Replacement Master Plan

Gull Lake Dam

Prepared for

Gull Lake Association

May 2018

2170631

Contents

Figures

1 Introduction

The Gull Lake Dam acts as the outlet control structure for Gull Lake. It is located approximately 1/2 mile south of the community of Yorkville and 3 miles east of Richland in Ross Township, Kalamazoo County. The dam was originally constructed in the early 1830's and provided power a mill for the Price Cereal Food Co until 1906. In 1921, the Gull Lake Association was formed to acquire the dam, make repairs, and regulate the lake water level.

The Dam is regulated by the Michigan Department of Environmental Quality under Part 315, Dam Safety, Natural Resources and Environmental Protection Act, Act 451 of 1994 and subject to regular inspections every five years. The last inspection was completed by Prein&Newhof in April 2018.

The dam is in fair condition and while hazards presenting concern for immediate failure were not observed, the dam's condition has deteriorated and the Association has identified a need to plan for rehabilitation or replacement.

The purpose of this report is to evaluate the remaining useful life of the dam and propose alternatives for rehabilitation or replacement for the Gull Lake Dam. This report supplements the Dam Safety Inspection Report prepared by Prein&Newhof in April 2018. Please refer to the Report for additional details as to the current condition, observed deficiencies, and physical description of the dam.

2 Remaining Useful Life

The useful life of a dam is based on the various structural, mechanical, and hydraulic components of the dam and the overall safety of the dam. We typically assume that concrete and earthen components of a dam will last 50-100 years depending on construction materials and methods. Original construction plans do not exist for the dam therefore the evaluation of remaining useful life is based on engineering judgment and observed deterioration. The Gull Lake Dam has deteriorated primarily through the following means:

- Physical and mechanical processes such as cracking due to freezing and thawing or wetting and drying cycles. Numerous cracks, spalls, and loss of concrete were observed throughout the spillway. With repair, these components may last an additional 10-20 years. Other portions of the dam, such as the right downstream abutment wall, have deteriorated beyond repair and are assumed to be at their useful life.

- Chemical processes such as oxidation of metal components within the gate house.
- Biological processes such as growth of plants in cracks.
- Seepage under the foundation or through the embankment. Seepage was observed at the toe of the concrete wall on the left downstream toe of slope and will continue to progress and increase the uplift pressure on the wall and toe over time and increasing the risk for failure. Therefore, we believe the embankment has reached its useful life.

The lifespan of a dam and its various components can reach up to 100 years or longer depending on construction and maintenance. Given that the Gull Lake Dam was originally constructed prior to 1900 and repairs made in 1921, it appears that the dam is nearing the end of its useful life. Assuming no catastrophic failure occurs, we estimate the remaining useful life of the dam to be 10-20 years. The dam may continue to stand and operate as intended even if no repair or replacement occurs; however, the risk of critical failure will continue to increase over time.

3 Repair Alternatives

Repair or rehabilitation alternatives are intended to address minor deficiencies and extend the useful life of specific components. Concrete deficiencies may be repaired using patching, pressure grouting, or by removing deteriorated concrete, inserting dowels, and forming new concrete on top of the existing concrete features. Concrete repair is likely to extend the useful life of the existing concrete features for another 10-20 years.

Repair alternatives for the seepage through the embankment are limited due to the presence of a longitudinal seepage plane along the sides of the spillway. Installation of a bentonite slurry wall or a vinyl or steel sheet pile wall could act as a cutoff wall but would require excavating a portion of the embankment to secure it to the spillway wall.

4 Replacement

The purpose of replacement is to extend the useful life of the dam to an additional 50-100 years. Figure 2 depicts the recommendations for spillway and embankment repair.

4.1 Spillway Replacement

The purpose of a spillway is to maintain a consistent and safe upstream water level and allow for a controlled release of flow downstream. This report assumes full replacement of the spillway as numerous cracks, spalls, and loss of concrete were observed in the existing spillway. Multiple options exist for the control structure, entrance and discharge channels, and energy dissipation. For dams similar to the Gull Lake Dam, two primary types of spillways are used: concrete structure with an ogee spillway or steel sheet pile drop spillways. A description of each spillway type with its construction methods, advantages, and drawbacks is provided below. A final recommendation on spillway type is contingent upon a more in depth geotechnical analysis.

4.1.1 Concrete Ogee Spillway

An ogee (or S-shaped) spillway is considered the most hydraulically efficient spillway as the shape generally matches the shape of water falling freely and smoothly transitions falling water into the tailrace. The Lake Isabella Dam in Isabella County is an example of an ogee-shaped spillway. A description of the construction methods, advantages and drawbacks are below.

4.1.1.1 Method of Construction

- Reinforce east embankment crest for construction traffic
- Drive temporary sheet pile or place earthen cofferdam upstream of existing spillway
- Install pumps and piping to dewater site
- Demolish and remove existing concrete structures
- Install low flow pipe
- Form concrete abutment walls and spillway. Baffles should be constructed in the spillway to dissipate energy prior to flow reaching the receiving channel.
- Install stop logs or gate (if necessary)
- Restore site

4.1.1.2 Advantages

- Proven design that is adaptable to multiple types of foundations, including unstable or muck foundations. The Natural Resource Conservation Service soil survey shows that dam site is located on top of Houghton muck, which has very poor structural strength.
- Useful in areas with known water level control issues (i.e. seasonal fluctuations that impact low-lying properties) as an ogee spillway can be designed to pass increasing levels of flow with minimal raise in water level.

