UPPER MISSISSIPPI RIVER SYSTEM
ENVIRONMENTAL DESIGN HANDBOOK

CHAPTER 3

LOCALIZED WATER LEVEL MANAGEMENT

Contents

Tables

Figures

Photographs

CHAPTER 3

LOCALIZED WATER LEVEL MANAGEMENT

3.1 Resource Problem

Large river ecosystems such as the UMRS are characterized by seasonal cycles of flood and drought (or low flow). A variety of ecological functions and processes are linked to this cycle. Development of water resources for hydropower or navigation typically alters and disrupts these natural cycles. Fortunately in the UMRS, the flood stage of the hydrograph is relatively unaltered, but low stages have been eliminated to support commercial navigation.

Much of the flora and fauna native to the Upper Mississippi River region is adapted to the wide variations in water level that characterized the river and its floodplain prior to establishment of the lock and dam system. Since the implementation of the 9-Foot Channel Project, however, these variations have been truncated and the low river stage portion of the hydrograph has been increased to support commercial navigation. This water level control, coupled with other cumulative effects, has degraded ecosystem conditions, mainly the loss of backwater depth and aquatic plants in many areas.

Numerous (twenty seven as of 2005) EMP habitat projects have attempted to recreate this variability in specific areas to benefit such species. Several responses to water level management projects have been demonstrated since the 1997 Report to Congress. For example, Lake Chautauqua on the Illinois River near Havana, Illinois has been managed as a National Wildlife Refuge since 1936, but wetland management capabilities and habitat quality had degraded over the years. Improved water level management capabilities in the southern pool completed in 1999 resulted in phenomenal wetland plant response, which, in turn, was met with the highest waterfowl use since the 1970s. Submersed aquatic vegetation and marsh plants colonized almost 1,400 acres after project completion. Fish response monitoring indicates the site can produce and export hundreds of millions of larval fish to the Illinois River.

Water level management projects that include levees, pumps, and control structures are more costly to build, maintain, and operate relative to other types of Habitat Rehabilitation and Enhancement Projects (HREPs). Recent evaluations of habitat objectives and opportunities through pool planning and the Upper Mississippi River-Illinois Waterway Navigation Feasibility Study are revealing; however, that water level management may be the only reliable mechanism in some instances to counteract the impacts of impoundment and floodplain development and thus achieve the desired habitat conditions. Evidence from EMP and other water level management projects indicates these projects can be effectively operated for multiple management objectives, including waterfowl, shorebirds, wading birds, reptiles, amphibians, and fisheries. Connectivity with main stem habitats will be a focus of future project investigations. Water control structures that can also permit fish movement are being designed and tested.

Water level management features are named differently depending on the type of habitat improvements and other considerations. For the purpose of this report, they are divided into three categories, moist soil management units, backwater lakes, and green tree reservoirs. The features which can control water levels will apply regardless of which name is chosen for the habitat.

3.2 Moist Soil Management Units

Generally, the goal of a moist-soil management unit (MSMU) is wetland habitat enhancement with the objective of providing suitable habitat for waterfowl. MSMUs are typically managed to include annual draw-downs. This technique is well accepted for wetland management and has been considered necessary for rejuvenating older, unproductive impoundments (Kadlec 1962). Stabilizing water levels, particularly at high levels, can be detrimental; and periodic drying and flooding is beneficial for establishment of desired aquatic vegetation (Weller 1978, 1981:70). The need for seasonal instability should not be equated with erratic water level changes at any time of the year (Weller 1981:70). Wildlife productivity will likely increase as wetlands experience a regular flooding cycle (Mitsch and Gosselink 1986:430).

The basic operating plan for a MSMU is to keep water out in the late spring and summer and to gradually flood the area in the fall. In a multiple cell system, it is best to be able to control water levels independently. One way to accomplish this independent filling is to have the pump discharge into a water control structure along the cross dike. This structure would be designed to have structures at both ends to control flow to either cell. A gate structure would be installed within each cell to allow independent gravity drainage. Table 3.1 represents a typical annual management plan for a MSMU.

Table 3.1. Typical MSMU Annual Management Plan

Month	Action	Purpose
April to July	Dewater area	Expose and maintain mudflats to allow vegetation
Aug to Nov	Gradually increase water levels to correspond with growth of marsh plant community	Provide access to food plants for migratory waterfowl
Dec to April	Maintain water levels to maximum extent possible and then release water late during early spring	Maintain winter furbearer habitat and then prepare for aquatic plant germination through gradual water release

MSMUs are typically designed to include water containment, water supply, and water control structures. Water containment is provided by construction of perimeter levees, cross dikes, and overflow spillways; which are used to impound water during seasonal waterfowl migrations or keep water out of the impounded area. Water supply may be provided by either river water or ground water through the use of a pump station or well, respectively. Water control structures are utilized to maintain desired water elevations throughout the year. There are many types of water control structures such as stoplog, gatewell, overflow weir, and fuse plug. The water control structures typically used for HREP projects include stoplogs, gatewells or other measures.

MSMUs are part of the HREPs listed in table 3.2.

Table 3.2. HREPS Which Include Moist Soil Management Units

Andalusia Refuge HREP, Pool 16, Upper Mississippi River Miles 462.0 - 463.0, Rock Island County, Illinois, CEMVR
Batchtown HREP, Pool 25, Upper Mississippi River Miles 242.5 - 246.0, Calhoun County, Illinois, CEMVS
Bay Island HREP, Pool 22, Upper Mississippi River Miles 311.0 - 312.0, Marion County, Missouri, CEMVR
Calhoun Point HREP, Pool 26, Upper Mississippi River Miles 221.0 – 221.0, Calhoun County, Illinois, CEMVS
Clarksville Refuge HREP, Pool 24, Upper Mississippi River Miles 275.0 – 275.0, Pike County, Missouri, CEMVS
Dresser Island HREP, Pool 26, Upper Mississippi River Miles 206.0 – 209.0, St. Charles County, Missouri, CEMVS
Guttenberg Waterfowl Ponds HREP, Pool 11, Upper Mississippi River Miles 614.0 - 615.0, Grant County, Wisconsin, CEMVP
Pleasant Creek HREP, Pool 13, Upper Mississippi River Miles 548.7 - 552.8, Jackson County, Iowa, CEMVR
Pool Slough HREP, Pool 9, Upper Mississippi River Miles 673.0 - 673.0, Allamakee County, Iowa CEMVP
Potters Marsh HREP, Pool 13, Upper Mississippi River Miles 522.5 - 526.0, Carroll and Whiteside Counties, Illinois, CEMVR
Princeton Refuge HREP, Pool 14, Upper Mississippi River Miles 504.0 - 506.4, Scott County, Iowa, CEMVR
Rice Lake HREP, LaGrange Pool, Illinois Waterway River Miles 132.0-138.0, Fulton County, Illinois, CEMVR
Spring Lake HREP, Pool 13, Upper Mississippi River Miles 532.5 - 536.0, Carroll County, Illinois, CEMVR
Stump Lake HREP, Alton Pool, Illinois Waterway River Miles 7.2 – 12.7, Jersey County, Illinois, CEMVS
Swan Lake HREP, Alton Pool, Illinois Waterway River Miles 5.0 – 13.0, Calhoun County, Illinois, CEMVS

3.3 Backwater Lake with Water Level Control

Prior to construction of the navigation system, water levels typically dropped during the summer months allowing backwater lakes to consolidate. This drying effect encouraged emergent aquatic plants, such as bulrush and arrowhead to grow. With the more stable water levels created by the navigation pools, this low-water effect and drying of sediments no longer occurs. Plant beds that depend on this drying process have decreased in extent or disappeared entirely. Stands of perennial emergent aquatic plants are important to fish and wildlife populations because they provide food, shelter, and dissolved oxygen. Hence, a backwater lake with water level control may be implemented to help improve conditions for the growth of aquatic vegetation.

Generally, the goal of a backwater lake with water level control is aquatic habitat restoration with the objective of providing suitable habitat for waterfowl and fisheries. Water level control of a backwater lake consists of a temporary seasonal increase or decrease in water elevations to mimic natural hydrologic regimes in order to improve large areas of shallow aquatic habitat.

Similar to MSMUs, backwater lakes with water level control are typically designed to include water containment, water supply, and water control structures. These are similar to those described for MSMUs. Backwater lakes with water level control are listed in Table .

Table 3.3. Backwater Lakes with Water Level Control

Batchtown HREP, Pool 25, Upper Mississippi River Miles 242.5 - 246.0, Calhoun County, Illinois, CEMVS
Banner Marsh HREP, LaGrange Pool, Illinois Waterway River Miles 138.0 - 144.0, Fulton and Peoria Counties, Illinois, CEMVR
Calhoun Point HREP, Pool 26, Upper Mississippi River Miles 221.0 – 221.0, Calhoun County, Illinois, CEMVS
Clarksville Refuge HREP, Pool 24, Upper Mississippi River Miles 275.0 – 275.0, Pike County, Missouri, CEMVS
Lake Chautauqua HREP, LaGrange Pool, Illinois Waterway River Miles 124.0 - 129.5, Mason County, Illinois, CEMVR
Lake Odessa HREP, Pools 17-18, Upper Mississippi River Miles 435.0 - 440.0, Louisa County, Iowa, CEMVR
Peoria Lake HREP, Peoria Pool, Illinois Waterway River Miles 162.0 - 181.0, Peoria and Woodford Counties, Illinois, CEMVR
Rice Lake HREP, Minnesota River Miles 15.0 – 17.5, Scott and Hennepin Counties, Minnesota, CEMVP
Small Scale Drawdown HREP, Pool 5, Upper Mississippi River Miles 746.0 – 746.0, Buffalo County, Wisconsin, CEMVP
Stump Lake HREP, Alton Pool, Illinois Waterway River Miles 7.2 – 12.7, Jersey County, Illinois, CEMVS
Swan Lake HREP, Alton Pool, Illinois Waterway River Miles 5.0 – 13.0, Calhoun County, Illinois, CEMVS
Trempealeau National Wildlife Refuge HREP, Pool 6, Upper Mississippi River Miles 718.0 – 724.0, Trempealeau County, Wisconsin, CEMVP

3.4 Green Tree Reservoirs

3.4.1. Design Methodology and Criteria . A green tree reservoir (GTR) is a forested bottomland that is temporarily flooded throughout the winter months to attract ducks, mainly mallard and wood ducks. The availability of flooded bottomland hardwood timber during the winter months is critical to the breeding success of the mallard duck. A GTR is designed to hold water while trees are dormant. This prevents permanent tree damage and possible death; hence, the name “green tree” reservoir.

GTRs enhance waterfowl habitat by providing reliable resting and feeding areas during the fall and winter months. The flooding of bottomland hardwoods to a depth of 1 to 18 inches provides ducks access to fallen acorns and other seeds.

General design criteria for a GTR include (1) a dominance of bottomland hardwood oaks, gums, and ashes at least 40 years old, (2) a minimum of 10 acres in order to attract ducks on a regular basis, (3) an area that is relatively flat to maximize the flooded acreage with a depth of 1 to 18 inches (otherwise the trees in low locations will be flooded too long and eventually die), (4) soils with good water holding capabilities, (5) an adequate water supply, (6) a close proximity to traditional waterfowl wintering grounds and flight paths, and (7) the water table must be at least 3 feet deep (totally saturated soil) during the growing season to reduce root pruning. If root pruning occurs, the tree will develop a swelled butt, have stem tip dieback, and produce few acorns. Soil moisture conditions during the growing season must be dry enough for regeneration to occur. Regeneration is the key for future GTRs.

