perimeter levee, interior levee and cross dike

Challenges or Difficulties. During the spring flooding in 2001, the cross dike was breached. The exact cause of the breach is unknown but there are a few possible explanations. (1) The levee was designed for a 1 foot per day water level rise. During the 2001 flood, the water rose more rapidly than 1 foot per day. (2) Strong southerly winds during the 2001 flood generated waves of 3 to 4 feet, which eroded and eventually breached the dike. Strong southerly winds at this location are very unusual in early spring. (3) The section of dike that failed may have had a higher sand content than other areas, which lead to accelerated erosion and eventual failure of the dike.

As previously mentioned, muskrat burrowing has caused extensive damage to the interior levees. The west side of the perimeter levee has scouring due to the 2001 flood. The lower end of the west levee has some unfavorable tree/shrub growth. Interior levees have some wave wash and scouring due to the 2001 flood. The flood of 2001 also caused two washout areas and overtopping erosion on the Hemi-Marsh levee.

Actions and Recommendations. Until a permanent solution to the muskrat problem is found, continual effort will be required to fill the damaged areas of the levees. The cross dike area that failed during the 2001 floods is being rebuilt as a spillway, to the elevation 588.0 feet MSL. The section will be designed to meet the specifications of the two original cross dike spillways. Areas with woody vegetation are mowed twice a year. In the spring of 2002, maintenance personnel filled erosion areas in the Hemi-Marsh levee. Maintenance is still being done to remedy problems caused by the 2001 flood. The Hemi-Marsh stoplogs should be pulled in late winter to allow Hemi-Marsh water levels to equalize with the Lower Lake. This will reduce or eliminate overtopping damage.

6.2.2 Pump station

Challenges or Difficulties. The door to the building is rusting from the inside due to the moisture in the pump station. Site personnel have added a jib hoist and crane to the pump station to facilitate removal of the pumps for inspections.

Actions and Recommendations. Site personnel should paint the door and perform appropriate maintenance to repoarit rust damage. They should also check for obstructions to the vents and perform appropriate maintenance as required.

6.2.3 Stoplog structures

Challenges and Difficulties. No maintenance difficulties have been experienced with the stoplog structures. Visitors have been throwing riprap onto the ice that is a nuisance.

Actions and Recommendations. Site personnel should replace the missing riprap. Signs indicating penalties could be posted to discourage visitors from throwing riprap.

6.2.4 Water control structure and gatewell structure

Challenges and Difficulties. No maintenance difficulties have been experienced with either structure.

Actions and Recommendations. The gauge sight glass was replaced and the top of the gate stem was painted as per normal maintenance requirements. Both structures were completely opened and closed in 2002. Maintenance personnel also greased mechanical equipment in 2002.

6.2.5 Well station

Challenges and Difficulties. The motor minder and transformer burned out. The discharge channel fills with debris and vegetation.

Actions and Recommendations. The motor minder and transformer are being repaired at the service shop. No other maintenance requirements are expected once repairs are complete and pump operation restored. The discharge channel should be cleared of debris before operating the well to ensure that water does not overflow the channel.

7 GENERAL CONCLUSIONS AND RECOMMENDATIONS

7.1 Project Goals, Objectives And Management Plan

Reducing the inflow of sediments, improving water control, increasing the distribution of dissolved oxygen in the 3-cell moist soil unit and the Lower Spring Lake, and maintaining a steady water supply to the Hemi-Marsh will increase habitat suitability and overall value of the project. Observations by USFWS personnel indicate that waterfowl usage at Spring Lake has increased substantially since project completion. Fishermen at Spring Lake indicate better fishing conditions overall.

7.2 Project Features

7.2.1 Level Of Protection

A 2-year level of protection, such as the interior levees in Upper Spring Lake, should only be used at sites where impacts of frequent flooding are acceptable for project operation and maintenance. Flooding in the spring of 1997 caused damage to some of the embankment materials. The 50-year perimeter levee was not overtopped during the floods of 1997, 1999, or 2001, and is considered an appropriate level of protection.

7.2.2 Water Control Structures

It is recommended that consideration be given to a different design for stoplogs and lifting device. Stoplog structures in future projects should be designed and constructed to allow easy removal and installation of the stoplogs by one person.

7.2.3 Water Quality

The project has not been successful in attaining the target DO concentration (>5 mg/l). Extended periods of low DO concentrations have been observed in both the summer and winter months. The gated inlet structure could be utilized during the summer months; however, close monitoring would be required in order to keep undesirable amounts of sediment from entering the lake. A large fish kill, most likely attributable to low DO concentrations, occurred during the winter of 2000/2001.

7.3 Project Monitoring and Evaluation

The project has not been successful in attaining the target DO concentration (>5 mg/l). The gated inlet structure was only opened six inches during the 2000/2001fish kill. The gated inlet structure should be utilized more to prevent low DO concentration. Proper operation and maintenance of water control structures will result in enhanced wetland and aquatic habitats. Vegetation growth has been successful and waterfowl use has increased although the amount of increase has not been determined.

In general, the project features are constructed and hopefully corrective actions will allow the development of habitat objectives as expected. The next PER to assess project features and objectives is due in March 2005, covering 5-Years post-construction. Continued monitoring by the Corps and the Site Manger is needed to determine the continued development of the project's habitat areas.

APPENDIX A

POST-CONSTRUCTION EVALUATION PLAN
AND
MONITORING AND PERFORMANCE PLAN

Table A-1 Post-Construction Evaluation Plan

Goal	Objective	Enhancement Feature	Unit	Year 0 (1999) Without Alternative	Year 3 (2003) With Alternative (As-Built)	Year 50 (2049) Target With Alternative	Feature Measurement	Annual Field Observations by Site Manager
Enhance Aquatic Habitat	Improve water quality for aquatic life	Levee restoration and control structures	DO (mg/L)	<5.0 during critical periods	<5.0 during winter and summer	>5.0 at all times	Perform water quality tests	Describe fishing conditions
	Maintain backwater lake	Gated inlet structures Excavated channel Mechanical aerator Upper Lake water control	Lineal Feet of Eroded Levee	44,800	*	0	Perform levee system transects and profiles	Describe the effects of erosion
Enhance Wetland Habitat	Provide reliable wetland vegetation/food source in Upper Lake for migratory birds	Upper Lake water control Levee restoration	Acres of vegetation	0	**	500	Aerial vegetation surveys/vegetation transects Timber inventory	Observe/record development of emergent vegetation Observe/record tree mast
	Provide reliable wetland vegetation/food in Lower Lake for migratory birds and other wetland species	Lower Lake water control Hemi-Marsh	Acres of vegetation	0	**	108	Aerial vegetation surveys/vegetation transects	Estimate acres of emergent and submergent vegetation

* Transects have not yet been completed
** Vegetation surveys have not yet been completed

Table A-2 Monitoring And Performance Evaluation Matrix

Project Phase	Type of Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source	Implementation Instructions/Notes
Pre-Project	Pre-Project Monitoring	Establish need of proposed project features.	USFWS	USFWS	LTRMP	--
Design	Baseline Monitoring Data Collection for Design	Establish baseline conditions; meet specific design requirements.	Corps	Corps	HREP	--
Construction	Construction Monitoring	Assess construction impacts; meet permit requirements.	Corps	Corps	HREP	See state section 401 stipulations
Post-Construction	Performance Evaluation Monitoring	Monitoring and assess physical and vegetative performance of project relative to design goals and objectives.	Corps (quantitative) Sponsor (field inspect)	Corps Illinois DNR	Corps Illinois DNR	--
	Analysis of Biological Responses to Projects	Evaluate biological response predictions and assumptions.	Corps Sponsor	Corps USFWS	HREP USFWS	Intensive biological response monitoring of this project, as part of the HREP element of the UMRS-EMP, is not scheduled. Annual waterfowl census data will be obtained from the USFWS to evaluate waterfowl response to the project.

Table A-3 Resource Monitoring And Data Collection Schedule

Type of Measurement	Water Quality Data						Engineering Data			Natural Resource Data			Sampling Agency
	Pre-Project Phase		Design Phase		Post-Const. Phase		Pre-Project Phase	Design Phase	Post-Const. Phase	Pre-Project Phase	Design Phase	Post-Const. Phase	
	APR-SEPT	OCT-MAR	APR-SEPT	OCT-MAR	APR-SEPT	OCT-MAR							
POINT MEASUREMENTS													
Water Quality Stations													USACE LTRMP
Turbidity	--	--	2W	M	2M	3M							
Secchi Disk Transparency	2W	--	2W	--	2M	3M							
Suspended Solids	2W	--	2W	M	2M	3M							
Dissolved Oxygen	2W	--	2W	M	2M	3M							
Specific Conductance	2W	--	2W	M	2M	3M							
Water Temperature	2W	--	2W	M	2M	3M							
Ph	2W	--	2W	M	2M	3M							
Total Alkalinity	--	--	2W	M	2M	3M							
Chlorophyll	2W	--	2W	M	2M	3M							
Velocity	--	--	2W	M	2M	3M							
Water Depth	2W	--	2W	M	2M	3M							
Water Elevation	2W	--	2W	M	2M	3M							
Percent Ice Cover	--	--	--	M	--	3M							
Ice Depth	--	--	--	M	--	3M							
Percent Snow Cover	--	--	--	M	--	3M							
Snow Depth	--	--	--	M	--	3M							
Wind Direction	--	--	2W	M	2M	3M							
Wind Velocity	--	--	2W	M	2M	3M							
Wave Height	--	--	2W	M	2M	3M							
Air Temperature	2W	--	2W	M	2M	3M							
Percent Cloud Cover	--	--	2W	M	2M	3M							
Elutriate Test Stations			1										USACE
Column Settling Stations								1					USACE
Column Settling Analysis													
Boring Stations								1					
Geotechnical Borings													

Table A-3 (continued)

Type of Measurement	Water Quality Data						Engineering Data			Natural Resource Data			Sampling Agency
	Pre-Project Phase		Design Phase		Post-Const. Phase		Pre-Project Phase	Design Phase	Post-Const. Phase	Pre-Project Phase	Design Phase	Post-Const. Phase	
	APR-SEPT	OCT-MAR	APR-SEPT	OCT-MAR	APR-SEPT	OCT-MAR							
Fish Stations										1	1	1	ILDNR
Electrofishing													
TRANSECT MEASUREMENTS													
Sedimentation Transects													
Hydrographic Soundings							1		5Y				USACE
Vegetation Monitoring													
Vegetation Survey												5Y	USACE
Levee System							1		5Y				
Cross-sections at even 500-foot intervals and profile of cross dike and perimeter levee													
AREA MEASUREMENTS													
Mapping													
Land Cover / Land Use Map										1		5Y	USACE

Legend

W = weekly
M = monthly
Y = yearly

nY = n-year interval
nW = n-week interval
1, 2, 3, ... = number of times data is collected within designated project phase

Table A-4 Resource Monitoring And Data Collection Summary

Enhancement Feature	Unit of Measure	Objective	Field Observations [1]			Quantitative Measurements		
			Observation	Monitoring Interval	Monitoring Agency	Monitoring Plan	Monitoring Intervals (Years [2])	Monitoring Agency
Control structures and restored levees	DO (mg/L) Turbidity	Improve water quality for fish	Describe fishing conditions	Annually	USFWS	Perform water quality tests	April-September 2 times per month October-March 3 times per month	Corps
Control structures, excavated channel and restored levees	Ft. of erosion, site inspections	Maintain backwater lake	Describe effects of erosion, maintenance	Annually	USFWS	Perform levee system transects and profiles	5	Corps
Upper and Lower Lake water control	Acres of vegetation	Provide reliable food source in Upper Lake for migratory birds	Estimate acres of emergent/ submergent vegetation	Annually	USFWS	Perform vegetation transects	5	Corps
Hemi-Marsh	Acres of vegetation	Provide reliable food source in Lower Lake for migratory birds	Estimate acres of emergent/ submergent vegetation	Annually	USFWS	Perform vegetation transects	5	Corps

[1]To be submitted to the Corps of Engineers by the USFWS with the annual management report for Cooperative Agreement Lands.
[2]Monitoring intervals are based on 1999 as being year zero, with subsequent 5-year intervals.

