FOUNTAIN LAKE RESTORATION PROJECT: INTERNAL PHOSPHORUS LOADING

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ABSTRACT

Fountain Lake is central to the identity and tourism industry of the City of Albert Lea, MN. The 211 hectare (521 acre) lake is a popular destination for boating, swimming, and fishing. However, for years, Fountain Lake has suffered from poor water quality, and the lake was added to the Minnesota Pollution Control Agency's (MPCA) list of impaired waters in 2008. Specifically, Fountain Lake suffers from high phosphorus concentrations, overabundant algae, and low clarity. The Shell Rock River Watershed District (SRRWD) was established in 2003 at the request of local citizen's petition with the purpose of improving the quality of water resources within the district boundaries.

Results of several lake studies have determined that there is significant internal phosphorus loading from bottom sediments. Fountain Lake is controlled by an outlet dam and has a tributary watershed of approximately 25,496 hectares (63,000 acres) of largely agricultural land. SRRWD has implemented many upstream improvements to decrease future sedimentation into the lake, and now plans to remove the source of internal phosphorus loading through a multi-year hydraulic dredging project.

To support hydraulic dredging, an upland site within two miles of the lake has been selected for the construction of a multi-cell confined disposal facility (CDF) to place the dredged sediment. Three CDF cells have been designed, and construction of the first CDF cell is scheduled for 2017 with the first phase of dredging to follow upon completion. The planned sediment removal is estimated at approximately 974,808 m^3 (1,275,000 yd^3).

The Fountain Lake Restoration Projects exemplifies a situation that occurs in artificial lakes that are subject to progressive filling through sedimentation. In predominantly agricultural areas, such as the location of Fountain Lake, the deposited sediment not only decreases water depth, but is also an unwanted source of excess nutrients that can degrade water quality. These water bodies are not the target for an environmental cleanup from historic contamination or for commercial navigational needs. Instead, they are the target for restoration by local groups, such as SRRWD. While the motives are different between environmental cleanups versus restoration projects, the path to implementation is similar. This paper outlines the steps to implementation for a lake restoration project.

Keywords: Dredging, nutrients, dredged material disposal, eutrophication, confined disposal facility

INTRODUCTION

Fountain Lake, located in Albert Lea, Freeborn County, MN, covers approximately 211 hectares (521 acres) and is central to the City's identity and tourism as a popular destination for boating, swimming, waterskiing, fishing, canoeing, and kayaking. The lake was created by the construction of a dam across the Shell Rock River that was built in 1855 and rebuilt in the early 1900s. Fountain Lake has three bays connected to its Main Bay: Edgewater Bay, Dane's Bay, and Bancroft Bay. Four creeks flow into Fountain Lake: Bancroft Creek (from the north), Goose Creek (from the northeast), Shoff Creek (from the southwest), and Wedge Creek (from the west).

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Fountain Lake is a complicated shallow lake system in which climate conditions, external phosphorus loading to the lake and internal phosphorus loading from lake sediment have a significant effect on water quality. The maximum depth of Fountain Lake is approximately 2.4 m (8 ft), based on a 2009 bathymetric survey.

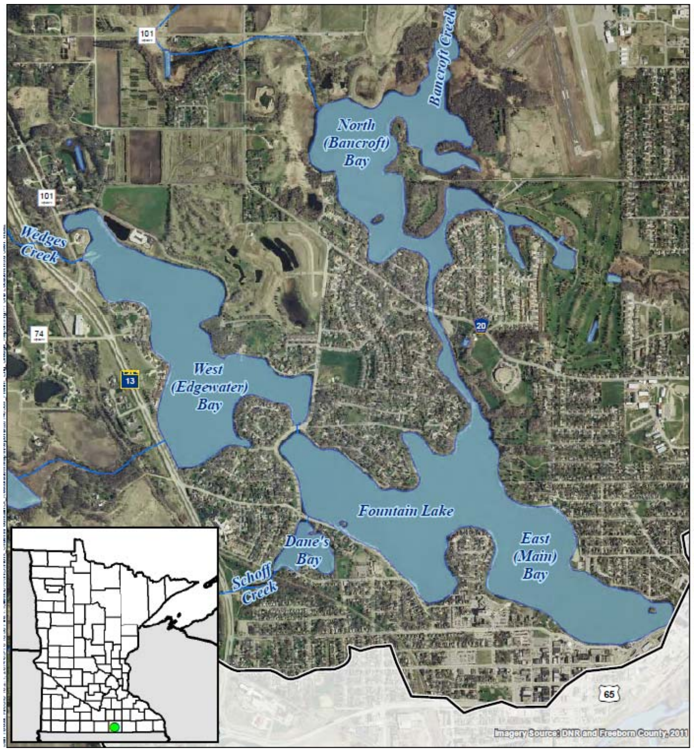

Figure 1. Fountain Lake Location Map

The Shell Rock River Watershed District (SRRWD) was established on June 25, 2003 with the mission of improving water quality in area waterbodies, and implementing reasonable and necessary improvements to water-related and other natural resources within its limits. Since its creation, SRRWD has pursued a comprehensive watershed approach to reduce sedimentation and improve water quality throughout the watershed through implementation of the Shell Rock River Watershed District 10-year Water Management Plan.