Preferred mast trees (oaks) for a GTR must have a small acorn (fruit/seed) that can be easily consumed by waterfowl (e.g. Pin, Overcup, Nuttall, Swamp White, and native small seeded Pecan). Other preferred mast trees will depend on the project location. Ash, elm, and maple are not good mast producers in the fall, but their winged seeds are valuable and are consumed by ducks during the late winter when other mast producers are scarce.

Most GTRs are created by the construction of perimeter levees and the installation of water control structures. When necessary, pump stations or wells are also constructed to provide an adequate water supply.

There are several construction considerations when designing a perimeter levee for a GTR. The topography of the site should be surveyed. The perimeter levee should be located to flood the maximum number of hardwood trees to a depth of 1 to 18 inches. Where possible, existing roads, natural ridges, etc. should be utilized as part of the perimeter levee to lower costs. In some cases, it may be necessary for the water depth at the lower end to be greater than a couple feet to increase the water surface acreage at the upper end of the GTR. The location of the GTR should be easily accessible by vehicle for construction and O&M. The top width of the perimeter levee should be a minimum of 10 feet to accommodate vehicular access. The height of the perimeter levee should include a minimum of two feet of freeboard from the maximum water depth. An overflow spillway is typically incorporated within the perimeter levee. The side slopes of the perimeter levee and overflow spillway should be gradual to reduce erosion damage from overtopping events. The perimeter levee should be seeded with perennial grass following construction.

When designing water control structures for a GTR, the capacity of these structures is critical. Flood events that inundate the GTR during the growing season (early spring to late fall) need to be removed as quickly as possible. Flooding during the growing season can cause stress and ultimately tree mortality if not removed within a few days.

The design of a pump station or well for a GTR would be similar to that for a MSMU.

GTRs have a basic operating plan. They are flooded in the late fall and dewatered in the early spring. However, to ensure that the habitat provided by a GTR is available throughout the project life, site managers should implement the following techniques.

Flooding and dewatering dates should vary. The GTR should not be flooded before the leaves begin to turn color in the fall and should be dewatered before new leaves appear in the spring. Vary the dates of flooding in the fall up to one month and dewatering in the spring up to three months. Continue this over a several year period. Leave the GTR unflooded one out of every six to eight years.

Flooding depths should vary from year to year and even within the same season. The preferred feeding depth of many ducks is less than six inches. Partial dewatering can produce "puddles" where invertebrates concentrate, which provide an important food source.

Flood and dewater slowly. Flooding the GTR slowly provides optimum habitat conditions over an extended time period. The dewatering rate should be less than one inch per day. Otherwise, the nutrients associated with leaf decomposition that promote invertebrates and good timber vigor may be flushed away.

Timber management can improve the habitat benefits for ducks by adjusting the species composition and density of the mast trees present. This can be accomplished by selectively harvesting or killing single trees or groups of trees. The reasons for conducting timber management include the following; (1) to optimize mast production, especially those trees with a d.b.h. of greater than 14 inches, by maintaining approximately 80 square feet basal area of desirable species, (2) to maintain a variety of mast producers since no single species will produce suitable quantities of mast every year, (3) to remove less desirable trees to make room for better mast producers, and (4) to create snags that may function as suitable habitat for nesting by wood ducks and other wildlife.

General maintenance of a GTR includes periodic mowing of the perimeter levee to suppress undesirable growth, inspection of the water control structures to ensure they are functioning properly, and controlling rodent damage on the perimeter levee.

3.4.2. Lessons Learned. No lessons learned have been reported.

3.4.3. References

EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, CECW-ED-H, 16 January 1990 (original) 31 August 1992 (errata #1), http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1603/toc.htm

EM 1110-2-1913, Engineering and Design - Design and Construction of Levees, CECW-EG, 30 April 2000, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1913/toc.htm

EP 415-1-261 (Volume 2), Construction - Quality Assurance Representative's Guide - Pile Driving, Dams, Levees and Related Items, CEMP-CE, 31 March 1992, http://www.usace.army.mil/inet/usace-docs/eng-pamphlets/ep415-1-261(volume2)/toc.htm

EM 1110-2-3104, Engineering and Design - Structural and Architectural Design of Pumping Stations, CECW-ED, 30 June 1989, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-3104/toc.htm

ER 1110-2-100, Engineering and Design - Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, CECW-EP, 15 February 1995, http://www.usace.army.mil/inet/usace-docs/eng-regs/er1110-2-100/toc.htm

EM 1110-2-2705, Engineering and Design - Structural Design of Closure Structures for Local Flood Protection Projects, CECW-ED, 31 March 1994, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2705/toc.htm

Agri Drain Corporation, Inline Water Level Control Structures, http://www.agridrain.com/watercontrolproductsinline.asp

Agri Drain Corporation, Inlet Water Level Control Structures, http://www.agridrain.com/watercontrolproductsinlet.asp

EM 1110-2-3104, Engineering and Design - Structural and Architectural Design of Pumping Stations, Appendix C, CECW-ED, 30 June 1989, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-3104/toc.htm

Brinson, M. M.; Hauer, F. R.; Lee, L. C.; Nutter, W. L.; Rheinhardt, R. D.; Smith, R. D.; and Whigham, D. (1995). *A Guidebook For Application Of Hydrogeomorphic Assessments To Riverine Wetlands, Technical Report WRP-DE-11*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, NTIS No. AD A308 365.

DeZellar, Jeff. *Upper Mississippi River Water Level Management Program*, U.S. Army Corps of Engineers, St. Paul District, http://www.mvp.usace.army.mil/environment/default.asp?pageid=122 .

Frentress, Carl; Haucke, Hayden; Ortego, Brent; and Rose, Julie Hogan. *Green-Tree Reservoir Management*, Texas Parks and Wildlife Department, Wildlife Division.

Hayes, D. F.; Olin, T. J.; Fischenich, J. C.; and Palermo, M. R. (2000). *Wetlands Engineering Handbook*, ERDC/EL TR-WRP-RE-21, U. S. Army Engineer Research and Development Center, Vicksburg. View on-line or download Part1.

Lane, J. J. and Jensen, K. C. (1999). *Moist-Soil Impoundments for Wetland Wildlife, Technical Report EL-99-11*, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Managing Wetlands: Greentree Reservoirs (Flooded Live Timber), Missouri Department of Conservation, http://www.conservation.state.mo.us/landown/wetland/wetmng/10.htm .

3.4.4. Case Studies. Case studies are listed in table 3.4.

Table 3.4. Green Tree Reservoirs

Calhoun Point HREP, Pool 26, Upper Mississippi River Miles 221.0 – 221.0, Calhoun County, Illinois, CEMVS
Cuivre Island HREP, Pool 26, Upper Mississippi River Miles 233.0 – 239.0, Lincoln and St. Charles Counties, Missouri, CEMVS

3.5. Design Features Common for Water Level Management

Water level management projects have several similar design features important to the proper operation and maintenance of these systems. These features are described in the following sections.

3.5.1. Perimeter Levees, Cross Dikes, and Overflow Spillways

3.5.1.1. Design Methodology and Criteria. Some general design criteria for this project feature are to 1) construct a reliable levee system that provides adequate flood protection to meet the sponsor's seasonal and/or annual management goals and 2) locate borrow sites in areas that improve the suitable habitat for migratory birds.

Level of Protection. When designing a perimeter levee, it is crucial to prevent interior sedimentation and to provide protection against loss of water control due to flooding. Therefore, the level of protection provided by the levee system needs to be adequate. When determining the level of protection needed for the levee system, consider various flood elevations (2- year, 5-year, 10-year, 15-year, 20-year, 25-year, etc.) and determine how many times each flood elevation has been exceeded based on the data available. Then evaluate the additional cost of raising the levee to a higher levee of protection versus the decrease in the exceedance rate. The approximate level of protection of some of the HREPs are shown in table 3.5.

Table 3.5. Level of Protection

Project	Feature	Level of Protection
Andalusia	Levee	2 year
Bay Island	Levee	2 year
Spring Lake	Levee	50 year
	Cross Dike	5 year
Princeton	Levee	15 year
Lake Odessa	Levee	varies
	Upper Spillway	17 year
	Lower Spillway	10 year
Banner Marsh	Levee	50 year
Lake Chautauqua	Cross Dike and Perimeter Levee	10 year
	Radial Gate Structure	10 year
Rice Lake	Control Dike	less than 2 year
Clarksville	Levee	20 year
Stump Lake	Levee	3 to 4 year

Levee Slopes. If the perimeter levee is located adjacent to a major river, its profile parallel to that river may be sloped upstream to allow for gradual overtopping during flood events, which could minimize damage potential. Top widths for a perimeter levee are typically a minimum of 10 feet, especially for those levees that are also used for access (At times the top of the levees are used as a roadway for levee inspections or maintenance). Side slopes are typically a minimum of 3:1 horizontal to vertical. Interior side slopes of 5:1 horizontal to vertical or less can be desired to minimize rodent damage and to minimize erosion caused by overtopping (although conditions in MVS allow for interior slopes of 3H:1V) . Vegetative bank stabilization is often planted to help prevent scouring.

Cells. A MSMU may have a single perimeter levee (1-celled) or consist of multiple cells through the construction of interior cross dikes. When determining whether the levee system should be single or multiple celled, consider the existing site topography. If the site is relatively flat, a single cell may be adequate. If the site varies in elevation, multiple cells may be desired to maximize the acreage of ideal water depth. Also, large MSMU may be portioned into multiple cells for management purposes. The top elevation of a cross dike is typically set to provide a minimum freeboard of 2 feet during the highest ponding scenario.

Spillways. To provide controlled overtopping of a levee system, overflow spillways are constructed, typically at the downstream end of the site, at an elevation lower than the perimeter levee. This elevation provides for overtopping during a lesser flood event. During a flood event, the overflow spillway allows rapid filling of the MSMU interior prior to overtopping of the perimeter levee. The spillway provides a defined location for filling the cells that can be adequately armored and protected against erosion. An overtopping analysis should be conducted to determine the elevation difference between the perimeter levee and the overflow spillway.

Levee Material Sources. When considering options for borrow material for the levee system, it may be beneficial to use on-site material that is suitable. The utilization of interior borrow areas offers additional habitat benefit by converting existing cropland to non-forested wetland. Ideally, these areas would be developed as large and shallow, which would not only maximize habitat benefits but may also yield the most suitable impervious borrow material. Essentially, these borrow areas may be considered potholes. Dredged material from within or outside the levees may also be used to construct the berms. Using dredged material may provide additional aquatic habitat for the HREP.

Maintenance. Maintenance of the perimeter levees, cross dikes, and overflow spillways should include project inspections on an annual basis (ideally after the area is drained) in addition to immediately following a high water event. Project inspections should determine if the following conditions exist; (1) settlement, slough, or loss of section, (2) wave wash and scouring, (3) overtopping erosion, (4) inadequate vegetative cover (too much or not enough), (5) unauthorized grazing or traffic, (6) encroachments, (7) unfavorable tree/shrub growth, and (8) seepage distress. Corrective action should be taken upon discovery of any adverse conditions.

