

BELLAIRE DAM INSPECTION REPORT

DECEMBER 2018

**JAMES COUGHLIN, P.E., LLC
TRAVERSE CITY, MI**

**DAM SAFETY INSPECTION REPORT
BELLAIRE DAM
DAM ID NO. 435
ANTRIM COUNTY; INTERMEDIATE RIVER**

OWNER/OPERATOR: Mr. Mark Stone
Antrim County Drain Commissioner
205 E. Cayuga
Bellaire, MI 49615
Phone: (231) 533-8819

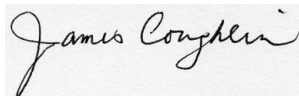
HAZARD POTENTIAL CLASSIFICATION: HIGH HAZARD

INSPECTED BY: James J. Coughlin, P.E., LLC

INSPECTION DATE: November 2018

REPORT DATE: December 2018

PREPARED BY:



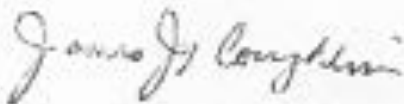
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James J. Coughlin, P.E., U.C.

State of Michigan

Consulting Engineer



I. INTRODUCTION

The Bellaire Dam is located in Bellaire, Michigan, on the Intermediate River, which connects Intermediate Lake with Lake Bellaire in the village of Bellaire, Michigan in Antrim County.

This report summarizes the dam safety inspection performed on November 2, 2018. This summary is primarily based on physical above-water inspections of the facilities and a review of pertinent documents. This inspection and report was done in compliance with Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended (Part 315).

The Bellaire Dam has a contributing drainage area of 145 square miles and creates a hydraulic head of approximately 12 feet. This dam is also regulated by Part 307, Inland Lake Levels, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 307). Part 307 requires the dam to be operated in such a fashion as to maintain legally established lake levels upstream of the dam.

Documents reviewed include 1973-74 construction drawings; prior dam safety inspection reports dated January 1991, October 1993, November 1997, December 2000, December 2003, December 2006, September 2009 and July 2016.

II. PROJECT DESCRIPTION

The Bellaire Dam is an earth embankment dam and is classified as a high-hazard dam by the MDEQ. The high-hazard rating is due to the appreciable economic loss and the high potential threat to human life in the event of dam failure. The dam was constructed before 1906 and consists of a 120-foot long eastern embankment, 63-foot wide spillway structure, and a 30-foot long western embankment. The spillway structure consists of a newer 25-foot wide concrete spillway with two 11-foot wide underflow radial gates, added in 1974, and the original 26 foot wide with three 6 foot wide underflow sliding gates.

The purpose for the dam is to control the level of Intermediate Lake pursuant with Part 307, Inland Lake Levels, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 307). Legal lake level elevations were established on January 11, 1986. The winter level which is from November 1st through the next year's major spring thaw, but no later than May 15th, is 606.54 feet above mean sea level datum 1929 (MSLD). At all other times the lake level shall be 607.15 feet (MSLD). Measurement and monitoring of the lake level is done at the north end of the Central Lake bridge while control of the water level is accomplished at the Bellaire Dam.

The operator of the Bellaire Dam, Mr. Mark Stone, has assured that the EAP requirements for this dam has been maintained.

III. Summary of Field Inspection

Any reference to "right" and "left" are with respect to looking downstream so the leftmost face would be the far eastern end of the dam. The gates are numbered 1 through 5 with 1 and 2 being the two radial gates starting at the east end and progressing westward.

A. Earthen Embankments

The eastern end of the embankment appears to be in good condition with both the upstream face and the top well vegetated with grassy vegetation. There is no evidence of animal burrows in the upstream face. The sheet piling that forms the east entrance to the spillway is in good condition. There is a small willow that has taken root at the edge of the sheet piling. This willow should be removed before it becomes a problem. Refer to the photograph in the appendix. The downstream face of the eastern end is in good condition and covered with grassy vegetation with a notable exception. There are two large willow trees at the toe of the dam that should be removed to prevent piping from root penetration. A photograph of the trees in question is also noted in the appendix. There is a minimal amount of seepage at the toe of this embankment. This seepage has been constant for several

years and does not pose a risk to this dam. The large riprap at the toe of the embankment is in good condition.

The security fence on the eastern end is in good shape.

The center embankment is in good condition and covered with grassy vegetation. The prior inspection noted the presence of small woody vegetation at the toe of the dam. This vegetation should be removed before it gets larger.

