Edenville Dam Inspection Report

Dam Identification No.: 549
Hazard Potential: High
SE ¼ Section : T.17N. – R.01W.
Tobacco Township, Gladwin County, Michigan
Located on Tobacco & Tittabawassee Rivers
Per Part 315, Act 451 of 1994

Prepared for:

Four Lakes Task Force

Prepared By:

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Date of Inspection: June 2019 to March 2020

Project No. 126234SG2018

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INTRODUCTION

The Four Lakes Task Force (FLTF), is a Michigan non-profit IRS 501(c)(3) charitable organization representing the lake associations and property owners on Sanford, Wixom, Smallwood and Secord Lakes ("The Four Lakes"). The FLTF was established for the purpose of lessening the burden of government and to ensure a sustainable future of the Four Lakes for the benefit of property owners around the lakes, the environment, local businesses, recreational lake users and the economic welfare of Midland and Gladwin Counties. To this end, in 2018 the FLTF was appointed to serve as Delegated County Authority for Midland and Gladwin Counties with respect to managing the normal lake levels of the Four Lakes pursuant to Part 307 "Inland Lake Levels" of the Michigan Natural Resources and Environmental Protect Act (NREPA). In accordance with Part 307, the FLTF has sought to acquire the dams from its current dam owner, Boyce Hydro and related Boyce Hydro entities.

At the time of this report, the Part 307 legal lake levels and Special Assessment District was established, and a financial plan to issue municipal securities for up to $35 million was approved by Gladwin and Midland Counties in order to make repairs to the dams on each of the Four Lakes. In addition, the State of Michigan appropriated $5 million, through the Michigan Economic Development Corporation (MEDC) to assist the FLTF with implementing engineering design and repairs (MEDC Grant). However, the primary source of funding for the acquisition, design, and capital improvements to the dams would come from special assessments on the properties within the Four Lakes Special Assessment District (SAD).

As part of its due diligence as a prospective purchase of the dams, the FLTF inspected the Edenville Dam by means of observation. The inspection was undertaken by the FTLF engineering team, led by Spicer Group. At the time of the inspection, the purchase and acquisition of the dams had not been completed. As noted, Boyce Hydro is the owner of the dam. This report is not submitted on behalf of Boyce Hydro nor represents Boyce Hydro.

During the FLTF due diligence associated with the pending purchase of the Edenville Dam, it was known that significant repairs are needed. The MEDC Grant enabled FLTF to start the repair process. The repairs currently under consideration will be implemented in phases. The current phased repair and improvement schedule is as follows:

- Winter Operations Repairs – 2020
- Phase I Construction – Existing Dam Repairs – 2021
- Phase II Construction – Dam and Spillway Improvements – 2024
- Annual Maintenance – On going

As noted above, in accordance with the due diligence associated with the purchase of the dams from Boyce, the FLTF engineering team began conducting a series of inspections of the Edenville Dam beginning in 2019. Inspections and data collection efforts with respect to the Edenville Dam and its history are presently ongoing and the FLTF is planning repair and improvement efforts.

The FLTF has compiled an engineering team to assist with repairing dams. On behalf of the FLTF, Spicer Group (SGI) has been coordinating initial findings and repair efforts with the Michigan Environment, Great Lakes, and Energy (EGLE) including coordination meetings, Part 301 and 315 permit applications and pre-application meetings for anticipated major repairs and improvement currently under consideration.

Some of the information contained in this report, includes information previously provided to EGLE Dam Safety. This report will serve as a supplement to previous inspections performed on the dam, will document the repairs proposed for 2020, and discuss future repairs and improvements.

All references regarding the orientation of the dam shall be made as viewed looking downstream. All elevations provided in this report are in the NGVD 29 datum. The terms “satisfactory”, “fair”, “poor”, and “unsatisfactory” will be used to describe the conditions of the dam. Each term is generally defined as follows:

SATISFACTORY
No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.

FAIR
No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.

POOR
Dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. POOR may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency: further investigations and studies are necessary.

UNSATISFACTORY
Dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary until problem resolution.

CONCLUSIONS AND RECOMMENDATIONS

Overall Condition

The visual inspection of the dam and its appurtenant structures indicate that the dam is in fair to poor condition. This dam consists of a long earthen embankment with two concrete spillways which results in a 2,650acre impoundment at normal pool, containing the flowage for the upper reaches of the Tittabawassee River and its tributary, the Tobacco River. In September 2018, the Federal Energy Regulatory Commission (FERC) revoked the license for the Edenville Project, which impounds the Tittabawassee and Tobacco Rivers creating Wixom Lake. FERC revoked its license because of the Edenville Dam's history of non-compliance with FERC regulations; foremost being inadequate spillway capacity to meet FERC Dam Safety standards. Upon revocation, under Michigan law, regulatory oversight of the Edenville Dam came under the jurisdiction of EGLE’s Dam Safety Division.