APPENDIX B

COOPERATING AGENCY CORRESPONDENCE

OPERATION AND MAINTENANCE MANUAL
SPRING LAKE REHABILITATION AND ENHANCEMENT

UPPER MISSISSIPPI RIVER
ENVIRONMENTAL MANAGEMENT PROGRAM
POOL 13, RIVER MILES 522.5 THROUGH 526
CARROLL AND WHITESIDE COUNTIES, ILLINOIS

SITE MANAGER'S PROJECT INSPECTION AND MONITORING RESULTS

Inspected By William B. Davison Date 10-17-02

Type of Inspection: (X) annual ( ) emergency-disaster ( ) other

1. PROJECT INSPECTION.

Item	Condition
a. Upper Perimeter Levee	
(✓) Settlement, sloughs or loss of section	ok
(✓) Wavewash, scouring	West side scouring due to 2001 Flood
(✓) Vegetative cover (mowing)	Mowed entirely once + woody encroachment twice
(✓) Burrowing animals	some beaver + groundhog – minimal
(✓) Unauthorized grazing or traffic	ok
(✓) Encroachments	ok none noted
(✓) Unfavorable tree/shrub growth	Extensive encroachment of locust + willow on North + West levee.
( ) Other	
a. Lower Perimeter Levee	
(✓) Settlement, sloughs or loss of section	ok
(✓) Wavewash, scouring	Some scouring on west levee
(✓) Vegetative cover (mowing)	ok - Mowed once
(✓) Burrowing animals	minimal
(✓) Unauthorized grazing or traffic	ok
(✓) Encroachments	none noted
(✓) Unfavorable tree/shrub growth	lower end of west levee has some locust/willow encroachment – mowed twice
( ) Other	

b. Interior Levees

(✓) Settlement, sloughs or loss of section	ok
(✓) Wavewash, scouring	some due to 2001 flood
(✓) Overtopping erosion	None this year
(✓) Vegetative cover (mowing)	mowed once
(✓) Burrowing animals	extensive muskrat burrowing - some rehab performed on A+C dike
(✓) Unauthorized grazing or traffic	None noted
(✓) Encroachments	None noted
(✓) Unfavorable tree/shrub growth	ok
( ) Other	

b. Cross Dike

(✓) Settlement, sloughs or loss of section	Began filling in major Breach in July
(✓) Wavewash, scouring	ok - Still fixing 2001 damage
(✓) Overtopping erosion	none this year
(✓) Vegetative cover (mowing)	Mowed one
(✓) Burrowing animals	minimal
(✓) Unauthorized grazing or traffic	none noted
(✓) Encroachments	none noted
(✓) Unfavorable tree/shrub growth	minimal - mowed once
( ) Other	- Projected that major breach will be filled + riprapped by December.

c. Hemimarsh Levee

(X) Settlement, sloughs or loss of section	2 washouts - filled in in Spring '02
(X) Wavewash, scouring	some - " " " " "
(X) Overtopping erosion	several spots - fixed Spring '02
(X) Vegetative cover (mowing)	Mowed once
(X) Burrowing animals	extensive muskrat burrowing
(X) Unauthorized grazing or traffic	ok
(X) Encroachments	None
(X) Unfavorable tree/shrub growth	ok
( ) Other	

d. Stoplog Structure A

(X) Stoplogs, stoplog keepers, stoplog slots	OK
(X) Concrete	OK
(X) Steel rails, grating, fasteners	ok
(X) Displaced/missing riprap	ok - Visitors like to throw Riprap on ice
(X) Erosion adjacent to structure	ok
(X) Sedimentation	ok
( ) Other	

d. Stoplog Structure B

(X) Stoplogs, stoplog keepers, stoplog slots	ok
(X) Concrete	ok
(X) Steel rails, grating, fasteners	ok
(X) Displaced/missing riprap	ok
(X) Erosion adjacent to structure	ok
(X) Sedimentation	ok
( ) Other	

d. Stoplog Structure C

(X) Stoplogs, stoplog keepers, stoplog slots	ok
(X) Concrete	ok
(X) Steel rails, grating, fasteners	ok
(X) Displaced/missing riprap	ok
(X) Erosion adjacent to structure	ok
(X) Sedimentation	ok
( ) Other	

d. Stoplog Structure HM

(X) Stoplogs, stoplog keepers, stoplog slots	ok
(X) Concrete	ok
(X) Steel rails, grating, fasteners	ok
(X) Displaced/missing riprap	ok
(X) Erosion adjacent to structure	ok
(X) Sedimentation	ok
( ) Other	

e. Pump Station

(X) Building/hardware	- Door Needs Repainting or Replacing (Rusting inside)
(X) Control panel	- Pump 1 will not run on auto (*)
(X) Pumps	Inspected by Qual. personnel in june
(X) Gate	ok
(X) Sump (sediment, debris)	ok
(X) Trash racks	ok
(X) Inlet & outlet channels	ok
(X) Displaced/missing riprap	ok
(X) Erosion or seepage adjacent to structure	ok
(X) other	Added a jib hoist + Crane to facilitate removing pumps for inspection.

* - Service company does not know why. Need to fix.

f. Gated Inlet Structure

(X) Concrete	ok
(X) Gates and operating mechanism	ok - Gauge Sight Glass replaced + stem top painted
(X) Displaced/missing riprap	ok
(X) Inlet & outlet channels	ok
(X) Erosion or seepage adjacent to structure	ok
(X) other	- opened & closed completely + greased.

g. 24-in. Gatewell

(X) Concrete	ok
(X) Gate and operating mechanism	ok
(X) Inlet & outlet channels	ok
(X) Erosion or seepage adjacent to structure	ok
(X) other	opened & closed completely + greased.

h. Well

(X) Protective casing	ok - Slightly buckled
(X) Bollards	ok
(X) Outlet apron (riprap)	ok
(X) Electrical controls	- Motor minder + transformer burned out
(X) Pump	Runs ok - if motor minder etc. bypassed
(X) Other	

2. COMMENTS.

2-12-02 Motor minder + transformer are at the pump services shop. Have called several times to have them replaced. Says he has not forgotten us. Apple River Well + Pump.

Ed Britton

Site Manager

APPENDIX C

WATER QUALITY DATA

SPRING LAKE
WATER QUALITY REPORT

Goal – Enhance Aquatic Habitat

Objective – Improve Water Quality for Fish

Enhancement Feature – Inlet Structure/Excavated Channel

(1) Overview. A gated inlet was constructed in Lower Spring Lake for the purpose of allowing oxygenated water into the lake during periods when low dissolved oxygen (DO) concentrations are present. The ability to distribute oxygenated water throughout the lake, especially during periods of ice cover, is essential for the prevention of fish kills. The water quality objective of the Spring Lake project is to improve water quality for fish by maintaining a minimum DO concentration. As shown in Appendix A, Table A-1, the Year 50 Target of the project is to maintain a DO concentration greater than 5 mg/l at all times. In order to determine the effectiveness of the project in attaining this goal, post-project water quality monitoring commenced on December 17, 1998 at three sites: W-M532.6Q, W-M534.8R and W-M534.6V (see Plate 3 for site locations). This monitoring was performed by CORPS personnel. Samples were also collected at site W-M532.3T by ILDNR personnel as part of the LTRM program. This report discusses post-project data collected through 2002 by Corps personnel and through 2001 by ILDNR personnel. The results from a special dye tracer study performed by CORPS personnel during February 2002 are also discussed.

(2) Monitoring. CORPS data were obtained through a combination of periodic grab samples and the use of *in-situ* continuous monitors. Grab samples were collected just below the surface on 47, 45 and 44 occasions, respectively, at sites W-M532.6Q, W-M534.8R and W-M534.6V. The three sites were usually visited about twice per month from June through September and two to four 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. ILDNR personnel collected grab samples approximately every other week at site W-M532.3T.

In-situ water quality monitors (YSI model 6000UPG or 6600UPG sondes) were deployed by CORPS personnel on 36 occasions at site W-M532.6Q. The sonde was positioned 3 feet above the bottom during each deployment. Deployments were typically for a period of two weeks during the summer months and four to eight weeks during the winter months. The sonde was normally equipped to measure DO, temperature, pH, specific conductance, depth and turbidity.

The results from water quality monitoring at all sites are found in Appendix D. Table D-1 gives the monitoring results from grab samples collected at site W-M532.6Q. This site is located in a channel, nearly two miles downstream from the gated inlet structure. DO concentrations here ranged from 2.20 mg/l – 22.98 mg/l. Ten DO measurements were less than or equal to 5 mg/l; however, none of these occurred during the winter months. Six of the low DO readings occurred from July 11-September 17, 2002. These readings could possibly be due to oxygen demand created by an algal bloom which was evident in the main basin of the lake for nearly the entire summer. The monitoring results from grab samples collected at site W-M534.8R are found in Table D-2. This site is located in the main basin of the lake, about one-half mile east of the gated inlet structure. DO concentrations here ranged from 3.45 mg/l – 23.33 mg/l. Five DO measurements were less than or equal to 5 mg/l, with one occurring during the winter months (3.88 mg/l on January 20, 1999). Table D-3 shows the monitoring results from grab samples collected at site W-M534.6V. This site, located in a shallow area dominated by American lotus, is nearly 1.5 miles east of the gated inlet structure. DO concentrations here ranged from 1.94 mg/l – 24.89 mg/l. Twelve DO measurements were less than or equal to 5 mg/l, with all occurring during the summer months. The monitoring results from grab samples collected by ILDNR personnel at site W-M532.3T are found in Table D-4. This site is located in an open area of the lake, about three miles southeast of the gated inlet structure. DO concentrations here ranged from 2.5 mg/l – 25.0 mg/l. The DO concentration was less than or equal to 5 mg/l only once (January 11, 2001) at this location.

Of the 28 DO measurements which were less than or equal to 5 mg/l, only two occurred during the winter months. The first of these was a concentration of 3.88 mg/l, measured on January 20, 1999 at site W-M534.8R. The DO concentrations at sites W-M532.6Q and W-M534.6V on this date were 5.94 mg/l and 14.92 mg/l, respectively. On January 15, 1999 the gate to the inlet structure was opened 3 inches. The results from the dye study (to be discussed later) would suggest that at a gate opening of only 3 inches, inflowing oxygenated water probably did not reach site W-M534.8R by the January 20, 1999 sampling date. Sites W-M534.6V and W-M532.6Q are located in or near vegetation beds; thus, it is possible that photosynthesis by attached algae contributed to the higher DO concentrations measured here. Site W-M534.8R is located in an open area that is relatively devoid of vegetation.

The second low winter DO concentration (2.5 mg/l) was measured by ILDNR personnel at site W-M532.3T on January 11, 2001. On December 1, 2000 the gate to the inlet structure was opened 6 inches. Apparently this was not sufficient to prevent low DO concentrations at site W-M532.3T. CORPS personnel did not collect grab samples on this sampling date; however, an in-situ continuous monitor deployed on December 20, 2000 at site W-M532.6Q also measured DO concentrations below 5 mg/l on January 11, 2001. The results from this deployment (to be discussed in detail later) showed an extended period of low DO concentrations, which was likely responsible for a fish kill reported during this time. According to Ed Britton, District Manager for the Savanna District of the Upper Mississippi River National Wildlife and Fish Refuge, ice fisherman first reported dead fish on January 14, 2001 in the lower unit of Spring Lake and on January 16, 2001 in the upper unit. Several species were found including carp, walleye, northern pike, gar, bluegill and redear sunfish. The fish kill was confirmed by CORPS personnel on their January 31, 2001 sampling trip.

In-situ continuous monitors were deployed at site W-M532.6Q on seven occasions during the winter months. The monitor deployed on January 3, 2002 did not contain any useable data; however, DO readings taken in the field at the time of deployment and retrieval indicated supersaturated conditions. As discussed previously, a fish kill was reported in January 2001. This event coincided with an extended period of low DO concentrations measured from late December 2000 through mid-February 2001 (see Figures D-1 and D-2). The DO concentration was below 5 mg/l for 44 consecutive days. In fact, near anoxic conditions were observed for much of the period. With the exception of a brief excursion below 5 mg/l during the January 20 through February 17, 1999 deployment (see Figure D-3), the DO concentrations of the remaining winter deployments were similar to those shown in Figure D-4, where concentrations always exceeded 5 mg/l and were occasionally supersaturated.

In-situ continuous monitors were deployed at site W-M532.6Q on 29 occasions during the summer months. Data from monitors deployed on July 1, 1999 and June 11, 2002 were not useable. Representative graphs of the range of DO concentrations observed during the remaining summer deployments are found in Figures D-5 through D-8. Every summer deployment had at least one concentration fall below the 5 mg/l target level. The results from most summer deployments were similar to the August 3-17, 1999 deployment (see Figure D-5). The typical diel pattern of rising daytime DO concentrations followed by falling nighttime concentrations is evident in this figure. For most summer deployments, the diel DO pattern oscillated around the 4 to 6 mg/l range, with high DO concentrations commonly in the 6 to 8 mg/l range and low values typically in the 2 to 4 mg/l range. The most favorable DO conditions observed during a summer deployment occurred from June 8-20, 2000 (see Figure D-6). During this deployment, only two DO concentrations were below 5 mg/l and supersaturated concentrations were common during the daytime. The most adverse summer DO conditions were observed over a period of two deployments: August 21 through September 4, and September 4-17, 2002. As shown in Figures D-7 and D-8, there was one stretch where the DO was continuously below 5 mg/l for nearly 11 days.

(3) Dye Tracer Study. A dye tracer study was performed during February 2002 for the purpose of determining how oxygenated water entering via the gated inlet structure disperses throughout the lake when ice cover is present. A single slug injection of Rhodamine WT dye was dispensed in the inlet structure and tracked over a period of ten days as it dispersed throughout the lake. At the time of the study, the south gate of the inlet structure was open 10 inches.

