MORGAN STREET RESERVOIRS

ALTERNATIVES ANALYSIS REPORT

City of Oberlin, Ohio

Environmental Design Group Project No. 19-00153-010

ODNR File No. 1221-018

Prepared for:
City of Oberlin
85 South Main Street
Oberlin, Ohio 44074

Prepared By:
Environmental Design Group
450 Grant St.
Akron, Ohio 44311

September 21, 2020

MORGAN STREET RESERVOIRS

ALTERNATIVES ANALYSIS REPORT

City of Oberlin, Ohio

TABLE OF CONTENTS

INTRODUCTION

The Morgan Street Reservoirs (Reservoirs) are two Class II dams located in the southern portion of Oberlin, Ohio, in Lorain County (Figure 1). The Reservoirs are also known as Oberlin Waterworks Upground Reservoirs No. 1 and 2. The Reservoirs were built about 100 years ago to support the City's Municipal Water Service. Several of the treatment buildings are still located on site, but these facilities are no longer used for drinking water. In late 2018, the Ohio Department of Natural Resources, Division of Water Resources (ODNR) performed a Dam Safety Inspection, which noted numerous required remedial measures. To comply with this inspection, significant modifications need to be performed on both dams. With the impending requirement to make considerable changes to the dams, the City hired Environmental Design Group (the Design Team) to assist with developing three alternatives that 1) either meet or provide exemption from ODNR dam requirements, 2) reflect the public's desires for the space, and 3) conceptualize more effective uses for the space.

FIGURE 1 – MORGAN STREET RESERVOIRS LOCATION MAP

The site consists of approximately 12.15 acres over five parcels. The location's address is 199 Morgan Street, where the Historic Water Plant buildings front the street along with a gravel maintenance access drive. This drive terminates at Reservoir No. 1 with a bulb area for turn-around. This turn-around area was noted during public meetings by some participants as "the beach area" due to the gentle slopes adjacent to the water.

Public parking for the site includes seven parallel parking stalls immediately adjacent to Morgan Street. Gravel walking loop paths provide approximately 2,850 linear feet (0.54 miles) of passive recreation along the perimeter of both Reservoirs (shown in tan on Figure 1 and below in Figure 2). These paths connect to the Oberlin College's Arboretum trail system. A foot bridge over Plum Creek on the arboretum property just south of the site provides this important connection across the creek.

There is approximately 1.5 acres of turfgrass area onsite, concentrated at the northeastern portion of the site. Turfgrass areas include around the Historic Water Plant buildings, the flat historic settling basin, the open area along the east berm of Reservoir No. 1, and areas north of Reservoir No. 1. The remainder of the site's landcover is either open water or forest. Most of the trees on the reservoir dams, bank slopes and outlying areas are no larger than 12 inches in diameter.

The water surface area of Reservoir No. 1 is approximately 4.1 acres, while Reservoir No. 2's water surface area is approximately 2.4 acres. The site has nine residential properties adjacent to the north & west, with Oberlin College owned properties to the south and east.

FIGURE 2 - EXISTING GRAVEL PATH ON TOP DAM EMBANKMENT

SITE HISTORY

The site is an integral part of the history of the City. In 1886, due to a series of fires over the previous years that ravaged the City, voters passed a $50,000 bond to build a city water system. Although situated directly adjacent to Plum Creek, a water supply line from the east branch of the Vermilion River near Kipton was built to the Morgan Street site to provide water. The water was treated and pumped to an elevated tank on site for distribution throughout the city. The tower, whose stone base remains onsite today, housed a 66,000-gallon steel tank, which was built in 1893 (Figure 3). Due to water shortages in the 1890s, Reservoir No. 1 was built, containing 15,000,000 gallons of water storage. Since the

FIGURE 3 - PHOTO OF ORIGINAL WATER WORKS FACILITY CIRCA. 1916

water was particularly hard with dissolved calcium and magnesium, the City installed the first municipal lime-soda water softening plant in the United States. Reservoir No. 2 was built in 1908, to provide additional storage capacity for treated water. This process of water softening created a buildup of sediments and the plant required an engineer to always be on site.