Currently, there are deficiencies which need to be corrected. The dam does not provide adequate capacity to pass the ½ Probable Maximum Flood (PMF) event sufficiently to meet EGLE Dam Safety requirements. This has been previously identified during review of the rating curves by EGLE Dam Safety Engineers and confirmed by the FLTF engineering team. Currently, the FLTF has initiated engineering studies and the planning process to address increasing spillway capacity of the dam and bring it into compliance with both state and federal requirements. For that to occur, FLTF must secure ownership of the dam to implement this plan.

Observed Deficiencies/Prioritized Recommendations
While the dam was under FERC jurisdiction, Part 12D independent safety inspections were completed every five years and a Consultant's Safety Independent Report (CSIR) was published. This report lists recommendations for needed repairs, maintenance, or monitoring which should be implemented by the owner/licensee, Boyce Hydro. Typically, FERC staff accept these recommendations, may add additional recommendations based on their annual safety inspections and provide a schedule to complete the identified repairs.

Further Detailed Studies and/or Investigations
Further detailed studies, engineering, and permitting is needed to implement repairs. The FLTF has received engineering work plans from their consulting team. This includes tasks to reevaluate the PMF and conduct engineering tasks to winter operations repairs, phase I repairs and II repairs.

In the 2019 Lake Level Report submitted to the Circuit Court (used as basis for Court Order of lake levels and special assessment district) budgeted $20 million for repair on all four dams. Following the court order, the team proceeded with its due diligence and increased the repair budget to $35 million and established a preliminary repair implementation program. This plan developed a proposed phased approach to undertaking the necessary improvements which took into consideration engineering design, permitting, Part 307 legal procedures, bonding and financing procedures, and the overall scope of repairs.

Phase I consists mostly of concrete and embankment repairs, as previously outlined in past inspections, while Phase II would involve significant improvements, including additional auxiliary spillway capacity.

A more immediate study related to winter operations of the dam is being performed as well. Since the revocation of the FERC license, water cannot be passed through the powerhouse, which leads to all water being passed over the concrete spillways to maintain the legal lake levels. As the dam exists now, this method leads to excess ice buildup on the dam during the winter months and creates unsafe working conditions for the dam operators. The winter operation repair plan includes concrete repairs (April 2020), installation of new gate hoists (October 2020), site operational safety improvements (July 2020) and installation/purchase of new ice removal/prevention equipment (October 2020). On-going coordination with EGLE staff to review these plans and obtain necessary permits are in the process. The intent is to make all above mentioned improvements in 2020.

Other engineering tasks are planned, and contracts are in place, subject to the FLTF on behalf of the Special Assessment District, securing a bond anticipation note and access to the dam in accordance with the understandings associated with the purchase of the Edenville Dam, between the FLTF and Boyce Hydro.

Hazard Potential Classification
The Edenville Dam, which includes both the Edenville (Tittabawassee River side) and Tobacco embankments, is classified as having a high-hazard potential due to the impact that a potential failure could have on downstream developments, potential for loss of life and potential for failure of downstream dams. The maximum height is 54.5 feet. The State of Michigan law requires this dam to have spillway capacity to convey the 1/2 PMF.

We do not recommend changing this classification.

The hazard potential classification is only an indication of the potential for loss of life and economic loss due to failure of the dam. It is our opinion that the hazard potential classification of "High" for this structure is appropriate. The hazard potential is not an indication of the stability or integrity of the dam.

PROJECT INFORMATION

General Description of Dam

The Edenville Dam, built in 1924, is located on the Tittabawassee and Tobacco Rivers near the town of Edenville, Michigan. The dam includes the Edenville spillway and powerhouse located on the Tittabawassee River and the Tobacco spillway located on the Tobacco River. The total earthen embankment length is approximately 6,200 feet. The Michigan State Highway 30 (M-30) causeway effectively divides the embankment with the east side of the embankment impounding water from the Tittabawassee River and the west side of the embankment impounding water from the Tobacco River. The M-30 bridge opening acts to connect the water impounded on both rivers. The combined impoundments create Wixom Lake.

Wixom Lake has a surface area of approximately 3,658 acres in size and gross storage volume of 40,000 acre-feet when the normal summer elevation of 675.8 feet is achieved. Most of the shoreline of Wixom Lake is developed with residential properties. Based on the Counties of Midland and Gladwin records, there are 2,875 parcels of property that front the lake and 828 parcels which do not front the lake but have private easement access to the lake. The flowage right contour for Wixom Lake is 678.8.

