VERMONT

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Agency of Natural Resources

MEMORANDUM

TO:	To The File
FROM:	Benjamin Green, PE, Dam Safety Engineer
DATE:	October 3, 2019
SUBJECT:	Visual Dam Safety Inspection of Curtis Pond Dam, Calais, Vermont State ID No: 40.09, National ID No: VT00063

On July 19, 2019, Benjamin Green, PE, Steven Hanna and Nicholas Brustin of the Dam Safety Program performed a visual dam safety inspection of the Curtis Pond Dam. The current ownership of the dam is unknown. Refer to the Dam Safety Inspection Program General Information page at the end of this report for more information and definitions of terms used in this report. The last documented inspection of the dam was conducted on June 23, 2015

BACKGROUND

Curtis Pond Dam is an earth embankment dam with a dry-set, vertical stone masonry wall downstream face, primary spillway, and low-level outlet (LLO). The dam is currently classified as a SIGNIFICANT hazard. According to file information, the dam is 120 feet long with an approximate height of 11 feet. The principal spillway consists of an approximately 5-foot-wide stone lined channel located near the center of the embankment. There is no auxiliary spillway at the dam. The LLO consists of an approximately 2 foot by 2-foot stone masonry penetration through the dam. There do not appear to be any operable works associated with the LLO. The drainage area of the dam is reportedly 1.29 square miles and the area of the pond at normal pool is about 75 acres. The estimated normal and maximum storage of the dam are 740 and 850 acre-feet, respectively. The dam discharges to Curtis Pond Brook, then flows to Pekin Brook, a tributary of the Kingsbury Branch of the Winooski River. The construction of the dam reportedly raised the normal water level in Curtis Pond on the order of ten feet, causing the two natural ponds upstream to combine into what is now Curtis Pond. The dam was original constructed circa 1900. The current purpose of the reservoir is for recreation.

CONDITION RATING AND RECOMMENDATIONS FOR OWNER

Based on this visual inspection, the overall condition of the dam is considered **POOR**. The specific concerns are identified in more detail in the Inspection Findings section. The following recommendations and remedial measures describe the recommended approach to address current deficiencies at the dam. It is intended that maintenance level activities can be performed by the Owner, while Studies and Analyses and Remedial Repair Recommendations will require the services of a qualified professional engineer registered in the State of Vermont who is experienced in dam safety engineering design, permitting, and construction.

The condition and stability of the dam have been a concern for some time. While the observable deterioration of the dam appears to be slow, the future stability of the dam is dependent on the loading conditions it is subjected to and internal factors that cannot be fully evaluated. The dam has numerous of deficiencies that make it susceptible, including an under sized spillway that could lead to overtopping during a storm event and erosion/destabilization of the dam, there is no operable LLO, so in the event there were a concerning safety concern (such as a stability or internal erosion issue), the pond could not be readily drawn down to reduce the risk of failure, there are multiple leaks through the downstream face and into the LLO that likely will, over time, continue to weaken the dam, and the downstream wall is tilting in the downstream direction with enlarged stone masonry joints and cracked stones in some areas indicating load shifting and

settlement/stressing. A project to address these deficiencies and reduce the risk associated with the dam should be pursued as soon as possible.

Maintenance Level Recommendations:

1. Monitor the dam regularly and particularly during and following high flow/flood events. Any indications of instability should be reported to the Dam Safety Program immediately.
2. Remove trees, brush, and weeds from the dam and extend and maintain clearing limits for brush and trees a minimum of 15 feet from all portions of the dam. Once removed, re-inspect the areas for any deficiencies that were not observable due to vegetative cover.
3. Maintain the spillway free of debris to ensure free flow conditions. Consider removing the beaver that regularly clog the principal spillway. This should be done in compliance with state laws regarding beaver removal.
4. Regularly monitor the condition/alignment of the downstream stone masonry wall and the leakage exiting the wall. Also, monitor the downstream side of the crest where it contacts the downstream wall and near the spillway for the formation of sinkholes.
5. Fill depressions and seed and mulch the repaired areas as well as bare areas on the crest of the dam to promote a healthy grass cover.
6. Fill enlarged masonry joints in the downstream wall with stone/chink gaps to improve stability.
7. Install stone slope protection as needed to repair/prevent erosion of the upstream slope near the normal waterline.
8. Further raise or remove the footbridge over the principal spillway to prevent it from becoming a flow impediment.
9. Update the EAP every two years and provide a copy of it to the Dam Safety Program for informational and record keeping purposes.

