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Ms. Debbie Bluso-Rogers
Administrator
Richfield Joint Recreation District
4410 West Streetsboro Road
Richfield, Ohio 44286

September 1, 2016
2016257.00

RE: Dam Structural Concrete Conditions Assessment

Lower Camp Crowell Lake Dam

Dear Ms. Bluso-Rogers:

Below is a summary of GPD's findings from our site visit that took place between June 2 and June 14, 2016. Alek Babel and Micah Nine, of GPD Group, visited the lower Camp Crowell Lake Dam to gather information with the intent to assess the condition of the concrete portions of the dam.

SCOPE OF WORK

The scope of work includes the following:

- Conduct a field inspection and concrete structure assessment of the visible surfaces
- Obtain concrete core samples, including petrographic analysis and report of the concrete conditions
- Prepare a structural condition assessment report with summary of results and recommendation for rehabilitation or replacement

LIMITATIONS

The observations provided in this report were generally non-destructive in nature, and limited to portions of the dam that were accessible and could be visually observed. Three (3) concrete core samples were taken for analysis, but a full petrographic analysis was conducted on one sample only; the other two were examined for physical integrity. Concrete core samples may not be representative of concrete throughout the entire structure. The scope of services did not include an exhaustive technical investigation. No special testing and/or engineering calculations were performed. Only the dam components listed in this report were observed during the site visit.

GENERAL DAM OVERVIEW

The Lower Camp Crowell Lake Dam is a cast in place concrete dam installed in 1920. The dam is approximately 25.1' high and 140' long. The dam is ODNR jurisdictional as a Class II

Dam based on downstream hazard conditions. The latest ODNR Dam Safety Inspection Report (File number: 1115-003, dated April 23, 2014) indicates that investigation and engineering action was required. Original drawings for the dam were not available, but drawings indicating repairs had been proposed in 1979 were available.

OBSERVATIONS

- The concrete "cut off" wall which extends to the west from the Millhouse appears to be generally sound, considering the age of the dam. There are a number of vertical cracks which are indicative of shrinkage cracking due to the lack of control joints in the wall. The portions of the wall that are exposed to the retained lake show some signs of spalling.
- The ogee spillway concrete surface is in poor condition. The surface shows extensive signs of erosion, with extensive surface pitting, delaminated concrete repairs, and spalls throughout the surface.
- The splash wall, which was part of the 1979 improvements to the dam, was in good condition. The surface showed some irregularity, but this did not appear to be due to deterioration of the surface.
- The chute on the eastern portion of the dam is in poor condition. The surface of the chute showed signs of delaminated concrete on the surface, with cracking throughout. Toward the bottom half of the chute, a hole has opened up, and an area of soil approximately 4'X10' has washed out from underneath the chute. The headwall at the top of the chute shows signs of spalling where it intersects the ogee spillway.
- The retaining wall to the south of the chute is in fair condition. There is some cracking, and surface delamination present. A concrete core was taken from the face of this wall.
- The stilling basin at the bottom of the dam was in fair condition. Much of the basin has eroded away. The basin did not appear to be constructed of concrete, rather the natural stone base upon which the dam was originally built is eroding.
- The top of the spillway showed signs of surface distress. Due to site conditions at the time of the visit, the top of the spillway was not accessible and could only be viewed from a distance. There appeared to be evidence of previous concrete repairs, some of which appeared to be debonded from the original substrate. Some erosion of the original concrete was observed.
- The wall supporting the south wall of the millhouse is in fair to poor condition. The outside face of the wall has repair mortar on the surface, which showed signs of cracking. The repair material on the inside face of the wall showed signs of debonding from the original substrate. A concrete core was taken from the inside of the wall. The portion of the wall nearest the wheel showed greater

signs of distress, with surface spalling, and debonding of repair material. Weeds were found to be growing in cracks in the wall.

- The wall supporting the east wall of the millhouse is in fair condition. There are previous surface repairs that show signs of debonding from the original substrate. It should also be noted that there is a visible gap at the top of the wall below the wood patio that allows rainfall surface runoff water to enter the basement of the millhouse.
- While the level of the lake was lowered to allow inspection of the spillway surface, the upstream side of the dam was not accessible and was not inspected at the time of our visit.
- The hollow areas of the dam below the ogee spillway were not accessible, and were not inspected.