Edenville Dam - Tittabawassee River Section -The left embankment of the Tittabawassee River section extends from natural ground to the gated spillway and is approximately 860 feet long. The right embankment of the Tittabawassee River section extends 3,180 feet from the powerhouse to M-30. The minimum crest elevation of the Tittabawassee embankments are approximately 682.1 feet. The powerhouse is located adjacent to the Tittabawassee spillway and has a concrete substructure and brick superstructure, is approximately 50.6 feet wide, and contains two (2) vertical shaft generating units. The concrete spillway has three bays, each having a steel Tainter Gate (radial gate).

Edenville Dam -Tobacco River Section - The left embankment of the Tobacco River section extends 520 feet from M-30 to the Tobacco spillway. The right embankment of the Tobacco River section extends approximately 2,030 feet from the Tobacco spillway and ties into natural ground. The minimum crest elevation of the Tobacco embankments are approximately 682.1 feet. The concrete spillway has three bays, each having a steel Tainter Gate (radial gate). For more details related to the spillways and gates, please see the spillway summary of the Field Inspection Section.

Currently, the Edenville Dam is owned by Boyce Hydro Power, LLC which purchased the dam in 2006. The FLTF has a purchase agreement with Boyce Hydro and is preparing to make the first payment at which time the bottomlands associated with the impoundment will be transferred to FLTF, the properties associated with the dam structure will be put into an escrow account, and FTLF will contract with Boyce to operate the dam until 2022, at which time FLTF will take over complete ownership and operations.

Purpose of Dam

The Edenville Dam was originally constructed in 1924 as a hydro-electric dam for Wolverine Power Corporation. The dam was not designed to be a flood control structure. There is a long-time recreational use of the impoundment with a resulting residential area present.

Available Design, Construction and Maintenance Information
The FLTF team, starting in summer of 2019, started obtaining and reviewing past inspections and records kept on site at the Edenville Dam. This database is still being developed as information becomes available, there is a tremendous amount of information and FLTF is actively compiling and reviewing past information.

Previous Inspection Reports

2015	Consultant's Safety Inspection Report
2010	Consultant's Safety Inspection Report
2000	Consultant's Safety Inspection Report
1994	Report on Inspection, Edenville Hydroelectric Project
1991	Initial Consultant's Safety Inspection
1982	Report on Condition of the Secord, Smallwood, Tobacco, Edenville, and Sanford Hydro Facilities
1976	Inspection Report of the Hydro Dam on the Tittabawassee River
1973	Inspection Report, Sanford, Edenville, Smallwood, and Secord Hydro Plants on the Tittabawassee River

FIELD INSPECTION
Beginning in the summer 2019, the FLTF engineering team performed visual inspections/observations of the dam along with reviewing and with beginning the process to gather historic records and reports. During inspection, the sight was observed, and photographs were collected. The inspection teams relied on the 2015 CSIR report as a basis for the inspections. The following is a summary of the visual observations made during the inspection:

Dam Structure – Existing Conditions

Buttress, Abutments, and Retaining Walls
The Edenville Dam consists of two concrete spillways, one on the Tobacco River, referred to as the Tobacco Spillway and the other being on the Tittabawassee River, referred to as the Edenville Spillway. The Tobacco spillway is constructed between two concrete buttress walls with a walkway over top. The Edenville spillway is constructed between a concrete buttress wall on the east side, and the powerhouse on the west. For more information specific to the spillways, please see the spillway section below.

Retaining walls exist primarily at the spillway structures and serve to support the upstream face of the embankment. These concrete retaining walls also serve as the cap to the sheet pile cutoff wall beneath. In addition, a retaining wall exists in the tailrace area on the Edenville spillway side. This wall also acts as an erosion control measure, however as shown in the photos of Appendix C, this wall is in poor condition.

A steel sheet pile cutoff wall is incorporated on the upstream face of the embankment to the left and right of each spillway.

During the field inspection, numerous areas were observed where spalling and cracking concrete was present on the buttress, abutments, and retaining walls. Repairs to abutment and retaining wall are recommended.

Earthen Embankments / Crest of Dam

The embankments on the Edenville and Tobacco side extend from the dam to the natural high ground on either side. The minimum crest elevation is approximately 682.1 feet at the Tittabawassee embankment and the Tobacco embankment. The upstream and downstream slopes of to 2.5H:1V and 2H:1V, respectively, are steeper in some areas. The earthen embankment does not have a core wall but is constructed of relatively impermeable glacial till deposits with a seepage tile system for internal drainage. Adjacent to each spillway, a steel sheet piling core-wall exists.

An embankment stability analysis is recommended.