3.5.1.2. Lessons Learned. Lessons learned are described in Table 3..

3.5.1.3. References

EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, CECW-ED-H, 16 January 1990 (original) 31 August 1992 (errata #1), http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1603/toc.htm

EM 1110-2-1913, Engineering and Design - Design and Construction of Levees, CECW-EG, 30 April 2000, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1913/toc.htm

EP 415-1-261 (Volume 2), Construction - Quality Assurance Representative's Guide - Pile Driving, Dams, Levees and Related Items, CEMP-CE, 31 March 1992, http://www.usace.army.mil/inet/usace-docs/eng-pamphlets/ep415-1-261(volume2)/toc.htm

3.5.2. Pump Stations and Wells

3.5.2.2. Design Methodology and Criteria. Water can be introduced or removed from a MSMU or backwater lake through the use of a pump station, portable pumps, wells or a water control structure. Pumps can obtain either surface water (for example, from the river) or groundwater.

Groundwater. When evaluating a pump station versus a well (i.e. surface water versus ground water), keep in mind that reuse of surface water is desired where practicable. The size and volume of the unit will generally dictate whether a groundwater well can be feasibly constructed. Groundwater wells are limited in capacity due to available well yield from the aquifer, construction limitations, commercially available well pump size, and availability of utility power. There is also a potential of encountering poor groundwater quality (high sulfur, etc.) It may be necessary to incorporate provisions into the design to deal with situations where testing of groundwater quality reveals problems.

Surface water. Surface water is often used as a source due to its abundance and ease of access. When surface water is used, it can remove sediment from its source, and add potentially nutrient rich sediment to the MSMU or backwater lake. Additionally, the use of surface water can remove nitrogen and phosphorous from the river system, with the nutrients eventually being uptaken by plant organisms within the MSMU.

Pump Stations. Pump stations can be designed to have the intake sump and pumps with associated equipment all in one structure or they can be separate. The equipment for both pump stations and wells is required to be at or above certain flood elevations and will depend on where the project is located. Pumping stations can either be a dedicated permanent station or be mobile, including floating type pumping plants.

Water Direction. Pump stations can be designed to pump from the river to the MSMU, from the MSMU to the river, or be multi-directional to pump to multiple MSMUs as well as either way. Extra flexibility may be desired by the project sponsor, although water control could be obtained through the use of various closure structures if so designed.

Pump Size. When determining the size of the pumps for a pump station or well, a minimum of three variables need to be determined; the evaporation rate, the seepage rate, and the desired fill rate.

Energy Source. Pumps may be electric or diesel driven depending upon the availability of utility power and user needs. Electric driven pump stations have the advantage of being quieter to operate (little vibration), easier automation, and less routine maintenance. They may also be submerged and require less labor time to operate. Some of the disadvantages are that the electrical equipment must be protected from flooding, available utility power can limit capacity, high demand charge, and usually larger more elaborate structures are required to house electrical equipment.

Diesel driven pump stations have the advantage of being ideally suited where utility power in unavailable, they have a large capacity, can be permanently mounted pumps with submersible gear drives, can be mounted vertically or angle mounted, can be made trailer mounted to reduce the threat of flooding, and the drive arrangements afford flexibility (direct, belt, hydraulic). Disadvantages to diesel driven pumps are they are noisy to operate, require more routine maintenance, capacity and availability of on site fuel supply can be restrictive, and are difficult to automate.

Maintenance. Maintenance of a pump station or well should include project inspections on an annul basis (ideally after the area is drained) in addition to immediately following a high water event. Project inspections should follow the inspection guide provided later in this chapter and include the following items as a minimum where applicable; (1) structural steel, (2) structural concrete, (3) displaced / missing riprap, (4) electrical lighting / standby generator, (5) discharge pipe, (6) sump, (7) hydraulic pump, and (8) stoplogs. Corrective action should be taken upon discovery of any deficiencies found during the inspection.

3.5.2.2. Lessons Learned. Lessons learned are contained in Table 3..

3.5.2.3. References

EM 1110-2-3104, Engineering and Design - Structural and Architectural Design of Pumping Stations, CECW-ED, 30 June 1989, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-3104/toc.htm

ER 1110-2-100, Engineering and Design - Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, CECW-EP, 15 February 1995, http://www.usace.army.mil/inet/usace-docs/eng-regs/er1110-2-100/toc.htm

3.5.2.4. Case Studies. Case studies are listed in tables 3.6 and 3.7.

Table 3.6. Pump Stations

Andalusia Refuge HREP, Pool 16, Upper Mississippi River Miles 462.0 to 463.0, Rock Island County, Illinois, CEMVR
Banner Marsh HREP, LaGrange Pool, Illinois Waterway River Miles 138.0 - 144.0, Fulton and Peoria Counties, Illinois, CEMVR
Batchtown HREP, Pool 25, Upper Mississippi River Miles 242.5 - 246.0, Calhoun County, Illinois, CEMVS
Bay Island HREP, Pool 22, Upper Mississippi River Miles 311.0 - 312.0, Marion County, Missouri, CEMVR
Calhoun Point HREP, Pool 26, at the confluence of Illinois Waterway River and Upper Mississippi River Mile 220.0, Calhoun County, Illinois, CEMVS; Clarksville Refuge HREP, Pool 24, Upper Mississippi River Miles 275.0 – 275.0, Pike County, Missouri, CEMVS
Lake Chautauqua HREP, LaGrange Pool, Illinois Waterway River Miles 124.0 - 129.5, Mason County, Illinois, CEMVR
Lake Odessa HREP, Pools 17-18, Upper Mississippi River Miles 435.0 - 440.0, Louisa County, Iowa, CEMVR
Peoria Lake HREP, Peoria Pool, Illinois Waterway River Miles 162.0 - 181.0, Peoria and Woodford Counties, Illinois, CEMVR
Spring Lake HREP, Pool 13, Upper Mississippi River Miles 532.5 - 536.0, Carroll County, Illinois, CEMVR
Stump Lake HREP, Pool 26, Illinois Waterway River Mile 7.0 to 13.0, Jersey County, Illinois, CEMVS
Swan Lake HREP, Alton Pool, Illinois Waterway River Miles 5.0 – 13.0, Calhoun County, Illinois, CEMVS
Trempealeau National Wildlife Refuge HREP, Pool 6, Upper Mississippi River Miles 718.0 – 724.0, Trempealeau County, Wisconsin, CEMVP

Table 3.7. Wells

Cuivre Island HREP, Pool 26, Upper Mississippi River Mile 233.0 to 239.0, Lincoln and St. Charles Counties, Missouri, CEMVS
Pleasant Creek HREP, Pool 13, Upper Mississippi River Miles 548.7 - 552.8, Jackson County, Iowa, CEMVR
Potters Marsh HREP, Pool 13, Upper Mississippi River Miles 522.5 - 526.0, Carroll and Whiteside Counties, Illinois, CEMVR
Spring Lake HREP, Pool 13, Upper Mississippi River Miles 532.5 - 536.0, Carroll County, Illinois, CEMVR

3.5.3. Stoplog Structures

3.5.3.1. Design Methodology and Criteria. A general design criteria for this project feature is to construct a structure with operational flexibility that provides the site manager with the capability to meet their seasonal and/or annual management goals. Stoplogs can be placed in various types of structures to meet the sizing requirements for raising or lowering water levels. Additionally, the design of the stoplogs themselves can vary widely. The advantages to using stoplog structures are that they are (1) relatively cheap and (2) low maintenance. Some disadvantages to using stoplog structures may include the following. (1) Removal of a stoplog can in some cases be more than a one-person operation. (2) When the head over the stoplogs is high, removal can become nearly impossible. (3) Stoplogs with eyes at top are difficult to remove and are often hard to hook, which can also cause problems with sealing properly.

Material for Stoplog Structure Housing. Stoplog structures may be constructed of various materials such as concrete, CMP, combination concrete & CMP, PVC, or steel.

Concrete stoplog structures may have single or multiple bays. The concrete structure may be cast-in-place or precast. Additionally, the structure may or may not have footings. Dewatered versus in the wet construction methods should be considered, especially if control of construction costs are critical.

CMP stoplog structures generally consist of a 5-foot diameter riser pipe.

PVC stoplog structures have not been used extensively for HREP projects but have proven to be successful on other Corps projects so they should be considered for future HREP projects. Stoplog structures may also be designed to have a combination of both stoplogs and sluice gates. The ability to resist deflection and warping must be considered. Protection against damage from ultraviolet radiation is important, because the breakdown of the outer surface can expose glass fibers.

Stoplog structures may also be constructed with **sheet pile cells** as abutments (Batchtown, Swan Lake and Calhoun Point) or with internally tied-back Z-shaped sheet pile wing and face walls (Calhoun Point). Concrete footing structures at the top of each abutment support access bridges and stoplog support framing. These footings may be soil-founded (Batchtown) or pile-founded within the retained embankment (Calhoun Point) as local conditions require.

Material for Stoplogs

Aluminum stoplogs generally weigh less but cost more. While the material weight for aluminum stoplogs is less than wood, hollow stoplogs can accumulate internal silt and thus additional lifting weight over time. Aluminum stoplogs have been designed to have rubber stripping along the bottom and sides to provide a tighter seal. Options for aluminum stoplogs include extruded cross-sections (for individual one-foot stoplogs) or fabricated cross sections of skin plates and connecting members (for one-foot or higher stoplogs). Aluminum stoplogs are also subject to being stolen when aluminum recycling costs are high.

Wood stoplogs are buoyant and require ballasting or some type of mechanism to prevent from floating. Wood stoplogs may have a tendency to seal better as wood will swell when saturated. To help with sealing, wood stoplogs have been designed to have grooves so that they "interlock" when installed, however, this is not always the case (for example at Swan Lake they do not).

Bay Widths. A stoplog structure can involve a series of bays. The stoplog bay width depends on local user requirements. In Rock Island District, a 5-foot bay is often used. At Batchtown (in St. Louis District), several structures are across channels where duck blind access is required. A clear width in each bay of ten feet between stoplog supports, and head clearance of five feet between the maximum water level and the low surface of the access bridge, is provided. At Swan Lake, where such access is not required, the clear opening in each bay is only four feet. If a number of similar structures are anticipated at a project site, using similar bay widths, and therefore similar stoplogs throughout, can provide interoperability.

Height. Structures can vary in height to meet customer requirements. At Swan Lake, a number of both one-foot-high and six-foot-high stoplogs are being provided for flexibility in operation. At Calhoun Point, one-foot-high stoplogs that can be ganged together in the field are being provided. In general, the structure should be located and designed to allow for appropriate drainage or flooding of the site, and to ensure that there is adequate height to maintain water levels upstream of the structure.

Storage. Stoplogs may be stored either off site or on-site, such as in a pump house. If stored on-site, keep stoplogs at the highest elevation possible. It is important to establish storage capabilities of the site managers during the design process.

Protection. Stoplog structures need to be protected from vandalism, theft, and unauthorized use. This can be accomplished through use of padlocks and locking bars. The safety of stoplog structures can be provided through use of inlet/outlet guards, ladders, guardrails, and other such devices.