In 2005, Albert Lea voters overwhelmingly approved a 0.5% sales tax to fund local water projects. Through this supplemental funding source, SRRWD has leveraged substantial grant and other funding opportunities to improve water quality and decrease sedimentation.

SRRWD samples lakes and streams annually for phosphorus, chlorophyll-a, and other water quality indicators, as well as measuring water transparency. In 2008, Fountain Lake was added to the Minnesota Pollution Control Agency (MPCA) list of impaired waters for an "aquatic recreation" impairment due to nutrient loading (specifically phosphorus) and eutrophication. Historic and ongoing water monitoring has indicated summer average concentrations for phosphorus and chlorophyll-a (an algae indicator) exceed state standards for shallow lakes.

In 2012, SRRWD worked in cooperation with the MPCA to perform a Total Maximum Daily Load (TMDL) Study to determine pollution reduction strategies for Fountain Lake. The TMDL Study indicated that approximately 65 percent of the annual phosphorus loading to Fountain Lake is from internal sources (e.g., phosphorus release from lake bottom sediment). This accumulated phosphorus in sediment can be released into the water column through wind, wave, and rough fish action, decreasing water quality. The remaining 35 percent of the phosphorus load is from external sources (e.g., urban stormwater, tributary inflows, wet and dry deposition). In 2013, SRRWD developed a TMDL Implementation Plan that provided a comprehensive list of Best Management Practices (BMP) to reduce external phosphorus loads to Fountain Lake. Watershed protection initiatives that have been implemented include tributary creek stabilization, septic system improvements, and rough fish management, including common carp. Carp are bottom-feeding fish whose activities disturb sediments, resulting in cloudy, turbid water and the release of phosphorus into the water column. SRRWD has installed a fish barrier at the Fountain Lake outlet and in three locations on upstream tributary streams to limit the spread and breeding habits of carp.

With the completion of many upstream management practices, SRRWD seeks to further improve lake water quality by removing phosphorus-laden sediment through hydraulic dredging. Fountain Lake has been historically dredged twice before: once from 1940 to 1944 when the dredge "Captain George" removed approximately 1,376,199 m^3 (1,800,000 yd^3) of sediment, muck, and debris from Fountain Lake; and a second time from 1962 to 1967 when the dredge "Foun-Da-Lea" removed approximately 1,394,021 m^3 (1,823,310 yd^3) of sediment.

Pursuant to Minnesota Session Laws 2014, Chapter 295, Section 2, subdivision 3, the Minnesota State Legislature appropriated $7,500,000 from the general fund for a grant to the SRRWD for sediment removal and cleanup of Fountain Lake, including engineering, design, permitting, and land acquisition for deposit of removed sediment.

The priority goals for the Fountain Lake Restoration Project are to (1) improve lake water quality by dredging accumulated sediment to reduce internal phosphorus loading, and thereby reducing nutrient loads to downstream waterbodies; (2) enhance aquatic habitat by increasing water depth to provide wintering holes and summer refuge areas for fish; and (3) improve recreational opportunities by increasing water clarity for swimming and increasing water depths for boating.

SEDIMENT CHARACTERIZATION

Sediment sampling was performed in Fountain Lake from 2006 to 2015. In general, sediment consisted of organic and clayey silts (i.e., soft deposited sediment) with some localized sand shoals. Collected sediment samples were analyzed in accordance with procedures in the MPCA guidance document, "Managing Dredge Materials in the State of Minnesota" (MPCA, 2014). The guidance document lists laboratory testing parameters and comparison concentrations referred to as Soil Reference Values (SRV). By comparing laboratory results of collected sediment samples to the SRVs, the sediment can be characterized as Tier 1 (i.e., least impacted), Tier 2, or Tier 3 (i.e., most impacted), which have different management considerations.

All laboratory results for collected sediment samples were below MPCA's Tier 1 SRVs, except for three samples that were between Tier 1 and Tier 2 concentrations for Arsenic or Copper. To be more representative of how removed sediment will be managed, a composite sediment sample was collected and analyzed. All tested parameters from the composite sample were below Tier 1 concentrations. Based on the analytical data collected in compliance with MPCA requirements, the Fountain Lake sediment is categorized as Level 1 Dredge Material, which is not considered environmentally impacted and is suitable for use or reuse on properties with a residential or recreational use category. Collected sediment samples were also analyzed by the University of Minnesota Soil Testing Laboratory for evaluation of nutrient requirements for farm and field application. These data indicate dredged sediment could be suitable for beneficial reuse through land application.