Spillways

The two spillways on the Edenville dam consist of six spillway bays total, each with a Tainter gate (radial gate). The spillways consist of a hollow barrel arch design. The internal portion of the spillway, referred to as the gallery, can be accessed from atop the spillway. The Edenville spillway contains two gates that are 20 feet wide by 9 feet 6 inches high and one gate that is 23 feet 7 inches wide by 9 feet 6 inches high. The Tobacco spillway has two gates which are 23 feet 7 inches wide by 9 feet 6 inches high and one gate that is 20 feet wide by 9 feet 6 inches high. From abutment-to-abutment, the Edenville and Tobacco spillways are 68.6 and 72.2 feet wide. Gate sill elevation of the current structures are 667.8 feet. Each spillway has an electric hoist mounted on a movable trolley. Based on gate test performed June 2019, the gate openings are approximately 9.5 feet, except for Gate No. 2 (middle bay) on the Tobacco spillway which has an opening of 2.5 feet. Please note that during the gate test that Gate No. 2 bound on the concrete abutment and was not able to be opened past a height of 2.5 feet. In August, a diver inspected and modified the chains attached to the existing lifting lugs beneath the water which resulted to an increased opening of 4.5 feet. The Dam owner/operated was aware of this and has stated this has been repaired.

The gate test in June demonstrated that the current method to operate the gates was not an adequate or safe method. Gate test reports have previously been provided to EGLE.

For this reason, the FLTF has purchased, using the MEDC appropriations, six new electric stationary hoists which are to be installed the fall of 2020. In addition to the new hoists, new lifting lugs were also installed on each gate to provide dual lifting points rather than the one centered point. Two lifting points is the standard in the industry and reduces the likelihood of uneven lifting and binding.

Repairs to existing spillways and gate system are recommended.

Powerhouse

The powerhouse is located adjacent to the Tittabawassee spillway. It has a concrete substructure and brick superstructure, is approximately 50.6 feet wide, and contains two vertical shaft generating units. The turbines are identical 73-inch Francis-type Allis Chalmers turbines rated at 3,000 horsepower at a 45-foot head and 138 revolutions per minute (rpm). As previously mentioned, these turbines have since been shut down following the revocation of the FERC license, and are not presently able to pass any flow.

Drainage Structures

The embankments have seepage tiles at regular intervals and monitoring wells to observe the phreatic water surface within the embankment. The seepage tiles were installed during the original construction of the dam to provide adequate drainage to the earthen embankment. In most instances, the seepage tiles discharge to an open channel ditch. Over the years, some of the

seepage tile system has been modified to discharge into enclosed storm sewers. Weirs are in place at the end of the discharge ditches to estimate the amount of the seepage at each portion of the embankment. Other modifications to the drainage system include the construction of toe filter drain along portions of the right embankment of the Tittabawassee side and the left embankment of the Tobacco side in 2007.

Security

To meet the previous recreational requirements of the FERC license, public access points to the upstream and downstream side of the dam exist, however security fences and gates are in place on both spillways to restrict public access to these features. In addition, security cameras are in place and monitored at the main office. Signage is also present indicating dangers to boaters and also indicating restricted/no trespassing areas.

STRUCTURAL STABILITY

Presently, the FLTF engineering team is prepared to complete a structural stability analysis. The results will be submitted to EGLE upon completion.

HYDROLOGY AND HYDRAULICS

As defined by FERC, the PMF event is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin study. The PMF was calculated to be 74,360 cfs. Later in 2011, a study by accounting for the timing of the hydrographs on the Tittabawassee and Tobacco Rivers was done. The resulting PMF was determined to be 61,926 cfs.

In 2013, a study to determine the Inflow Design Flood (IDF) for the Edenville project was done. This study refined past studies by reconfiguring various elements of the HEC-RAS model. The resulting PMF at the Tittabawassee Dam is 41,900 cfs and the PMF at the Tobacco Dam is 25,900 cfs.

Currently, the FLTF engineering team is completing an independent review PMF which will be used as the basis for Phase II design. It is anticipated that PMF flow rates will increase and that substantial spillway capacity improvements are needed.

Contributing Drainage Area

The drainage area is estimated to be 932 square miles.

Design Flood Determination

Per EGLE Dam Safety Unit, high hazard dams are required to safely pass the 1/2 PMF event while maintaining adequate freeboard capacity. The ½ PMF flowrate calculated by EGLE is 25,900 cfs. To meet FERC requirements, the Edenville Dam must safely pass the full PMF flowrate. The FLTF engineering team expects the PMF flowrate to increase from 62,000 cfs.