Lifting Devices. A stoplog lifting hook is typically furnished for the installation and removal of the stoplogs. Lifting devices should be designed for easy transportation and use, especially during high flows. Stop log hoists may be used to manipulate the structure. Lifting devices can be manual or power-assisted. Electric or hydraulic hoists can be used for raising and lowering stoplogs. The lifting equipment can be supported on a trolley beam running across all bays or on a jib crane. The support requirements for a trolley beam or job crane will determine to some extent the layout of the supporting structures at the sides of the channel to be controlled. Jib crane manufacturers can provide anchor bolt patterns and minimum footing requirements to be used in support structure layout. Keep in mind when designing a stoplog structure that some site managers may prefer a one-person operation when installing and removing stoplogs. This can become difficult when the head is too high over the stoplogs, the stoplogs are too heavy, and/or the lifting devices are too bulky.

Top of Structures. If vehicular access across a structure is required, the weight and width of the equipment must be considered. If pedestrian access is required, appropriate safety measures for guardrails, steps, etc. must be included. Additionally, Operator safety should be considered in developing structure features. Non-skid grating and guardrails should be provided on catwalks, etc.

Operation. Stoplog structures should be operated so that when the MSMU is in use or the river water levels are expected to rise, the stoplogs should be installed and are to remain in place until one of the following occurs; (1) flood waters recede, (2) project no longer in use, or (3) overtopping of the perimeter levee is anticipated.

Maintenance. Maintenance of stoplog structures should include project inspections on an annul basis (ideally after the area is drained) in addition to immediately following a high water event. Project inspections should consist of the following to ensure; (1) stoplogs, slots, keepers, staff gages, and lifting hooks are in good condition, (2) steel rails, posts, grating, and fasteners are in good condition, (3) concrete is in good condition, (4) inlet and outlet channels are open, (5) trash, debris, and sediment is not accumulating in and around the structure, (6) erosion, seepage, and encroachments are not occurring adjacent to the structure which might endanger its function, and (7) riprap is not displaced or missing. Corrective action should be taken upon discovery of any adverse conditions at the structures.

3.5.3.2. Lessons Learned. Lessons learned are contained in Table 3..

3.5.3.3. References

*EM 1110-2-2705, Engineering and Design - Structural Design of Closure Structures for Local Flood Protection Projects, C*ECW-ED, 31 March 1994, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2705/toc.htm

Agri Drain Corporation, Inline Water Level Control Structures, http://www.agridrain.com/watercontrolproductsinline.asp

EM 385-1-1, Safety – Safety and Health Requirements, CESO-ZA, 03 November 2003, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em385-1-1/toc.htm

EM 1110-2-2100, Stability Analysis of Concrete Structures, CECW-CE, 01 December 2005, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2100/toc.htm

EM 1110-2-2102, Engineering and Design – Waterstops and Other Preformed Joint Materials for Civil Works Structures, CECW-EG, 30 September 2005, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2102/toc.htm

EM 1110-2-2104, Engineering and Design – Strength Design for Reinforced Concrete Hydraulic Structures, CECW-ED, 30 June 1992 (original), 20 August 2003 (Change 1), http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2104/toc.htm

EM 1110-2-2105, Engineering and Design – Design of Hydraulic Steel Structures, CECW-ED, 31 March 1993 (Original), 31 May 1994 (Change 1), http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2105/toc.htm

EM 1110-2-2503, Engineering and Design – Design of Sheet Pile Cellular Structures, Cofferdams and Retaining Structures, CECW-EP, 20 September 1989 (Original), 11 June 1990 (Errata sheet), http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2503/toc.htm

EM 1110-2-2504, Engineering and Design – Design of Sheet Pile Walls, CECW-ED, 31 March 1994, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2504/toc.htm

EM 1110-2-2906, Engineering and Design – Design of Pile Foundations, CECW-ED, 15 January 1991, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2906/toc.htm

3.5.3.4. Case Studies. Case studies are listed in table 3.8.

Table 3.8. Stoplog Structures

Banner Marsh HREP, LaGrange Pool, Illinois Waterway River Miles 138.0 - 144.0, Fulton and Peoria Counties, Illinois, CEMVR
Bay Island HREP, Pool 22, Upper Mississippi River Miles 311.0 - 312.0, Marion County, Missouri, CEMVR
Guttenberg Waterfowl Ponds HREP, Pool 11, Upper Mississippi River Miles 614.0 - 615.0, Grant County, Wisconsin, CEMVP
Pleasant Creek HREP, Pool 13, Upper Mississippi River Miles 548.7 - 552.8, Jackson County, Iowa, CEMVR
Pool Slough HREP, Pool 9, Upper Mississippi River Miles 673.0 - 673.0, Allamakee County, Iowa CEMVP
Potters Marsh HREP, Pool 13, Upper Mississippi River Miles 522.5 - 526.0, Carroll and Whiteside Counties, Illinois, CEMVR
Princeton Refuge HREP, Pool 14, Upper Mississippi River Miles 504.0 - 506.4, Scott County, Iowa, CEMVR
Swan Lake HREP, Pool 26, Illinois Waterway River Mile 5.0 to 13.0, Calhoun County, Illinois, CEMVS
Stump Lake HREP, Pool 26, Illinois Waterway River Mile 7.0 to 13.0, Jersey County, Illinois, CEMVS
Cuivre Island HREP, Pool 26, Upper Mississippi River Mile 233.0 to 239.0, Lincoln and St. Charles Counties, Missouri, CEMVS
Batchtown HREP, Pool 25, Upper Mississippi River Miles 242.5 - 246.0, Calhoun County, Illinois.
Lake Chautauqua HREP, LaGrange Pool, Illinois Waterway River Miles 124.0 - 129.5, Mason County, Illinois, CEMVR
Lake Odessa HREP, Pools 17-18, Upper Mississippi River Miles 435.0 - 440.0, Louisa County, Iowa, CEMVR
Peoria Lake HREP, Peoria Pool, Illinois Waterway River Miles 162.0 - 181.0, Peoria and Woodford Counties, Illinois, CEMVR
Rice Lake HREP, Minnesota River Miles 15.0 – 17.5, Scott and Hennepin Counties, Minnesota, CEMVP
Spring Lake HREP, Pool 13, Upper Mississippi River Miles 532.5 - 536.0, Carroll County, Illinois, CEMVR
Stump Lake HREP, Alton Pool, Illinois Waterway River Miles 7.2 – 12.7, Jersey County, Illinois, CEMVS

3.5.4. Gatewell Structures

3.5.4.1. Design Methodology and Criteria. The primary purpose of a gatewell structure is to provide gravity drainage from the MSMU. It may be desirable to have at least one gatewell structure installed within each cell. A gatewell structure may also be used to enhance MSMU filling operations. If high water events were to occur during the late summer and fall, the gatewell structure could be opened to help capture water, thereby decreasing the pumping requirements. In addition, the gatewell structure may serve as an additional opening for water to enter the MSMU prior to overtopping events.

The gatewell may be cast-in-place with the piping being precast reinforced concrete pipe (RCP). The inverts may also be reinforced with riprap. Stop log structures could be cast-in-place or precast.

Concrete gatewells may be cast-in-place or precast. In some cases this might be specified as the Contractor's option. Weight and size limitations might limit this choice. Gatewells may also be constructed of corrugated metal pipe. Desired level of durability and dewatering requirements during construction will also influence the choice of structure. It is important to consider they expected life of a CMP structure when designing this type of feature.

The type of gate that may be installed is dependent upon the type of gatewell constructed. Sluice gates requiring a flat back for installation require a concrete gatewell. Other types of gates (for example, gates which can be installed on the end of a pipe) are not as dependent upon the type of gatewell structure. The gatewell must provide an operating platform from which the gate may be manipulated and which supports any equipment required to do so. This platform can be steel or fiberglass grating. Guardrails should be provided where required by the safety manual.

3.5.4.2. Lessons Learned. Please refer to table 3.11 for lessons learned.

3.5.4.3. References

EM 1110-2-3104, Engineering and Design - Structural and Architectural Design of Pumping Stations, Appendix C, CECW-ED, 30 June 1989, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-3104/toc.htm

3.5.4.4. Case Studies. Case studies are listed in table 3.9.

Table 3.9. Gatewell Structures

Andalusia Refuge HREP, Pool 16, Upper Mississippi River Miles 462.0 to 463.0, Rock Island County, Illinois, CEMVR
Batchtown HREP, Pool 25, Upper Mississippi River Miles 242.5 - 246.0, Calhoun County, Illinois, CEMVS
Calhoun Point HREP, Pool 26, Upper Mississippi River Miles 221.0 – 221.0, Calhoun County, Illinois, CEMVS
Clarksville Refuge HREP, Pool 24, Upper Mississippi River Miles 275.0 – 275.0, Pike County, Missouri, CEMVS
Dresser Island HREP, Pool 26, Upper Mississippi River Miles 206.0 – 209.0, St. Charles County, Missouri, CEMVS
Guttenberg Waterfowl Ponds HREP, Pool 11, Upper Mississippi River Miles 614.0 - 615.0, Grant County, Wisconsin, CEMVP
Princeton Refuge HREP, Pool 14, Upper Mississippi River Miles 504.0 - 506.4, Scott County, Iowa, CEMVR
Stump Lake HREP, Alton Pool, Illinois Waterway River Miles 7.2 – 12.7, Jersey County, Illinois, CEMVS
Cuivre Island HREP Pool 26, Upper Mississippi River Mile 233.0 to 239.0, Lincoln and St. Charles Counties, Missouri., CEMVS
Swan Lake HREP, Alton Pool, Illinois Waterway River Miles 5.0 – 13.0, Calhoun County, Illinois, CEMVS
Batchtown HREP, Pool 25, Upper Mississippi River Miles 242.5 - 246.0, Calhoun County, Illinois, CEMVS
Calhoun Point HREP, Pool 26, Upper Mississippi River Miles 221.0 – 221.0, Calhoun County, Illinois, CEMVS
Clarksville Refuge HREP, Pool 24, Upper Mississippi River Miles 275.0 – 275.0, Pike County, Missouri, CEMVS
Lake Chautauqua HREP, LaGrange Pool, Illinois Waterway River Miles 124.0 - 129.5, Mason County, Illinois, CEMVR
Lake Odessa HREP, Pools 17-18, Upper Mississippi River Miles 435.0 - 440.0, Louisa County, Iowa, CEMVR
Spring Lake HREP, Pool 13, Upper Mississippi River Miles 532.5 - 536.0, Carroll County, Illinois, CEMVR
Stump Lake HREP, Alton Pool, Illinois Waterway River Miles 7.2 – 12.7, Jersey County, Illinois, CEMVS
Swan Lake HREP, Alton Pool, Illinois Waterway River Miles 5.0 – 13.0, Calhoun County, Illinois, CEMVS

3.5.5. Sheet Pile Cells

3.5.5.1. Design Methodology and Criteria. Sheet pile cells are fabricated from flat PS-series steel sheets. The number of sheets required for a particular radius cell is standard for a particular width sheet and can be ascertained from manufacturers' handbooks. A cutoff wall of Z-shaped steel sheet piles is driven between the two cells and capped with a sill beam (cast-in-place or precast and grouted onto the cells). Fabricated piles are used to create the connection between the cells and the cutoff wall.

Because the Government is required to purchase American steel, the sources for sheet piling and cross-section profiles allowed are limited. This requirement must be considered in the design stage of a project so the correct cross-sections can be included in the Plans and Specifications. PS- and Z-profile sheets are rolled in this country by Chaparral Steel (http://www.chapusa.com/), which distributes through L.B. Foster (http://www.lbfoster.com/). Additional information on these products is available at http://www.sheet-piling.com/main. Another American supplier of these products is Nucor-Yamato steel (http://www.nucoryamato.com/).