ASSESSMENT AND RECOMMENDATIONS

Considering the age of the dam, it appears to be in fair-to-poor condition. The problems with the concrete observed during the site visits are typical for a structure of the age, use, and exposure. Areas of concrete that are potentially exposed to flowing water and freeze-thaw cycles exhibited higher levels of distress than concrete that is generally not exposed to these conditions.

The concrete "cut off" wall to the north of the main spillway appears to be in good condition. Cracking in this portion of the dam may be indicative of shrinkage cracking. There is some spalling present on the retained side of the wall below the spillway elevation, which may be indicative of freeze-thaw damage. At this time, we would recommend continued observation of the "cut off" wall concrete for additional signs of distress, with no immediate repairs being required. If repairs to the main spillway concrete are undertaken, repair of cracks should be considered as added scope. As the spalling below the spillway elevation appears to be freeze-thaw induced, we would suggest that the lake be drawn down every fall to reduce the impact of freeze-thaw on the lower portions of the wall.

The ogee spillway concrete showed varying surface conditions. There were areas where previous repairs were made, with some of the repair work showing signs of debonding from the concrete substrate. In some areas the original concrete substrate was spalling away. A concrete core sample was taken from the spillway for petrographic analysis. This concrete core indicated cracking in the repair materials applied in the 1980s. Given the condition of the surface and existing repairs, GPD recommends that the surface of the ogee spillway be repaired. Repair would entail removal of the existing repair materials and a portion of the original concrete down to sound concrete. A repair wire mesh & mortar would be applied to the prepared spillway surface.

The splash wall which was installed during the 1980s appeared to be in good condition. Superficial surface imperfections were observed, but at this time, no repair work should be required.

The chute on the south end of the dam is in poor condition. The concrete condition varies along the length of the chute, with cracking on the vertical surface of the chute, and spalling and delamination present on the bottom surface of the chute. A hole has formed in the chute, with the earth supporting the chute eroding away, leaving a void approximately 4 feet wide by 10 feet long. GPD recommends repair of the chute, but further investigation should be executed to determine the full extent of the repairs needed. At minimum, the vertical surfaces of the chute should be repaired, with existing repair material and original concrete removed down to sound concrete. A concrete core taken from the chute wall indicates freeze-thaw distress down to 7 inches below the surface. GPD recommends that the concrete be removed to at least this depth for surface preparation. The thickness of the existing chute walls was unknown to GPD at the time of this inspection, and further investigation of the chute could lead to a recommendation of full removal and replacement of the chute. Additional core samples should be taken to determine the original thickness of the concrete structure to determine if a surface repair will be effective, or if full removal or replacement is required. In addition, the void that has formed below the chute requires attention. All loose material that has been weakened by washing out of the soil over time should be removed, the void should be filled with lean concrete, and the chute atop this fill should be repaired.

The stilling basin at the base of the dam is showing signs of erosion. Assuming the dam is founded on rock as indicated on the 1979 repair drawings, no action should be required, but continued observation of the stilling basin for further distress should occur.

The top of the ogee spillway is in poor condition, with previous repairs debonding from the original substrate. GPD recommends that the top of the ogee spillway be repaired, with existing repair materials and original concrete removed to sound concrete, and a repair mortar installed over the prepared surface.

The millhouse foundation walls are in fair to poor condition. The south wall supporting the millhouse showed signs of cracking in the previously made surface repairs, and the original substrate showed signs of freeze-thaw damage to depths of approximately 4 inches on the interior face of the wall. The wall supporting the east wall of the millhouse is in fair condition, with prior surface repairs debonding from the original concrete. GPD recommends that the millhouse walls be repaired, with further investigation required to determine the extent of the repairs. For a surface repair, extensive amounts of concrete would need to be removed, and this further investigation could lead to the recommendation that the south wall be removed in its entirety and replaced. This would cause some challenges as the millhouse sits atop these walls, and support of the millhouse during replacement would need to be designed.

GPD has prepared an opinion of costs for the recommended concrete repair work. Due to the uncertain nature of surface preparation, certain assumptions have been made in preparing the estimate.

Assumptions include:

- This is an opinion of cost solely for the rehabilitation of select portions of the concrete dam; no assessment or costs have been attributed to the earthen dam, earthen spillway, wooden bridge, lake drain, millhouse structure, or lake sediment.
- No repair work done to the cut-off wall
- In the ogee spillway, 8" of surface concrete will be removed and repaired
- In the chute, 8" of surface concrete will be removed and repaired, and the hole will be filled with lean concrete
- The wall under the south millhouse wall will be completely removed and replaced, and the remainder of the wall will be repaired on the exterior

Also, due to the nature of the site, and the possibility that additional concrete will have to be removed to attain a sound surface, the opinion of cost is listed as a range of values

The opinion of costs is not a bid, and is not based upon a detailed rehabilitation design. The opinion of cost should be considered an order of magnitude estimate to assist with planning.