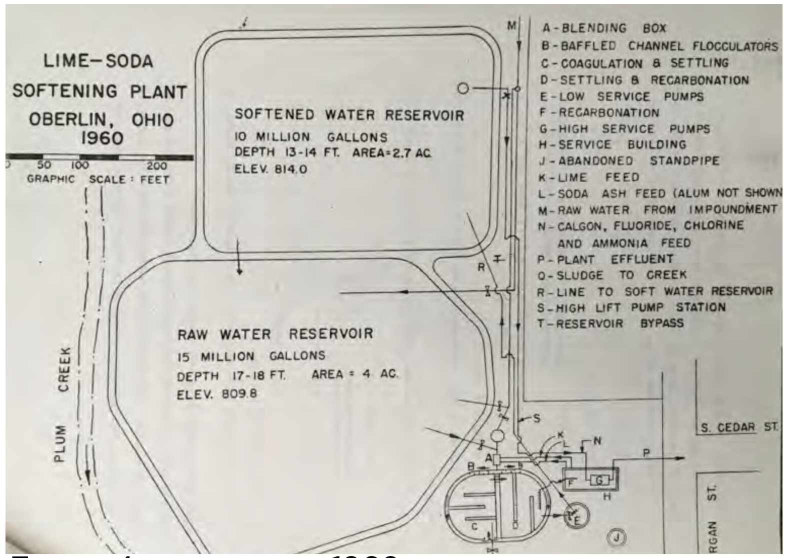


FIGURE 4 - DIAGRAM OF 1960 WATER WORKS – PLAN VIEW

In the late 1950's, based on the plant issues as well as dwindling water flow from the Kipton Reservoir, a new Water Treatment Plant was constructed on Parsons Road. This new plant was located southeast of the City and utilized water from the west branch of the Black River, approximately 1 mile west of the new Water Treatment Plant site. The Morgan Street Water Plant and Reservoirs shown in Figure 4, were mothballed in 1960 when the new WTP came online. The historic infrastructure on Morgan St. (Figure 5) has been vacant since that time. Various ideas for the adaptive reuse of the buildings and the site are now under consideration by the City.

FIGURE 5 - VIEW OF HISTORIC INFRASTRUCTURE – LOOKING NORTH

Today the structures are still standing but the rear addition of the Service Building sustained significant fire damage including the destruction of the existing roof rafters, heavy heat damage to the existing masonry, and destruction of the mezzanine and stairs. The original portion of the building sustained minor heat, water, and smoke damage as well as damage to the existing doors. The City performed a separate architectural analysis that concluded with the recommendation of a modest restoration. This proposed restoration includes the demolition of the old addition, necessary code upgrades to the original structure, repointing of the brick, new windows and door repairs and replacement, with new utilities including electrical, water and sewer services. Future renovation of the Service Building is a separate project and not included within the scope of EDG's work.

Today, the site is part of the City's park system, mainly used for passive recreation. Participants inf the public meetings identified they use the site for fishing, hiking, bird watching, and/or picnicking.

See Appendix A for a complete copy of the historic "Report of the Oberlin Water Works Board – 1916".

SUMMARY OF DAMS & ODNR COMPLIANCE REQUIREMENTS

The original configuration of the two Reservoirs remains generally the same as they existed almost 100 years ago. The average height of Reservoir No. 1 dam is 5.3-feet with a maximum 11.5-foot height. The average height of Reservoir No. 2 dam is 6.25-feet with a maximum 13.5-foot height (Figure 6).

FIGURE 6 - RESERVOIR'S CALCULATED ESTIMATED DATA

Since both reservoirs have dam that are over 10 feet and have a combined storage of over 50 acres, they are regulated by the ODNR as class II dams (Figure 7).