Where sheet pile cells are used as abutments for water control structures, the cells are assumed to be stable within a plane parallel to the axis of the berm (i.e., if the end of the berm is stable in itself, a cell situated within the end of the berm will be stable). Stability in a plane transverse to the axis of the berm is checked, based on the depth of the sheet piling and the internal pressures and external pressures on the cell. The internal pressures will be influenced by the method with which the cell fill is placed.

The need for dewatering of the site prior to placement of the cells must also be considered, because it affects means of construction as well as cost.

Developing a clearly-defined construction sequence is critical for proper installation of the cells. Placement of the cells relative to each other in the field should consider the "bulge" the cells may experience after fill is placed. The resulting clear distance between cells must be considered with regard to installation of footings on top of the cells and stoplog support appurtenances.

Special connection details (e.g., bent plates above the sill analogous to the cutoff wall fabricated piles below the sill) are necessary to provide watertight closure between the cells and the stoplog supports. Selecting steel details that will accommodate the final disposition of the cells, and allowing extra distance between the driven cells to account for bulge, can assist in successful erection of appurtenant details.

Sheet pile cells have provided an opportunity for recycling steel sheet piling originally used for temporary purposes (e.g., sheet piling that had been used in the Melvin Price Locks and Dam cofferdam has since been utilized in cell abutments at EMP projects).

Concrete footings installed on top of the cells support structural/mechanical features such as access bridges, jib cranes, etc. The sheet piling can be used as part of the formwork for these footings. The footings may be supported on the cell fill alone or on foundation piles driven through the fill, as conditions warrant.

Placement of a concrete slab on top of the cell will prevent loss of cell fill in the event a cell is overtopped. Provision of plugged holes in the slab will allow grouting beneath the slab if excessive fill settlement should occur.

Guardrail should be installed around the tops of cells in accordance with the safety manual. In lieu of installing a toeboard, the sheet piling may be cut off four inches above the top of the cell fill/slab. Fiberglass-reinforced plastic guardrails have been used at some locations (Swan Lake); however, because of ultraviolet deterioration and difficulty in making repairs should these items be damaged during floods, wire rope guardrails are an appropriate alternative (Batchtown, replacement of guardrails at Swan Lake).

3.5.5.2. Lessons Learned. Please refer to table 3.11 for lessons learned.

3.5.5.3. References

EM 385-1-1, Safety – Safety and Health Requirements, CESO-ZA, 03 November 2003, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em385-1-1/toc.htm

EM 1110-2-2100, *Stability Analysis of Concrete Structures,* CECW-CE, 01 December 2005, http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2100/toc.htm

EM 1110-2-2104, *Engineering and Design – Strength Design for Reinforced Concrete Hydraulic Structures*, CECW-ED, 30 June 1992 (original), 20 August 2003 (Change 1), http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2104/toc.htm

3.5.5.4. Case Studies. Case studies are listed in table 3.10.

Table 3.10. Sheet Pile Structures

Lake Chautauqua HREP, LaGrange Pool, Illinois Waterway River Miles 124.0 - 129.5, Mason County, Illinois, CEMVR
Swan Lake HREP, Alton Pool, Illinois Waterway River Miles 5.0 – 13.0, Calhoun County, Illinois, CEMVS

3.5.6. Rubber Dams

3.5.6.1. Design Methodology and Criteria. Rubber dams are becoming an increasingly popular alternative to more tradition dam structures, as they are easier to install and are more environmentally friendly. Photograph 3.1 and figure 3.1 show examples of rubber dams. The design, installation, and operation of each of these gates are basically identical even if they come from different manufacturers. Each gate uses an inflatable rubber bladder (made from 3.ply nylon) that can be adjusted to produce a desired pool elevation. The first step in the installation of a rubber dam is to construct a foundation structure for the dam. The bladder is then connected to the foundation using anchor bolts and steel plates to clamp the bladder in place. Finally, the bladder is inflated using a blower system with 0.05kgf/cm^2 to 0.6kgf/cm^2 of air (Bridgestone) to the desired elevation. Once inflated, the dam is idle and an air pressure sensor alerts the compressor to keep the dam at a constant pressure. The bladder can also be filled with water.

Photograph 3.1. Typical Rubber Dam Application (Sumitomo Electric)

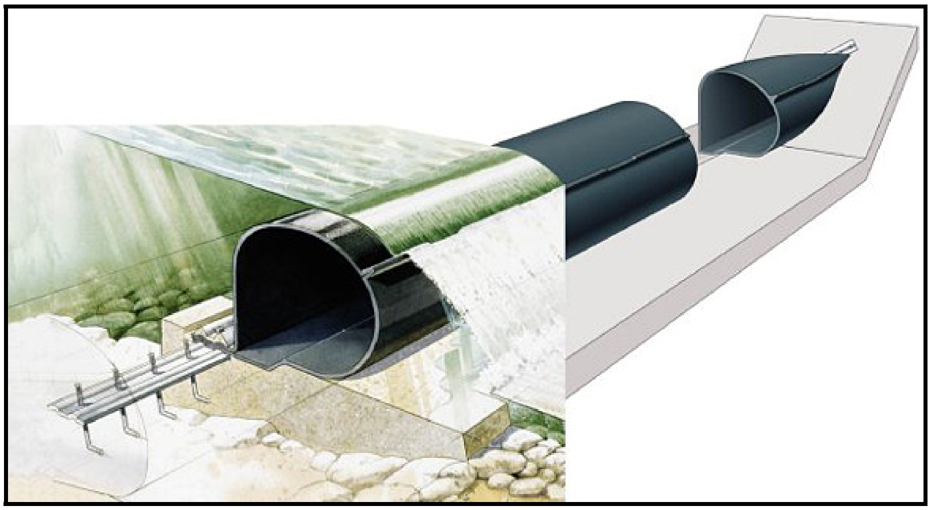


Figure 3.1. Overview of a Rubber Dam (Bridgestone)

Similar to the Obermeyer Gate, the rubber dam can be regulated automatically via an electrical or mechanical control system. A generator is needed to supply the necessary power for the operation of the dam. Maintenance is minimal as there are no moving parts within the dams and they are known to be naturally self-cleaning of debris. Also, according to Bridgestone, debris rarely punctures the bladder. However, like other inflatable dam alternatives, rubber dams are prone to vandalism as they are possible to puncture, resulting in a failure. The cost for a rubber dam depends heavily on the size and other variables; however, the smallest rubber dams generally cost around $200,000 (Bridgestone).

3.5.6.2. Lessons Learned. No lessons learned have been identified to date at HREP sites.

3.5.6.3. References

Bridgestone, Rubber Dam
http://www.bridgestone.co.jp/english/diversified/rubberdam/design.html

Trelleborg, Trelleborg Flexidam, www.trelleborgqr.com/Content/Product_Flexidam1.asp

Sumitomo Electric, Sumigate, http://www.sumigate.com/

3.5.6.4. Case Studies. No case studies at HREP sites had been identified.

3.5.7. Aqua-Barrier

3.5.7.1. Design Methodology and Criteria. The Aqua-Barrier is a water-filled dam that can be used in a variety of applications. Photographs 3.2 and 3.3 show Aqua-Barriers in use. The most common applications of the Aqua-Barrier are flood protection, construction site dewatering, and containing spilled hazardous materials. The barrier is available in a variety of standard sizes, with a height ranging from 2 to 8 ft and a length from 25 to 100 ft (custom sizes are available as well), and is made from a 30 oz. PVC vinyl. The installation and operation of the aqua barrier is relatively simple. The barrier is unrolled and placed along its desired location. It is then filled with water that is pumped from a local source. Once the barrier has been filled with water, it is held in place by its own weight and surface friction (no ties). It is important that the barrier is completely filled with water in order to create a stable structure. The aqua barrier can generally be moved or re-filled 15 to 20 times before it needs replacing.

Photograph 3.2. Installation of an Aqua-Barrier

Photograph 3.3. Inflation and Operation of an Aqua-Barrier (Aqua-Barriers)

Maintenance is minimal as the structure contains no moving parts. In the event of a rupture, the barrier can be repaired without necessarily being completely removed from the field. The cost per linear foot ranges from $19 to $95 (EconoDam), but depends heavily on the site specifications.

The Aqua-Barrier is rather vulnerable to vandalism as it would be fairly easy to puncture the barrier, resulting in a failure. Moving the structure while it is filled with water can also result in a puncture as the structure is extremely heavy and would break easily when in contact with a sharp object. One major concern is the amount of UV that the barrier receives, as too much exposure to sunlight will eventually breakdown the structure and reduce its lifespan to around 5 years. Another disadvantage is that the barrier seems to be more of a temporary structure and may not be suited for a more permanent application even though there have been a few cases of permanent application. Finally, the aqua barrier requires a 20 percent freeboard in order to maintain its stability without floating or rolling. As a result, it would not be possible to run water over the top of the structure and the aqua barrier would not be a suitable replacement for a stop log structure.

3.5.7.2. Lessons Learned. No lessons learned have been identified to date at HREP sites.

3.5.7.3. References

Aqua-Barriers, Water Inflated Dams, http:www.aquabarrier.com
EconoDam, Water Inflated Dam Pricing, http://www.econodam.com/prices.htm

3.5.7.4. Case Studies. No case studies at HREP sites had been identified.

3.5.8. Obermeyer Gates

3.5.8.1. Design Methodology and Criteria. An Obermeyer Gate (photograph 3.4 and figure 3.2) is a spillway/overflow gate that is often used in dam applications. The Obermeyer Gate is composed of steel plates that are supported by an inflatable air bladder on their downstream side. The bladder is made of “A Butyl rubber inner liner provides excellent air retention characteristics. A section of high tensile strength rubber compounds containing multiple layers of polyester or arimid, e.g. duPont Kevlar® tire, cord reinforcement provide the mechanical strength needed to contain the internal pressure. A cover compound utilizing aging and ozone resistant polymers such as EPDM is used to protect the bladder from wear and weathering.” (Obermeyer Hydro Inc.). The installation process for the gate is relatively simple. First, anchor bolts are connected to the foundation for the gate. The bladders are then secured to the anchor bolts and are connected to an air source. Finally, the steel panels are attached to the hinge flaps on the bladder.

Once installed, the gate can be raised or lowered by controlling the amount of air that is being supplied to the bladder. Air is not constantly supplied to the bladder. The internal pressure is regulated by a system of valves and is adjusted by an external compressor. A control system can also be used to automatically regulate the elevation of the gate. The two major types of control systems are solar powered and pneumatic water level controls. The solar powered controls use 12 volt solar panels, a battery, and a compressor in order to supply power to the control system and compressor. The pneumatic water level controls are the most popular because they do not require any electrical power. However, most applications involve the use of a generator unless they are small enough to employ the solar power system.

Photograph 3.4. Typical Gate Section - (Obermeyer Hydro Inc.)

