REPORT	3060/20
TO:	Board of Directors, Mississippi Valley Conservation Authority
FROM:	Juraj Cunderlik, Director, Water Resources Engineering
RE:	**Shabomeka Lake Dam Rehabilitation Update**
DATE:	June 10, 2020

Recommendations:

That the Board direct MVCA staff to:

a) Complete detailed design of the Shabomeka Lake Dam water control structure using a manually operated mechanical (bascule) gate for water level regulation;

b) Commence regular monthly inspections of the Shabomeka Lake Dam as described in this report until construction begins; and

c) Develop a financing plan to ensure completion of the Shabomeka Lake Dam rehabilitation in 2021.

1.0 PURPOSE

The purpose of this report is to summarize the main advantages and disadvantages including cost implications of two design options for replacement of the Shabomeka Dam; and to provide a revised project schedule and recommended next steps in light of the denial of MVCA's provincial grant application under the Water Erosion Control Infrastructure (WECI) program for this project.

2.0 BACKGROUND

Shabomeka Lake Dam is located on the southwest shore of Shabomeka Lake in the Township of North Frontenac. The dam was originally built with timber cribbing around the turn of the last century to help move lumber down the river. As the lumber trade declined, the dam fell into disrepair. During the 1950's, the Mississippi River Improvement Company assumed ownership of the structure and rebuilt it with earth embankments and a wooden sluice gate. In 1959, the wooden sluice gate was replaced with a concrete structure.

Substantial rehabilitation of the Shabomeka Lake Dam was completed by Ontario Hydro in 1988. Deteriorated concrete was replaced, and steel reinforcing bars were installed on the control structure. Steel cross braces were installed between the abutments to stabilize the control section. A clay core was added to reduce seepage and rock filled gabion baskets were installed between the abutments to reduce erosion. In 1989, Ontario Hydro stated that the repairs completed in 1988 were of a temporary nature and that the concrete structure should be replaced.

MVCA took ownership of the structure in 1991. MVCA engaged Trow in 2005 to complete a dam safety review and geotechnical analysis of the dam. The analysis concluded that the factor of safety against failure of the downstream face of the embankment did not meet Ontario safety standards.

More recent dam inspections revealed several structural, erosion, and seepage deficiencies, including settlement and dip in the top of the earth embankments, seepage and erosion along the downstream face of the earth embankments, and longitudinal cracks on the top of the north earth embankment. The inspections concluded that the dam *does not* meet current Ontario dam safety standards.

Due diligence and standard of care must be exercised at all stages of a dam's life cycle. In response to the findings of recent dam inspection studies, MVCA initiated a Class Environmental Assessment (EA) for the Shabomeka Lake Dam rehabilitation. In 2019, the Class EA was approved and MVCA proceeded with the detailed design.

In October 2019, MVCA submitted an application under the *Lakes and Rivers Improvement Act* (LRIA) for the reconstruction of the Shabomeka Lake Dam to MNRF and is currently waiting for approval. Once approval is obtained, MVCA can complete detailed design.

Table 1 itemizes provincial grants received under the WECI program for the dam.

Table 1: WECI grants received for Shabomeka Lake Dam

Year	Project Scope	WECI Grant Value
2015	Geotechnical study	$15,000
2016	Replacement of decking	$7,700
2017-18	Preliminary design and environmental assessment	$40,000
Total		**$62,700**

The 2020 grant application was in the amount of $475,000, representing 50% of the cost estimate prepared in 2018 for like-for-like replacement of the dam.

3.0 EXISTING DAM AND OPERATION

The Shabomeka Lake Dam is the first major water control structure on the Mississippi River system. The dam is located in a remote part of the watershed and the long driving times combined with manual stoplog operation do not allow for fast response times during emergency situations.

The dam consists of a single concrete sluiceway containing eight 0.25 m x 0.25 m x 2.44 m stoplogs. The concrete structure, measuring 3.8 metres wide by 3.2 metres high, is founded at an elevation of 268.5 m, and has a deck elevation of 271.7 m. An earth embankment on either side of the sluice forms the remainder of the dam. The stoplogs are operated by a steel overhead gantry using two 1-ton chain fall hoists to manipulate the logs.

The north and south embankments are 50 m and 20 m long, respectively, and vary in height to a maximum of 3 m. The shoreline portion of the embankments were built using local materials. The other sections were built with wooden cribs and aluminum sheeting on the upstream surface and are impervious with fill on top of the cribs. Wing walls on the upstream facing embankments are wire mesh gabion baskets filled with rocks.