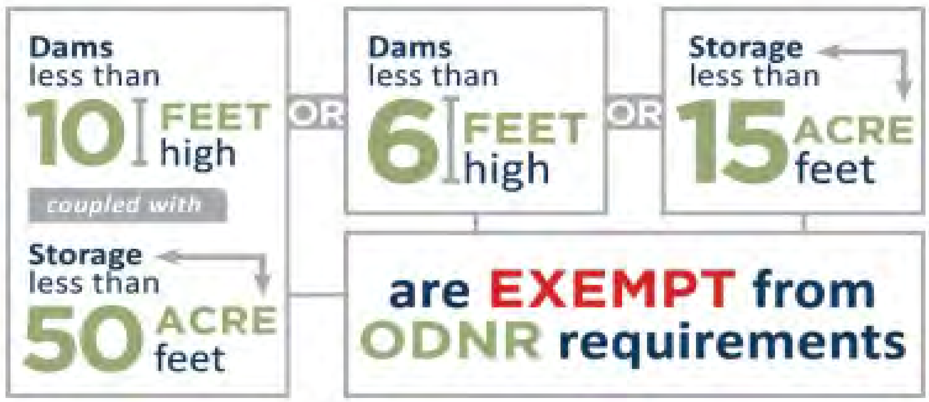


FIGURE 7 - ODNR DAM EXEMPTION REQUIREMENTS

The two dams were first inspected by ODNR in 1985. A routine inspection was performed by ODNR on September 18, 2018. The inspection report estimates the combined storage capacity of the two Reservoirs as 60.6 acre-feet.

Our team reviewed the September 2018 ODNR Dam Safety Inspection Report, which listed the following required remedial measures:

Engineer Repairs and Investigations

1. Every upground reservoir shall have an overflow or other device to preclude overfilling of the reservoir during normal filling operation. Prepare plans and specifications to install an overflow or other device.
2. The embankment crest alignment must be uniform. Perform a survey of the entire embankment and appurtenant structures, including existing and abandoned conduits and drains and, as necessary, prepare plans and specifications for the correction of any problems.
3. The maximum operating pool must be lowered and/or a request for a freeboard variance with supporting justification must be submitted to the division. Additionally, the reservoir pool level must be monitored weekly until the pool is lowered below the maximum operating pool level.
4. The unused and abandoned piping must be removed or properly abandoned. Prepared plans and specifications for removal or abandonment. The conditions of the unused and abandoned piping must be monitored quarterly until repairs can be made.
5. Seepage from the dam must be controlled to prevent stability and maintenance problems. Investigate the sudden drop in pool level in Reservoir Number 2 and determine the cause. As necessary, prepare plans and specifications for the collection, control, and/or monitoring of the seepage. Until repairs can be made, the pool level must be monitored weekly.

6. This dam must have a device to permit draining of the reservoir within a reasonable period of time.
7. This dam must have a dam failure inundation study and map included in an Emergency Action Plan (EAP).

FIGURE 8 - EAST EMBANKMENT OF RESERVOIR NO. 1 WITH VEGETATION

<u>Owner Repairs and Monitoring</u>

1. Remove the trees and brush from the entire main embankment. Seed all disturbed areas to establish a proper grass cover.
2. Install a staff gauge to facilitate accurate monitoring of the pool level.
3. Seed the bare areas on the crest of the embankment to establish a proper grass cover.
4. Repair the erosion on the crest and interior slopes.
5. Repair the rodent burrows on the entire embankment.
6. Repair the footpaths on the crest.
7. Remove the obstructions from the emergency overflow catch basin. Repair the low areas on the crest of the main embankment.
8. Monitor the wet area on the southern exterior tow monthly for any signs of increased flow, muddy flow, or instability on or adjacent to the embankment.
9. The Dam Safety Inspection Report also indicated that an Operation, Maintenance, and Inspection Manual (OMI) and an Emergency Action Plan (EAP) were required to be submitted and approved.

In summary, numerous significant measures need to be performed to meet the ODNR standards for the two Class II dams. Due to the cost implications, there may be a significant cost benefit in altering the size and function of these Reservoirs so that they do not meet the standards for classified dams and become exempt from ODNR requirements. It will still be necessary, however, for the City to manage these facilities in a safe and efficient manner.

The full ODNR inspection report is found in Appendix B. The ODNR Dam Safety Fact Sheet is also included within this section of the appendix.