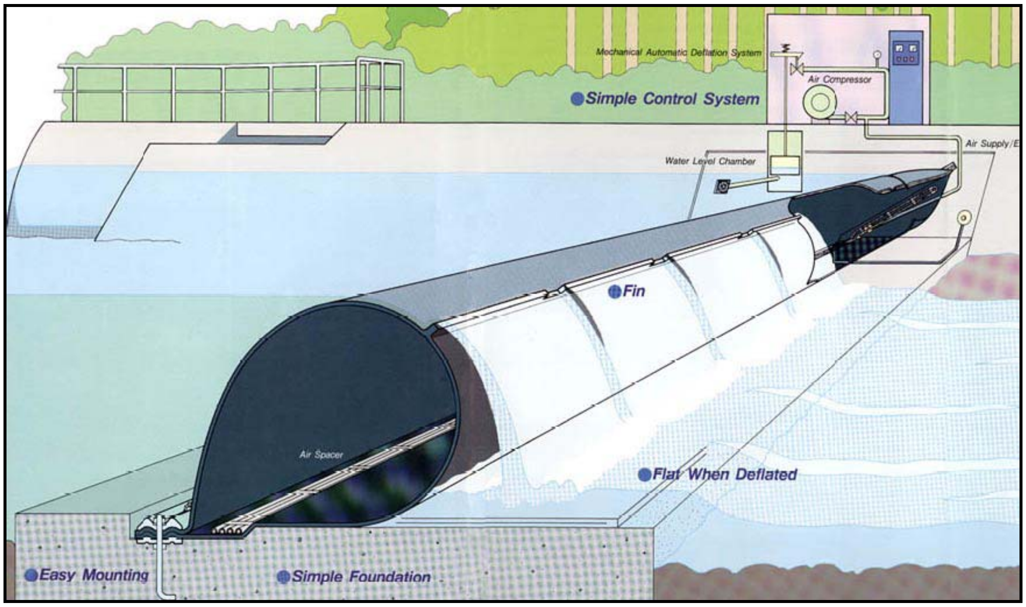


Figure 3.2. Overview of an Obermeyer Gate System (http://www.crrel.usace.army.mil/ierd/tectran/IERD30.pdf)

The profile of the Obermeyer Gate does little to disturb its surrounding environment as debris, ice, and fish can easily pass over the structure depending on its elevation. The major problem associated with an Obermeyer Gate is that it is vulnerable to vandalism. A puncture to the air bladder could cause a section of the gate to deflate completely. Fortunately, the steel panels on the upstream side of the gate form a protective covering over the bladder. Also, depending on the size of the gate, multiple air bladders can be used and separated by check valves so that a puncture to one section of the bladder will not result in a complete failure.

3.5.8.2. Lessons Learned. No lessons learned have been identified to date at HREP sites.

3.5.8.3. References

Obermeyer Hydro Inc., www.obermeyerhydro.com

US Army Corps of Engineers Cold Regions Research and Engineering Laboratory, *Performance Survey of Inflatable Dams in Ice-Affected Waters*, http://www.crrel.usace.army.mil/ierd/tectran/IERD30.pdf

Corporation of the City of London, Environmental Assessment Report Springbank Dam Rehabilitation, http://www.fanshawepioneervillage.ca/Hydrology_&_Regulatory_Service/Springbank_report_without_figures.pdf

3.5.8.4. Case Studies. No case studies at HREP sites had been identified.

3.6 Photographs of Project Features

3.6.1. Perimeter Levees, Cross Dikes, and Overflow Spillways

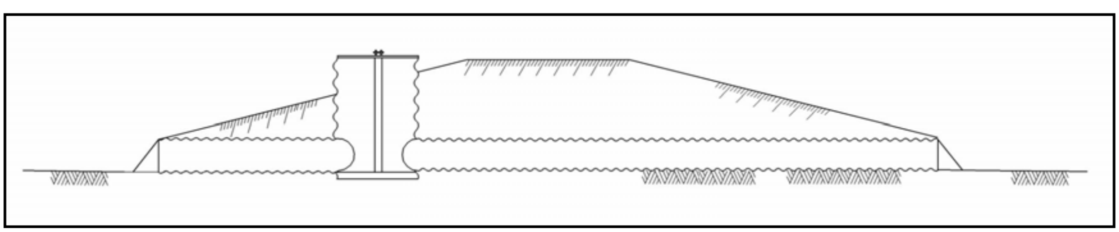
Andalusia Refuge HREP, Pool 16, Upper Mississippi River Miles 462.0 - 463.0, Rock Island County, Illinois, CEMVR

Princeton Refuge HREP, Pool 14, Upper Mississippi River Miles 504.0 - 506.4, Scott County, Iowa, CEMVR

3.6.2. Pump Stations and Wells

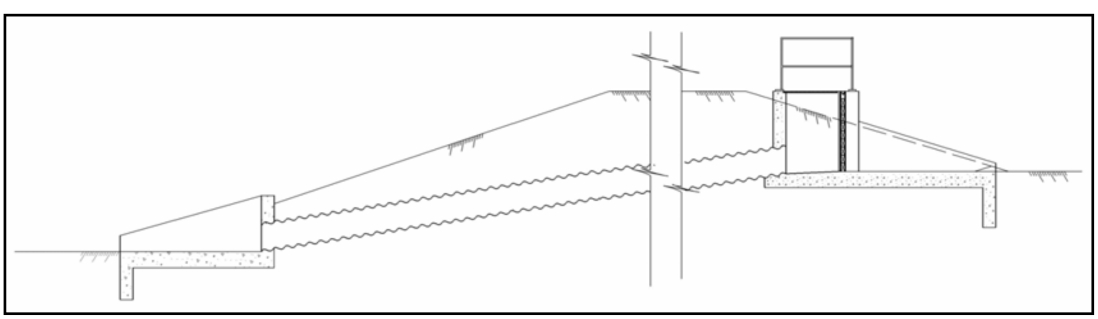
Andalusia Refuge HREP, Pool 16, Upper Mississippi River Miles 462.0 - 463.0, Rock Island County, Illinois, CEMVR

3.6.3. Stoplog Structures



Banner Marsh HREP, LaGrange Pool, Illinois Waterway River Miles 138.0 - 144.0, Fulton and Peoria Counties, Illinois, CEMVR

Bay Island HREP, Pool 22, Upper Mississippi River Miles 311.0 - 312.0, Marion County, Missouri, CEMVR



Potters Marsh HREP, Pool 13, Upper Mississippi River Miles 522.5 - 526.0, Carroll and Whiteside Counties, Illinois, CEMVR

Princeton Refuge HREP, Pool 14, Upper Mississippi River Miles 504.0 - 506.4, Scott County, Iowa, CEMVR

Spring Lake HREP, Pool 13, Upper Mississippi River Miles 532.5 - 536.0, Carroll County, Illinois, CEMVR

3.6.4. Gatewell Structures

Andalusia Refuge HREP, Pool 16, Upper Mississippi River Miles 462.0 - 463.0, Rock Island County, Illinois, CEMVR

Princeton Refuge HREP, Pool 14, Upper Mississippi River Miles 504.0 - 506.4, Scott County, Iowa, CEMVR

3.7 Pump Station Inspection Report

Name of Habitat Rehabilitation and Enhancement Project:

Date/Hour Inspection Began:
Date: Time:

Date/Hour Inspection Ended:
Date: Time:

Inspectors:

Corps Representatives:

Local Sponsor Officials:

River/Forebay Elevations:

River El.: _________ Stage El.: __________ Zero Gage El.: _________
Management Unit El.: _________ Stage El.: __________ Zero Gage El.: _________

Project Data:
Pumping Arrangement and Configuration:

Size of Moist Cell Unit(s) (Acres):

Fill Time (Days):

Empty Time (Days):

General Comments:

3.8. Pump Station Maintenance Inspection Guide

RATED ITEM	A	M	U	EVALUATION	REMARKS
SECTION I				**FOR INTERNAL USE AND EVALUATION**	
1. Pump Station Size				Pump station has adequate capacity (considering pumping capacity, ponding areas, Compare Fill/Empty times with Design, etc.). (A or U.)	
SECTION II				**FOR LOCAL SPONSOR USE**	
2. O&M Manual				O&M Manual is present and adequately covers all pertinent areas. (A or U.)	
3. Operating Log				Pump Station Operating Log is present and being used. (A or U.)	
4. Annual Inspection				Annual inspection is being performed by the local sponsor. (A or U.)	
5. Plant Building				A Plant building is in good structural condition. No apparent major cracks in concrete, no subsidence, roof is not leaking, etc. Intake louvers clean, clear of debris. Exhaust fans operational and Maintained. Safe working environment. M Spalling and cracking are present, or minimal subsidence is evident, or roof leaks, or other conditions are present that need repair but do not threaten the structural integrity or stability of the building. U Any condition that does not meet at least Minimum Acceptable standard.	
6. Pumps				A All pumps are operational. Preventive maintenance and lubrication are being performed. System is periodically subjected to Performance testing. No evidence of unusual sounds, cavitation, or vibration. M All pumps are operational and deficiencies/minor discrepancies are such that pumps could be expected to perform through the next period of usage. U One or more primary pumps are not operational, or noted discrepancies have not been corrected.	

3.8. Pump Station Maintenance Inspection Guide

RATED ITEM	A	M	U	EVALUATION	REMARKS
7. Motors, Engines and Gear Reducers				A All items are operational. Preventive maintenance and lubrication being performed. Systems are periodically subjected to performance testing. Instrumentation, alarms, and auto shutdowns operational. M All systems are operational and deficiencies/minor discrepancies are such that pumps could be expected to perform through the next Expected period of usage. U One or more primary motors are not operational, or noted discrepancies have period of usage.	
8. Sumps/Trash Racks				**SPECIAL INSTRUCTIONS:** Measure silt accumulation in sumps and trash racks. Measure water depth at inlet and outlet. A Sumps/Trash Racks are free of concrete deterioration, protected from Permanent damage by corrosion and free of floating and sunken debris. Sumps are clear of Accumulated silt. Passing debris is minimized by spacing of trash rack bars. Periodic maintenance performed on trash racks and removal of accumulated silt in sumps is performed. M Trash racks and sumps have some accumulated silt or debris but are not currently inhibiting the pump(s) performance. No periodic maintenance has been performed. Present condition could be expected to perform through the next expected period of usage provided removal of floating debris is accomplished. U Proper operation can not be ensured through the next period of usage. Possible damage could result to the pumping equipment with continued operation.	

3.8. Pump Station Maintenance Inspection Guide

RATED ITEM	A	M	U	EVALUATION	REMARKS
9. Other Metallic Items				A All metal parts in plant/building are protected from permanent damage by corrosion. Equipment anchors and grout pads show no rust or deterioration. M Corrosion on metallic parts (except equipment anchors) and deterioration period of usage. U Any condition that does not meet at least Minimum Acceptable standards.	
10. Ancillary Equipment i.e. Compressed Air Siphon Breakers Fuel Supply Vacuum Priming Pump Lubrication Heating/Ventilation Engine Cooling Engine Oil Filtering				A All equipment operational. Preventive and annual maintenance being performed. Equipment operation understood and followed by pump station operators. M Ancillary equipment is operational and deficiencies/minor discrepancies are such that equipment could be expected to perform through the next period of usage. U One or more of the equipment systems is inoperable. The present condition of the inoperable equipment could reduce the efficiency of the pump station or jeopardize the pump station's role in flood protection.	
11. Backup Ancillary Equipment				A Adequate, reliable, and enough capacity to meet demands. Backup units/equipment are properly sized, operational, periodically exercised, and in an overall well maintained condition. M Backup ancillary equipment is operational and deficiencies/minor discrepancies are such that equipment could be expected to perform through the next period of usage. U Backup ancillary equipment not considered reliable to sustain operations during flooding conditions.	