The western end of the embankment appears to be in good condition with the upstream face, crest and downstream face well vegetated with grassy vegetation. There does not appear to be any animal burrows along the upstream face. The sheet piling that forms the western entrance of the spillway is in good condition.

B. Spillways and Outlets

As mentioned in the Project Description there are five outlets at the Bellaire Dam; the newer spillway to the left with two outlets controlled by radial gates and the older spillway on the right with three outlets controlled by sliding gates.

Left spillway

The left spillway was built in 1974 and consists of two bays both controlled by 10 foot wide by 4 foot high radial gates. Both gates appear operational and were open at the time of this inspection. The rubber seal along the edge of both gates is in poor condition and should be inspected more closely. If necessary, these rubber seals should be replaced next summer. Please refer to the photographs for more information. The concrete near the radial gate bearings has eroded, perhaps aggravated by the continual use of depositing feces by raccoons. This concrete should be patched and sealed to reduce water infiltration and spalling. Ongoing efforts to reduce access to this area by raccoons have proven ineffective as the raccoons are easily capable of climbing the fences. If they continue to utilize this spot for a bathroom, it might be wise to contact an animal control expert.

The spillway walls downstream of the radial gates is being eroded and may require repairs in the future to mitigate future damage. Maintenance work on the right three slide spillways to correct severe spalling and leakage around the gates using epoxy and stainless steel has proven very effective. This approach may be considered for the left two radial gates to remedy this issue. The concrete energy dissipation blocks at the bottom of the spillway appear to be in good condition.

Right spillway

The right spillway was constructed in 1906 and modified in 1974. The 1974 modification included a new upstream apron and the new slide gates. The spillway is divided into three bays numbered 1, 2, and 3 from left to right. Each bay consists of a concrete sluice and is controlled by a 6 foot wide by 4 foot high vertical slide gate. The gates are power operated under manual control.

The 2012 report noted the upstream faces of the concrete spillways had significant leakage around the gates as well as serious spalling near the spillway gates. The deficiencies were addressed using a combination of stainless steel to wrap the leading edge of the concrete dividers between the spillways, and epoxy to seal and strengthen the concrete. These repairs appear to have resolved the spalling issues, and appear in good condition on the date of this inspection. There are numerous cracks along the top of the concrete dividers. These cracks should be filled and the tops of the concrete sealed to reduce future damage.

Prior inspection reports noted the spillway walls had been repaired with epoxy to address spalling concrete. These repaired sections continue to be in good condition but should be monitored and appropriate action taken if cracking or spalling reappears.

Prior inspection reports also noted the spillway walls have experienced significant erosion at the toe of the dam. The 2012 report noted this damage had been repaired, but it was difficult to ascertain the extent and effectiveness of the repairs below the water line due to the water discharge at the time of this inspection. Those portions visible above the waterline appear in good condition at the time of this inspection.

The three vertical gates are in good condition with any concerns about flow around the gates being addressed by the aforementioned repairs. The motor operators were not cycled during this inspection but appeared to be fully functional with evidence of recent operation. The ongoing concern regarding buckling in the threaded actuator rod when the gates reach their lower travel limit still exists and should be addressed. A travel limit and/or force limit switch should be installed on the motor operator as part of a long-term plan to provide safe operation of the slide gates.

IV. Structural Stability

No evidence of structural instability was noted at the time of this inspection. No further analysis is warranted at this time.

V. Spillway Capacity

From information provided by the MDEQ and included in the appendix, the design discharge to be used in evaluating this dam is the 0.5% probability (200 year) flood discharge of 1,200 cubic feet per second (cfs). The combined capacity of the primary and auxiliary spillway is approximately 912 cfs (refer to Appendix C) which is insufficient to pass the peak discharge of the design flood event.

However the storage capacity of this watershed is substantial. Based upon rough storage estimates in the system, the design flood event produces an increase in stage of approximately 0.67 feet, leaving approximately 1.8 feet of freeboard. This dam is deemed to have sufficient spillway capacity/impoundment storage to attenuate the 200 year design flood event.

As noted in Appendix C some conservative assumptions were made in performing the hydrologic/hydraulic analysis. It is recommended that a complete flood routing for this watershed be performed by MDEQ to better determine the impoundment elevations and freeboard during the design flood event. This information would also be useful in assisting Mr. Mark Stone's proposal to automate lake level gage readings.