Studies and Analyses:

1. Develop a brief operations and maintenance manual for the dam.
2. Design and purchase the materials for a siphon or series of siphons that could be locally stored and rapidly installed and used to draw the water level down in the pond should an emergency condition develop.
3. Perform necessary analyses to support the design of remedial repairs to the principal spillway, embankment, downstream masonry wall, and LLO.

Remedial Repair Recommendations:

1. Retain a professional engineer qualified in dam safety to design and construct repairs to the dam including the principal spillway, embankment, downstream masonry wall, and LLO to improve its condition and bring it into compliance with State requirements and current dam safety practice.

INSPECTION FINDINGS

The Curtis Pond Dam was inspected on July 19, 2019. The weather was sunny with temperatures in the 70s. The water level in the pond was approximately 2 inches above the principal spillway weir. Photographs to document the current conditions of the dam were taken and are kept on file. Only exposed, accessible portions of the dam were inspected (i.e. underwater areas were not inspected).

- ***Abutments:*** The right and left abutment contacts of the dam appeared to be in good condition.

- ***Upstream Slope:*** The upstream slope appeared to be in fair to poor condition. Much of the upstream slope was underwater and somewhat obscured from view. The upper portion of the slope is armored with occasional stone protection. The slope inclination appears to vary from 1 to 2H:1V. Minor brush and weed growth on the upstream slope prevented a thorough inspection. No sinkholes or animal burrows were observed. Some minor erosion was observed in some areas near the normal water line. There were exposed roots observed on the upstream slope.

- ***Crest*****:** The crest of the dam appeared to be in fair condition. The crest of the dam appeared to have fair horizontal and vertical alignment. The crest appears lower near the spillway than at the abutments. The crest was surfaced with

cut grass and appeared to be better maintained on the right side. There was some bare areas/exposed soil and some slight rutting and depressions observed on the left side of the crest. There is a maple tree on the left abutment that should be removed.

- ***Downstream Face:*** The downstream face, consisting of a dry-set stone masonry wall, is in poor condition. The surface conditions were poor and there was evidence of wall tilting and stones overhanging lower courses by more than one foot in some areas. Enlarged masonry joints were observed and many of the stones comprising the wall are cracked indicating load shifting, settlement, and movement of the wall. There was exposed bedrock observed in the downstream channel. There was leakage observed from multiple locations along the wall and on the right side one concentrated leak of about 4 gallons per minute was observed. Refer to the Structural Stability Section below for more information.

- ***Drains/Seepage Collection:*** There is no seepage collection system at this dam.

- ***Instrumentation:*** There was no instrumentation found on the Curtis Pond Dam.

- ***Principal Spillway:*** The principal spillway at Curtis Pond Dam is a broad crested, dry laid stone lined channel. The overall condition of the spillway was poor. Sizable voids were observed in the left and right training walls. The right training wall had subsided slightly, and water was observed flowing into the wall, and leaking out of the downstream face. Loose stone were also observed. The approach area was clear, as was the downstream plunge. It is our understanding that the spillway is frequency plugged with beaver debris. The stone lining the channel on the left side downstream appears to have subsided. Some of the stones in the channel appeared to have been cemented in place. There is a small footbridge that crosses the spillway channel that appeared to be in fair condition. The bridge should be further raised or removed to prevent it becoming an impediment to flow.

- ***Auxiliary Spillway:*** There is no auxiliary spillway at the Curtis Pond Dam.

- ***Low Level Outlet/Drawdown Facility:*** As noted above, there is a 2-foot square stone culvert that penetrates the dam near the base of the downstream stone masonry wall. Several of the stones supporting the roof of the conduit appear to have cracked The channel discharges approximately 24-inches above the toe of the dam. The LLO is inoperable, no operable gate or stoplogs were observed. Accordingly, there are no means at the dam to readily lower the water level in the pond in an emergency. About 7.5 feet upstream from the outlet, timbers and wood debris was observed in the conduit. There were large amounts of leakage into the LLO channel on the spillway side of the channel. There was approximately 20 gallons per minute flowing through the channel. The leakage prevented a thorough inspection.