- Transitions water from high-energy (supercritical) to low-energy (sub-critical) efficiently which reduces wear and deterioration on abutment walls.

4.1.1.3 Drawbacks

- Higher construction costs
- More difficult to construct
- Minimal ability to seasonally adjust water level as stop logs are not typically installed with an ogee spillway
- Does not address the longitudinal seepage plane along the sides of the concrete spillway wall or along the low flow conduit. Seepage may continue to occur along these locations.

4.1.2 Steel Sheetpile Drop Structure

The spillway could also be constructed solely as a drop or free-flowing structure out of steel sheetpile. The Park Lake Dam in Clinton County and the Weidman Millpond Dam in Isabella County are examples of steel sheet pile drop spillways. A description of the construction methods, advantages and drawbacks are below.

4.1.2.1 Method of Construction

- Reinforce east embankment crest for construction traffic
- Drive steel sheet piles upstream of existing dam. Tie sheetpile into the existing embankment on each side of the dam.
- Install low flow gate and pipe
- Install pumps and piping to dewater site
- Remove metal fencing and the gate house and metal appurtenances.
- Demolish existing concrete spillway and leave on site for energy dissipation.
- Infill sheet pile spillway with additional riprap, as needed, for energy dissipation.
- Grade downstream channel, as needed
- Cut channel in sheet pile and install stop logs
- Construct access walk over spillway to facilitate access to the stop logs
- Restore site

4.1.2.2 Advantages

- Simple design that has been used effectively in numerous locations.
- Minimizes longitudinal seepage planes compared to other spillway designs
- Saves construction costs by making use of coffer dam as the final spillway and re-using concrete from the existing structure as riprap.
- Ability to seasonally adjust water levels

4.1.2.3 Drawbacks

- Plunge type spillways are not suitable for unstable foundations as the vibration forces may crack or displace the structure or embankment.
- Riprap will deteriorate over time and require replacement.
- Less aesthetically pleasing than other spillway alternatives

4.2 Embankment Replacement

Seepage has been observed at various locations along the existing earthen embankment on each side of the concrete spillway, therefore replacement of the embankment, at least in part, should be considered. All work completed on the embankment should be performed with thought to careful construction means, including adequate foundation preparation and proper placement of materials in the earthfill dam, and ensuring proper degree of compaction. We recommend the following items to address repair and replacement of the embankment.

First, fully remove the old mill foundation wall. Seepage was observed along the bottom of the old mill foundation wall on the east side (left) of the spillway. The design of the wall, including depth and presence of footings, is unknown. It is evident that the wall is not deep enough to cutoff seepage and hydraulic pressure will continue to increase behind the wall. Therefore, we recommend full removal of the old mill foundation wall.

Second, the left downstream toe of slope should be extended south (outward) to provide additional seepage control. The embankment should be constructed in a zoned manner, with an impervious clay core and pervious sand flanks covered with topsoil and seed. The purpose of a zoned embankment is to control seepage and stabilize the embankment when the water level fluctuates. Earthfill embankments should also be constructed with a toe drain to further control seepage and provide stability.

5 Conclusion and Recommendations

Based on an overall evaluation of available data, we recommend complete removal of the old mill foundation wall and spillway, regrading the downstream slope of the east embankment, and installation of a steel sheet pile spillway with stop logs. This alternative is preferred since it is more cost-effective and has fewer long term risks for failure. The total estimated construction cost for the preferred alternative is included in the appendices.

A successful design will require topographic survey, soil borings and geotechnical analysis of the foundation material, as well as hydraulic and structural design. Permits would be required by the Michigan Department of Environmental Quality pursuant to Part 301, Inland Lakes and Streams, Part 315, Dam Safety, Part 31, Floodplains, and Part 91, Soil Erosion and Sedimentation Control, of the Natural Resources and Environmental Protection Act (NREPA), 1994 P.A. 451, as amended.

5.1 Funding Opportunities

Funding a dam rehabilitation project can be difficult given the emphasis placed on dam removal and habitat restoration. The primary funding source current available for reconstruction is the Michigan Department of Natural Resources (MDNR) Dam Management Grant. In 2017, the grant program made available $350,000 for dam repair, rehabilitation, or removal. Applications are typically due in the fall of each year with awards announced in the following spring. The MDNR Dam Management Grant has a 10% minimum match requirement.

In 2016, Congress passed the National Dam Rehabilitation Program Act which established a grant program to assist local communities with dam repair, rehabilitation, or removal of high-hazard dams. The Gull Lake Dam is considered a low-hazard dam and may not be eligible for funding through this source.

Bonds, donations, and fees to lake residents may also be used to fund the project. Consult with an attorney familiar with special assessments to assist with these funding mechanisms.