VI. Recommendations Listed by Priority

A. Short Term Recommendations

1. Remove all woody vegetation from the upstream and downstream embankments.
2. Perform a detailed inspection of the rubber seals on the radial gates, and replace if necessary.
3. Fill cracks in concrete along top of concrete spillway walls, and seal concrete to reduce future damage.

B. Long Term Recommendations

1. Design and install limit switches on the right spillway slide gate motor operators.
2. Perform a complete flood routing to more accurately determine staging during significant rainfall events.

VII. List of Participants

The following individuals were present during various parts of the physical inspection:

James J. Coughlin, P.E. Consulting Engineer

Appendix A: Photographs



East end of upstream embankment looking east with small willows that should be removed



Downstream embankment at east end



Downstream embankment at east end showing willow trees that should be removed



Downstream embankment west end of dam



Radial gates looking upstream



Radial gate looking downstream showing erosion on side walls



Radial gate showing deteriorated rubber seal along edge of gate



Support section between radial gates showing raccoon feces



Slide gate discharge chutes



Concrete divider between slide gate discharge sluices showing cracked concrete



Close up of cracks in concrete that should be repaired and sealed



Close up of cracks in concrete that should be repaired and sealed



Downstream walls of slide gate discharge sluice showing repairs in good condition



Middle embankment showing woody vegetation that should be removed

Appendix B Location Map



Appendix C

Hydrologic/hydraulic analysis

Spillway capacity:

Standard weir analysis was used in computing spillway capacities:

Left spillway (radial gates)

Gate 1: 240 cfs

Gate 2: 240 cfs

Subtotal for left spillway: 480 cfs

Right spillway (slide gates)

Gate 1: 144 cfs

Gate 2: 144 cfs

Gate 3: 144 cfs

Subtotal for right spillway: 432 cfs

Total spillway capacity 912 cfs

As indicated the combined spillway capacity for the Bellaire Dam is estimated to be approximately 912 cfs. The design storm discharge was given by the MDNR as 1200 cfs. The total discharge capacity is approximately 288 cfs less than that needed to pass the design flow. This excess would have to be attenuated by the impoundment.

Storage capabilities:

The impoundment storage capability is substantial. Intermediate Lake provides approximately 4 square miles of surface area. Using a conservatively rectangular hydrograph with peak discharge of 288 cfs, and assuming a 3 day event produces (288 cfs x 3 days x 86400 s/day) for a total of $74.6 \times 10^6 \text{ ft}^3$ of water to be stored. The increase in stage is computed to be $74.6 \times 10^6 \text{ ft}^3 / (4 \text{ mi}^2 \times 640 \text{ acres/mi}^2 \times 43560 \text{ ft}^2/\text{acre})$ for a total increase of 0.67 feet.

The limiting factor on freeboard is the crest of the dam on the eastern embankment. The elevation of the crest of the dam is 610 feet while the highest legal lake level allowed is 607.54 feet. A 0.67 feet increase in stage would leave approximately 1.8 feet of freeboard. It is concluded that spillway discharge combined with impoundment storage would be sufficient to attenuate the peak discharge of the design flood event leaving 1.8 feet of freeboard.

Appendix D

Response from MDEQ for design flood discharges for Bellaire Dam:

This reply is being sent via email only.

We have estimated the flood frequency discharges requested in your email of December 27, 2018 (Process No. 20180727), as follows:

Intermediate River at Bellaire Dam, Dam ID 435, Section 19, T30N, R07W, Kearney Township, Antrim County, has a total drainage area of 145 square miles and a contributing drainage area of 145 square miles. The design discharge for this dam is the 0.5% chance (200-year) flood. The 0.5% chance peak flow is estimated to be 1200 cubic feet per second. (Watershed Basin No. 13 Elk).

Please include a copy of this letter with your inspection report or any subsequent application for permit. These estimates should be confirmed by our office if an application is not submitted within one year. If you have any questions concerning the discharge estimates, please contact Ms. Susan Greiner, Hydrologic Studies and Dam Safety Unit, at 517-284-5579, or by email at: GreinerS@michigan.gov. If you have any questions concerning the hydraulics or the requirements for the dam safety inspection report, please contact Mr. Jim Pawloski of our Dam Safety Program at 989-370-1528, or by email at: PawloskiJ@michigan.gov.