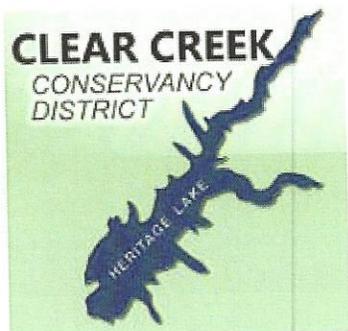


Principle Spillway Investigation

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Principle Spillway Investigation

Project Background

In the spring of 2016 Banning Engineering P.C. provided a report to the Clear Creek Conservancy District summarizing the history of maintenance on the principle spillway for Heritage Lake. Banning Engineering's recommendation at that time was to perform a series of test and exploratory excavations to determine the root cause of concrete cracking and water infiltration under the concrete slab. The board elected to proceed with this investigation in the Fall of 2016. Attached you will see the findings of this investigation.

Scope of Investigation

The investigation was performed to answer the following questions:

- Geotechnical Investigation
 - Review soils behind headwall
 - Is there a sand seam allowing water around or under the headwall?
 - If there is a seam allowing water at what depth is it at?
- Dye Test
 - Is there water going through the headwall?
- Open Cutting Spillway Floor
 - What is the condition of the drainage system under the concrete?
 - How vast is the void network under the concrete?
 - Can we see water flowing through the drain system?
 - What soil materials are under the concrete?

Principle Spillway History

In the spring of 2016 Banning Engineering P.C. provided a report to the Clear Creek Conservancy District summarizing the history of maintenance and investigations on the spillway. In general, the spillway is a concrete structure 160 feet long and 100 feet wide. The concrete was designed to be 12 inches thick with a 12" base that includes a perforated corrugate metal pipe drain network. Numerous repairs have been completed in the nearly 50 years the spillway has been in place.

2016 Investigation Timeline

The investigation was delayed due to weather and scheduling concerns. On Monday October 24, 2016 Banning Engineering met with staff from Earth Exploration, McCullough Excavating and Clear Creek Conservancy District. A time frame for cutting holes in the spillway and performing the investigation was determined. On Tuesday and Wednesday a significant rain event occurred. Due to this rainfall, the spillway investigation was delayed until Monday October 31st. Though cutting the spillway was delayed, the dye test was started on Thursday October 27th. Banning Engineering and Earth Exploration staff periodically stopped by the site to view water levels.

On October 31st McCullough Excavating cut (4) holes in the spillway for visual inspection of the voids and drain system. Additional dye was placed in the spillway entrance channel to test for seepage around or through the spillway headwall. Lastly, Earth Exploration was on site performing (2) soil borings at the spillway crest. Banning Engineering staff was present to inspect the holes.

On November 1st Banning Engineering staff met with McCullough Excavating to coordinate repairing the holes cut and failed crack seals where appropriate. During that time, Clear Creek Conservancy District Staff observed the pipe under drains using a push camera.

Results of the Investigation

- **Dye Testing**

Dye was not observed downstream of the headwall of the spillway. At the time of testing the lake was down approximately 15 to 18 inches from normal pool.

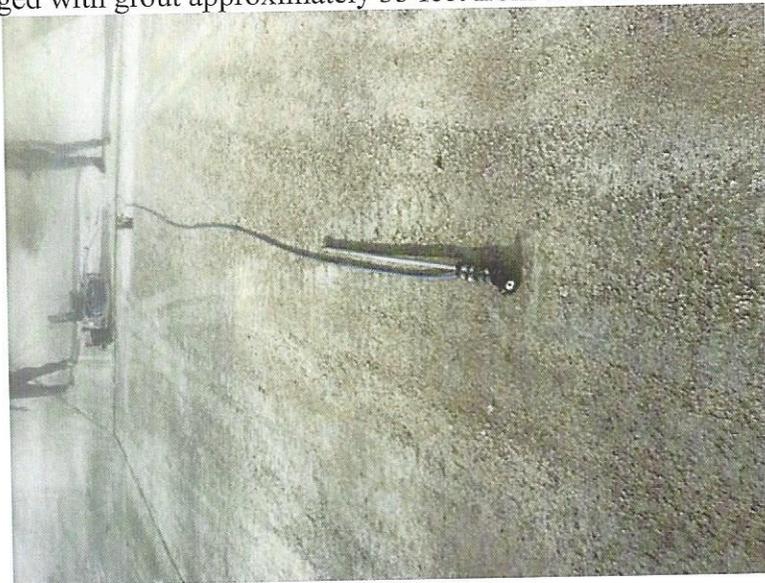
- **Geotechnical Investigation**

Earth Exploration provided soil borings at two locations at the crest of the embankment. Preliminary results show no “red flags” were found. However, at the time of this report, their testing has not been fully completed. A geotechnical report will be delivered under separate cover.