Some collected sediment samples were analyzed for various types of phosphorus to help understand the concentrations and forms (or fractions) of phosphorus within the sediment. Mobile and organic phosphorus concentrations generally contribute most to internal lake phosphorus loading. Sample results indicated that phosphorus concentrations in the top several feet of lake sediment are higher than concentrations deeper within the lake sediments (Figure 2), and that a significant nutrient source to Fountain Lake is internal phosphorous loading from lakebed sediment (Barr, 2014). This information was considered during design of dredge areas to target phosphorus laden sediment for removal.

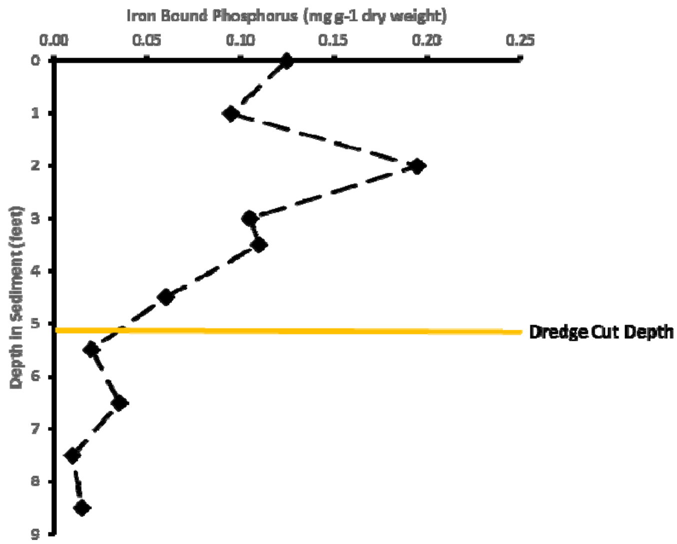

Figure 2. Vertical Phosphorus Distribution in Sediment

A Long Tube Column Settling Test (LTCST) was performed using sediment and water from Fountain Lake that is representative of material to be removed through hydraulic dredging. The LTCST was performed based on the USACE guidance document "Confined Disposal of Dredged Material" (EM 1110-2-5027). The LTCST describes sediment settling characteristics that could be expected in a CDF. Data from the LTCST were evaluated to estimate CDF effluent concentrations of Total Suspended Solids (TSS). Evaluation of LTCST data incorporated conservative assumptions including the minimum recommended CDF water ponding depth of 2 ft and continuous CDF inflow/outflow at the maximum design flow rate for the minimum possible hydraulic residence time. The hydraulic residence time was further reduced by a reduction factor based on the CDF geometry. The settling data were plotted to show the relationship between supernatant TSS and retention time. Figure 3 shows that the TSS concentration continues to decrease with increasing retention time (Palermo, 2016). Ponding depth and flow rate, and therefore retention time, are CDF operating parameters that can be monitored and adjusted as needed to control effluent TSS concentrations.

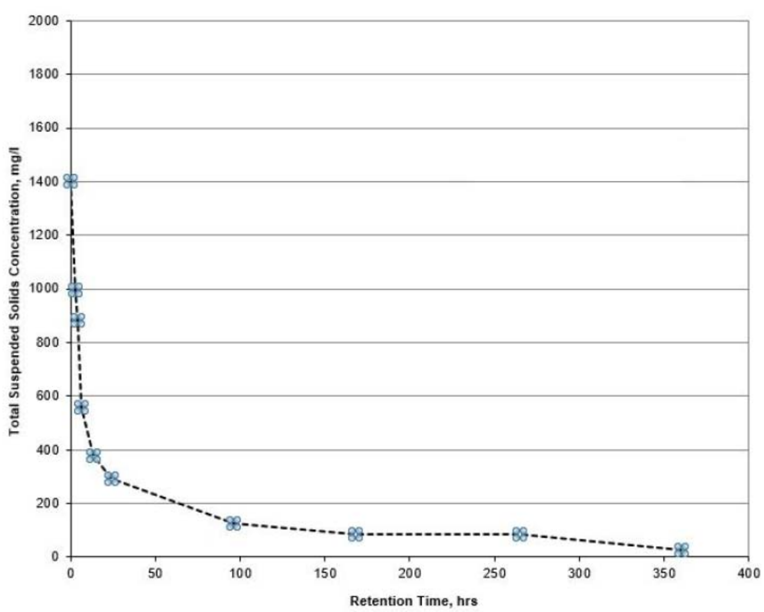

Figure 3. Suspended Solids vs. Retention Time

Lake Water Quality Model

Lake characterization activities incorporated a comprehensive modeling analysis to evaluate the impacts of dredging on water quality in Fountain Lake. Delft 3D modeling software was used to simulate the complex hydrodynamic and biological processes that occur within the Fountain Lake system (Barr, 2014). The model uses climate, external inputs, lake bathymetry, and lake sediment chemistry to predict how water moves, how constituents transform, how chemistry changes, and how some biota (e.g., phytoplankton) respond to these factors.