The fluorescent dye used for the study was a 20 percent solution of Rhodamine WT. On the morning of February 5th, the dye was dispensed into the south gate well of the inlet structure and tracked over a period of ten days as it dispersed throughout the lake. Water samples were collected on nine occasions at up to 31 sampling points located throughout the lake.

The locations where dye was detected are shown on orthophotos of Spring Lake in Figures D-9 through D-11. The photos are positioned sequentially for the nine sampling events and include the time elapsed from initial addition of the dye to the beginning of each sampling event. The last photo is a cumulative map, showing all sites where dye was detected. The dye was detected only at site 1 during the first two sampling events. By sampling event three (elapsed time 7 hours), the dye was also detected at site 3. At the 22¾-hour mark, the dye was detected at sites 3 and 4 but was no longer detected at site 1. The dye was present at sites 2, 3 and 4 during the fifth sampling event (elapsed time 1 day, 5¾ hours). The dye continued to be detected at these three sites during the sixth (elapsed time 2 days, 1¼ hours) and seventh (elapsed time 3 days, 2 hours) sampling events. Dye was also detected at site 5 during the sixth sampling event and sites 5 and 8 during the seventh sampling event. During the eighth sampling event (elapsed time 6 days, 1¼ hours), the dye was additionally detected at site 7, but was no longer detected at site 3. On the final sampling event (elapsed time 10 days, 1½ hours), the dye was present at sites 5, 6, 7, 8, 11, 12, 14, 15, 19, 24 and 25. Sampling was discontinued following the ninth event as unusually warm winter temperatures resulted in significant ice melt and there was concern that dispersion of the dye by wind/wave action was becoming a factor. The final sampling event results indicate the maximum distance the dye traveled was approximately 2.5 miles over the 10-day period. The average velocity of the dye from the inlet to site 24 was approximately .015 ft/sec. The cumulative map figure indicates that over the course of the study, the dye was detected at 15 of the 31 sampling sites.

The middle portion of lower Spring Lake is bisected by Silo Island. The primary route of the dye appears to be to the east side of the island in the deeper portions of the lake. The area west of the upper part of Silo Island is relatively shallow. A significant amount of sediment deposition has occurred here due to previous failures of the perimeter levee. Much of this area is above the normal lake level and is covered with willow trees. This has somewhat isolated the area from the main basin of the lake. On the final sampling event, dye was detected at site 19, which is located in a channel near the perimeter levee where a previous failure occurred. With time, the dye most likely flowed down channels in the vicinity of the former levee breach and eventually reached sites 20, 21 and 22.

At a gate opening of 10 inches, the inflow to the lake is less than 10 percent of the total capacity of the inlet structure. The water velocity measured at site 1 (at the end of the dredged inlet channel) was 0.11 ft/sec; however, it was undetectable at site 3, which is less than 1,000 feet away. In all likelihood, the velocity of the inflow drops markedly once it leaves the dredged channel and enters the main basin of the lake. This was predicted by model studies conducted prior to project construction. A two-dimensional flow computer model, RMA-2, was used to predict the magnitude and direction of flow velocities within the lower lake. At an inflow of 175 cfs, RMA-2 predicted velocities in the range of .02 to .03 ft/sec for much of the main basin of the lake. This range is higher than the average velocity of the dye over the course of the study (.015 ft/sec). However, the inflow at the time of the study was estimated to be less than 15 cfs, which is significantly lower than the 175 cfs used in the RMA-2 model.

(4) Conclusions. The project has not been successful in attaining the target DO concentration (>5 mg/l). Extended periods of low DO concentrations have been observed in both the summer and winter months. The DO concentration during the summer months often fell below 5 mg/l; however, most of these excursions were short-lived. Only occasionally would the DO remain below 5 mg/l for more than two consecutive days. The gated inlet structure could be utilized during the summer months; however, close monitoring would be required in order to keep undesirable amounts of sediment from entering the lake.

A large fish kill during the winter of 2000/2001 was most likely attributable to low DO concentrations. The gated inlet structure was open only 6 inches at this time and by the December 20, 2000 sampling date, the ice was already 5 inches thick and snow-covered. In response to the fish kill, a dye study was performed the following winter in order to determine the dispersion pattern of oxygenated Mississippi River water entering the lake through the gated inlet. The results of this study indicate that with a 10-inch gate opening, reoxygenation of the lake occurs slowly, with the dispersion pattern favoring the deeper portions of the lake north and east of Silo Island. Dye was not detected in the sub basin of the lake west of Silo Island by day 10. A computer flow model (RMA-2) predicted a similar dispersion pattern, with virtually no flow west of Silo Island. A larger gate opening would allow for a more rapid dispersion of oxygenated water throughout the lake. However, it is difficult to predict how quickly the sub basin west of Silo Island would reoxygenate (if at all). Performance of a dye study under more typical winter conditions would most likely provide data for addressing this concern. One potential downside of using a larger gate opening would be an increase in water velocity in the main body of the lake. Over wintering centrarchids prefer areas with little or no velocity. It is unlikely that a significant increase in velocity would occur under a moderate increase in gate opening. As seen in the dye study, and predicted by the RMA-2 model, velocity falls rapidly once the inflowing water enters the main basin of the lake. Velocity measurements taken at selected locations in the lake following an increase in gate opening could verify this.

Comparisons of pre- and post-project DO data from surface samples collected at sites W-M532.6Q, W-M534.8R and W-M534.6V are summarized in Table D-5. The average DO concentration at the three sites during the post-project period was lower than that for the pre-project period. Due to the short time frame of the two study periods, the value of making statistical comparisons is somewhat limited. One factor that probably resulted in the lower post-project average DO concentrations was closure of the breach in the perimeter levee. Pre-project data were gathered while the breach still existed. A significant volume of oxygenated water entered the lake through the breach, along with an undesirable sediment load; thus, it was essential that the breach be closed. The gated inlet structure was designed to allow oxygenated water into the lake during periods when the suspended sediment load of the river is relatively low (primarily winter months). Results from this initial performance evaluation indicate that a larger gate opening may be necessary in order to prevent fish kills during winters when particularly adverse conditions (early onset of snow-covered ice) occur. Opening the gate sooner may also help prevent fish kills, but this would increase the likelihood of undesirable sediment entering the lake.

Further studies are needed to determine how the inlet structure should be operated in order to maximize fishery benefits.

DATE	WATER DEPTH (M)	VELOCITY (FT/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)	TOTAL SUSPENDED SOLIDS (MG/L)
12/17/1998	1.52	0.11	1.9	15.17	*	78.0	31.0
1/20/1999	1.31	0.00	3.1	5.94	7.80	-	7.0
2/17/1999	1.10	**	1.4	15.74	8.60	38.0	9.0
3/18/1999	2.13	0.32	5.4	11.74	8.80	100.0	65.0
5/25/1999	2.74	**	17.0	8.89	7.67	80.0	27.0
6/15/1999	2.26	0.10	21.1	8.24	8.30	90.0	37.0
7/1/1999	2.32	0.04	24.5	6.46	8.30	110.0	24.0
7/20/1999	2.32	0.09	27.2	3.37	7.70	49.0	24.0
8/3/1999	2.41	0.12	26.0	5.09	7.70	43.0	23.0
8/17/1999	2.38	0.04	23.4	6.65	7.90	32.0	11.0
8/31/1999	2.33	0.10	22.0	4.23	7.70	21.0	9.0
9/14/1999	2.30	0.18	17.1	4.88	7.80	14.0	<1
9/28/1999	2.18	0.00	16.3	6.16	8.20	19.0	23.0
2/1/2000	2.41	0.00	1.3	11.88	7.80	36.0	6.0
3/2/2000	2.35	-	6.7	13.00	8.50	22.0	18.0
3/28/2000	2.40	**	7.9	10.95	8.40	66.0	43.0
6/8/2000	2.62	0.09	22.2	12.32	8.80	37.0	18.0
6/20/2000	2.40	-	22.9	6.94	8.10	24.0	39.0
7/11/2000	2.20	-	26.0	4.76	7.80	30.0	15.0
8/1/2000	2.03	-	25.1	6.53	8.10	14.0	6.0
8/15/2000	2.17	-	27.3	5.50	8.10	13.0	2.0
8/29/2000	2.15	*	24.4	5.10	7.80	14.0	7.0
9/12/2000	2.14	*	23.0	6.54	7.90	21.0	6.0
9/26/2000	2.00	*	13.3	7.54	7.70	9.4	23.0
12/20/2000	2.23	-	1.6	13.89	8.60	18.0	6.0
1/31/2001	2.30	0.00	0.4	6.52	7.60	3.4	3.0
2/27/2001	2.38	0.00	1.5	20.26	8.10	6.3	1.0
3/27/2001	2.08	0.00	2.7	16.07	8.60	11.0	8.0
5/30/2001	2.58	-	19.3	9.52	8.40	30.0	10.0
6/13/2001	0.81	0.16	26.7	10.10	8.70	54.0	21.0
6/26/2001	2.78	0.05	24.5	14.40	8.80	77.0	19.0
7/10/2001	2.23	0.10	29.6	8.56	8.50	49.0	20.0
7/24/2001	2.24	0.00	30.4	7.52	8.40	29.0	5.0
8/7/2001	1.80	-	29.8	8.69	8.80	22.0	4.0
8/21/2001	2.00	-	22.4	7.34	7.90	23.0	16.0
9/5/2001	2.17	0.00	22.6	5.85	8.30	17.0	3.0
1/3/2002	2.10	0.00	24.0	22.98	8.10	30.0	10.0
3/6/2002	2.22	0.00	1.5	20.89	8.20	13.0	1.0
6/11/2002	2.25	-	25.4	6.68	8.50	41.0	15.0
6/25/2002	2.15	-	29.6	8.52	8.70	41.0	8.0
7/11/2002	2.30	-	24.4	4.32	7.70	2.5	2.0
7/25/2002	2.20	0.00	25.5	3.73	8.10	12.0	1.0
8/8/2002	2.10	0.00	24.8	3.69	7.90	7.0	3.0
8/21/2002	2.20	-	23.5	4.92	8.00	5.5	1.0
9/4/2002	2.17	0.00	22.8	2.20	7.40	5.1	1.0
9/17/2002	1.40	0.00	21.0	3.69	7.50	6.1	<1
12/12/2002	2.09	-	3.6	18.67	8.57	-	-
MIN.	0.81	0.00	0.4	2.20	7.40	2.50	<1
MAX.	2.78	0.32	30.4	22.98	8.80	110.0	65.0
AVG.	2.15	0.06	18.0	8.99	-	32.52	13.74

* Meter malfunction

** Too windy to take measurement

Table C-1 Water Quality Monitoring Results At Site W-M532.6Q

Table C-2 Water Quality Monitoring Results At Site W-M534.8R

DATE	WATER DEPTH (M)	VELOCITY (FT/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)	TOTAL SUSPENDED SOLIDS (MG/L)
12/17/1998	0.82	0.00	1.9	15.09	*	49.0	31.0
1/20/1999	0.82	-	3.6	3.88	7.90	4.2	5.0
2/17/1999	0.90	**	0.8	15.84	8.60	39.0	12.0
3/18/1999	0.75	**	5.7	12.64	8.60	80.0	79.0
5/25/1999	1.37	**	16.8	10.63	8.23	110.0	26.0
6/15/1999	1.10	**	21.8	8.40	8.40	110.0	29.0
7/1/1999	0.98	0.05	24.2	5.80	7.80	66.0	12.0
7/20/1999	1.22	0.11	26.5	3.72	7.60	38.0	28.0
8/3/1999	1.10	0.10	26.4	6.18	7.80	59.0	15.0
8/17/1999	0.91	0.00	23.1	6.17	7.80	50.0	20.0
8/31/1999	1.22	0.00	21.7	4.30	7.80	31.0	29.0
9/14/1999	0.90	0.00	17.1	6.02	7.90	31.0	27.0
9/28/1999	0.87	*	16.4	6.49	8.20	37.0	94.0
2/1/2000	0.85	0.00	0.8	14.12	7.80	13.0	<1
3/2/2000	0.98	-	7.6	13.71	8.60	26.0	10.0
3/28/2000	0.90	**	7.5	12.07	8.20	53.0	54.0
6/8/2000	1.35	0.06	21.4	6.82	8.10	16.0	20.0
6/20/2000	1.25	-	23.1	6.73	8.20	18.0	37.0
7/11/2000	0.95	-	26.4	6.95	8.00	21.0	15.0
8/1/2000	0.87	-	24.9	6.58	8.10	32.0	25.0
8/15/2000	0.94	-	27.5	5.82	8.00	20.0	6.0
8/29/2000	0.84	*	24.5	5.20	7.80	29.0	29.0
9/12/2000	1.20	*	22.9	6.81	7.90	32.0	26.0
9/26/2000	0.90	*	13.8	8.35	7.90	23.0	35.0
1/31/2001	1.00	0.00	0.4	11.53	7.60	<1	2.0
2/27/2001	1.00	-	1.6	17.79	8.00	14.0	6.0
3/27/2001	1.56	0.00	1.9	16.04	8.60	<1	13.0
5/30/2001	1.49	-	19.3	9.53	8.60	<1	30.0
6/13/2001	1.44	0.12	25.7	9.90	8.60	41.0	19.0
6/26/2001	1.65	0.00	25.2	13.29	9.30	84.0	18.0
7/10/2001	1.28	-	27.8	7.62	8.80	78.0	28.0
7/24/2001	1.18	0.00	30.1	5.02	7.90	32.0	8.0
8/7/2001	1.44	-	29.7	5.00	7.80	48.0	11.0
8/21/2001	1.08	-	21.9	6.11	7.80	83.0	26.0
9/5/2001	1.02	0.00	23.4	6.27	8.00	60.0	14.0
3/6/2002	1.03	0.00	2.5	23.33	8.30	26.0	14.0
6/11/2002	1.51	-	25.5	7.09	8.80	12.0	9.0
6/25/2002	1.28	-	29.8	17.8	9.90	114.0	17.0
7/11/2002	1.36	-	24.2	6.95	8.90	150.0	21.0
7/25/2002	1.33	-	24.5	3.45	8.50	156.0	22.0
8/8/2002	1.20	0.00	25.4	8.20	8.50	139.0	27.0
8/21/2002	1.32	-	22.9	6.65	8.20	190.0	36.0
9/4/2002	1.41	0.00	23.6	5.95	7.80	116.0	21.0
9/17/2002	1.45	0.00	20.9	8.08	8.00	101.0	28.0
12/12/2002	1.14	-	2.8	19.70	8.46	-	-