3.8. Pump Station Maintenance Inspection Guide

RATED ITEM	A	M	U	EVALUATION	REMARKS
12. Pump Control System				A Operational and maintained free of damage, corrosion, or other debris. M Operational with minor discrepancies. U Not operational, or uncorrected discrepancies noted from previous inspections.	
13. Intake and Discharge Outlets				Functional. No damaging erosion evident. Opening/closing devices for vertical gates, flap gates, etc. are functional in a well-maintained condition. (A or U).	
14. Insulation Megger Testing (For pump stations with Electric pumps only)				A Megger test has been performed within the last 36 months. Results of megger test show that insulation of primary conductors and electric motor meet manufacturer's or industry standard. M Results of megger test show that insulation resistance is lower than manufacturer's or industry standard, but can be expected to perform satisfactorily until next testing or can be corrected. U Insulation resistance is low enough to cause the equipment to not be able to meet its design standard of operation.	
15. Final Remarks					

3.8. Pump Station Maintenance Inspection Guide

GENERAL INSTRUCTIONS

1. All items on this guide must be addressed and a rating given.
2. The lowest single rating given will determine the overall rating for the pump station.
3. Additional areas for inspection will be incorporated by the inspector into this guide if the layout or physical characteristics of the pump station warrant this. Appropriate entries will be made in the REMARKS block.
4. Rating Codes:
   - A – Acceptable
   - M - Minimally Acceptable
   - U - Unacceptable

SPECIFIC INSTRUCTIONS

SECTION I. Actual fill and emptying times for the project shall be compared with design data and size of management unit to assess adequacy of design.

3.9. Lessons Learned. Lessons learned from various HREP projects are provided in table 3.11.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Botulism	Lake Chautauqua (MVR)	Chautauqua experienced botulism deaths of many migratory waterfowl (waterfowl mortalities in 1997 through 2000 were 8,000, 2,500, 250 and 900). Sick birds generally appear in late August when there are low water levels (2 to 10 inches), low precipitation, and high temperatures for extended periods. These conditions set the stage for the botulism organisms to start reproducing. Birds pick up the toxin and die. Flies lay eggs on the carcasses and the maggots concentrate the toxin to the point where only 3 maggots will kill a duck. The botulism problem usually subsides after the first killing frost. Drying the lake bottom would force the birds to go elsewhere and therefore, avoid the botulism toxins. Therefore, the lower lake dewatering channels was extended from the pump station to the stoplog structure. This required dredging a shallow channel 35 ft wide and approximately 11,000 ft long. The extended channel allows the area to be dewatered completely. This removes the habitat for waterfowl and shorebird use and allows the Site Manager to do complete searches of any remaining small wet areas. If dewatered early enough, the area will produce moist soil plant foods that can be used by waterfowl and other wildlife when re-flooded in the fall. It will also allow the bottom to dry to the point where equipment can be brought into the area to control invasive vegetation such as willow.
Cell Operation	Andalusia Refuge (MVR)	For HREPs with water control structures requiring operation during inclement weather, granular surfacing should be provided along the perimeter levee to strengthen the surface under adverse conditions.
Cell Operation	Bay Island (MVR)	The MSMU was not designed to allow independent operation of the cells. The existing water supply berm was raised and a new gatewell structure was installed in the water supply berm. This added height to the water supply berm in combination with the new gatewell structure now allows independent operation of the cells.
Cell Operation	Princeton Refuge (MVR)	The concrete stoplog structure did not allow for complete drainage of the north cell into the south cell. As a result, two CMP stoplog structures were installed along the cross dike to provide water level control between the cells at lower elevations by gravity flow.
Erosion Protection: Levees	Bay Island (MVR)	Severe erosion along the northwestern edge of the perimeter levee was evident after the Flood of 1993. Approximately 1,070 feet of the perimeter levee toe eroded due to Clear Creek. Clear Creek is a meandering stream that runs along this portion of the levee. The erosion created a 2 to 3.foot vertical cut into the levee toe. The levee slope was re-graded and riprap was placed from the base of the levee toe to 6 feet from the edge of the levee crown.
Erosion Protection: Levees	Peoria Lake (MVR)	The erosion control mats and seeding for erosion control along the levees of Cells B and C were not successful with water level fluctuations, resulting in bank erosion. Traditional riprap was installed in place of these mats at various locations.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Erosion Protection: Pump Station	Andalusia Refuge (MVR)	Riprap was found to be missing in several areas at the water control structure. However, it was determined that the lack of riprap was not causing any problems.
Erosion Protection: Pump Station	Peoria Lake (MVR)	Erosion occurred around the concrete pad at the pump station outlet. The site manager installed riprap around the concrete pad to help reduce the erosive effects around the pump station outlet.
Erosion Protection: Wells	Potters Marsh (MVR)	The well outlet was provided with a splash pad; however, following testing of the well, it was evident that additional erosion protection would be necessary. To remedy the erosion, a mixture of slush concrete and riprap was placed around the splash pad.
Gatewell	Spring Lake (MVR)	The gate position was difficult to read. The site manager painted the top of the gate stem bright orange to make its position easier to read. Stoplogs are used in the gated inlet structure during maintenance of the structure. The stoplogs are difficult to remove with a high head against them. To ease removal of the stoplogs, the gate is closed temporarily so that water levels are allowed to equalize on either side of the stoplogs.
Guardrails	Swan Lake (MVP)	Fiberglass-reinforced plastic guardrails have been used at some locations (Swan Lake); however, because of ultraviolet deterioration and difficulty in making repairs should these items be damaged during floods, wire rope guardrails are an appropriate alternative (Batchtown, replacement of guardrails at Swan Lake).
Levee Construction	Swan Lake (MVS)	The exterior berm was constructed 1995 and 1996 with large (8 cy) clamshell bucket using lake bottom silts and clays. Portions of the berm have settled more than expected, especially in areas were the berm alignment was across lower elevational areas, such as sloughs. A 5 to 10% design overbuild of berms were to account for anticipated settlement. Some of these areas have now settled below the overflow spillway grade, now making them the low point in the system. The project has experienced overtopping at these low areas and has resulted in higher maintenance caused by washing road stone off of the top of the berm. The low spots of the berms are expected to be brought back up to grade in 2006, subject to funding availability.
Levees: Rodent and ATV Control	Andalusia Refuge (MVR)	Settlement of the levee was discovered due to animal burrowing, unauthorized vehicle use, and scouring and erosion. Trapping has resolved the settlement due to burrowing animals. Unauthorized vehicle use from ATVs and snowmobiles no longer seems to be a problem. The settlement from scouring and erosion also appeared to be corrected.
Levees: Rodents	Spring Lake (MVR)	Since construction has been completed, muskrat burrowing has caused severe erosion on the side slopes and large sinkholes on the levee crown. As a result, water is flowing between the units. This has caused the refuge manger to be unable to manipulate water levels within individual cells as desired. The problem has also become a safety hazard to vehicles traveling on the levee crowns. Annual inspection and maintenance will continue to assess the muskrat damage. 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, such as trapping. Some site managers claim that having flatter side slopes, such as 10:1 vertical to horizontal, can help prevent muskrat burrowing.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Level of Protection	Bay Island (MVR)	The perimeter levee provides a 2-year level of protection. This level of protection should only be used at sites where impacts of frequent flooding are acceptable for project operation and maintenance. It was recommended that perimeter levees provide at least a 5-year level of protection. A higher level of protection will decrease the rate of sedimentation within the MSMU, increase controlled management opportunities, and decrease the risk of prolonged flooding when trying to establish desired vegetation.
Level of Protection	Spring Lake (MVR)	A 2-year level of protection, as provided by the interior levees (or cross dikes) in Upper Spring Lake, should only be used at HREPs 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.
Pump Cavitation	Banner Marsh (MVR)	The existing pump station structure was modified as part of the HREP to install a new 48” submersible pump. The existing sump was modified and an anti-vortexing plate was installed prior to pump installation. The pump was factory tested but not to the low sump elevation level as specified. After installation, the pump developed a cavitation noise in the sump level operating range during operation of the pump, which has led to complete failure. As a result, heavy rains have caused localized flooding within the MSMU. It may also cause accelerated wear of pump components, thus shortening the expected service life of the pump. The pump was pulled for inspection and measurements with no conclusive findings. The pump was reinstalled with the cavitation noise present and a spare impeller was purchased for replacement in the future. The recommendation has been to continue using the pump as normal. Under normal operation, the 48” submersible pump is a backup that only turns on when the 24” service pump is unable to keep up. The 24” service pump can handle about 90% of the annual MSMU pumping requirements.
Pump Controller Valve	Banner Marsh (MVR)	The 48” pump controller failed twice. The first failure was due to condensation in the pump controller cabinet, which caused a component in the soft start drive to fail. The condensation was caused when the power was turned off to the entire pump station by opening the main breaker. This made it impossible for the pump controller cabinet heater to function and condensation resulted. The Site Manager was instructed to not turn off the main breaker anymore. No O&M Manual was available at the time to provide instruction for pump operation. The second failure was a different component in the soft start drive, which is believed to have failed due to stress caused from the first failure. Both problems were corrected by replacing the faulty components. If further components of the soft start drive fail, it has been recommended replacing the entire drive, which is only one part of the pump controller.
Pump Inspections	Spring Lake (MVR)	The project did not include a system for pump removal so the site manager had to add a jib hoist and crane to the pump station to facilitate removal of the pumps for inspections.
Pump Operation	Banner Marsh (MVR)	A light was installed on the outside of the pump building so that the Site Manager can verify that the pump is running from his house rather than having to drive out to the pump station.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Pump Size	Lake Chautauqua (MVR)	Configuration: Lake Chautauqua pump station is a single submersible turbine that pumps from a lower level pump station to the upper level. It is located at the junction of 2 lakes and the river. It is gate controlled and capable of pumping into or out of any of the 3 water bodies or is capable of gravity flow into or out of any of the 3 water bodies. This configuration greatly increases its versatility and also simplifies pump controls. Pump Size: When the pump station was designed, the pump criterion was to dewater the lower lake in 30 days (allows sufficient time for moist soil production). This resulted in a 41,000 GPM pump. Multiple smaller pumps were ruled out as being too expensive. The design criteria were flawed in the following respect: The pump station has never been used to dewater the entire lake within the 30 day timeframe. The cost to run the pump and pay the demand charges is too costly. The FWS refuge staff would rather wait for the river to drop before dewatering mostly by gravity. In fact, waiting is usually faster. (The pump can pump down a full lake by about 0.10 ft per day). The pump is more than adequate to pump remnants out of the lake and to maintain the lake in a dewatered condition. For these purposes a smaller pump would also work. It would have resulted in less demand and electric charges as well as less submergence requirement and a less expensive pump station.
Pump Station	Andalusia Refuge (MVR)	When the pump was turned on in the fall of 1994 to fill the MSMU, the trash rack clogged with vegetation and cut off the water supply. Subsequently, a chain link fence was installed 6 feet from the pump intake, and an outer mesh fence was installed 100 feet from the pump intake. The outer mesh fence was subjected to damage from ice during the winter of 1995 to 1996. The site manager stated that the fences were not working as intended and had been destroyed by ice, and that the vegetation had filled back in from shore to shore. The trash rack fence system had been designed for those years when there was an excess of floating (or dead) vegetation, river levels were low, and fall pumping was required, which didn't meet the needs of the site manager. It was decided that the outer mesh fence could be removed, leaving the posts in place, and re-installed when needed. Otherwise, if the outer mesh fence remains in place, annual maintenance would be necessary prior to ice-over of the refuge.
Pump Station	Swan Lake (lower compartment), Calhoun Point and Stump Lake (MVS)	At, there are permanent pump stations in which the pump is installed in a slanted intake tube supported in the water on the supply side by a system of piles and cross-beams. The discharge pipe passes through the berm (an embankment created between parallel rows of cross-tied sheet piles) and discharges through a duckbill. The pile support system for the pump allows installation without creating a dewatered location for building a sump. The pump support system must accommodate removal of the pump for maintenance.
Pump Station in Cold Weather.	Banner Marsh (MVR)	The pump floatation system would freeze up so the Site Manager purchased a bubbler system to prevent the floats from freezing.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Pump Station Inlet	Princeton Refuge (MVR)	The river grating on the pump station inlet box has been a challenge. It will plug with debris and create a vortex during pumping operations. It is recommended that a secondary fence be installed between the ends of the wingwalls. This fence would then extend along the top of the wingwalls up to the top of the inlet box to keep debris out during flood events. The grating on top of the pump station inlet box is heavy to remove and replace. Removal and replacement of the heavy grating for maintenance is dangerous to the operator and hazardous to the public if left off. The grating on top of the pump station inlet box was designed to be heavy for safety reasons and to prevent vandalism. If the grating is replaced with a lighter, hinged section, a padlock should be installed.
Pump Station Location	Princeton Refuge (MVR)	During construction, the existing pump station was relocated from the downstream end to the middle of the perimeter levee. However, the existing pump station only consisted of a single pump. As a result, a portable pump with a diesel engine mounted on a highway trailer was supplied following construction.
Pump Station Materials	Spring Lake (MVR)	The door to the pump station rusted on the inside due to moisture. All metal should be galvanized to help prevent rust damage.
Pump Station Siltation	Bay Island (MVR)	The pump station had a continuous problem with the pumping chamber and intake structure filling in with 2 to 3 feet of silt. The silt enveloped the pump impellers, thus making the pump station inoperable until the pumping chamber was cleaned out. In addition, removal of the silt in the pumping chamber had been labor intensive and difficult to complete without easy access to the pumping chamber and intake structure. Silt accumulation in the pumping chamber and around the pump impellers created different power demands on the pump motor. Fluctuation in the pump motor loads or possibly incoming power supply had been throwing the phase converter out of balance. The services of an electrical contractor to recalibrate the phase converter had been needed about twice annually since the pump station had been in service. A sluice gate was installed on the outside of the pump station intake structure and that a platform structure was constructed in the pumping chamber. The sluice gate was placed at the intake of the pump station near the existing trash rack. This gate is closed during non-pumping times to prevent the buildup of silt in the pumping chamber. A platform structure with a ladder was installed to facilitate cleaning out of any silt that collects inside the pumping chamber.
Pump Station Stoplogs	Andalusia Refuge (MVR)	The pump station stop logs would not seal due to the presence of construction debris in the channels. Therefore, the stop log channels had to be cleaned out. Additionally, the stop logs were difficult to remove because of their close proximity to the trash rack. As a result, the pump station trash rack was relocated and a hoist installed.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Pumps and Fishing Lines	Princeton Refuge (MVR)	Fishing line has been a challenge with the seals around the pump impeller head. A trash rack cleaning apparatus could be utilized to help with the fishing line. This apparatus would have to be used on a regular basis and could be stored in the pump station engine building.
Sheetpile Cells	Lake Chautauqua (MVR)	The project constructed 4 each 74 ft diameter sheet pile cells. The sheet pile was driven to bedrock and filled with stone. The 4 large cells were connected with arc cells to a lower elevation that would allow complete dewatering of the lake. The arc cells were filled with stone and capped with an H pile supported concrete cap that supported a flood wall and a 10 ft by 10ft heavy duty sluice gate. The main cells included bridges to span the arc cells and provide access to open and close the gates. The bridge abutments were supported on H-piles driven within the main cells. The gates had back-up bulkheads and aluminum stop logs. The upper lake at Lake Chautauqua had a 60 year old water control structure consisting or 4 radial gates 12 ft wide. The gate had not been used for over 30 years. During a flood event, the structure washed out, leaving a large scour hole in the levee system. A flood damage report analyzed various closure alternatives to allow rapid inflow before an over-top event could damage the levee. Other desirable design features were maintaining a consistent water level and increasing the ability to dewater the lake. Analysis showed that another gated concrete structure would be very expensive. Other alternatives included spillways, fuse plug spillway, culverts with gate control, and the selected alternative described below. This design worked well to close the breach in the levee, meet all functional purposes, minimize maintenance, and ease operation. Downstream scour is not a concern and the cost of a stilling basin was eliminated. Used sheet pile was utilized from St Louis District saving additional money. Hydraulics developed an operating plan for when to open the gates. To date the gate plan has worked well and has been used twice. During construction, Engineering used State Plane Coordinates to locate the next main cell after the first cell was constructed and surveyed. Cell spacing was critical so that the gates and floodwall would fit properly. During the gate construction contract, the contractor was required to work up to a designated flood level. He was able to do this by leaving the arc cells extended to the flood elevation and providing interior supports. This worked well and allowed construction within the arc cells during relatively high river levels.
Spillway	Princeton Refuge (MVR)	During the Flood of 2001, the granular surfacing along the overflow spillway was washed to the downstream slope and the geotextile fabric beneath the granular surfacing had been shifted to the downstream shoulder. Despite the disturbance to the granular surfacing and geotextile fabric, the overflow spillway slopes were still intact with most of the vegetation remaining. It appeared that the geotextile fabric had acted as a slippage plane during the flood event for the granular surfacing to “peel” off the overflow spillway. Therefore, the geotextile fabric was not replaced when the overflow spillway was lowered 8 inches.