Existing Spillway Capacity

As reported by EGLE, the Edenville spillway capacity is 11,102 cfs and the Tobacco Dam has a spillway capacity of 9,967 cfs. The rating curve from EGLE is included in Appendix B. The ½ PMF is 25,900 and therefore the existing spillways do not have the capacity to pass this flow. Dam modifications are being considered to pass this flow through a passive auxiliary spillway and supporting modeling is being developed.

Routing of Spillway Design Flood
The dam cannot pass the half and full PMF which are required by EGLE and FERC respectively. It is anticipated that an additional auxiliary spillway will be needed and the FLTF engineering team is currently working on a PMF study and planning for additional spillway capacity in Phase II improvements on both sides of the dam.

Flood of Record
The estimated flood of record at the Edenville Hydroelectric Project is 21,600 cfs based upon the gate openings and reservoir level on June 3, 1945. On that date, all gates were fully open, and the reservoir level was 2.4 feet above normal. This is believed to be the maximum discharge recorded at the Edenville Dam since its completion in 1925.

OPERATION AND MAINTENANCE

Lake/Reservoir Operation
The Edenville Dam was constructed to provide headwater level control for the purpose of hydro-electric power generation and received its license from FERC in 1998. The FERC license was revoked September 2018. The FERC license included a requirement to operate lake between two sets of water levels. The summer water operation is within 0.3 above and 0.4 feet below of the normal pool elevation of 675.8 feet. The winter water operation is 672.8 feet. The winter drawdown may begin on December 15th and must be completed by January 15th. Lake level is to return to summer operating level when water temperature reaches 39 degrees Fahrenheit. The minimum flow which must be released into the bypassed reach of the Tobacco River is 40 cfs from October 1st through March 31st and 66 cfs from April 1st and September 30th. All minimum flows shall be continuous. There is not a reference to minimum flow through the Tittabawassee River. Section 402 of the FERC license references the water temperature and dissolved oxygen requirements.

Gate Operation
Spillway structures exist at the Edenville Dam. The Dam has one gate hoist trolley on the Tittabawassee River side and one gate hoist trolley on the Tobacco River side. Each gate is opened before the hoist trolley is disconnected from the hoist chain to begin opening the adjacent gate. Gate operators must always be on site when discharging from the spillway structures during flood events.

Gate tests were performed in June 2019, a summary was provided to EGLE. The existing gate hoists were deemed to have unsafe working conditions. The FLTF has purchased new gate hoists and plans to install in fall of 2020. The FLTF engineering team is also prepared to complete an engineering study of the existing gates and trunnion pin support system.

The normal gate operation procedure is to open the Tobacco Spillway Tainter gates first to make releases to control the pool level. The Tittabawassee spillway gates are opened when additional spillway discharge capacity is needed to control the lake level. Each gate is to be opened to an appropriate and safe height prior to opening an additional gate. The order of gate operation is rotated such that no one gate is opened more often than another gate, except in a situation when a gate is not operating correctly.

Because this dam is located downstream of the Smallwood Dam, the second most northern station operated by Boyce Hydro, water flow from the Smallwood Dam affects water levels in the downstream lakes. When Smallwood Dam is operated to pass increasing flow, in a manner of a few minutes, all downstream dams must be operated so increased flow is passed from dam to dam to maintain normal lake levels in the system. In practice, gates are opened when the inflow is

greater than normal capacity and water levels are expected to exceed the normal lake level range. There is a FEMA 100-year flood elevation and during large storm events, water level may exceed normal levels.

Evaluation of Current Maintenance Plan

Current maintenance includes grass mowing of the embankment faces, monitoring of the seepage tiles and monitoring wells, and monitoring of erosion upstream and downstream of the dam. Due to the ownership change from Boyce to FLTF, the maintenance plan is being evaluated and modified. This maintenance plan will be sent to EGLE dam safety when prepared.

Appendix A

2019 EGLE DAM INVENTORY SHEET

Dam ID	549	**National ID**	MI00549	**County**	Gladwin	**County #**	26
Dam Name	Edenville Dam			**File**	Yes	**State**	Michigan
Popular Name	Wixom Lake Dam			**Plan**	Yes		
Pond Name	Wixom Lake			**Quad**	O25SW		
1/4 Section	SE	**Sec**	35	**Town**	17N	**Range**	01W
DEQ District	Saginaw Bay						
City	Edenville	**Distance (mi)**	1	**Population**	500		

Print Record

Additional Information

Gaging plan approved by FERC 6-22-99

Max spillway capacity includes 2000 cfs through powerhouse. Spillway capacity of gate spillways only, is 26500 cfs. Capacity, inflows, and outflows taken from 2015 Part 12d inspection report. - LAT 10/9/18

FERC License revoked in September 2018. Dam now falls under Part 315 authority. - LAT 5/29/19