- ***Downstream Area:*** The downstream area is a stone lined/vegetated channel that flows through a culvert under Worcester Road immediately downstream of the dam. The area immediately downstream of the dam was overgrown with small brush and weeds that prevented a thorough inspection.

- ***Reservoir Area:*** The dam impounds Curtis Pond. The shorelines were wooded with some residentially developed properties. The dam is located in a small cove on the southwestern side of the pond. The slopes around the pond appear to be mild to moderate and do not appear to be overly susceptible to erosion.

- ***Access Roads and Gates:*** The access road is Worcester Road, which is owned and maintained by the Town of Calais and appears to be in good condition. The dam is located immediately adjacent to the road.

- ***Operation and Maintenance:*** There does not appear to be an Operation and Maintenance Manual for the Curtis Pond Dam. It appears that basic levels of maintenance are performed on the dam.

- ***Emergency Action Plan (EAP):*** It is our understanding that the dam has a basic EAP that includes inundation mapping from the 2004 Engineering Study and Evaluation by Dubois & King. The EAP should be updated at least

every two years and a copy of the EAP provided to the Dam Safety Program for information and record keeping purposes. As part of the 2019 Hazard Classification Study of the dam by Schnabel Engineering, updated inundation maps were developed that should be compared and potentially replace the maps from the 2004 study. As part of the 2019 study, the hazard classification was evaluated, and it was recommended the dam remain a SIGNIFICANT hazard.

- ***Hydrologic/Hydraulic Data*:** Since the Curtis Pond Dam is a SIGNIFICANT hazard dam, the Spillway Design Flood (SDF) has previously been considered to be between the 100-year storm the 1/2 PMF storm event according to Army Corps of Engineers Guidance (ER 1110-2106) generally used in the State of Vermont. New State guidelines are contemplating the use of the 1,000-year storm as the prescriptive SDF for SIGNIFICANT hazard dams. A hydrologic, hydraulic, and hazard classification assessment was performed on the dam in 2019 by Schnabel Engineering. The study assumed that the normal pool elevation/principal spillway is at El. 1,217.8 and the minimum elevation of the dam crest is at El. 1,219.3. All elevations are in feet and approximately reference the North American Vertical Datum of 1988 (NAVD88). The study yielded the following results:

Storm	Peak Inflow (cfs)	Peak Outflow (cfs)	Peak Reservoir Elevation (ft)	Freeboard (ft)*
10-year	221	18	El. 1,219.0	0.3
50-year	376	80	El. 1,219.6	-0.3
100-year	454	128	El. 1,219.7	-0.4
500-year	690	293	El. 1,220.1	-0.8
1,000-year	822	394	El. 1,220.3	-1.0
50% PMF	1,744	533	El. 1221.6	-2.3

*Negative values indicated dam crest overtopping

Based on the above results, the dam only has 1.5 feet of freeboard under normal pool conditions, which is below the lower allowable threshold (3 feet) according to State requirements. Furthermore, the dam overtops during events less than the 50-year storm event and well before the 1,000-year or 50% PMF SDFs. Accordingly, the dam is considered hydraulic inadequate.

- ***Structural Stability:*** A program of test borings was performed in the dam as part of the 2004 Engineering Study and Evaluation by Dubois & King, Inc. The test borings were advanced through the crest of the dam and found the embankment to be constructed of loose to medium dense sand with little gravel, rock fragments, and trace amounts of silt. Refusal conditions were encountered in each boring near the bottom of the embankment inferring bedrock. Additional engineering analyses of static and dynamic stability of the embankment and downstream stone masonry wall were not available and have not been conducted for this study.

  The upstream slope is over-steepened and inclined at 1H:1V to near vertical near the normal water line. The slope appears milder under water and based on historic survey, appears to be on the order of 2H:1V. This is steeper than generally accepted, stable inclinations (2.5H:1V) for earth embankments constructed of sand and gravel materials. The upstream slope does appear stable under normal loading conditions.