5.2 Estimated Timeline

The estimated timeline is based on funding for the project being available.

- Fall to Winter – Complete topographical survey, soil borings and geotechnical analysis, and engineering design.
- Late Winter to Early Spring – Submit permit to the MDEQ

- Summer – Bid Project, assuming permitting and funding are available. Submit soil erosion and sedimentation control permit to the County Enforcing Agency.
- From Labor Day to Early Fall – Begin construction on earth embankment. Complete earth work with enough time to establish vegetation on east and west embankments.
- Fall to Winter – Construct Spillway
- Spring – Restore site

Figures

Existing Conditions

Preferred Alternative Conceptual Layout

SCALE: 1 " = 30 '

GULL LAKE ASSOCIATION
Ross Township
Kalamazoo County, MI

Figure 1. Existing Conditions

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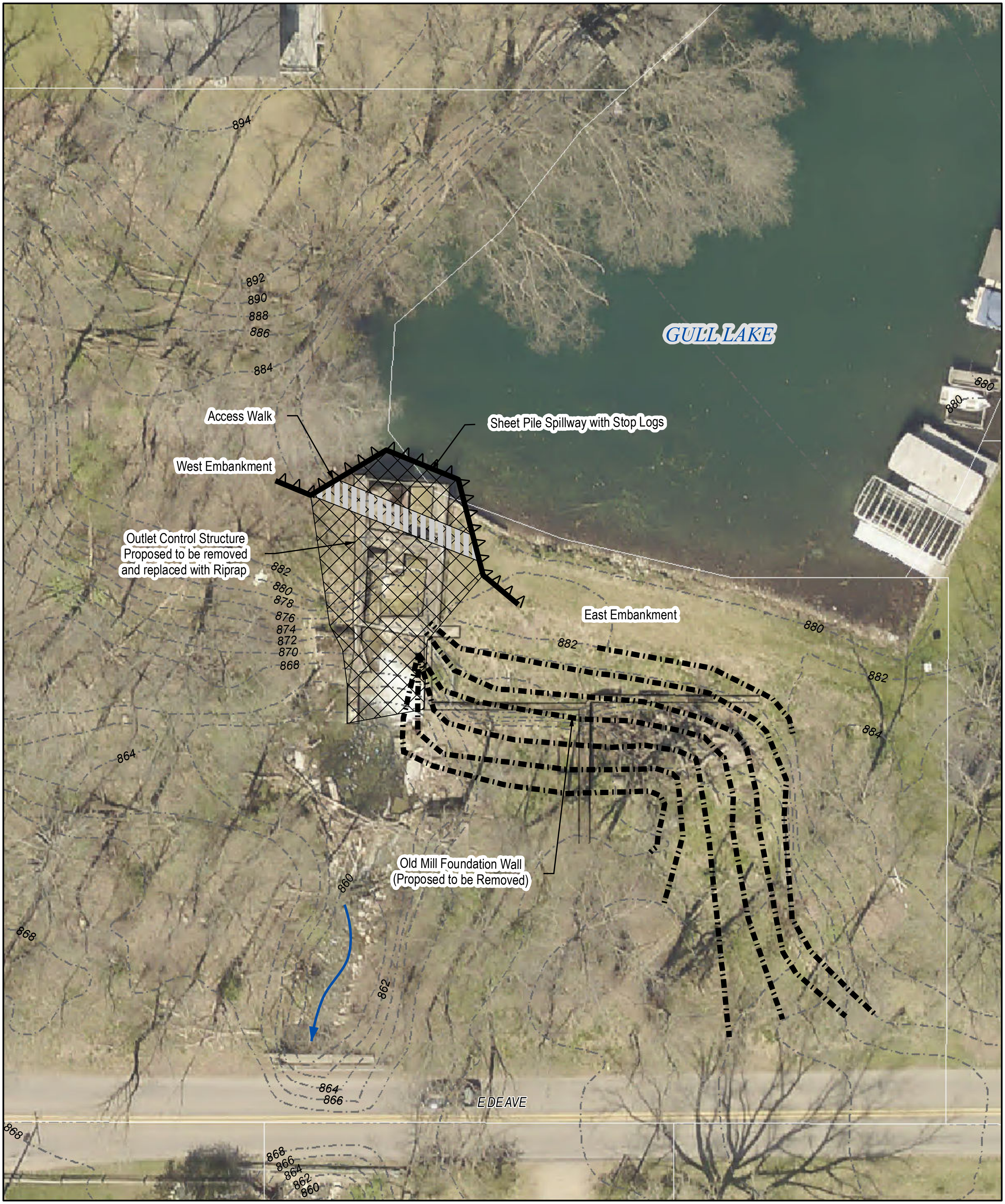

LEGEND

Approximate Fill Contours

Sheet Pile Spillway

Access Walk

Riprap Energy Dissipation

SCALE: 1 " = 30 '

Proposed features shown are for illustrative purposes only. Actual design and layout will depend on topographic survey, geotechnical analysis, and engineering design.

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Kalamazoo County, MI

Figure 2. Sheet Pile Spillway

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