No plan files | **Phase I (PL92-367) Inspection** | Yes

2 Inspection Reports | **1 Emergency Action Plan** | **Correspondence (12 Files)**

EAP	Yes	**EAP Last Updated**	6/29/2018	**Jurisdiction**	Gladwin County
Hazard	High	**Compliance Activity**			
Owner ID	1569	**Owner**	Boyce Hydro, LLC	**Owner Type**	Private
Authority	Part 307/Part 315	**Del. Authority**			
Inspection Date	05/25/2010	**Inspector**	FERC Peter N. Chapman, P.E.		
Report Date		**Next Inspection Date**			
Report Received		**Report Reply Date**		**Action Requested**	
Condition	Poor	**Condition Detail**	Deficiency recognized		
Year Built	1924	**Type**	Earth Gravity	**Purpose**	Hydro
Top Of Dam To Streambed (ft)	54	**Design Flood ElevationTo Streambed (ft)**	57		
Head {Headwater - Tailwater At Normal Flow (ft)}	46.1	**Normal Freeboard (ft)**	5.5		
Pond Acres At Normal Flow	2650	**Max. Storage (ac-ft)**	59200	**Normal Storage (ac-ft)**	40000
River	Tittabawassee River	**Watershed**	32D	**Drainage Area (sq. mi)**	985
Design Flood	PMF	**Design Inflow Discharge (cfs)**	67800		
Max. Spillway Capacity (cfs)	28500	**Design Outflow Discharge (cfs)**	61926		
Spillway Control	Controlled	**Spillway Width (ft)**	147	**Crest Length (ft)**	6597
Permit No.		**Repair Permit No.**		**Permit Expiration Date**	
DEQ/DNR Construction Approval	No	**Property ID**	None		
Year Legal Lake Level Established	2019	**Winter Level (ft)**	672.8	**Summer Level (ft)**	675.8
State Assessed	Yes	**SCS/NRCS**	None		
Public Access	Yes	**FERC No.**	10808	**Latitude**	43.816667
Trout Stream	No	**Installed Capacity (kw-hr)**	4800	**Longitude**	-84.388333
Lamprey Barrier	No	**Regulatory Agency**	Michigan DEQ		
Fish Passage	No				
Private on Federal	No				