- **Camera Investigation of Drain Pipes**

Clear Creek Conservancy District staff utilized a push camera to investigate the drain pipes outletting into the stilling basin. The following is a brief summary of the results from north to south:

1. The pipe was plugged with grout approximately 35 feet from the base.



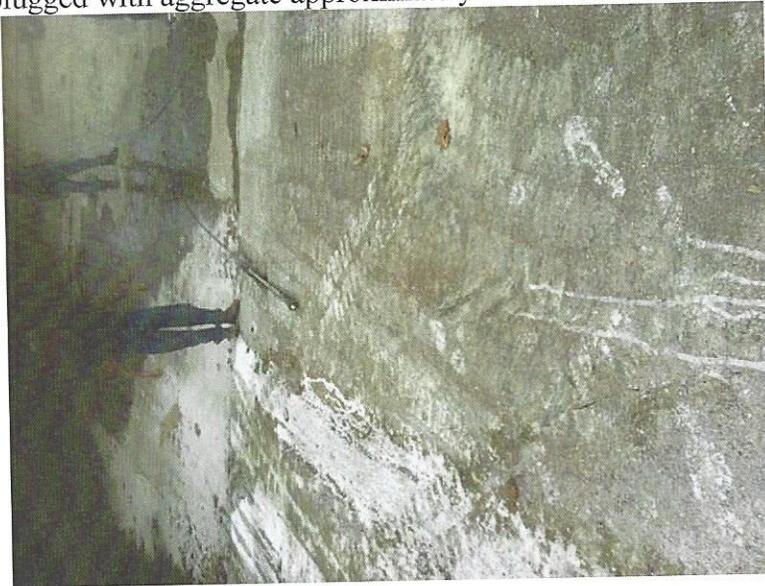
2. The pipe was plugged at the outlet with grout. The grout was removed from the outlet with a jack hammer. The investigation showed the pipe was plugged inside with grout.



3. The pipe was plugged with grout approximately 17 feet from the base.



4. The pipe was plugged with aggregate approximately 7 feet from the base.



It is apparent that none of the main drain pipes were functioning as intended when designed and installed.

- **Open Cut Spillway Floor Investigation**

Four holes were cut in the spillway at predetermined locations. The holes were approximately 4 feet x 4 feet in size. The holes cut were at the following locations:

Hole 1 was located just north of the drawdown valve about 14 feet from the headwall (See investigation layout in Appendix A). The void was noted to be 14 inches or greater at this location. A drain pipe was observed within the hole. The subsurface drain pipe is corrugated metal pipe with spiral corrugations. The void was measured using a tape measure. When measured it was evident, the void went all the way to the head wall. The headwall was observed and a failure in the joint sealant was found.



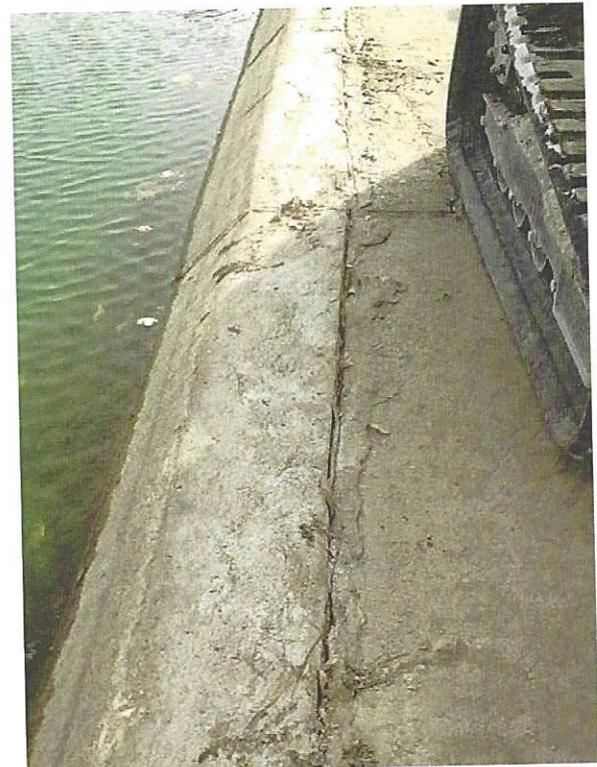
Investigation Hole #1
14 inch Void towards Headwall