The model of Fountain Lake was developed and calibrated using climatic data and water quality monitoring data from 2006 (for most water quality parameters) and 2013 (for selected parameters including silica, dissolved and total organic carbon, and nitrogen species). 2006 was an average year during the time period when detailed water quality and hydrodynamic monitoring occurred in Fountain Lake and its watershed. Therefore, the 2006 hydrodynamic year is considered to be a good baseline reference year for evaluating dynamic processes within Fountain Lake compared to modeled impacts of various dredging and phosphorus loading conditions on water quality.

Since Delft3D is a “mechanistic” model with many of the variables and coefficients being inter-related, model calibration is an especially complex process, as equations (e.g., coefficients) cannot be modified to simply force calibration. The model calibration process and interpretation of the model output identified and/or confirmed some key characteristics of Fountain Lake and its dynamic biological and chemical processes: (1) Phosphorus release from lake sediments occurs shortly after dissolved oxygen declines in the water column. Dissolved oxygen also changes readily in response to frequent periods of stratification and mixing in Fountain Lake; (2) Lack of light availability due to high concentrations of dissolved organic matter and phytoplankton limits the growth and maximum population size of phytoplankton in Fountain Lake (versus phosphorus limiting phytoplankton growth); (3) Elevated summer ortho-phosphate concentrations in the water column are primarily from internal sediment loading.

Review of model output concluded that dredging and deepening Fountain Lake could result in improved water clarity. The modeled dredge scenarios verified that deepening the lake could bring about more pronounced thermal stratification (e.g., longer periods of thermal stratification, a larger zone of thermal stratification, and fewer periods of complete mixing throughout the water column). Greater periods of thermal stratification could result in less time that the water column is completely mixed, and thus reducing conditions that are suitable for algal growth resulting in a reduction in algal concentrations. Lower algal densities correspond to increased water clarity. Water quality benefits resulting from dredging Fountain Lake include: (1) Reductions in average and maximum summer total phosphorus concentrations; (2) Reductions in the frequency and magnitude of phytoplankton blooms (chlorophyll-a); (3) Reductions in the average chlorophyll-a concentrations; and (4) Increased average and maximum summer water clarity.

CONFINED DISPOSAL FACILITY

To support sediment removal from Fountain Lake through hydraulic dredging, an upland sediment management area is necessary to separate the lake water and deposit the sediment. The U.S. Army Corps of Engineers and the dredging industry refers to these locations as Confined Disposal Facilities (CDF). A CDF is one or more engineered settling ponds or basins where dredge slurry is pumped to allow sediment to separate from the water through gravity settling. Clarified water accumulated in the CDF is removed from the ponded water surface by an overflow weir discharge structure.

Several parcels of land were identified and evaluated for potential use as a CDF construction site. Nine sites were evaluated and eliminated from consideration for various unfavorable conditions. These conditions included the presence of buried utilities (e.g., gas transmission pipelines), difficult dredge pipeline routing logistics, unfavorable topography (e.g., hills requiring extensive earthwork), dam safety risks to nearby residents, and unwilling landowners. Ultimately a suitable site of approximately 40.5 hectares (100 acres) was located and acquired by SRRWD. The CDF site is agricultural land located approximately 1.6 km (1 mile) north of Fountain Lake’s Bancroft Bay, north of Interstate 90 and east of County Highway 20. The site is strategically located along an existing tributary to Fountain Lake that will serve as the dredge pipeline route and a conduit to return CDF effluent back to the Lake.

Up to three separation basins (Cells) are designed and will be constructed in phases to support lake dredging. Cell 1 will be constructed first, and Cells 2 and 3 will be constructed later as the dredging project progresses and additional storage capacity is required. The earthen embankments creating the cells will be up to a maximum height of 7.62 m (25 ft) and will be constructed using existing on-site soil. Soil for embankment construction will be excavated from within the CDF cell footprint to increase storage capacity beyond the existing topography. Potential future uses of the CDF cells following the completion of dredging include returning the land to agricultural use, excavating the settled sediment for beneficial reuse as topsoil, or creating natural habitat.

CDF Siting

The CDF site was designed to achieve the following objectives: (1) Maximize CDF storage of dredged sediment; (2) Balance construction earthwork (e.g., cuts and fills) with existing site terrain to minimize project cost; and (3) Use passive water treatment such that influent dredge slurry is managed through gravity separation of the sediment from lake water used to convey the sediment without the need for additional active water treatment of CDF effluent.