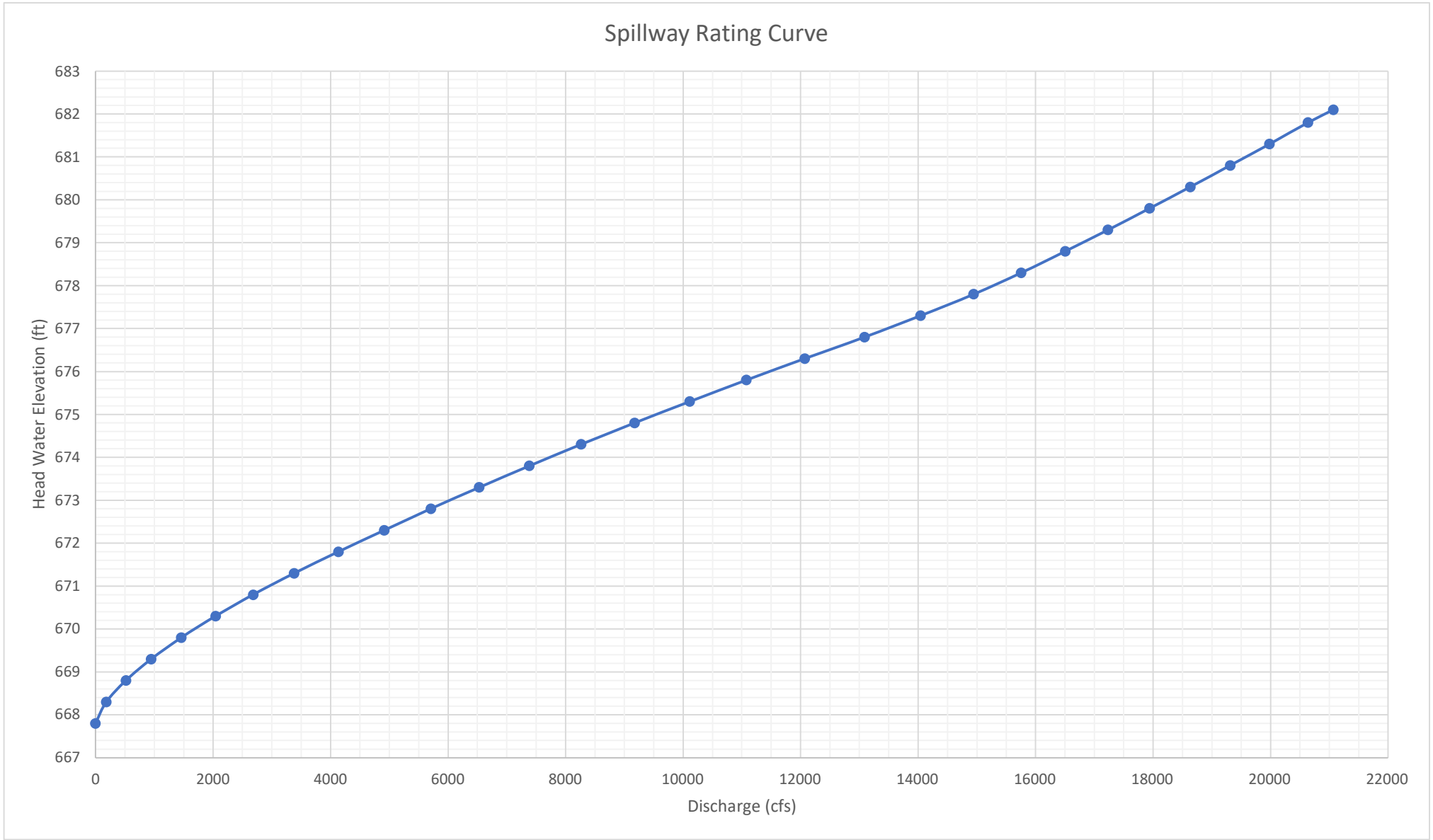
Close Inventory

Locate in Bing Maps

ArcMap

Appendix B

HYDROLOGY & HYDRAULICS


Spillway Rating Curve
Head Water Elevation (ft)
683
682
681
680
679
678
677
676
675
674
673
672
671
670
669
668
667
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
Discharge (cfs)

Edenville Dam - Dam ID No. 549, Gladwin County

Hydraulic Rating Curve

Combined Tittabawassee and Tobacco Spillways

HWEL	$Q_{Tittabawassee}$ (cfs)	$Q_{Tobacco}$ (cfs)	$Q_{combined}$ (cfs)	
667.80	0.00	0.00	0.00	
668.30	88.80	93.80	182.60	
668.80	251.15	265.31	516.46	
669.30	461.40	487.40	948.80	
669.80	710.37	750.41	1,460.78	
670.30	992.77	1,048.72	2,041.50	
670.80	1,305.04	1,378.58	2,683.62	
671.30	1,644.53	1,737.21	3,381.75	
671.80	2,009.23	2,122.47	4,131.70	
672.30	2,397.50	2,516.82	4,914.32	
672.80	2,807.99	2,899.24	5,707.23	
673.30	3,239.55	3,290.49	6,530.03	
673.80	3,691.20	3,691.34	7,382.54	
674.30	4,162.08	4,102.20	8,264.28	
674.80	4,651.44	4,523.25	9,174.69	
675.30	5,158.61	4,954.51	10,113.12	
675.80	5,682.97	5,395.98	11,078.95	
676.30	6,223.99	5,847.56	12,071.54	
676.80	6,781.16	6,309.15	13,090.31	
677.30	7,333.87	6,706.88	14,040.75	
677.80	7,848.73	7,098.13	14,946.85	
678.30	8,268.04	7,487.82	15,755.86	
678.80	8,666.10	7,839.59	16,505.69	
679.30	9,053.81	8,176.80	17,230.61	
679.80	9,432.37	8,506.52	17,938.89	
680.30	9,802.76	8,829.55	18,632.31	
680.80	10,165.82	9,146.54	19,312.36	
681.30	10,522.24	9,458.07	19,980.31	
681.80	10,872.62	9,764.61	20,637.23	
682.10	11,102.59	9,966.97	**21,069.56**	*overtopping begins*

Notes:

Assumes all gates fully open to maximum, per Spicer Gate Test

Appendix C

PHOTOGRAPHS

EDENVILLE DAM - TITTABAWASSEE RIVER SIDE

1 - Left Embankment, Looking West Towards Spillway

2 - Left Embankment - Downstream Slope near Embankment, Looking West

3 - Left Embankment - Downstream Slope, Looking East

4 - Left Embankment - Toe of Downstream Slope, Looking East

5 - Left Embankment - Downstream Slope, Looking West towards Spillway - Approximately in Center

6 - Left Embankment - Seepage Tiles & Drainage Ditch, Looking East - Near Access Drive