The dam is used to regulate water levels for flood control, recreational purposes, and fish habitat protection. Summer water levels are maintained between 270.90 m and 271.10 m. After the level drops below 270.93 m there is virtually no outflow from the lake until the fall drawdown. The drawdown begins mid-September with six of the eight stoplogs in the dam being removed by early October. Stable minimum winter water levels are targeted to reach 269.60 m to 269.80 m by early November. The number of operations per year vary between 15 to 25.

4.0 DAM DESIGN OPTIONS AND ANALYSIS

Two design options were considered for the control structure: a stoplog gate and a mechanical gate design.

<u>Stoplog gate</u> is a traditional control structure that was used frequently in the past. Stoplogs are usually wooden beams or steel or aluminium units stacked one upon the other to the desired height. They form a bulkhead that is supported in grooves recessed into the supporting piers at each end of the span. Water is controlled in the gate by manually adding or removing individual stoplogs. All dams owned by MVCA use wooden stoplogs that are operated manually.

<u>Bottom-hinged crest gates</u>, (bascule gates), are one of the simplest and most frequently used mechanical types of regulating gates. They were originally developed as a replacement for wooden flashboards. A hydraulic cylinder, cable drum hoist, or electric motor-driven cylinder is attached to the arm of the gate with a stem for operation. Bascule gates can be operated

manually or equipped with an automatic controller for remote operation. Mechanical gates have established history in Ontario with successful applications in Thornbury Dam, Wasdell Falls Dam, Omemee Dam, Earl Rowe Dam, Burks Falls Dam, and many others.

The main advantages and disadvantages of the stoplog and bascule gate options are provided in Table 2, which addresses the following considerations: operational aspects, performance in regulating water levels, maintenance requirements, and safety.

If the new Shabomeka Lake Dam was only designed for current operation, staff would recommend the stoplog gate design. However, the service life of the new dam will reach well into the next century and as such MVCA has an obligation to consider future operational needs to make sure the dam has the functionality required over time.

It is expected that the dam operation will need to address the following factors in future:

- Increased water demand, which will require more precise water level regulation,
- Climate change and extreme events, which will require more frequent water level regulation and faster operation response times,
- Integrated watershed management, which will require automated operation,
- Environmental considerations, which will require reduced footprint of field operations,
- Enhanced work safety, which will require more stringent safety measures and protocols.

The mechanical gate provides several advantages over the stoplog gate in all of these categories—it provides precise water level regulation, can support frequent and automated operation, requires reduced operation and maintenance in the field, and offers safe operating procedures. In contrast, stoplog gates are best suited to infrequent operation due to their high operation requirements, provide imprecise water regulation, and their operation can pose greater health and safety risks.

For these reasons, staff recommend a manually operated bascule gate design for the Shabomeka Lake Dam rehabilitation. The manual operation can be easily retrofitted for remote operation in the future once the supporting automation system is in place.

Table 2: Comparison of Stoplog and Bascule Gate Systems

Category	Stoplog Gate	Bascule Gate
Operation	**Advantages:** - Same as MVCA's other dams, in-house operation knowledge and experience - Existing overhead gantry could be reused in new design **Disadvantages:** - More labor-intensive, two operators required - Requires operator to enter the bay for jacking Logs are difficult to remove under high flows - Debris often gets lodged between logs - Stoplogs and pike poles can be lost during operations - Limited access across dam because of overhead gantry	**Advantages:** - Requires only one operator - No equipment stored on site (no theft/vandalism) - Opportunity to automate operation in the future - Does not require jacking - Debris can be easily flushed - Allowance for easy access/crossing - Operating mechanism provides effort only when raised **Disadvantages:** - No previous operation experience, will require training - Complex operation in ice conditions
Performance	**Advantages:** - Simple, robust mechanism, few parts could fail **Disadvantages:** - Imprecise water level regulation - Not suitable for short-term and frequent operation - Seepage problems - Stoplogs can jam	**Advantages:** - Precise water level regulation under all flow conditions - Better sealing, low seepage - Remote operation offers faster response times **Disadvantages:** - Mechanical parts can malfunction - Sensitive to aeration demand and vibration - Can become locked in ice during winter conditions
Maintenance	**Advantages:** - In-house knowledge, can be completed by MVCA staff - Spare parts readily available **Disadvantages:** - Overhead gantry system must be inspected by a structural engineer every 3 years - Stoplogs are replaced every 5-10 years - Chain falls must be replaced every 5 years.	**Advantages:** - Low annual maintenance - No trash accumulation in sluice **Disadvantages:** - No previous experience, will require training - Difficult inspection of hinge bearings - Mechanical parts more expensive to replace - Major refurbishment required every ~30 years
Safety	**Advantages:** - Not known **Disadvantages:** - Extensive procedures and PPE required for operation - Overhead gantry is prone to lightning strikes - Swinging cables can pose hazard - Operation (hooking logs) during high flows unsafe - Fall risk during operation - Entering gains to jack can be hazardous	**Advantages:** - Safer operation, low risk of injury - Reduced safety training required for staff - Failsafe condition lowers gate during emergency **Disadvantages:** - Not known