The CDF cells were designed following siting restrictions outlined in the MPCA guidance document "Managing Dredge Materials in the State of Minnesota" (MPCA, 2014) related to proximity to groundwater, proximity to parcel boundaries, and disturbance of wetlands. The bottom surface of the CDF cells was designed to be above the seasonal high water table based on observation of groundwater depths from temporary piezometers installed across the CDF site. Containment berms were designed to be at least 15.2 m (50 ft) from adjacent parcel boundaries as measured from the outside toe of the berms. Several wetlands exist on the CDF site that will be affected during cell construction. These wetland impacts will be permitted and will require mitigation through wetland replacement at a ratio of 2 to 1.

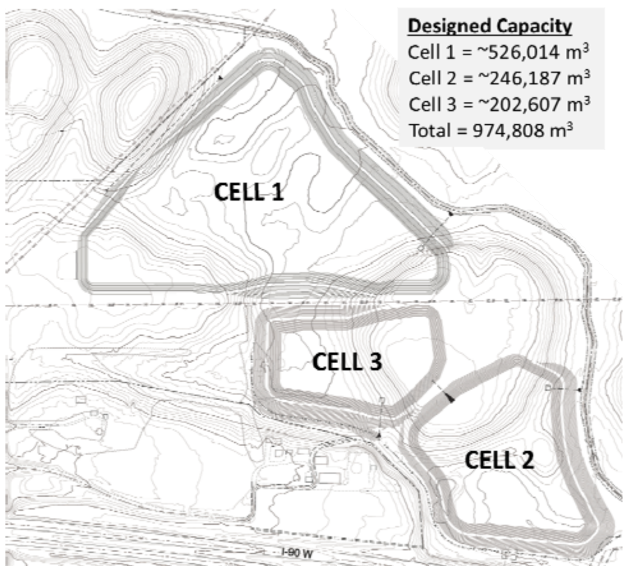

Figure 4. CDF Site Layout

CDF Geotechnical Investigation

A geotechnical investigation and laboratory testing program was performed during March and April 2016 to characterize site soils. Standard penetration tests and split spoon samples were collected from 35 borings using a hollow-stem auger drill rig. Temporary water table wells were installed in 11 borings to evaluate groundwater levels. Berm foundation borings were located along anticipated alignments of constructed CDF berms to evaluate foundation soil conditions to support slope stability and consolidation analyses. Berm borrow source borings were located in anticipated excavation areas for obtaining material to construct CDF berms. Borings and laboratory testing evaluated soil types for use in berm design and slope stability analyses. General investigation borings were located throughout the anticipated CDF construction areas to evaluate soil conditions and identify subsurface stratigraphy.

The generalized subsurface profile beneath perimeter berms is primarily sandy lean clay (i.e., glacial till) overlain by varying thicknesses of organic clay (i.e., topsoil). Layers of sand were encountered in a few borings with no apparent consistent pattern of thickness or depth/elevation. Along the anticipated south berm alignments of CDF Cells 2 and 3, soft organic deposits were encountered described as “peat”, “muck”, and “swamp deposits.” Soft deposits are generally unsuitable for foundation material and required specific consideration in the CDF design. As a result, a secondary investigation was performed to target this area of identified soft deposits to obtain physical and strength properties to evaluate potential construction methods or removal and replacement during CDF construction. Berm borrow source material was generally described as lean clay to sandy lean clay (i.e., glacial till) overlain by varying thicknesses of organic clay (i.e., topsoil). Like the borings under the berm alignments, layers of sand were encountered in a few borings with no apparent consistent pattern of thickness or depth/elevation. Laboratory tests are listed in Table 1.

Table 1. Geotechnical Testing Plan

CDF Geotechnical Investigation Laboratory Tests
Moisture Content (ASTM D2216)
Organic Content (ASTM D2974)
Dry Density (ASTM D7263)
Atterberg Limits (ASTM D4318)
Grain Size (ASTM D422)
Unconfined Compressive Strength (ASTM D2166)
Direct Shear (ASTM D3080)
Triaxial Compression – Unconsolidated, Undrained (ASTM D2850)
Triaxial Compression – Consolidated, Undrained (ASTM D4767)
Consolidation (ASTM D2435)
Compaction (ASTM D698)

CDF Berm Design

The containment berm was designed with a general trapezoidal geometry consisting of a maximum side slope, a maximum crest height, and a minimum crest width (Figure 5). The maximum crest height was designed at 7.6 m (25 ft) from the lowest ground surface elevation of the planned berm alignment. Berm sections along the alignment at higher ground surface elevations will have a lower height than the maximum section. MPCA’s guidance document “Managing Dredge Materials in the State of Minnesota” (MPCA, 2014) states that the exterior slopes of all dikes or berms must be no steeper than 3H:1V (i.e., horizontal:vertical); therefore, a 3H:1V exterior side slope was evaluated. A steeper side slope of 2.5H:1V was evaluated for the interior side slope to maximize storage capacity and minimize earthwork. The width of the berm crest was designed to accommodate inspection vehicles (e.g., pickup truck) and potential construction equipment (e.g., excavator). The design minimum crest width is 3.7 m (12 ft), which is the US Interstate Highway System standard traffic lane width. Before berm construction, an inspection trench will be excavated below the base of the constructed embankment centerline to identify and address any isolated pockets of unsuitable soils. The inspection trench also serves to locate and remove agricultural drain tile that may be present. If encountered, drain tile will be removed laterally from beneath the berm footprint and remaining pipe will be sealed with a concrete plug.