CONCRETE REHABILITATION OPINION OF COSTS

LOWER CAMP CROWELL LAKE DAM

WORK ITEM:	Cost
Ogee Spillway	\$ 70,000-110,000
Chute	\$ 80,000-130,000
Undermined Area Under Chute	\$ 40,000-60,000
Millhouse Wall - Replacement	\$ 10,000-30,000
Millhouse Wall – Exterior Repair	\$ 40,000-60,000
Scaffolding	\$ 10,000-15,000
Sub-Total	\$ 250,000-405,000
Engineering Design (~15%)	\$ 38,000-60,000
Construction Mobilization & General Conditions (~10%)	\$ 25,000-40,000
Construction Contingency (~25%)	\$ 65,000-105,000
Total Budget	\$ 378,000 – 610,000

The costs reflected in the table above do not consider design or supply of temporary shoring required to support the Millhouse while foundation wall repairs take place.

The costs in the table above consider surface repair of the dam structure only; the cost for full concrete dam replacement has not been considered. Additionally, there may be modifications to the dam structure that are required to bring the dam up to ODNR Standards. These modifications may include, but are not limited to, increasing the height of

the cut off wall and modifying the main spillway elevation. The evaluation and analysis of the existing dam structure when subjected to possible modifications was not within the scope of this evaluation. The uncertain nature of possible modifications, as well as the potential need for strengthening of the existing structure could increase the estimated construction budget. If additional strengthening of the structure is required to meet ODNR standards, it may be prudent to consider complete replacement of the dam.

Additionally, it is GPD's understanding that the Millhouse is a historical structure, and that RJRD would like to keep the structure in place, regardless of whether the dam is repaired, removed, or replaced. Assigning a cost to keep the Millhouse in place is beyond the scope of this investigation, however GPD believes the Millhouse structure can be saved regardless of action taken on the dam structure.

The recommendations mentioned in this report can be performed to slow the rate of deterioration of the concrete dam structure. However, GPD cannot guarantee that further deterioration will not take place.

The design of rehabilitation repair is not within the scope of this evaluation. This report presents areas to consider and potential repair options. Construction Documents are required to address all aspects of layout, site improvement, materials and design element selection.

The evaluation of this structure requires that certain assumptions are made about the existing condition of the concrete. Considering that some of these assumptions cannot be verified without expending additional sums of money and/or destroying otherwise serviceable portions of the structure, GPD Group cannot be held responsible for conditions that could not reasonably be determined during this study, or which have not been discovered within the scope of this evaluation.

RECOMMENDED NEXT STEPS

The following can be considered, based on decision to remove the dam:

- Engineering/design and construction plans for ODNR decommissioning and removal of the dam.
- Engineering/design and construction plans for channel/wetland restoration within the lake impoundment area and connection with downstream channel.
- Engineering/design and construction plans for restoring/protecting or relocating the existing Millhouse structure.
- No further requirement to operate and maintain the dam in conformance with ODNR regulations; owner obligations with respect to responsibility/liability of dam can be eliminated.

The following can be considered, based on decision to maintain/replace the dam:

- Conduct additional concrete core sampling and determine if rehabilitation is practical, or otherwise, if full concrete dam replacement would be required.
- Conduct an Alternatives Analysis Study to determine necessary dam modifications or replacement for compliance with ODNR requirement to manage the Probable Maximum Flood.
- Engineering/design and construction plans for the concrete dam and emergency spillway rehabilitation/modification or replacement.
- Remove or replace the bridge over dam.
- Coordinate with ODNR; meet protocol and permitting for rehabilitation/modification or replacement criteria.
- Implement construction of the dam rehabilitation/modification or replacement and update the ODNR Dam Safety Inspection Report; conduct annual maintenance and inspections thereafter. Continue to monitor dam conditions annually.
- Annually drain down lake to a defined winter pool elevation (to prevent further freeze/thaw deterioration of concrete).
- Perform a lake management study, including sediment dredge limits for optimum lake function, restore the upper sediment trap function, and restore lake perimeter condition (select planting, control invasive species, and select clearing for lines of sight to the lake).

