VERMONT

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MEMORANDUM

TO:	To The File
FROM:	Benjamin Green, PE, Dam Safety Engineer Steven Hanna, Dam Safety Engineer
DATE:	February 10, 2018
SUBJECT:	Visual Dam Safety Inspection of Shadow Lake Dam, Glover, Vermont State ID No: 81.02, National ID No: VT00070

On July 19, 2017, Benjamin Green, PE, Steven Hanna, and Deanna Lambert of the Dam Safety Program performed a visual dam safety inspection of Shadow Lake Dam. The dam is owned by the Town of Glover. Jack Sumberg of the Town of Glover Selectboard was present during the inspection. 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 on August 4, 2015.

BACKGROUND

Shadow Lake Dam is an earth embankment dam with a principal spillway and auxiliary spillway. The dam is currently classified as a SIGNIFICANT hazard. According to file information, the dam is approximately 130 feet long with a structural height of 12 feet. The upstream face of the dam consists of a riprap armored slope and granite block wall. The crest is about 8 feet wide and surfaced with grass. The downstream slope is earthen and surfaced with grass. The principal spillway is a cast-in-place concrete drop inlet- style spillway with a single stoplog section that controls elevation. Flow is released through a 36-inch diameter slide gate that is generally maintained in an open position. The stoplogs and slide gate are housed in a timber building. The auxiliary spillway is 33.5 feet long and 15 feet wide. The drainage area of the dam is reportedly 3,575 acres. Shadow Lake at normal pool is approximately 199 acres and the normal and maximum storage capacity of the dam are approximately 950 acre-feet and 1,700 acre-feet, respectively. The dam’s original construction dates to the 1800s and the auxiliary spillway was constructed to its current configuration in 1929.

CONDITION RATING AND RECOMMENDATIONS FOR OWNER

Based on this visual inspection, the overall condition of the dam is considered **FAIR**. This condition is a reflection of the increased maintenance effort at the dam, which if does not continue will likely result in the dam deteriorating to a poor condition. 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.

<u>Maintenance Level Recommendations:</u>

1. Establish clearing limits for brush and trees a minimum of 15 feet away from all portions of the dam. This includes the left and right abutment contact areas.
2. Remove rotten tree stumps from the dam and fill resulting voids with compacted granular material.
3. Place topsoil, seed, and mulch any areas on the crest and downstream slope with sparse grass to promote a healthy grass surface and resistance to erosion.
4. Maintain the principal and auxiliary spillways free of debris to promote free flow conditions.
5. Monitor the seepage observed in the right downstream area of the dam and under the auxiliary spillway.

6. Fill irregularities and depressions on the crest of the dam with compacted granular fill and finish with topsoil, seed, and mulch to promote a heathy grass surface.
7. Re-inspect the principal spillway during low flow conditions to determine the source of the leak and observed the condition of the concrete.
8. Update the Emergency Action Plan.

Studies and Analyses:
1. Perform updated hydrologic and hydraulic analyses of the dam to determine adequacy.
2. Develop an Operations and Maintenance Manual for the dam that documents regular maintenance activities and any stoplog operations.

Remedial Repair Recommendations:
1. Based on the results of the hydrologic and hydraulic study recommended above, identify and implement improvements to the dam to make it hydraulically adequate.

INSPECTION FINDINGS

Shadow Lake Dam was inspected on July 19, 2017. At the time of the inspection, the weather was sunny and 70°F. The ground conditions were generally dry. Photographs to document the current conditions of the dam were taken and are kept on file. The water was flowing approximately 8 inches over the stoplogs at the principal spillway on the day of the inspection. Only exposed, accessible portions of the dam were inspected (i.e. underwater areas were not inspected).

- ***General:*** The dam generally has good horizontal and vertical alignment and the concrete and stone masonry sections appear to be in fair to good condition. The upstream slope between the spillways had recently been renovated.

- ***Abutments:*** The right abutment has some brush and woody vegetation and a private wood pile on it. An 18-inch diameter tree was observed on the upstream slope at the right abutment. The left abutment is overgrown with mature trees and brush.

- ***Upstream Slope:*** The upstream slope, upstream of the masonry wall is armored with 6-inch riprap between the spillways. The riprap is reportedly underlain with sandy gravel fill. The slope is inclined at approximately 3H:1V. There was grass, weeds, brush, and rotting stumps to the left of the auxiliary spillway. No sinkholes, animal burrows, or erosion was observed.

- ***Upstream Masonry Wall:*** The granite masonry wall appeared to be in fair to good condition. The vertical and horizontal alignment of the wall appeared satisfactory. No unusual movement, burrows, or sinkholes associated with the wall were observed.

- ***Crest*:** The crest is approximately 6 to 8 feet wide and surfaced with well-maintained grass. Several rotting tree stumps were observed on the crest. The crest surface was uneven, appearing to differ as much as 12 inches along the dam. A depression was observed to the right of the principal spillway building. No surface cracking, sinkholes, or animal burrows were observed.

- ***Downstream Slope:*** The center portion of the downstream slope between the spillways is inclined at approximately 3H:1V. The slope has grassy vegetation with some brush growth near the abutments. The center portion has some thin and patchy grass areas and minor rutting was observed. On the right side, the slope was benched by two masonry walls that appear to be in fair condition. The downstream slope was moist along the right abutment near leaf debris. There was brush and rotting stumps near the left abutment.