MIN.	0.75	0.00	0.4	3.45	7.60	<1	<1
MAX.	1.65	0.12	30.1	23.33	9.90	190.0	94.0
AVG.	1.14	0.02	18.1	9.19	-	55.29	23.51

* Meter malfunction

** Too windy to take measurement

Table C-3 Water Quality Monitoring Results At Site W-M534.6V

DATE	WATER DEPTH (M)	VELOCITY (FT/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)	TOTAL SUSPENDED SOLIDS (MG/L)
12/17/1998	0.69	0.09	1.8	15.60	*	63.0	31.0
1/20/1999	0.78	-	2.3	14.92	8.20	5.6	5.0
2/17/1999	0.87	-	0.8	15.26	8.60	41.0	20.0
3/18/1999	0.70	**	5.8	12.97	8.60	90.0	130.0
5/25/1999	1.52	**	16.1	11.08	8.60	110.0	18.0
6/15/1999	0.98	**	22.2	9.79	9.00	140.0	38.0
7/1/1999	0.88	0.00	24.7	7.95	8.40	62.0	17.0
7/20/1999	0.85	0.00	26.5	2.25	7.40	<1	6.0
8/3/1999	0.61	0.00	25.8	3.48	7.60	47.0	41.0
8/17/1999	0.88	0.00	22.8	4.49	7.60	34.0	18.0
8/31/1999	0.88	0.00	21.0	1.94	7.50	8.6	3.0
9/14/1999	0.72	0.00	16.3	3.49	7.60	5.2	15.0
9/28/1999	0.67	0.00	15.4	5.87	8.10	25.0	25.0
2/1/2000	0.91	0.00	1.5	9.68	7.80	42.0	7.0
3/2/2000	0.91	-	6.9	13.20	8.50	30.0	24.0
3/28/2000	0.80	**	6.8	12.06	8.10	62.0	220.0
6/8/2000	1.26	0.00	22.1	6.60	8.10	15.0	14.0
6/20/2000	1.10	-	23.0	5.98	8.00	19.0	35.0
7/11/2000	0.83	-	25.6	5.47	7.80	15.0	42.0
8/1/2000	0.77	-	24.4	2.98	7.40	6.0	10.0
8/15/2000	0.77	-	26.5	3.57	7.40	27.0	15.0
8/29/2000	0.71	*	23.8	2.54	7.30	23.0	5.0
9/12/2000	0.80	*	21.8	3.03	7.30	19.0	27.0
9/26/2000	0.57	*	13.1	5.57	7.50	4.0	14.0
1/31//01	0.84	0.00	1.7	15.17	7.50	<1	2.0
2/27/2001	1.02	-	1.8	24.89	8.10	4.4	8.0
3/27/2001	0.78	0.00	2.5	15.98	8.80	17.0	10.0
5/30/2001	1.19	-	19.3	7.47	8.30	26.0	16.0
6/13/2001	1.13	0.00	26.8	9.50	8.60	33.0	17.0
6/26/2001	1.28	0.00	25.5	13.00	9.00	82.0	19.0
7/10/2001	0.90	-	28.7	5.47	8.10	3.1	4.0
7/24/2001	0.90	0.00	28.3	5.31	7.40	7.6	1.0
8/7/2001	0.90	-	27.6	5.12	7.20	33.0	7.0
8/21/2001	0.77	0.00	20.6	2.68	7.10	30.0	22.0
9/5/2001	0.76	0.00	20.7	2.43	7.20	22.0	15.0
3/6/2002	0.78	0.00	1.2	19.24	8.10	9.4	4.0
6/11/2002	1.15	-	25.2	7.52	8.90	10.0	6.0
6/25/2002	0.92	-	29.7	13.86	9.70	4.5	1.0
7/11/2002	1.05	-	23.4	7.41	9.10	<1	<1
7/25/2002	1.03	0.00	23.3	3.51	8.70	17.0	9.0
8/8/2002	0.90	0.00	23.4	8.33	9.10	5.0	2.0
8/21/2002	0.98	-	23.2	10.49	9.00	38.0	3.0
9/4/2002	0.94	0.00	23.3	7.03	8.70	5.4	<1
9/17/2002	1.05	0.00	20.1	6.79	8.20	6.4	<1

MIN.	0.57	0.00	0.8	1.94	7.10	<1	<1
MAX.	1.52	0.09	29.7	24.89	9.70	140.0	220.0
AVG.	0.90	0.00	18.0	8.43	-	28.38	21.1

* Meter malfunction

** Too windy to take measurement

Table C-4 Water Quality Monitoring Results At Site W-M532.3T By Bellevue, Iowa LTRM Personnel

DATE	WATER DEPTH (M)	VELOCITY (FT/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)	TOTAL SUSPENDED SOLIDS (MG/L)
12/14/1998	0.80	0.00	2.8	18.3	9.1	38.14	23.7
12/31/1998	0.85	0.00	1.2	19.3	8.4	20.10	6.7
1/12/1999	0.85	0.00	0.6	13.3	7.9	11.42	4.0
1/26/1999	0.92	0.00	1.2	12.3	7.9	3.39	4.7
2/4/1999	0.80	0.00	1.1	16.5	8.8	19.45	10.4
2/8/1999	0.96	-	2.0	14.0	8.1	3.00	3.0
3/10/1999	0.90	0.00	1.0	18.8	8.9	33.70	12.9
3/25/1999	0.90	0.00	7.4	14.3	9.0	85.76	71.4
4/7/1999	1.02	0.07	11.5	11.7	8.8	120.90	53.5
4/19/1999	1.32	0.00	10.6	19.4	9.4	76.67	26.2
5/6/1999	1.10	0.00	17.7	9.5	8.6	74.56	27.1
5/18/1999	1.48	0.08	18.2	8.0	7.9	-	46.5
6/1/1999	1.54	0.00	23.1	8.9	8.7	-	16.2
6/15/1999	1.20	0.01	21.2	7.2	8.4	93.61	30.1
6/29/1999	1.00	0.00	24.9	9.9	8.4	-	18.5
7/12/1999	1.14	0.00	29.4	25.0	8.9	-	18.9
7/29/1999	1.14	0.00	29.8	6.9	8.3	-	19.6
8/9/1999	1.02	0.00	22.8	5.7	7.9	-	21.2
8/26/1999	1.20	0.00	25.8	11.0	8.5	-	23.0
9/10/1999	0.90	0.02	19.2	7.7	8.0	-	22.2
9/23/1999	1.00	0.00	16.3	7.5	7.9	-	18.1
10/4/1999	0.90	0.00	10.7	9.5	8.2	-	29.6
10/19/1999	0.98	0.00	10.8	10.5	8.4	-	32.5
11/1/1999	0.82	0.00	13.3	10.7	8.4	-	28.0
11/15/1999	0.92	0.00	8.7	11.6	8.4	-	28.2
11/29/1999	0.82	0.00	3.1	14.1	8.6	24.42	22.4
12/14/1999	1.08	0.00	2.5	17.3	8.7	-	15.9
12/30/1999	0.98	0.00	0.7	16.4	8.3	-	8.0
1/12/2000	1.10	0.00	1.3	13.6	8.1	-	7.3
1/27/2000	0.90	0.00	1.7	14.7	8.1	-	10.6
2/10/2000	0.94	0.00	2.0	8.5	7.6	-	3.2
2/22/2000	0.90	0.00	2.5	9.9	7.5	10.84	4.8
3/6/2000	1.22	0.00	10.0	16.5	8.6	-	12.5
3/21/2000	1.12	0.00	5.3	14.6	8.4	19.91	16.1
4/6/2000	0.88	0.00	9.9	11.8	8.2	-	86.4
4/18/2000	0.99	0.00	9.2	12.7	8.7	-	28.2
5/1/2000	1.05	0.00	19.5	15.4	9.1	-	22.6
5/18/2000	0.98	0.00	19.0	5.2	7.5	17.45	19.8
6/2/2000	1.28	0.01	21.3	5.8	7.4	-	19.1
6/15/2000	1.58	0.00	22.5	9.3	8.1	-	-
6/28/2000	1.30	0.00	22.8	6.0	7.6	11.82	22.4
7/10/2000	1.10	0.00	26.2	7.5	7.9	-	20.1
7/28/2000	1.00	0.00	26.2	7.2	8.0	-	8.8
8/8/2000	1.00	0.02	25.5	6.9	8.0	1.00	13.6
8/24/2000	1.04	0.00	25.8	6.7	8.2	-	13.4
9/5/2000	1.00	0.00	20.0	7.5	8.0	-	21.2
9/21/2000	1.06	0.00	15.2	9.5	7.7	2.83	17.9
10/3/2000	1.10	0.00	19.1	7.2	8.3	-	15.9
10/16/2000	0.82	0.00	15.0	7.1	7.9	-	40.0

Table C-4 (Continued)

DATE	WATER DEPTH (M)	VELOCITY (FT/SEC)	WATER TEMP. (°C)	DISSOLVED OXYGEN (MG/L)	pH (SU)	CHLOROPHYLL a (MG/M^3)	TOTAL SUSPENDED SOLIDS (MG/L)
10/31/2000	1.18	0.00	14.1	9.8	7.9	8.63	17.8
11/15/2000	1.16	0.00	1.8	12.8	8.1	-	11.3
11/28/2000	1.06	0.00	3.3	24.0	8.8	26.79	10.8
12/13/2000	0.82	0.00	1.4	17.0	8.6	-	15.1
12/27/2000	0.74	0.00	1.5	9.1	8.0	-	7.9
1/11/2001	0.70	0.00	1.2	2.5	7.7	-	2.3
1/24/2001	0.80	0.00	1.4	5.4	7.8	-	6.4
2/7/2001	0.62	0.00	1.9	7.2	7.8	5.27	5.5
2/19/2001	0.53	0.00	1.6	19.7	8.3	-	3.7
3/6/2001	0.70	0.00	1.1	20.4	8.6	-	3.5
3/22/2001	0.90	0.00	5.2	15.3	7.9	1.00	3.2
4/4/2001	0.94	0.00	7.9	13.4	8.7	-	28.2
4/18/2001	2.80	0.00	9.2	10.2	7.8	-	19.8
5/3/2001	3.30	0.10	20.1	13.2	9.0	-	15.4
5/28/2001	1.40	0.00	18.6	10.6	8.9	-	11.7
6/15/2001	1.30	0.00	24.4	7.1	8.4	-	16.6
6/27/2001	1.40	0.00	27.6	13.8	8.9	40.72	11.9
7/11/2001	1.12	0.05	29.1	8.4	8.4	34.85	15.0
7/27/2001	0.98	0.00	24.5	8.8	8.6	-	4.4
8/7/2001	1.07	0.00	30.3	8.7	8.5	-	10.9
8/21/2001	0.90	0.00	23.0	11.5	9.0	-	12.8
9/4/2001	0.98	0.00	24.4	9.8	8.8	-	5.6
9/20/2001	1.06	0.00	19.0	7.4	7.9	5.14	8.7
10/1/2001	0.92	0.00	16.9	10.7	9.2	-	3.1
10/16/2001	1.03	0.00	9.8	11.6	8.5	-	10.0
10/29/2001	0.98	0.00	7.6	12.6	8.1	-	-
11/15/2001	0.84	0.00	12.4	15.2	8.9	100.26	34.5
11/28/2001	1.10	0.00	5.0	12.1	8.2	42.20	16.5
12/10/2001	1.08	0.00	3.5	14.5	8.7	-	17.8
MIN.	0.53	0.00	0.6	2.5	7.4	1.00	2.3
MAX.	3.30	0.10	30.3	25.0	9.4	120.90	86.4
AVG.	1.07	0.00	12.9	11.6	-	33.35	18.1