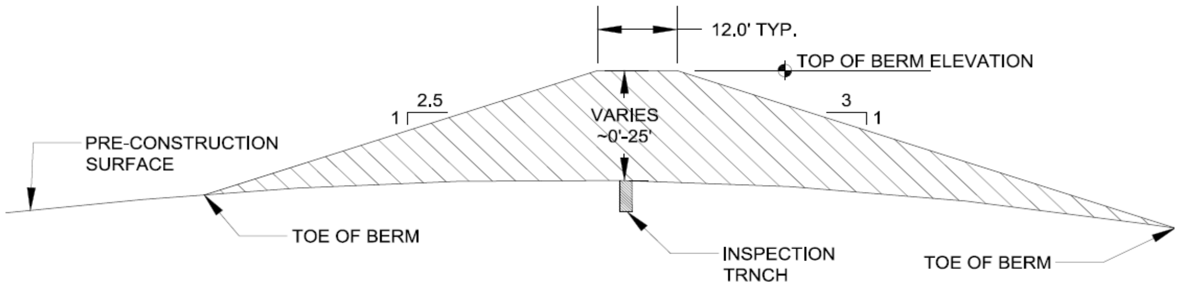

Figure 5. Conceptual CDF Containment Berm Cross Section

The containment berm design cross section at the maximum crest height of 7.6 m (25 ft) was modeled and evaluated for slope stability using limit equilibrium computer software (Geostudio’s Slope/W). The slope stability analysis determined safety factors at failure for various modeled conditions for both the interior and exterior slopes. The End-of-Construction condition evaluated the berm following completion of construction and prior to filling the CDF. The Long-Term Steady Seepage condition evaluated the berm with the CDF at full storage capacity with dredged sediment and water. The Rapid-Drawdown condition evaluated the berm for the unlikely scenario that water conditions fall rapidly but remain elevated within the containment berm, such as during emergency dewatering of ponded water within the CDF. The Seismic Pseudo-Static condition was evaluated for the berm with the CDF at full storage capacity and applying a representative horizontal ground acceleration of a potential earthquake. The slope stability analysis met the minimum design safety factors listed in Table 2 for all modeled failure conditions.

Table 2. CDF Berm Slope Stability Safety Factors

Stability Analysis Condition	Minimum Safety Factor
End of Construction	1.3
Long-Term Steady Seepage	1.3
Rapid Drawdown	1.0
Seismic	1.0

A seepage analysis was graphically performed using the Casagrande Method for earth dams to estimate the phreatic surface of a steady state seepage line through the earthen containment berm for use in the slope stability model, and to estimate the exit gradient at the outside toe of the berm. The theoretical fully developed seepage line was used in the Long-Term Steady Seepage slope stability model analysis. The estimated seepage exit gradient was low enough that design of additional seepage control measures (e.g., toe drain) was not necessary.

A consolidation/settlement analysis was performed for the maximum height berm section and multiple foundation soils using soil characteristics obtained from laboratory testing. The analysis estimated the magnitude of vertical consolidation or settlement resulting from the increased overburden pressure of the constructed berm. Specifically, the following consolidation elements were calculated: magnitude of primary consolidation; time to 90% consolidation; and magnitude of primary consolidation after a duration of 5 years. For berm construction over foundation material of primarily clay or sandy lean clay, consolidation was estimated at less than 0.3 m (1 ft) after 5 years, which can be accommodated through regular maintenance. For berm construction over the identified soft deposits, the estimated consolidation after 5 years was approximately 1.5 m (5 ft), which could be detrimental to the function and maintenance of constructed berms. Based on the isolated location of the soft deposits, the unsuitable foundation material will be removed and replaced prior to berm construction.