Investigation Hole #1



Investigation Hole #1
14.5 foot Void to Headwall

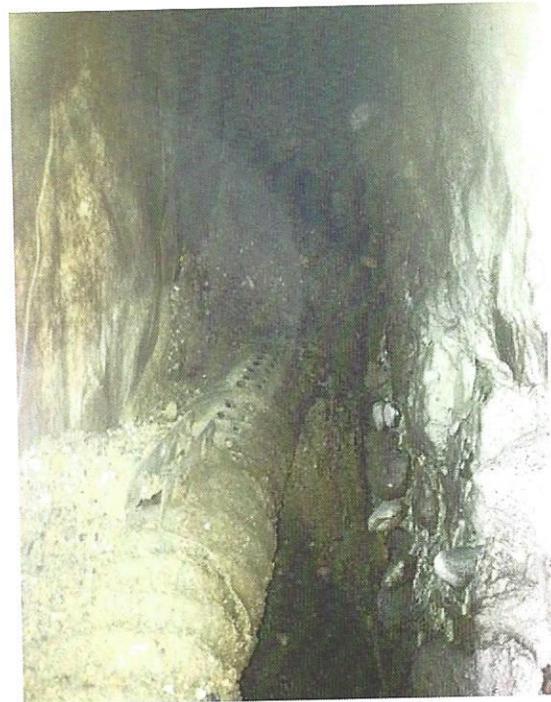


Joint Seal upstream of Hole #1
Failed Crack Seal where Water Enters System 14.5 feet
from Investigation Hole #1

Hole 2 is located approximately 20 feet down the slope from Hole 1. It is located further south of hole #1 and is adjacent to a primary drawdown drain pipe. Additionally, this location exposed a lateral drain connection. A 17 inch void was noted at this location. Lastly, it was observed that the perforations in the existing pipes are large enough to allow base material to be carried out with running water.



Investigation Hole #2
17 inch void



Investigation Hole #2
Large perforations observed in drain pipes



Lateral Drain in Hole #2



Investigation Hole #2
11 inch Void at Main Drain Pipe

Hole 3 was located approximately 50 feet down the slope from Hole 2. A primary drain pipe is located on the north side of Hole 3. A 14 inch void was noted at this location. Remnants of previous grouting operations were noted within this hole.



Inspection Hole #3
14 inch Void

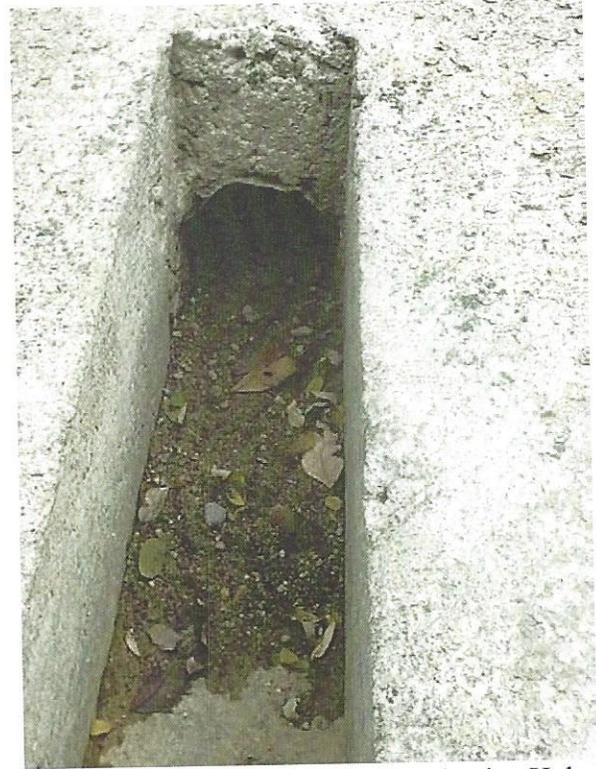


Inspection Hole #3
Drain Pipe Lateral (note apparent grout)

Hole 4 was located at the southern downstream portion of the spillway. This was an area known to have a void based on the Earth Exploration Ground Penetrating Radar (GPR) survey completed in 2015. The investigation observed the void to be 4 inches. The void was located directly adjacent to a drain pipe. The drain pipe was rusty, but in reasonable condition. It was noted that the drain outlet located approximately 20 feet away contained significant fine and course aggregate that was also observed to be in the hole.