5.0 COST PROJECTIONS

Class-D cost projections for the two dam gate options are provided in Table 3. The cost difference between the two options is approximately $195,000 (18% cost increase) for the manually operated bascule gate and $227,500 (21% cost increase) for a remotely operated bascule gate. The incremental cost of the remote bascule gate design is approximately $32,500 which can be undertaken at a later time once the supporting system is in place.

Table 3: Cost Comparison – Capital ($2020)

Cost Item	**Stoplog Gate**	**Bascule Gate**	
		Manual Operation	**Remote Operation**
Detailed design	$40,000	$50,000	$60,000
Tendering	$5,000	$5,000	$5,000
Construction	$780,000	$920,000	$935,000
Administration and Inspection	$20,000	$20,000	$20,000
Contingency (30%)	$253,500	$298,500	$306,000
Total	**$1,098,500**	**$1,293,500**	**$1,326,000**
Difference over Stoplog Option		*$195,000*	*$227,500*

Table 4 provides operation and maintenance (O&M) cost projections for the two design options. Operation of stoplogs at Shabomeka Dam requires 2 MVCA staff, whereas a bascule gate can be operated by one person; and if equipped for automated operation, field work would be limited to maintenance only. Initially annual maintenance costs would be low, however, the shorter service life of its mechanical parts would necessitate major repairs twice during the life of the dam structure.

Table 4: Cost Comparison – Annual Operating & Maintenance ($2020)

Cost Item	**Stoplog Gate**	**Bascule Gate**	
		Manual Operation	**Remote Operation**
Annual Operation	$4,500	$2,500	$500
Annual Maintenance	$1,500	$2,500	$3,000
Total	**$6,000**	**$5,000**	**$3,500**

The costs are approximate and exclude any repairs that will be needed for the concrete structure and embankments which would be similar for all options, as well as the cost of dam safety inspection studies.

In summary, while the capital cost for the mechanical gate option is approximately 20% higher than the stoplog gate design, the reduced operation requirements, especially when equipped for automated operation in the future, will provide long-term cost saving opportunity. At the end of the life cycle the total capital cost associated with both design options is expected to be similar.

6.0 PROJECT FUNDING, APPROVALS, AND SCHEDULE

As MVCA did not obtain a WECI grant for the Shabomeka Lake Dam this year, staff will explore other provincial and federal funding opportunities and develop a strategy for the WECI application as well as a financing plan that will allow for its construction in 2021.

In the meantime, staff recommend regular visual inspections be carried out to identify and record any hazards, deficiencies or changes to the structure from previous visits, including signs of dislocation, settlement, erosion, cracks, and seepage.

An updated project schedule for the Shabomeka Lake Dam rehabilitation project is provided below. The schedule assumes that MVCA will be successful in securing MNRF approval of its preliminary design under the LRIA by the end of July; and sufficient funding for the project in 2021. All design work will be completed this year to enable eligibility for any shovel-ready funding opportunities that may arise. Construction is planned for the fall 2021 period and would commence after the mid-September drawdown. Post-construction site restoration works and facility monitoring will take place in 2022.

		2020							2021													2022
	Task	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	Land Ownership/Easements	■	■																		
2	Access and Safety	■	■																		
3	Detailed Design			■	■	■															
4	Permitting/Approvals					■	■	■													
5	WECI Application								■	■	■	■	■								
6	Tendering													■	■						
7	Bid Evaluation and Award															■					
8	Mobilization																■				
9	Construction																	■	■	■	
10	Site Restoration																				■
11	Monitoring and Maintenance																				■