7 - Left Embankment - Seepage Tiles & Drainage Ditch, Looking Northwest

8 - Left Embankment - Seepage Tiles and Drainage Ditch, Looking East

9 - Left Sheetpile Wall in Tailrace, Looking South

10 - Left Embankment - Upstream Slope

11 - Left Embankment - Upstream Slope

12 - Left Embankment, Downstream Slope

13 - Left Embankment, Backside of Left Training Wall

14 - Left Training

15 - Lower End of Left Training Wall & Sheetpile Retaining Wall in Tailrace - Sheetpile has Failed

16 - Top Overview from Spillway - Downstream Left Side

17 - Right Embankment, Looking West Towards M-30

18 - Right Training Wall

19 - Right Embankment - Downstream Slope, Looking West Towards M-30

20 - Right Embankment - Downstream Slope, Looking West near Powerhouse

21 - Right Embankment - Downstream Slope, Looking East Towards Powerhouse

22 - Right Embankment - Downstream Slope, Looking East near Bend in Embankment

23 - Right Embankment - Downstream Slope, Looking Northwest Towards Office

24 - Right Embankment - Downstream Toe of Slope, Looking Northwest at Bend

25 - Right Embankment - Downstream Slope, Looking West Towards M-30

26 - Right Embankment - Downstream Slope & Drainage Ditch with Seepage Tiles, Looking East

27 - Right Embankment - Broken/Submerged Seepage Tiles, Looking Northeast

28 - Right Embankment - Seepage Tiles & Drainage Ditch, Looking Northeast

29 - Right Embankment - Top Access Drive, Looking West - Standing near Office

30 - Right Embankment - Top Access Drive, Looking Northeast Towards Bend

31 - Right Embankment - Upstream Slope, Looking East

32 - Right Embankment - Top Access Drive, Looking West

33 - Right Embankment - Top and Upstream Face, Looking Northwest near Bend

34 - Right Embankment - Upstream Slope, Looking Northwest - Halfway Between Bend and Powerhouse

35 - Right Embankment - Upstream Slope Armored with Riprap and Fieldstone, Looking Northwest

36 - Right Embankment - Upstream Slope, Looking Northwest towards Fishing Pier

37 - Right Embankment - Upstream Slope, Looking West

38 - Tainter Gate

39 - Gate Hoist & Right Powerhouse Wall

40 - Gate Hoist System

41 - Head Gate Hoist System

42 - Downstream Face of the Rollway

43 - Powerhouse Trash Rack

44 - Powerhouse Trash Rack

45 - Top Overview of Powerhouse Wall & Divider Wall

EDENVILLE DAM - TOBACCO SPILLWAY SIDE

1 - Left Embankment near M-30

2 - Left Embankment at Gate

3 - Left Training Wall

4 - Left Embankment - Upstream Slope, Looking East

5 - Left Embankment - Upstream Slope Armored with Concrete, Looking East

6 - Left Embankment - Upstream Concrete Wall, Looking West

7 - Left Embankment - Upstream Slope near Spillway, Looking West

8 - Left Embankment, Looking East

9 - M-30 Parking Lot looking at the Downstream Side of Left Embankment


10 - Left Embankment - Access Drive, Looking East towards M-30


11 - Left Embankment - Downstream Slope, Looking Southeast


12 - Left Embankment - Downstream Slope, Looking towards Spillway

13 - Left Embankment - Downstream Slope at M-30

14 - Left Embankment - Downstream Slope, near Spillway

15 - Left Embankment - Erosion at Left Training Wall

16 - Left Embankment - Upstream Slope, Looking East

17 - Left Embankment - Upstream Slope, Looking Northwest

18 - Left Embankment - Upstream Slope, Looking West towards Spillway

19 - Right Embankment - Upstream Concrete Wall

20 - Right Embankment, Westerly Side of Dam

21 - Right Retaining Wall

22 - West Embankment - Upstream Face, Looking Southeast

23 - Right Embankment - Downstream Slope, Looking West

24 - Right Embankment - Downstream Slope at Bend

25 - Right Embankment - Downstream Slope near Bend

26 - Right Embankment, Looking towards M-30

27 - Right Embankment near Spillway

28 - Right Embankment - Downstream Toe of Slope, Looking West

29 - Right Embankment - Downstream Slope, Looking West

30 - Right Embankment - Downstream Slope

31 - Right Embankment - Far West Side of Project, Looking East

32 - Right Embankment - Seepage Tiles, Looking East

33 - Right Embankment - Seepage Tiles, Looking Southeast

34 - Right Embankment - Seepage Tiles, Looking Southeast

35 - Right Embankment - Seepage Tiles & Drainage Ditch, Looking West

36 - Right Embankment - Seepage Tiles & Drainage Ditches, Looking Southeast

37 - Right Embankment - Seepage Tiles in Ditch

38 - Right Embankment - Seepage Tiles, Drainage Ditch & Access Rd., Looking West