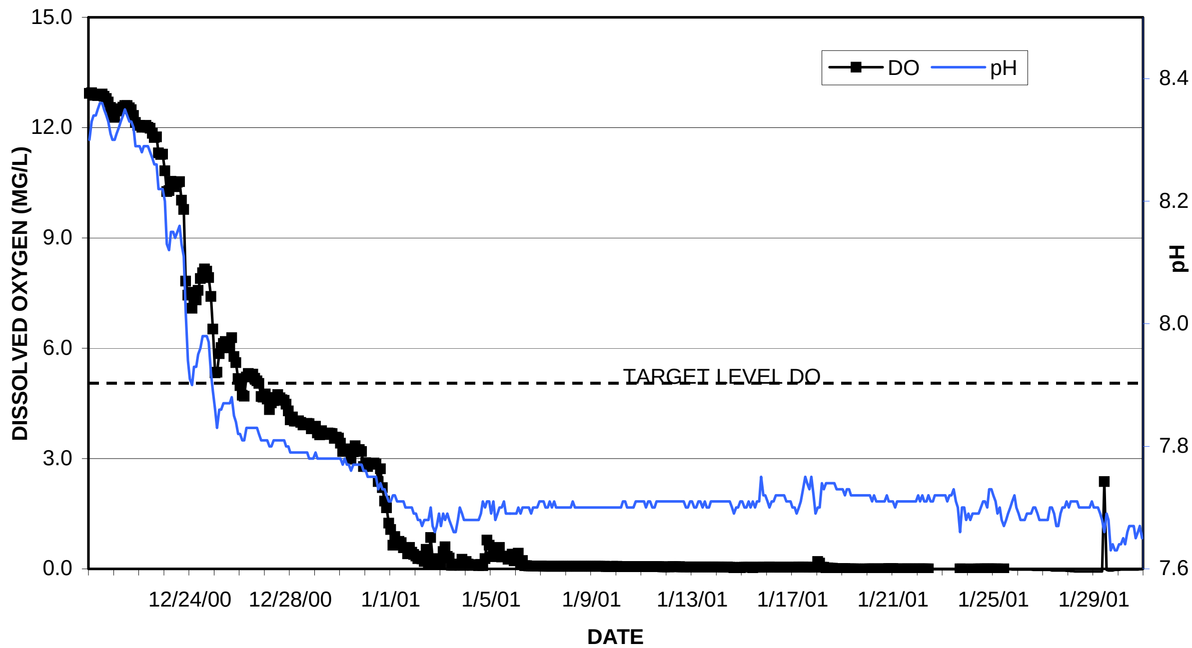

Figure C-1 W-M532.6Q Continuous Monitor (Dec. 20 2000 to Jan. 31 2001)

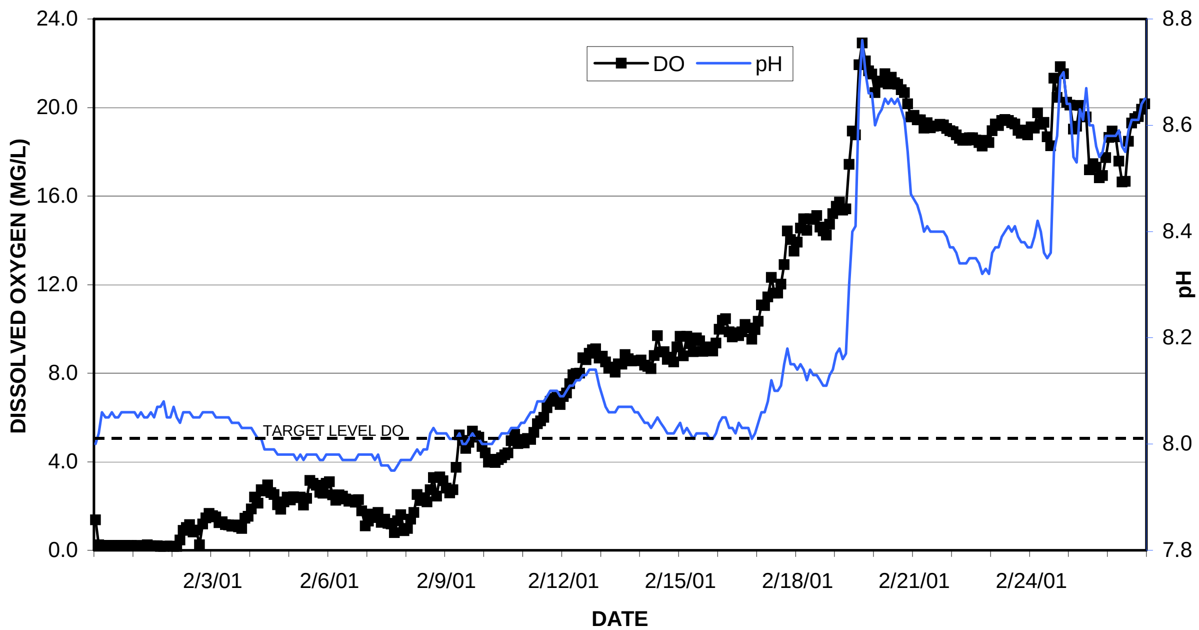

Figure C-2 W-M532.6Q Continuous Monitor (Jan. 31 to Feb. 27 2001)

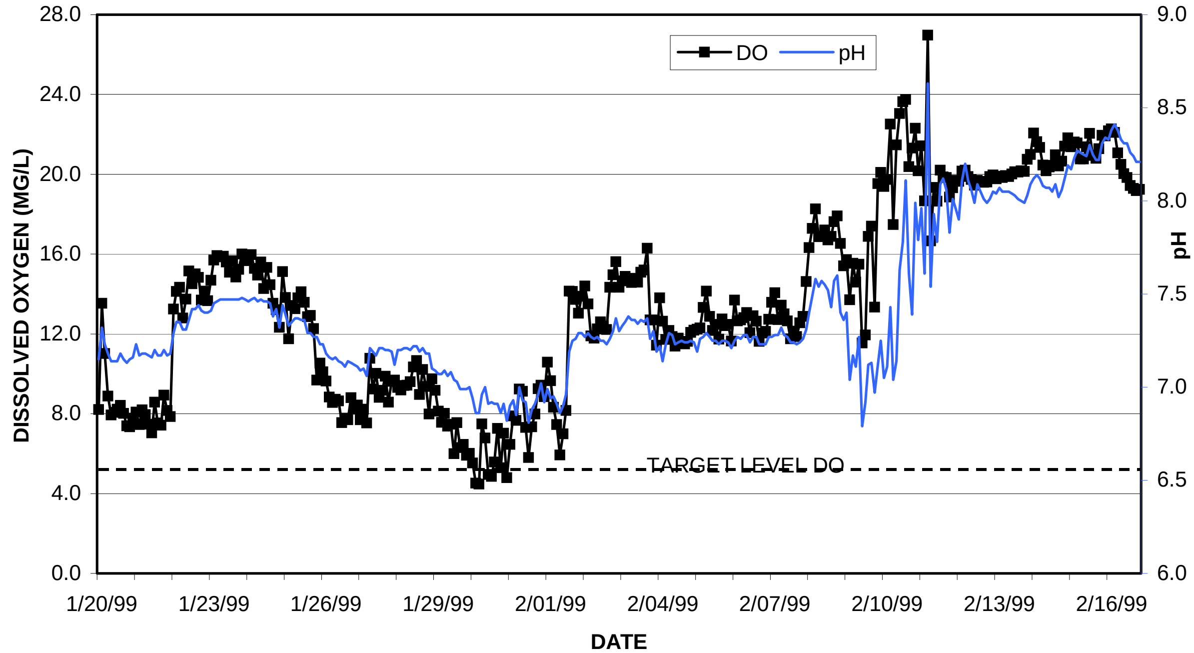

Figure C-3 W-M532.6Q Continuous Monitor (Jan. 20 to Feb. 17 1999)

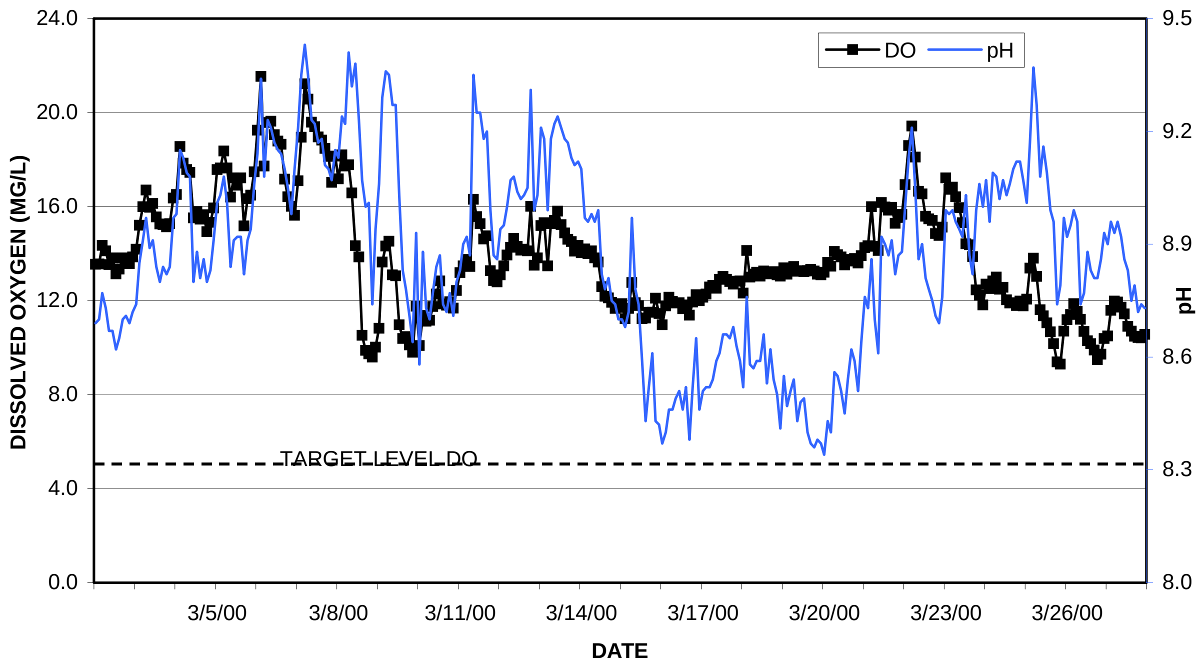

Figure C-4 W-M532.6Q Continuous Monitor (Mar. 2 to 28 2000)

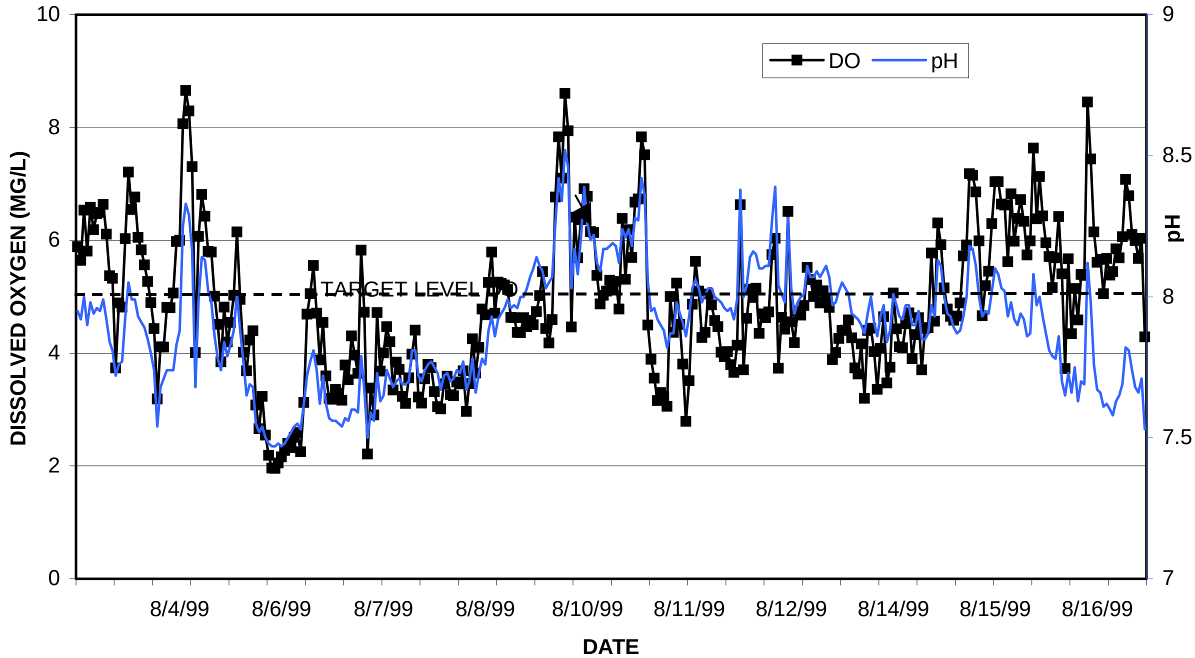

Figure C-5 W-M532.6Q Continuous Monitor (Aug. 2 to 18 1999)