Table 3.11. Lessons Learned

Topic	Location	Lesson Learned
Spillway	Princeton Refuge(MVR)	The design for the overflow spillway was to be 2 feet lower than the north perimeter levee to allow for rapid filling of the MSMU interior water surfaces prior to overtopping of the perimeter levee. The as-built construction drawings show the final grade of the north perimeter levee at elevation 582.3 feet MSL and the overflow spillway at elevation 580.3 feet MSL, which provides the required 2-foot difference. However, 8 inches (minimum) of granular surfacing was then placed on the overflow spillway. This would place the top of the overflow spillway at approximately elevation 581 feet MSL. A land survey verified that this was indeed the case. The average top elevation of the north perimeter levee was found to be 582.45 feet MSL, while the overflow spillway showed an average top elevation of 581.05 feet MSL. The result was a 1.4-foot difference between the two ends rather than the required 2-foot difference. This discrepancy may have contributed to a large breach in the north perimeter levee during the Flood of 2001. During the flood event, the Site Manager observed that the north perimeter levee and overflow spillway overtopped at the same time, rather than the latter first. As a result, the overflow spillway was lowered 8 inches.
Spillway	Stump Lake (MVS)	The exterior perimeter berm (levee) was designed with a 200 foot long overflow spillway on the downstream portion of the project. The riprap stone was graded stone C (400 lb top size). Severe erosion to the spillway and adjacent berm occurred during an overtopping event in 1997. In 1998, the spillway capacity was reanalyzed and redesigned with larger riprap stone (1,200 lb top size) and 500 feet additional length. To date the spillway has been overtopped numerous times and has maintained its integrity.
Spillway Vs. Stoplogs	Bay Island (MVR)	Overflow spillways were constructed within each cell to allow the MSMU to flood at a set elevation. The overflow spillways help remove the burden of constantly monitoring the river for rising elevations and the need to access the site for removal of all the stoplogs. After the overflow spillways were installed, it was noted that the transition from the perimeter levee crest down to the overflow spillway crest, a 1-foot vertical drop, may be too abrupt at a 10% slope.
Stoplog Materials	Banner Marsh (MVR)	One of the stoplog structures is starting to rust due to the high acidity of the water in the project area or it may be a natural occurrence. The Site Manager may need to repaint this structure.
Stoplog Operation	Banner Marsh (MVR)	The stoplog structures have been difficult to operate. The Site Manager has recommended that the stoplog structures have a sluice gate installed to stop flow. This would facilitate placement and removal of stoplogs. In the other stoplog structure, the stoplogs have a tendency to float. The Site Manager has wedged objects between the C-frame and the end of the stoplogs as a remedial effort to keep the stoplogs from floating. It has been recommended that the stoplog structures have locking mechanisms installed to prevent the stoplogs from floating or the procedure for installing the stoplogs needs to be changed.

Table 3.11. Lessons Learned

Topic	**Location**	**Lesson Learned**
Stoplog Operation	Bay Island (MVR)	The water control structures were designed and constructed with the intention of one person removing and replacing the stoplogs. Stoplogs were constructed out of pressure treated Spruce-Pine with a dimensional size of 5’-2½” x 5½“ x 2½“. However, removal of the wood stoplogs has proven to be more than a one person operation and can often be a struggle for two persons. It was recommended that the wood stoplogs be replaced with aluminum stoplogs, which are lighter. It was also recommended that one of the bays at each structure be converted to a sluice gate, thereby eliminating some of the stoplogs.
Stoplog Operation	Peoria Lake (MVR)	The site manager has expressed the inability to independently operate the three cells, which is undesirable. In addition, there have been challenges in operating the stoplog structures due to the weight of the wood stoplogs. Using solid plates or aluminum stoplogs in lieu of wood stoplogs has been discussed.
Stoplog Operation	Spring Lake (MVR)	Removal of the stoplogs underwater had been difficult. Locating the lifting lugs with the lifting device was a hit-and-miss operation. Therefore, the stoplog lifting device was modified by the site manager to make locating the lifting lugs easier. In addition, the stoplogs do not seal well, allowing seepage between cells. The stoplogs will eventually seal after several days due to fine sediment build-up between the gaps. It has been recommended that the stoplog settings not be changed frequently to avoid breaking this seal. If a more immediate seal is needed, it has been suggested to utilize cinders on the upstream side of the stoplogs.
Vegetation Control (interior)	Andalusia Refuge (MVR)	An abundance of woody vegetation was also reported on several islands in the MSMU. In 1996, the ILDNR Site Manager aerially sprayed the MSMU to control bulrush, lotus, and willow growth. The islands were also burned in 1997 and 1998 to control undesirable vegetation. A beaver dam was found across the main channel. A continual problem in the MSMU is the erosion of the island banks.
Vegetation Control (levees)	Andalusia Refuge (MVR)	In 1997 and 1998, thick woody vegetation was noted as growing among the riprap on the perimeter of the levee. The vegetation was removed and the riprap was sprayed with Round-Up. This process has since been repeated several times.
Vegetation Response on Berms	Andalusia Refuge (MVR)	The perimeter levee was originally seeded with a mixture which was predominantly Indian grass. Initial establishment was successful, however, there was no post-Flood of 1993 re-establishment of the Indian grass on the side slopes of the perimeter levee, nor was the perimeter levee re-seeded. Reed canary grass is now the predominant species. As reed canary grass is very invasive, spraying or controlled burns in the MSMU may be necessary to limit it to the perimeter levee only.