  Based on visual observations, the condition of the downstream masonry wall continues to deteriorate. The wall is tilting in the downstream direction in some areas, has enlarged masonry joints, and cracked stones in some areas, conditions that indicate load shifting and settlement/stressing of the wall. Based on visual inspection, the wall appears marginally stable under normal conditions and could be susceptible to failure during severe loading conditions, such as an embankment overtopping event. Alternatives to stabilize the downstream wall should be evaluated.

- ***Seepage:*** Seepage/leakage through the dam, existing through the downstream stone masonry wall and LLO conduit were observed in multiple places. A concentrated leak of 4 gallons per minute was observed to the right of the

spillway and total leakage of about 20 gallons per minute was observed exiting the LLO. Continued, uncontrolled leakage through the dam will continue to weaken the embankment.

- ***Inspection Safety Considerations:*** Other than the standard safety protocols when working adjacent to reservoirs and/or flowing water, there are no other inspection safety considerations for this dam.

DAM SAFETY INSPECTION PROGRAM GENERAL INFORMATION

The Dam Safety Program conducts periodic safety inspections of non-federal, non-hydroelectric dams to determine their condition and the extent, if any, to which they pose a potential or actual threat to life and property. Dams that impound more than 500,000 cubic feet of liquid require approval from the Department under provisions of 10 VSA Chapter 43 before alternating, reconstructing or breaching. The Department's current policy is to inspect only those dams that are capable of impounding more than 500,000 cubic feet unless specifically requested by the owner.

The condition rating assigned to the dam reported herein was based on available data and visual inspection. Detailed investigations and analyses were beyond the scope of this report. It should be realized that the reported condition of the dam was based on observations of field conditions at the time of inspection, along with data available to the inspection team. The condition of the dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Hazard Classifications: (U.S. Army Corps of Engineers Guidance)
High Hazard: Dams where failure is expected to cause loss of more than a few lives and excessive damage to homes, industrial or commercial facilities, important public utilities, main highways or railroads.
Significant Hazard: Dams where failure is expected to cause loss of a few lives and appreciable damage to homes, industrial or commercial facilities, secondary highways or railroads.
Low Hazard: Dams where failure is not expected to cause loss of life and only minimal property damage.

Condition Ratings:
Good: No existing or potential deficiencies recognized except for minor operational and maintenance deficiencies. Safe performance is expected under all loading including the Spillway Design Flood.
Fair: Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual or extreme loading conditions up to and including the Spillway Design Flood.
Poor: Significant structural and or operation and maintenance deficiencies are clearly recognized under normal loading conditions.

Definitions:
Upstream: The side of the dam that borders the impoundment.
Downstream: The high side of the dam, the side opposite the upstream side.
Right: The area to the right when looking in the downstream direction (also known as "river right").
Left: The area to the left when looking in the downstream direction (also known as "river left").
Height of Dam: The vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.
Embankment: The fill material, usually earth or rock, placed with sloping sides so it creates a permanent barrier that impounds water.
Crest: The top of the non-overflow portion of the dam, often provides a road or path across the dam.
Abutment: The part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed at the interface with a concrete gravity section.
Normal Pool: The elevation of the impoundment during normal operating conditions.
Maximum Storage Capacity: The volume of water contained in the impoundment at maximum water storage elevation, which is typically considered the crest of the dam.
Normal Storage Capacity: The volume of water contained in the impoundment at normal water storage elevation or normal pool levels.
Impoundment: The body of water or other liquid created by the dam.
Principal Spillway: A structure over or through which normal water flows are discharged. A "controlled" spillway is controlled by gates or boards, while an "uncontrolled" spillway is one with a fixed crest and no gates or boards.
Auxiliary Spillway: A structure over or through which only abnormal or extreme storm flows are discharged.
Outlet Works: A means to lower or control the water level in the impoundment below the normal pool level.
Spillway Design Flood (SDF): The flood used in the design of a dam for sizing items such as the spillway, outlet works, and dam height. Based on Army Corps of Engineers Guidance and State Statue, the following ranges of SDF's are typically used in Vermont, Low Hazard = 100-year Storm, Significant Hazard = 100-year Storm to ½ Probable Maximum Flood (PMF), High Hazard = ½ PMF to PMF.
Emergency Action Plan (EAP): A predetermined and properly documented plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam failure.
Operations & Maintenance Manual (O&M): Document identifying routine maintenance and operational procedures under normal and storm conditions.