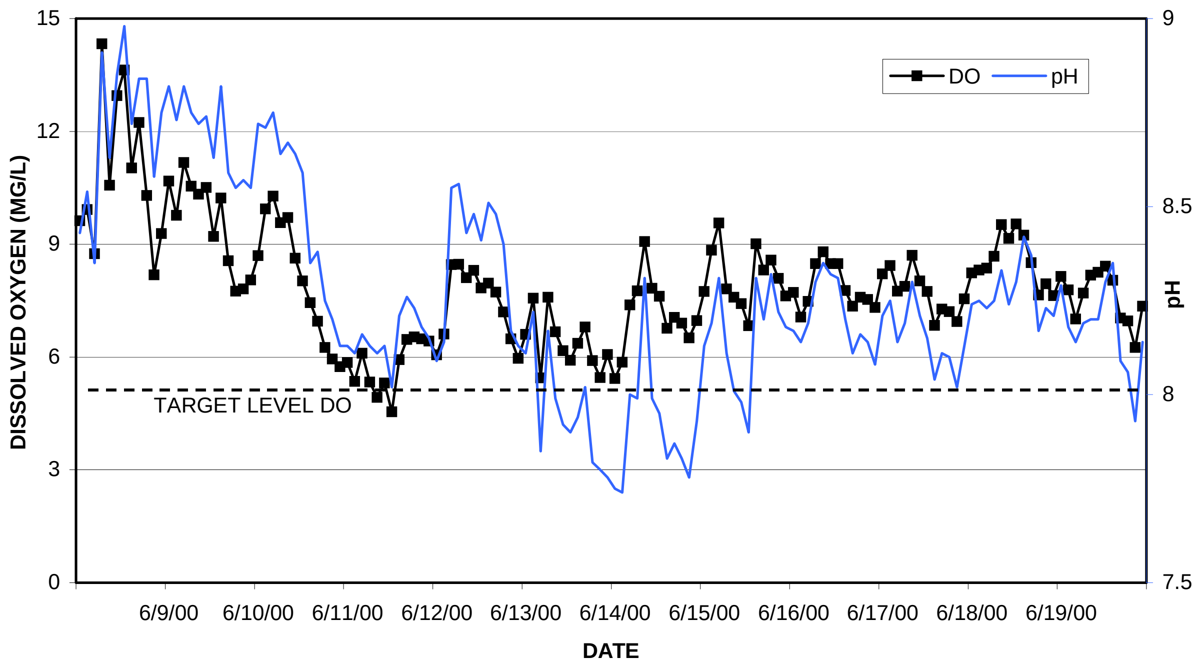

Figure C-6 W-M532.6Q Continuous Monitor (June 8 to 20 2000)

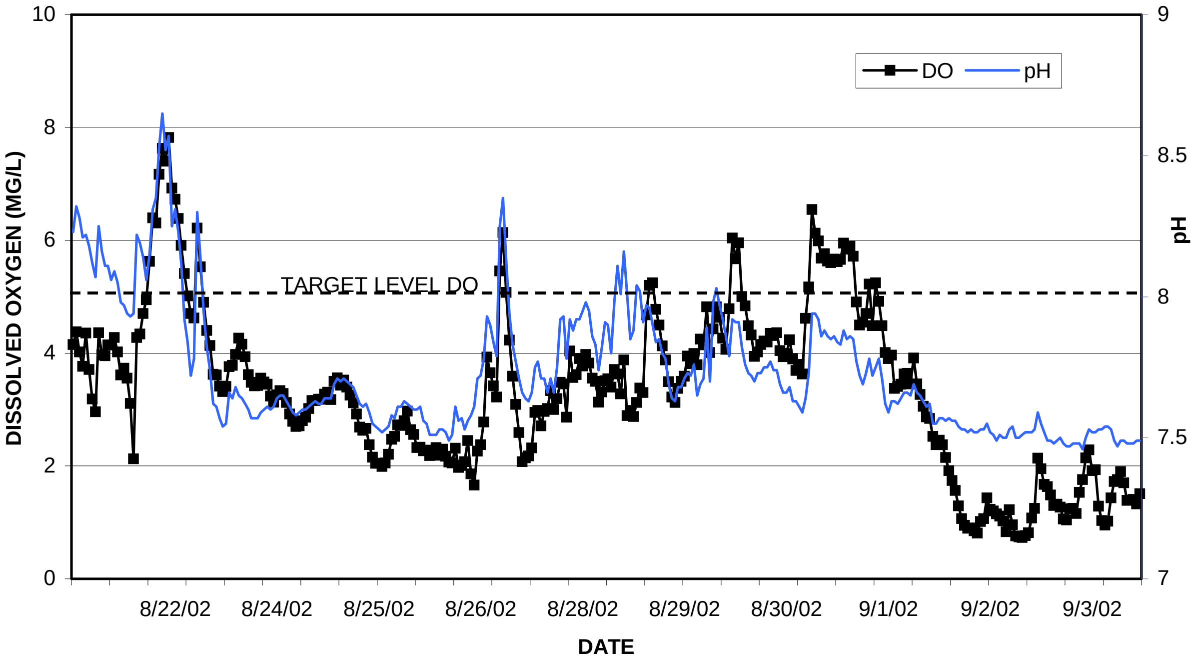

Figure C-7 W-M532.6Q Continuous Monitor (Aug. 20 to Sept. 5 2002)

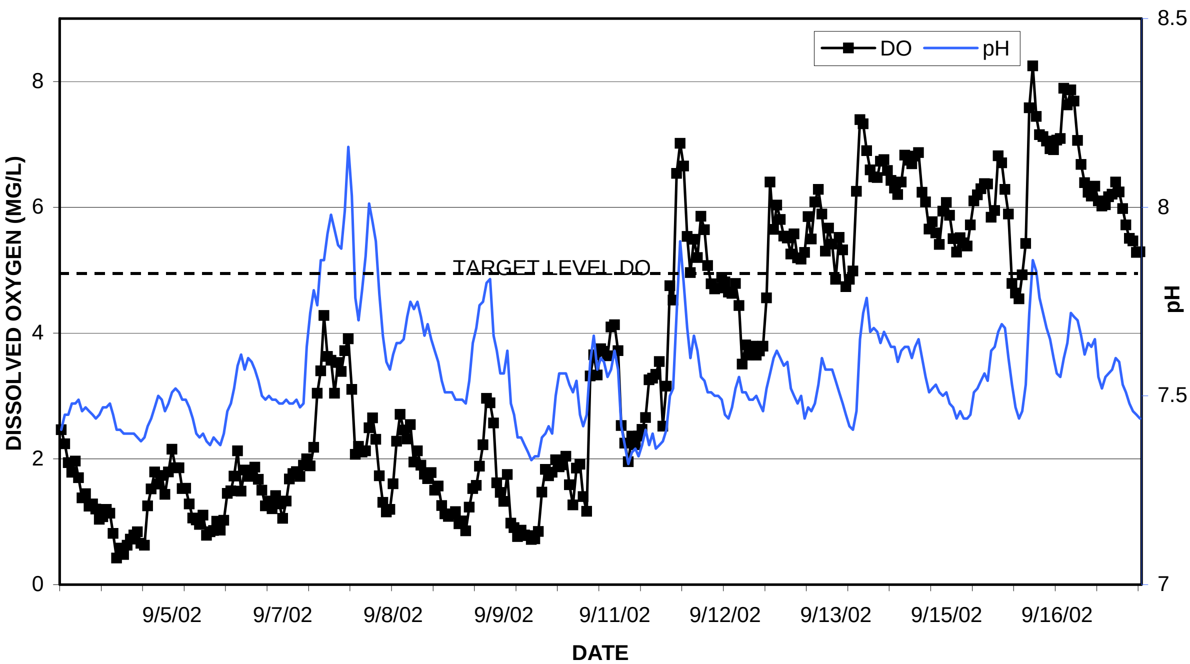

Figure C-8 W-M532.6Q Continuous Monitor (Sept. 3 to 18 2002)

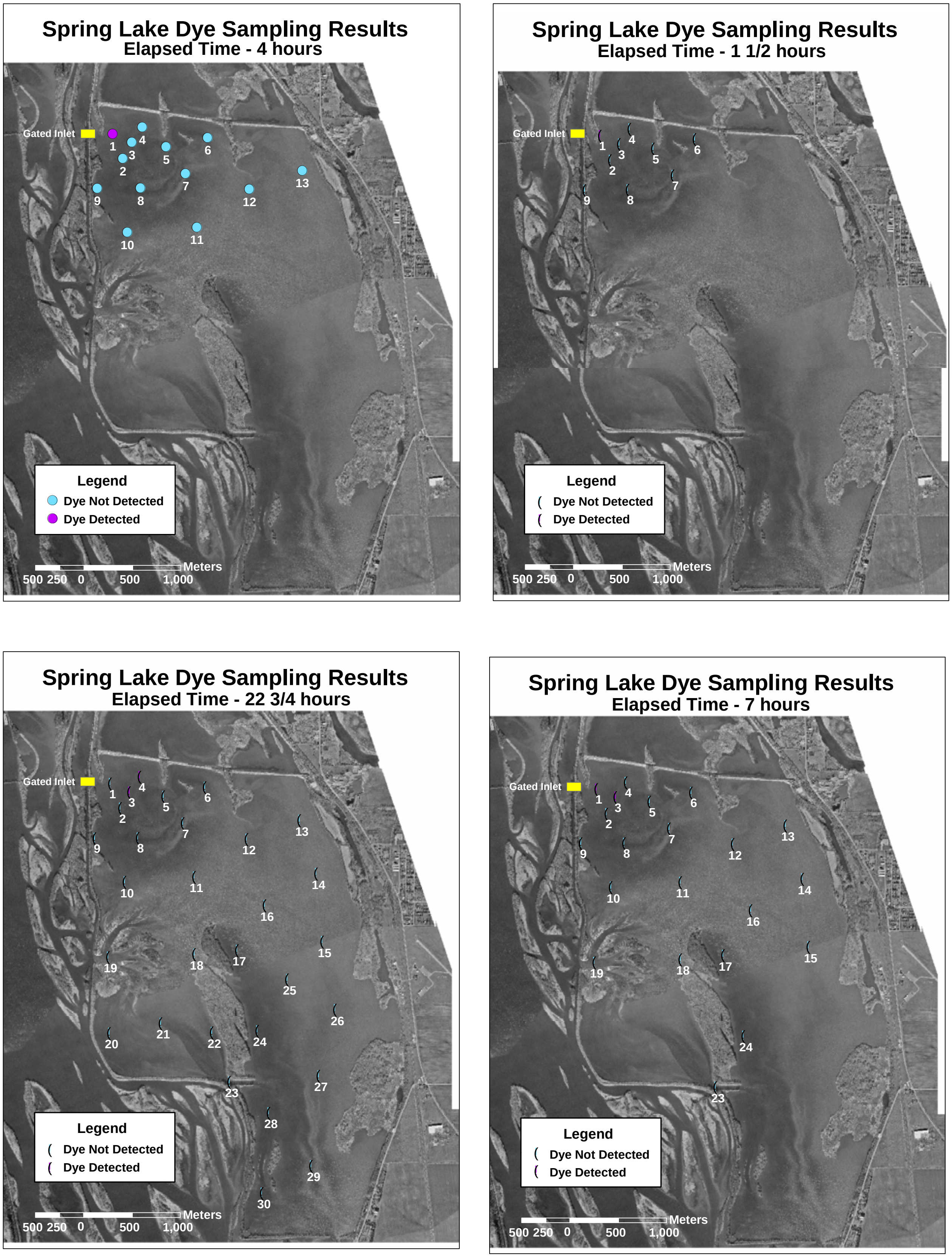

Figure C-9 Spring Lake Dye Dispersion, February 5-6, 2002.