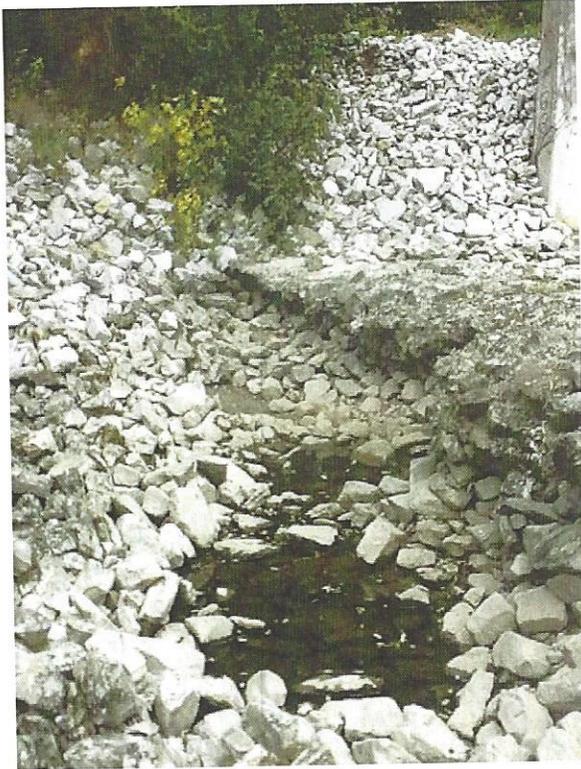
Investigation Hole #4
4 inch void (note aggregate material under concrete)



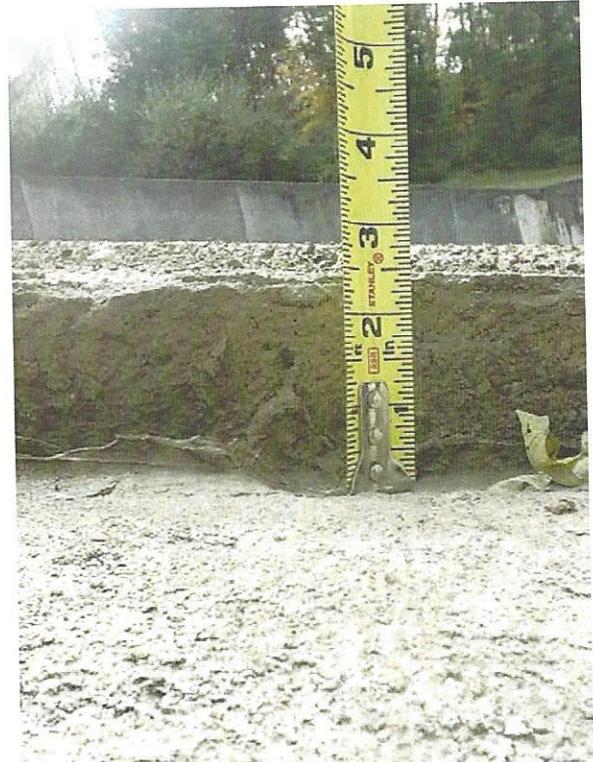
Outlet of adjacent drain pipe for Investigation Hole #4
(note deposited material similar to that observed within hole)

- **Other items noted**

A visual inspection of the drawdown conduit was completed. No items of concern were noted. Additionally, some riprap displacement was observed downstream of the stilling basin. It is recommended additional riprap be placed to fill the holes observed. Lastly, a 40 foot section of floor upward displacement was noted along the northern side of the basin. This was noted in the lower half approximately 10 feet from the side wall. It is believed this uplift is related to settlement of the middle portion of the spillway at this location.



Noted Riprap Displacement
Needs filled



Uplift noted along North Side of Spillway

Repairs of Inspection Holes and Crack

After the observations were completed, McCullough Excavating filled the inspection holes with #8 coarse aggregate. #5 rebar was dowelled into the existing concrete with epoxy on 12 inch centers. Lastly, 12 inches of concrete was placed to the existing spillway elevation. McCullough, then began repairing the joint at the headwall where the primary water infiltration was noted. Pictures of the repairs can be seen below.



Inspection Hole Repair



Joint Sealant Repair

Conclusions

1. The primary entry points for water under the concrete slab are the cracks and joints in the spillway floor.
2. The spillway under drain system has holes too large. These large holes allow sandy material to be carried out from under the concrete spillway floor through the drain system and ultimately downstream.
3. The voids under the concrete spillway have led to cracking, settlement and uplift of the spillway.
4. Cracking, settling and uplift has accelerated water infiltration and ultimately void development.
5. Previous pressure grouting repairs have plugged the under drain system.
6. Voids are still developing in spite of the drain system being plugged. (Water is finding a new path)

Recommendations

1. The spillway should be reconstructed from the headwall downslope to the stilling basin.
 - a. We currently recommend keeping the headwall, side walls, stilling basin, and drawdown pipe / structure in place. A structural analysis of the side walls is recommended to ensure stability during reconstruction.
2. A new under drain system needs to be installed beneath the spillway.
 - a. Precautions will be made to keep finer material under the spillway using either filter media or more appropriately sized perforations or both.
3. A repeatable and consistent maintenance plan will need to be implemented to ensure the joints are sealed and repaired appropriately on a year to year basis.

Appendix 'A'

Approximate Locations of Soils Borings and Investigation Holes