CONCLUSION

The lower Camp Crowell Lake Dam is generally in poor to fair condition, considering its age and lack of maintenance. Much of the dam requires repair, with some issues requiring more attention. With the exception of the splash wall, the entire surface of the dam should be repaired at minimum. Existing surface repairs should be removed, and original concrete removed down to sound concrete, with repair materials being placed over the prepared surfaces. Cracks and spalls should be repaired. The void that has formed below the chute requires further investigation, and the void should be filled with a lean concrete mix. Further, the millhouse walls require further investigation to determine if repair or full replacement is required. Modification/enlargement of the existing dam to meet ODNR compliance will require costs in addition to the estimated rehabilitation costs, and may warrant a decision to remove the lower dam. Should the RJRD decide to rehabilitate and enhance the dam to meet ODNR compliance, an alternatives analysis can be performed to determine the range of these costs. GPD Group can prepare a proposal for these added services if requested.

The opinion of cost presented in this report, represents the order of magnitude range in cost for design and construction of concrete rehabilitation for select portions of the concrete

dam. Additional upgrades/replacement of features adjacent to the lake dam should be considered by separate assessment not included in this scope.

We thank you for the opportunity to offer our services for the concrete condition assessment of the Camp Crowell Lake Dam.

Sincerely,
GPD Group



Alek Babel, PE
Structural Engineer



Matthew A. Lascola, P.E., LEED-AP
Project Manager

Attachment:

- RJRD Lower Dam Condition Assessment Laboratory Studies of Three Concrete Cores by Wis, Janney, Elstner Associates, Inc. Dated July 28, 2016

APPENDIX: REPRESENTATIVE PHOTOS OF THE CAMP CROWELL LAKE DAM:

Photo 1

Description:

Concrete "Cut Off" wall. A representative photo of the downstream side of the concrete cut off wall showing cracking (CR) indicative of shrinkage cracks due to no control joints in the wall.



Photo 2

Description:

Ogee spillway. The top portion of the north end of the ogee spillway. The concrete surface showed signs of spalling (SP), delamination (DL), and cracking (CR).



Photo 3

Description:

Ogee spillway. The bottom portion of the north end of the ogee spillway. The concrete surface showed signs of spalling (SP), delamination (DL), and cracking (CR).



Photo 4

Description:

Ogee spillway. The top portion of the center section (directly north of the splash wall) of the ogee spillway. The concrete surface showed signs of spalling (SP), delamination (DL), and cracking (CR).



Photo 5

Description:

Ogee spillway. The bottom portion of the center section (directly north of the splash wall) of the ogee spillway. The concrete surface showed signs of spalling (SP), delamination (DL), and cracking (CR).



Photo 6

Description:

Ogee spillway. The top portion of the east section (directly south of the splash wall) of the ogee spillway. The concrete surface showed signs of spalling (SP), delamination (DL), and cracking (CR).



Photo 9

Description:

Splash wall. Representative photo of the splash wall. Some surface imperfection, but generally sound concrete.



Photo 10

Description:

Chute. The bottom portion of the chute. Surface shows signs of delamination (DL), cracking, and spalling (SP).



Photo 11

Description:

Chute. The lower center portion of the chute looking to the east wall of the chute. Surface shows signs of delamination (DL), cracking, and spalling (SP). Note the hole in the bottom of the chute near the 15' mark. The arrow at the bottom of the photo represents the approximate lower extent of the void below the chute.

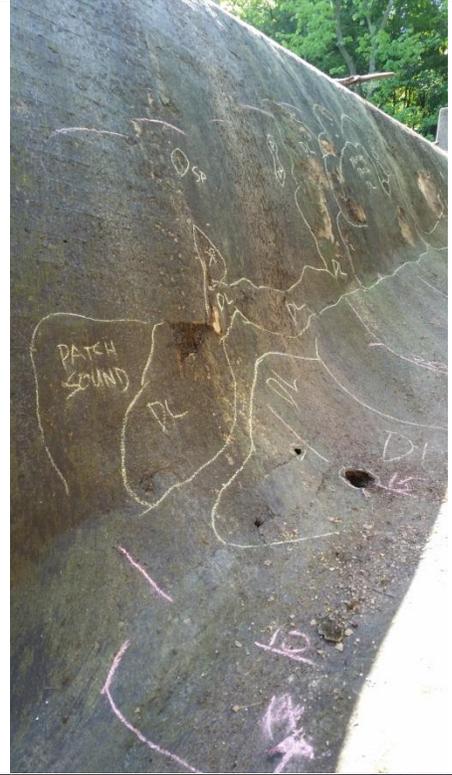


Photo 12

Description:

Chute. The upper center portion of the chute looking to the east wall of the chute. Surface shows signs of delamination (DL), cracking, and spalling (SP). Note the hole in the bottom of the chute near the 15' mark.