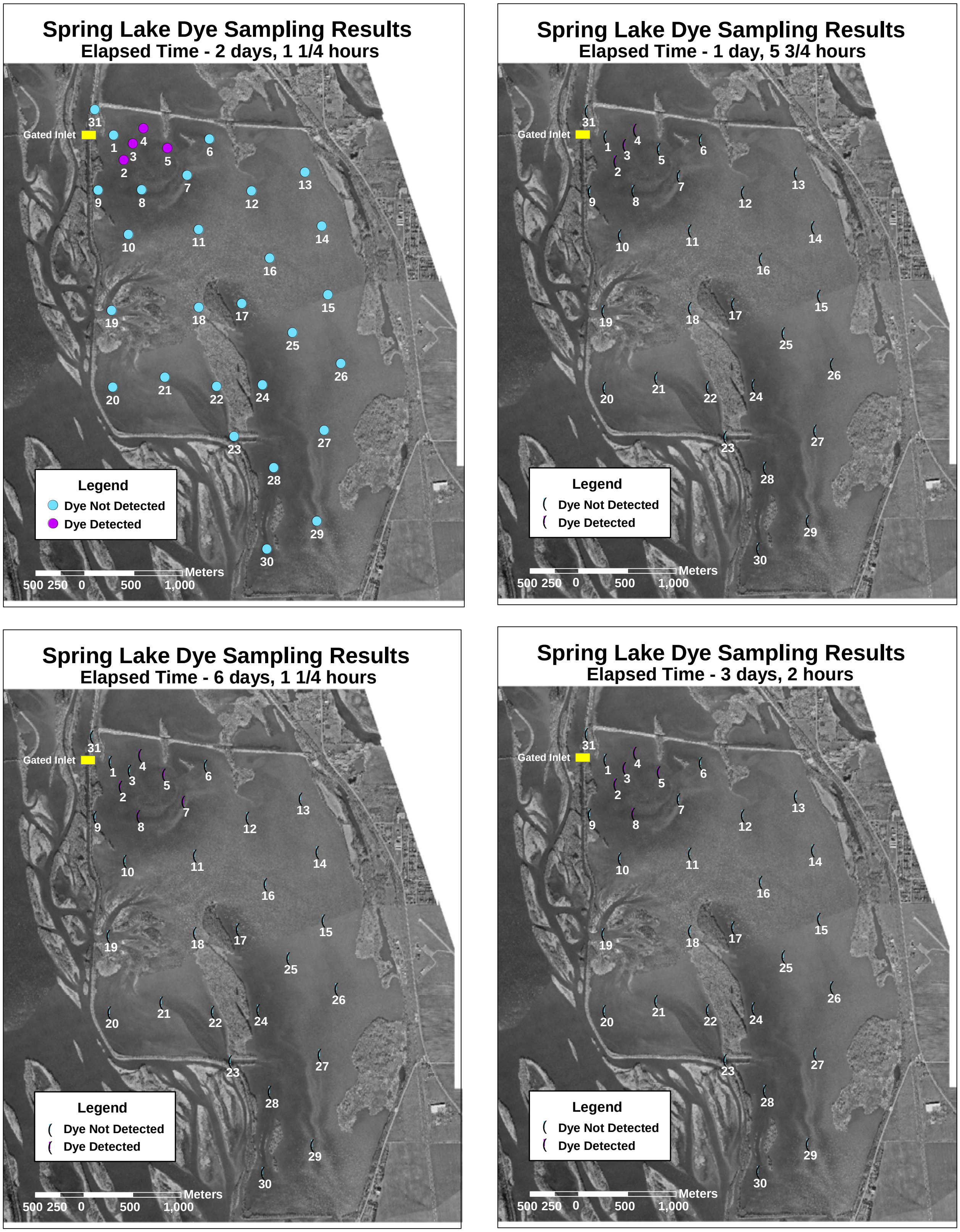

Figure C-10 Spring Lake Dye Dispersion, February 6-11, 2002.

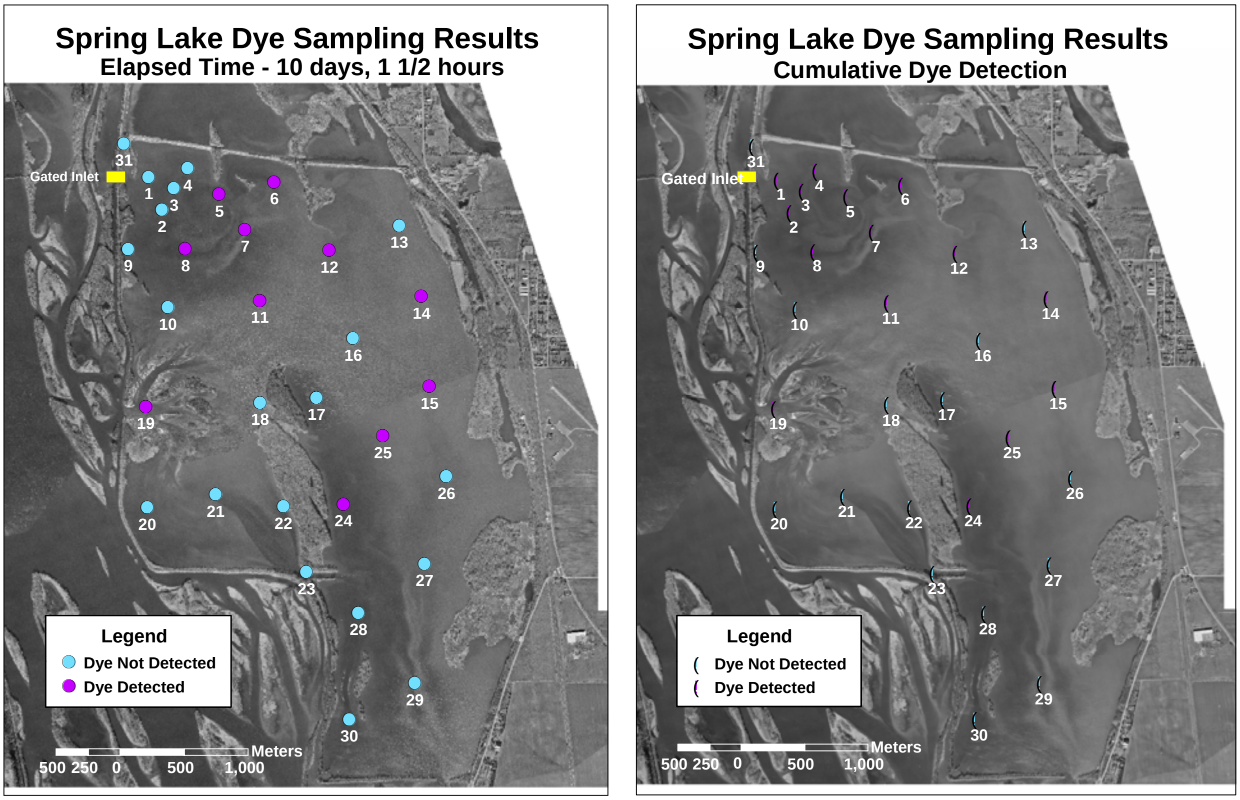

Figure C-11 Spring Lake Dye Dispersion, February 15, 2002, And A Cumulative Map Of All Sites Where Dye Was Detected.

Table C-5 Comparisons Of Pre- And Post-Project DO Data From Spring Lake

Site W-M532.6Q	Pre-Project 5/13/91–5/11/95	Post-Project 12/17/98–12/12/02
Number of Samplings	42	47
October – March Samplings	12	14
April - September Samplings	30	33
DO Concentrations ≤ 5 mg/l	3 (7.1%)	10 (21.3%)
DO Concentrations ≤ 5 mg/l (October – March Samplings)	0	0
DO Concentrations ≤ 5 mg/l (April - September Samplings)	3 (10.0%)	10 (30.3%)
Minimum DO Concentration (mg/l)	3.10	2.20
Maximum DO Concentration (mg/l)	22.70	22.98
Average DO Concentration (mg/l)	9.59	8.99

Site W-M534.8R	Pre-Project 5/13/91–5/11/95	Post-Project 12/17/98–12/12/02
Number of Samplings	41	45
October – March Samplings	13	12
April - September Samplings	28	33
DO Concentrations ≤ 5 mg/l	4 (9.8%)	5 (11.1%)
DO Concentrations ≤ 5 mg/l (October – March Samplings)	0	1 (8.3%)
DO Concentrations ≤ 5 mg/l (April - September Samplings)	4 (14.3%)	4 (12.1%)
Minimum DO Concentration (mg/l)	3.55	3.45
Maximum DO Concentration (mg/l)	18.37	23.33
Average DO Concentration (mg/l)	9.62	9.19

Site W-M534.6V	Pre-Project 9/29/93–5/11/95	Post-Project 12/17/98–9/17/02
Number of Samplings	18	44
October – March Samplings	8	11
April - September Samplings	10	33
DO Concentrations ≤ 5 mg/l	0	12(27.3%)
DO Concentrations ≤ 5 mg/l (October – March Samplings)	0	0
DO Concentrations ≤ 5 mg/l (April - September Samplings)	0	12 (36.4%)
Minimum DO Concentration (mg/l)	5.38	1.94
Maximum DO Concentration (mg/l)	20.60	24.89
Average DO Concentration (mg/l)	11.14	8.43

APPENDIX D

REFERENCES

Published reports which relate to the Spring Lake project or which were used as references in the production of this document are presented below.

(1) *Definite Project Report (R-12F) with Integrated Environmental Assessment, Spring Lake Rehabilitation and Enhancement, Pool 13, River Miles 532-536, Upper Mississippi River, Carroll County, Illinois*, May 1993 (DPR). This report presents a detailed evaluation of alternatives to enhance the wetland and aquatic habitat for resident species and migratory waterfowl at Spring Lake. Recommended alternatives include levee restoration, Upper Lake and Lower Lake water control, inlet structures, and hemi–marsh. This report marks the conclusion of the planning process and serves as a basis for approval of the preparation of final plans and specifications and subsequent project construction.

(2) *Plans and Specifications, Upper Mississippi River Environmental Management Program, Pool 13, River Mile 532 thru 536, Spring Lake Rehabilitation and Enhancement Sta*, Contract No. DACW25-95-C-0020. These documents were prepared to provide sufficient detail to allow for construction. Project features include two wetland management units, a 50-year flood event perimeter levee, a 5-year flood event cross dike, a gated inlet structure and a 24-inch gatewell to the lower lake, a two-way pump station to the upper lake, and four stoplog structures.

(3) *Plans and Specifications, Post Flood Tree Re-planting, Spring Lake, Pool 13, River Mile 311, Upper Mississippi River System, Environmental Management Program, Carroll County, Illinois,* Contract No. DACW25-95-C-0021. These documents were prepared to provide detail for the installation and location of trees to be re-planted due to post-construction flooding events.

(4) *Stage III, Structural Modifications contract.* The contract was awarded on 8 September 2000, in the amount of $43,791.41, to Del-Jen under the Regional Job Order Contract (JOC). The contract was to complete some minor structural modifications from the Stage I contract.

(5) *Draft Operation and Maintenance Manual, Spring Lake Rehabilitation and Enhancement, Upper Mississippi River Environmental Management Program, Pool 13, River Miles 532-536, Carroll County, Illinois,* March 1998 (O&M Manual). This manual was prepared to serve as a guide for the operation and maintenance of the Spring Lake project. Operation and maintenance instructions for major features of the project are presented in this manual.

APPENDIX E

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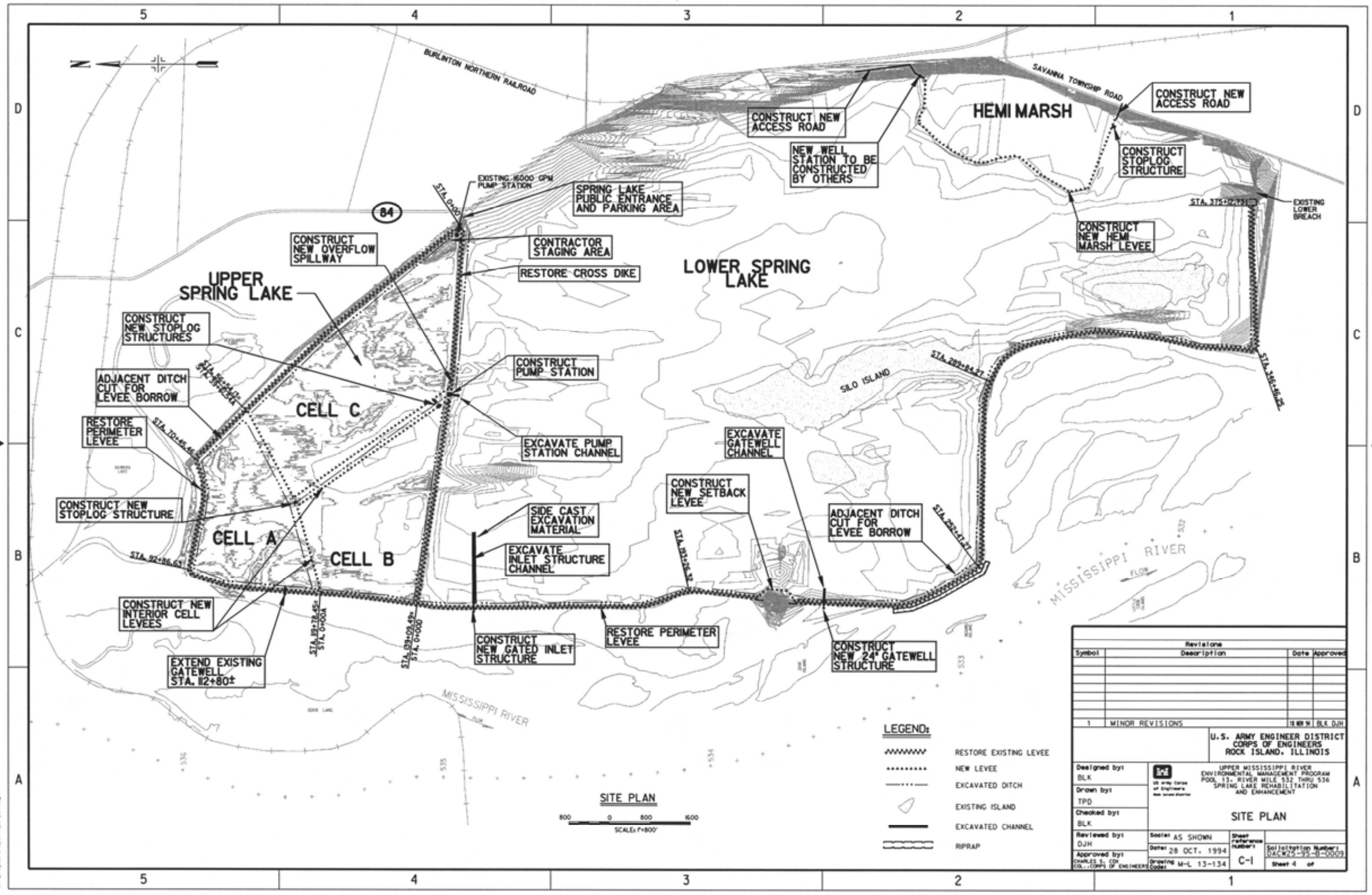
APPENDIX F