Box Riser Weir Structure

Each CDF cell is designed with a box riser weir outlet structure for controlling the elevation of ponded water within the cells and to manage discharge to meet effluent permit requirements. The minimum overflow weir length was determined to be 5.5 m (18 ft) based on a constant maximum CDF influent flow rate of 0.45 m3/s (7,160 gallons per minute [gpm]), a minimum 0.6 m (2 ft) ponding depth, and the dredge material settling characteristics. The project team coordinated with the USACE, Jacksonville District, to obtain design plans for a box riser weir (USACE, 2014a). The weir design uses a square box tower frame on a concrete foundation set within the CDF away from the inside berm toe (Figure 6). Weir board are inserted within each side of the box frame to raise the weir elevation, and a floating dock and gangway provide safe personnel access as the water elevation changes within the CDF. A discharge pipe exits the base of the weir box and passes through the base of the containment berm to remove clarified water from the CDF. A weir box with 1.5 m (5 ft) sides was designed for a total weir length of 6.1 m (20 ft) to achieve the minimum weir length.

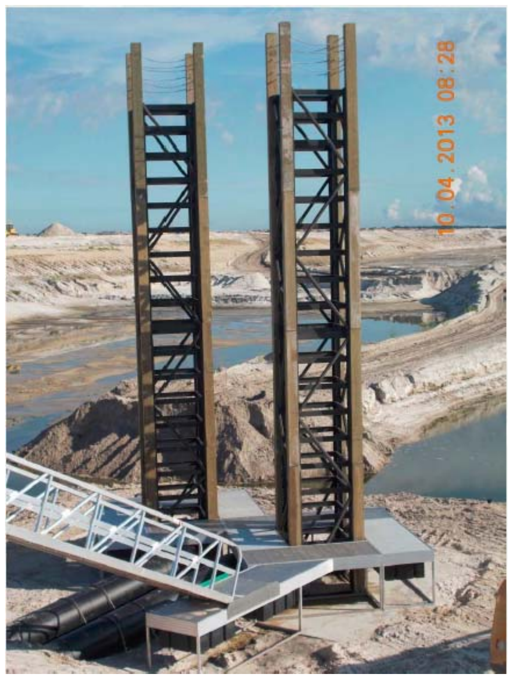

Figure 6. Set of Box Riser Weirs with Floating Dock and Gangway (USACE, 2014b)

HYDRAULIC DREDGING

Sediment removal is planned to occur over multiple years to achieve an estimated project total of approximately 974,808 m^3 (1,275,000 yd^3). Sediment dredging will decrease internal phosphorous loading and provide areas of deeper water as an additional benefit for improved fish habitat and recreation. The hydraulic dredging process removes sediment by cutting into accumulated sediment on the lake bottom, mixing the sediment into a slurry with lake water, and removing the slurry through a network a temporary pipes and pumps to the upland CDF area located north of the lake. A temporary pipeline will extend from the dredging equipment in the lake to the sediment management area. The maximum temporary pipeline length is anticipated to be approximately 6,096 m (20,000 ft) and will include a combination of in-water and overland routes.

Dredge Design

For several reasons, a maximum dredge flow rate corresponding to a 356 mm (14 inch) dredge was established for the project. This flow rate is 0.45 m^3/s (7,160 gpm). One reason is that the available CDF site limited the receiving flow rate to have sufficient retention time for sediment to gravity settle. Another reason is SRRWD has planned for this project to occur over several years to correspond with available funding sources. Therefore, the project did not justify the need to accommodate high flow rates for large dredges.

Sediment removal areas and depths have been designed with consideration for phosphorus removal, lake use, and aquatic habitat. Sediment removal will target identified deposited sediment and will not extend into the natural lake bottom. Approximately half of the lake surface area is planned for various depths of sediment removal. The average sediment removal cut is 0.9 m (3 ft). Final dredge areas are pending regulatory agency review of submitted permit applications.

REGULATORY AGENCY COORDINATION

Extensive coordination has been required with local, state, and federal regulatory agencies to plan, design, and implement the project. A list of required permits, authorizations, and approvals is provided in Table 3.

Table 3. List of Required Permits, Authorizations, or Approvals.

Unit of Government	Coordination	Purpose
City of Albert Lea	Various Access Agreements	Contractor staging and dredge pipeline route.
Federal Aviation Administration	Hazard Determination	Review of potential hazard to air traffic due to project proximity to municipal airport.
Freeborn County	Conditional Land Use Permit	To authorize construction of CDF on land zoned agricultural.
Freeborn County	Wetland Conservation Act Decision	Authorization of proposed project wetland impacts and mitigation.
Freeborn County	Right-of-Way Permit	Dredge pipeline route.
Minnesota Board of Water and Soil Resources (BWSR)	Project Plan Review	Review and comment on projects within BWSR jurisdiction.
Minnesota Environmental Quality Board	Environmental Assessment Worksheet	Review of project need, benefits, and impacts.
Minnesota Department of Natural Resources	Dam Safety Permit	CDF classified as a dam due to berm height and impoundment capacity.
Minnesota Department of Natural Resources	Public Waters Work Permit	To authorize hydraulic dredging.
Minnesota Department of Natural Resources	Water Appropriations Permit	To authorize removal of water in excess of 37,854 L/day (10,000 gal /day).
Minnesota Department of Transportation	Right-of-Way Permit	Dredge pipeline route.
Minnesota Pollution Control Agency	Construction Stormwater General Permit	Earthwork construction of CDF.
Minnesota Pollution Control Agency	Notification to Manage Dredged Material	Handling and placement of dredged sediment.
Minnesota Pollution Control Agency	Clean Water Act Section 401	Water quality certification for discharge from CDF.
United States Army Corps of Engineers	Clean Water Act Section 404	Authorization of dredging and discharge from CDF.