- ***Drains/Seepage Collection:*** There are no drains or seepage collection measures at this dam.

- ***Instrumentation:*** There is no instrumentation at this dam.

- ***Principal Spillway:*** The principal spillway is a 5.3-footh wide stoplog controlled concrete channel. There was some minor debris in the timber trash rack. There was some deterioration of the concrete at the normal waterline downstream of the stoplogs. Flow prevented a thorough inspection of the stoplogs, channel, and outlet area. The stoplogs were reportedly replaced a couple years ago. Downstream of the stoplogs is the hand operated slide gate that is operated every fall and spring and left in an open position the remainder of the year. The dry set masonry walls in the discharge channel appeared to be in fair to good condition. To the left of the outlet, there was a leak of about 1 gallon per minute through the concrete.

- ***Auxiliary Spillway:*** The auxiliary spillway is an ogee-style concrete chute. Some recent concrete repairs were observed on the training walls. Wetland vegetation was observed in the approach area. There are slots in the training walls for flashboards, but none were installed. The training walls and floor slab appeared to be in fair condition. The discharge area downstream of the chute is a stone lined channel that appeared to be in fair condition. There are voids between the concrete floor slab spillway and stone ranging six to eighteen (6-18) inches deep. There was some minor seepage emitting from under the auxiliary spillway floor slab.

- ***Low Level Outlet/Drawdown Facility:*** There is not a low-level outlet at the dam.The stoplogs can be removed at the principal spillway and the slide gate used to partially lower the water level in Shadow Lake.

- ***Downstream Area:*** The downstream area of the dam is a stone lined channel that flows into a wooded area.

- ***Reservoir Area:*** The reservoir area consists of Shadow Lake. The shoreline is heavily developed with residences including a town road along the southern half with some wooded areas along the northeastern end of the lake. The slopes around the lake appear to be mild to moderate and do not appear overly susceptible to erosion.

- ***Access Roads and Gates:*** The access road is South Shore Road off from Shadow Lake Road. The town roads are a two-lanes wide and appear to be in good condition and could be accessed year-round. The principal spillway building at the dam is kept locked to prevent unwanted operation of the principal spillway.

- ***Operation and Maintenance:*** It is our understanding that there is no formal Operation and Maintenance Manual (O&M) for the dam. Some regular maintenance is performed, such as cutting of brush and the recent repair to the upstream face. Operations of the slide gate in spring and fall are typically performed.

- ***Emergency Action Plan (EAP):*** The most current EAP on file is from April 1991, which was reportedly updated on January 22, 2015. Since Shadow Lake Dam is a SIGNIFICANT hazard, it is recommended that the EAP be maintained and updated, or at least properties downstream of the dam that could be damaged in the event of a dam failure be identified, contact information for affected property owners/tenants and local/State emergency personnel be collected, and triggers for making emergency contacts and taking preventative measures be identified.

  Based on a cursory map review of the downstream area, the discharge channel crosses under Stone Shore Road about 150 feet downstream. From there, the stream flows easterly down a well canyonized, wooded reach before entering the Barton River about 1 mile downstream and flowing northerly into residentially developed areas of Glover.

- ***Hydrologic/Hydraulic Data*:** Since Shadow Lake Dam is a SIGNFICANT hazard dam, the Spillway Design Flood (SDF) is considered to be between the 100-year storm and the ½ Probable Maximum Flood (PMF) event according to Army Corps of Engineers Guidance (ER 1110-2106) generally used in the State of Vermont. Based on file review, the most recent hydrologic and hydraulic assessment of the dam was performed by Dubois & King, Inc. (D&K) in 1991. As part of this work, D&K confirmed the elevations of key hydraulic features at the dam (National Geodetic Vertical Datum, NGVD in feet):

  - Principal Spillway Stoplogs/Normal Pool: El. 1,391.6+/-

- Auxiliary Spillway Weir: El. 1,392.6
- Dam Crest: El. 1,397.0

The hydrologic and hydraulic analyses by D&K provided the following results:

Storm Event	Inflow (cfs)	Outflow (cfs)	Peak WS El.	Freeboard (+) or Overtopping (-)
100-Year	2,168	96	1,394.4	+2.6
¼ PMF	2,612	305	1,396.6	+0.4
½ PMF	6,094	3,571	1,401.0	-4.0

Based on the above results, the dam has approximately 5 to 6 feet of freeboard to the lowest portion of the dam crest under normal pool conditions, which exceeds the lower allowable freeboard threshold (3 feet) according to State requirements. Based on the available analysis, it appears the dam has adequate freeboard during the 100-year storm but will overtop during the ½ PMF. Since the dam cannot safely pass the SDF without overtopping, the dam is considered hydraulically inadequate. It should be noted that this analysis is over 25 years old and a more updated analysis using more modern techniques would provide better clarity into the degree of hydraulic inadequacy of the dam.

- ***Structural Stability:*** Engineering analyses of static and dynamic stability of the embankment and spillway structures were not available and have not been conducted for this study. Based on visual observations, the upstream and downstream slopes of the dam are within generally accepted, stable inclinations and appear stable under normal loading conditions. As noted above, portions of the spillways and masonry walls appear stable based on visual observation.

- ***Seepage:*** Some uncontrolled seepage with iron staining was observed in the right downstream toe area.

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.

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