PLATES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NEW WELL STATION TO BE CONSTRUCTED BY OTHERS
HEMI MARSH
CONSTRUCT NEW ACCESS ROAD
CONSTRUCT STOPLOG STRUCTURE
EXISTING LOWER BREACH
CONSTRUCT NEW HEMI MARSH LEVEE
EXISTING 16000 GPM PUMP STATION
SPRING LAKE PUBLIC ENTRANCE AND PARKING AREA
84
CONTRACTOR STAGING AREA
CONSTRUCT NEW OVERFLOW SPILLWAY
RESTORE CROSS DIKE
LOWER SPRING LAKE
UPPER SPRING LAKE
CONSTRUCT NEW STOPLOG STRUCTURES
CONSTRUCT PUMP STATION
SILO ISLAND
ADJACENT DITCH CUT FOR LEVEE BORROW
CELL C
RESTORE PERIMETER LEVEE
EXCAVATE PUMP STATION CHANNEL
EXCAVATE GATEWELL CHANNEL
CONSTRUCT NEW SETBACK LEVEE
CONSTRUCT NEW STOPLOG STRUCTURE
SIDE CAST EXCAVATION MATERIAL
ADJACENT DITCH CUT FOR LEVEE BORROW
CELL A
CELL B
EXCAVATE INLET STRUCTURE CHANNEL
MISSISSIPPI RIVER
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CONSTRUCT NEW GATED INLET STRUCTURE
RESTORE PERIMETER LEVEE
CONSTRUCT NEW 24" GATEWELL STRUCTURE
EXTEND EXISTING GATEWELL STA. 112+80±
MISSISSIPPI RIVER
LEGEND:
RESTORE EXISTING LEVEE
NEW LEVEE
EXCAVATED DITCH
EXISTING ISLAND
EXCAVATED CHANNEL
RIPRAP
SITE PLAN
SCALE: 1"=800'
Revisions
Symbol
Description
Date
Approved
1
MINOR REVISIONS
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ROCK ISLAND, ILLINOIS
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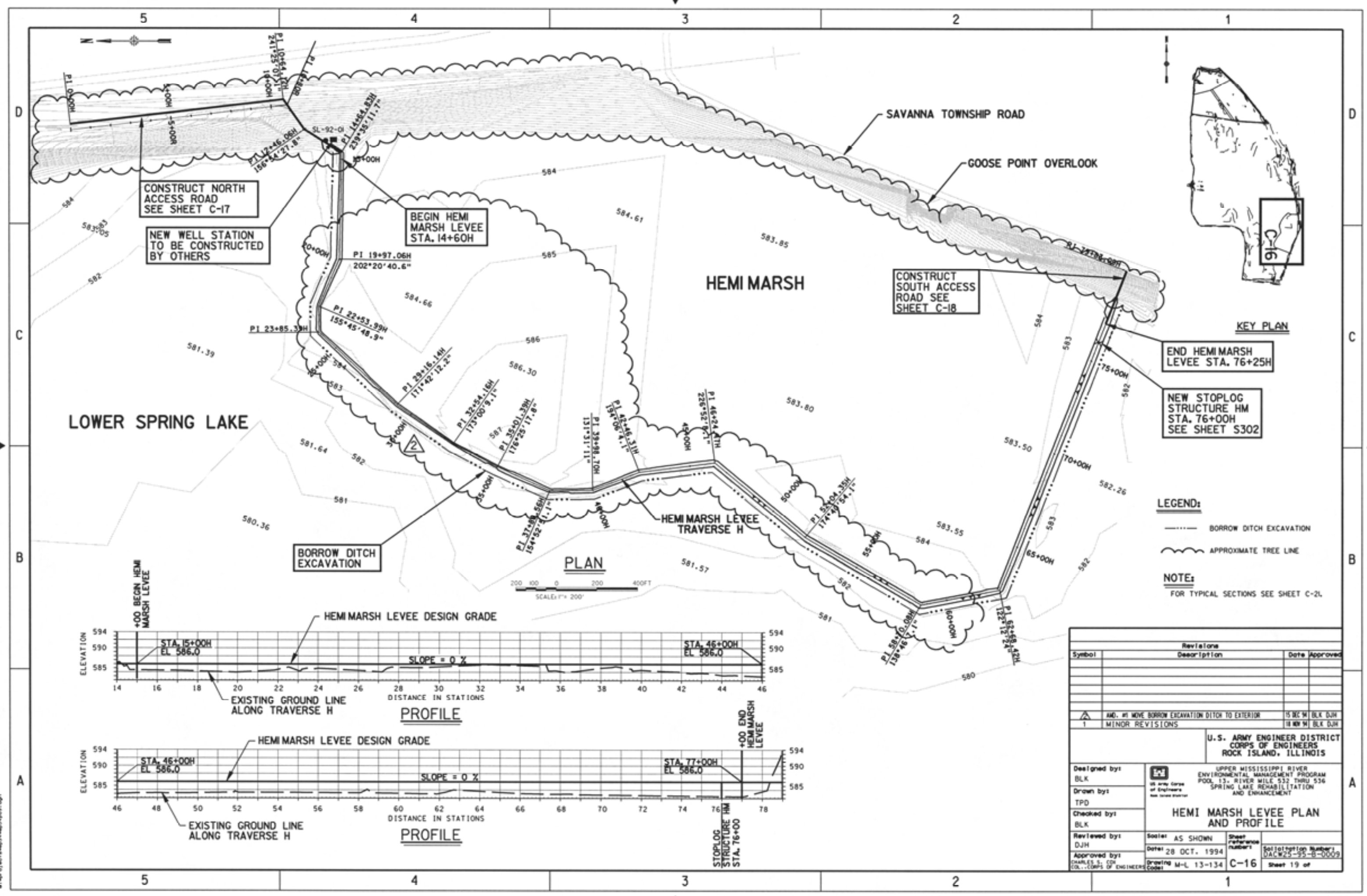
Designed by: BLK
Drawn by: TPD
Checked by: BLK
Reviewed by: DJH
Approved by: CHARLES S. COX COL., CORPS OF ENGINEERS
SITE PLAN
Scale: AS SHOWN
Date: 28 OCT. 1994
Drawing Code: M-L 13-134
C-1
Sheet 4 of

PLATE 1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HEMI MARSH
CONSTRUCT SOUTH ACCESS ROAD SEE SHEET C-18
KEY PLAN
END HEMI MARSH LEVEE STA. 76+25H
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BORROW DITCH EXCAVATION
HEMI MARSH LEVEE TRAVERSE H
PLAN
LEGEND:
BORROW DITCH EXCAVATION
APPROXIMATE TREE LINE
NOTE:
FOR TYPICAL SECTIONS SEE SHEET C-2L
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STA. 15+00H EL 586.0
STA. 46+00H EL 586.0
SLOPE = 0 %
EXISTING GROUND LINE ALONG TRAVERSE H
DISTANCE IN STATIONS
PROFILE
STA. 77+00H EL 586.0
STOPLOG STRUCTURE HM STA. 76+00
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ROCK ISLAND, ILLINOIS
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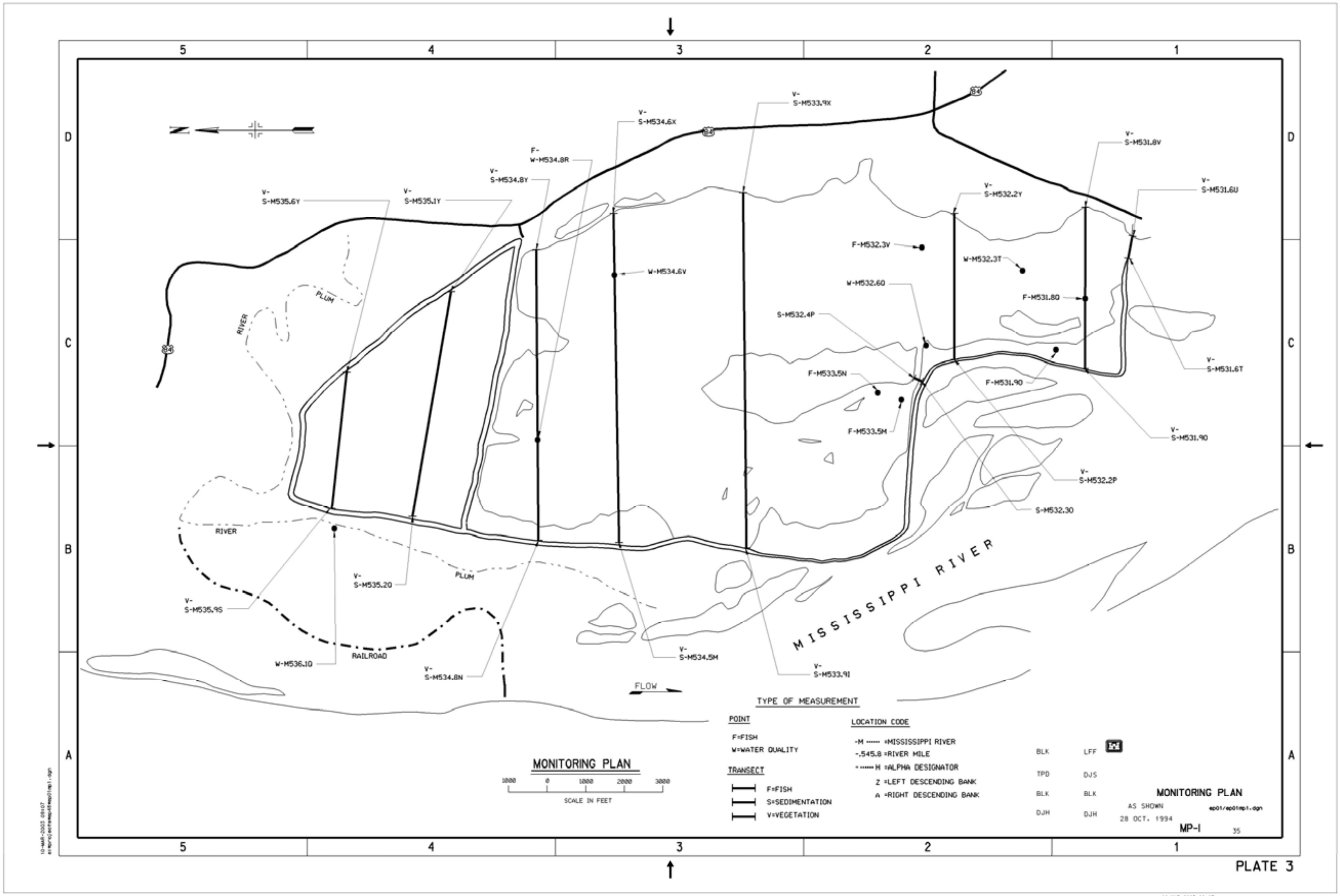
28 OCT. 1994
C-16

PLATE 2



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V-
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S-M535.9S
RAILROAD
W-M536.1Q
V-
S-M534.8N
V-
S-M534.5M
V-
S-M533.9I
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POINT
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W=WATER QUALITY
TRANSECT
F=FISH
S=SEDIMENTATION
V=VEGETATION
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-.545.8 =RIVER MILE
------ H =ALPHA DESIGNATOR
Z =LEFT DESCENDING BANK
A =RIGHT DESCENDING BANK
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SCALE IN FEET
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TPD DJS
BLK BLK
DJH DJH
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AS SHOWN
28 OCT. 1994
MP-I
35
PLATE 3