Photo 13

Description:

Chute. The upper portion of the chute looking to the east wall of the chute. Surface shows signs of delamination (DL), cracking, and spalling (SP).



Photo 14

Description:

Chute. The top of the chute looking to the east wall of the chute. Surface shows signs of delamination (DL), cracking, and spalling (SP).

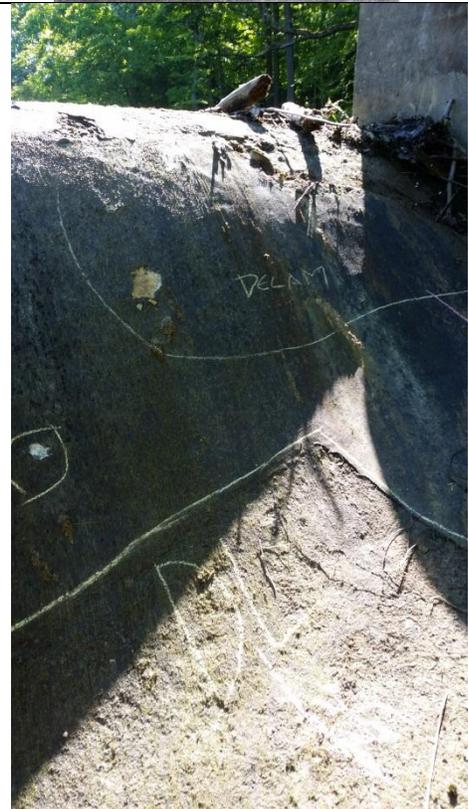


Photo 15Description:

Chute. A representative photo of the lower portion of the west wall of the chute. The surface shows signs of delamination (DL), cracking (CR).

**Photo 16**Description:

Chute. A photo of the west wall of the chute. The surface shows signs of delamination (DL), cracking (CR). Notice the opening in the bottom of the chute in the foreground of the photo.

**Photo 17**Description:

Chute. A representative photo of the upper portion of the west wall of the chute. The surface shows signs of delamination (DL), cracking (CR).



Photo 18Description:

Chute. Spall at the top of the chute.

**Photo 19**Description:

Millhouse. Lower portion of the outside face of the south millhouse wall. Wall shows signs of cracking (CR), delamination (DL), and spalling (SP).

**Photo 20**Description:

Millhouse. Upper portion of the outside face of the south millhouse wall. Wall shows signs of cracking (CR), delamination (DL), and pitting. Portions of the wall above this level were not accessible by ladder.

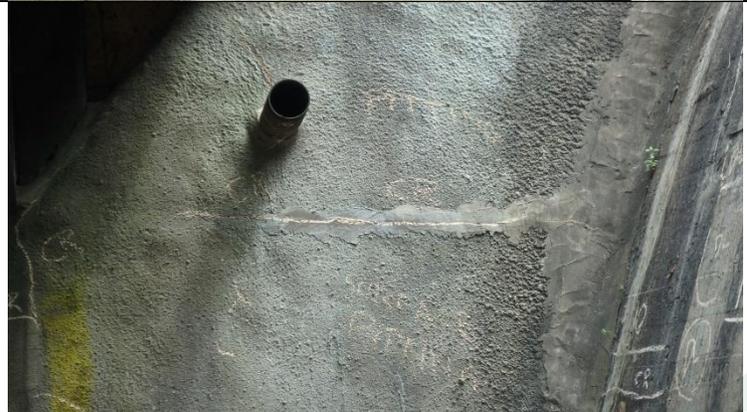


Photo 21

Description:

Millhouse. Portion of the wall below the lower patio of the millhouse between the wheel and millhouse. Wall shows delamination (DL) and spalling. The substrate is eroding, and vegetation is growing in the spalls and cracks.



Photo 22

Description:

Millhouse. Lower portion of the interior surface of the south millhouse wall. Wall shows delamination of surface repairs as well as heavy deterioration of the substrate.



Photo 23

Description:

Millhouse. Upper portion of the interior surface of the south millhouse wall. Wall shows delamination of surface repairs as well as heavy deterioration of the substrate.



Photo 24

Description:

Millhouse. Upper portion of the interior surface of the east millhouse wall. Wall shows delamination of surface repairs.