Permitting has been a large effort in terms of labor and expenses. As of this writing, all permits for construction of CDF cell 1 have been acquired and permits for sediment removal have been submitted and are under review. Significant efforts included the Environmental Assessment Worksheet (EAW) and the Dam Safety Permit. An EAW was required since the project fell into a classification requiring environmental review. In this instance, an EAW was required for impacting 0.4 hectare (1 acre) or more of a public water. The EAW is a detailed document that described the project scope, need, anticipated benefits, and potential impacts. Following completion, the EAW was distributed to a required list of recipients and posted for public viewing and comment. After the comment period, all comments were reviewed, responded to, and incorporated into the project design if determined necessary. The duration of the EAW process was approximately 4 months.

A Dam Safety Permit was required from the Minnesota Department of Natural Resources due to the height of the CDF embankments and the potential of the cells to impound water. Due to regulation as a dam, the design required a dam breach inundation study to delineate the inundation area in the event that a CDF embankment failed with the cells at full storage capacity. The analysis required evaluating the cells assuming all contents could be mobilized as fluid. CDF Cell 1 was evaluated since it was designed with the largest storage capacity, and CDF cell 2 was evaluated since it is located nearest to Interstate Highway 90. The inundation study was performed by Barr Engineering using a HEC-RAS model (Barr, 2016). The model incorporated the CDF design, actual LiDAR data of existing surrounding topography, and as-built plans of infrastructure at road crossings. The model was calibrated to a rating curve for the adjacent tributary from recorded flow monitoring data. Results of the inundation study indicated a low hazard classification since residences and infrastructure would not be affected by a breach of the CDF cells. Additional requirements of the Dam Safety Permit included preparation of a detailed Inspection, Operation, and Maintenance Plan, and an Emergency Action Plan for the CDF. The duration of the Dam Safety Permit process was approximately 13 months.

CONCLUSIONS

As of this writing, a contractor is under contract to SRRWD to construct CDF Cell 1 by August 2017. Prior to completion of CDF Cell 1, final design of dredge areas and acquisition of dredging permits is planned to be completed. Bidding and contracting for hydraulic dredging is planned to occur in parallel with CDF Cell 1 construction and dredge permitting such that dredging could begin in 2017.

The Fountain Lake Restoration Projects exemplifies a situation that occurs in artificial lakes that are subject to progressive filling through sedimentation. In predominantly agricultural areas, such as the location of Fountain Lake, the deposited sediment not only decreases water depth, but is also an unwanted source of excess nutrients that can degrade water quality. These water bodies are not the target for an environmental cleanup from historic contamination or for commercial navigational needs. Instead, they are the target for restoration to prior depths and water quality by local groups, such as SRRWD. While the motives are different between environmental cleanups versus restoration projects, the path to implementation is similar. This paper outlined the steps to implementation for one example of a restoration project.

REFERENCES

Barr Engineering (2014). “Draft Preliminary Engineering Report.” Fountain Lake Restoration Project

Barr Engineering (2016). “Fountain Lake Dredging Confined Disposal Facility (CDF) Dam Break Analysis.” June 3, 2016.

Maglio, C.K., Bearce, J.W., Presley, M.A., and Glover, J.L., (2014a). “New Standard Weir Design for Dredged Material Management Area, Jacksonville District.” ERDC/TN DOTS-14-01, August 2014.

Maglio, C.K., (2014b). “Dredged Material Management Area Weir Design, The State of the Art.” *Proceedings of the Western Dredging Association and Texas A&M University Center for Dredging Studies*, WEDA 34, June 17, 2014.

MPCA (2014). “Managing Dredge Materials in the State of Minnesota.” Minnesota Pollution Control Agency.

Palermo, M.R., (2016). “Technical Memorandum: Fountain Lake CDF Storage and Solids Retention.” May 3, 2016.

USACE (1987). “Confined Disposal of Dredged Material.” United States Army Corps of Engineers, Engineer Manual EM 1110-2-5027, September 30, 1987.

CITATION

Millspaugh, A.M., Weber, R.H., Henschel, A., Benkhe, B., and Kieffer, J. "Fountain Lake Restoration Project: Internal Phosphorous Loading," *Proceedings of The Dredging Summit & Expo '17, Western Dredging Association, Vancouver*, BC, June 26-29, 2017.

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