SITE RECONNAISSANCE

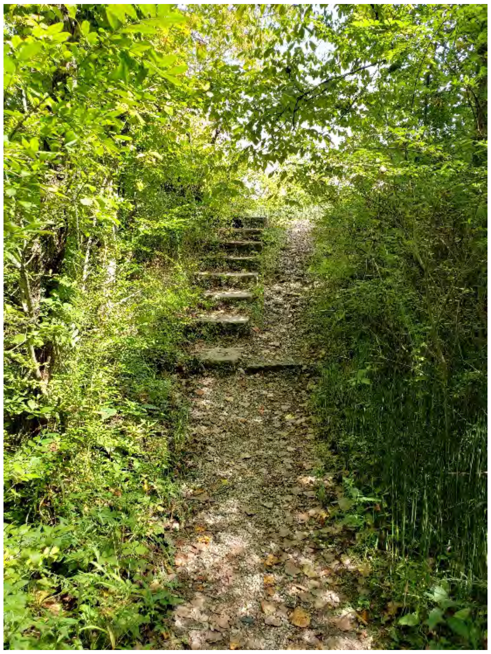


FIGURE 9 - SOUTH STEPS CONNECTING TO THE ARBORETUM TRAIL NETWORK

The design team performed several field visits to the site to obtain images, survey field points of the embankments, pertinent infrastructure and related topographic features, and field points below the water surface. This information was collected and organized into a photo library, topographic survey of the property in CAD, and a cross section of the adjoining embankment between both Reservoirs. The detailed topographic survey includes the building edges, current water surface edge, edge of existing vegetation, edge of gravel surfaces, found utilities, right-of-way, property lines, and one-foot interval contours. Using the limited surveyed points collected, a topographic survey of each reservoir's bottom was produced. This information was used to calculate the estimated storage volume for each reservoir.

SITE ANALYSIS & ALTERNATIVES DEVELOPMENT

Aspects of the site were analyzed to better understand the implications of altering the Reservoirs including adjacent flood elevations, hydrology, and embankment soils. Each of these elements provided information for the development of the three alternatives.

ADJACENT FLOOD ELEVATIONS

Plum Creek flows east through the south portion of the site. Plum Creek is a tributary to the Black River, which flows to Lake Erie. The drainage area for Plum Creek at this site is approximately 4.5 square miles (2,900 acres). The estimated 100-year peak discharge of the stream at this location, , calculated using USGS's StreamStats program,   is approximately 950 cubic feet per second (StreamStats.USGS.Gov).

Flood elevations within the immediate area south of the Reservoirs are restricted within the creek bank, due to steep side slopes from Reservoir 1 dam. This

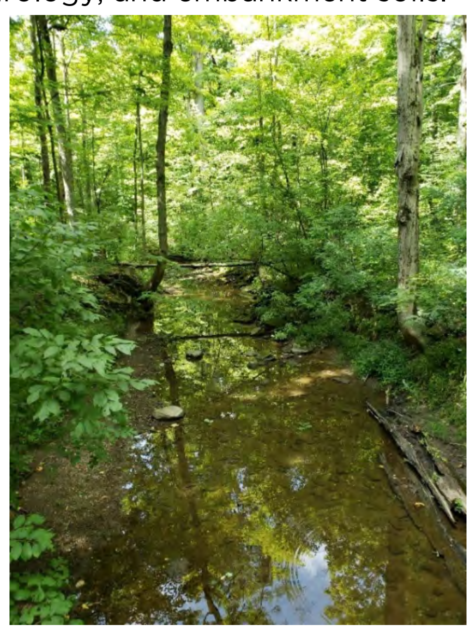


FIGURE 10 - PLUM CREEK – LOOKING EAST

portion of Plum Creek was not examined in detail by FEMA for the most recent Flood Insurance Study (Figure 10) as there are so few residential properties surrounding the reservoirs. These residents are also located at higher elevations than the potential bottom of Reservoir #2, and with little inflow or outflow volumes, it is unlikely there will be any change to existing FEMA conditions.

Downstream obstructions within the Plum Creek waterway include Morgan Street approximately 1,420 linear feet downstream of the site and South Professor Street approximately 1,600 linear feet downstream.

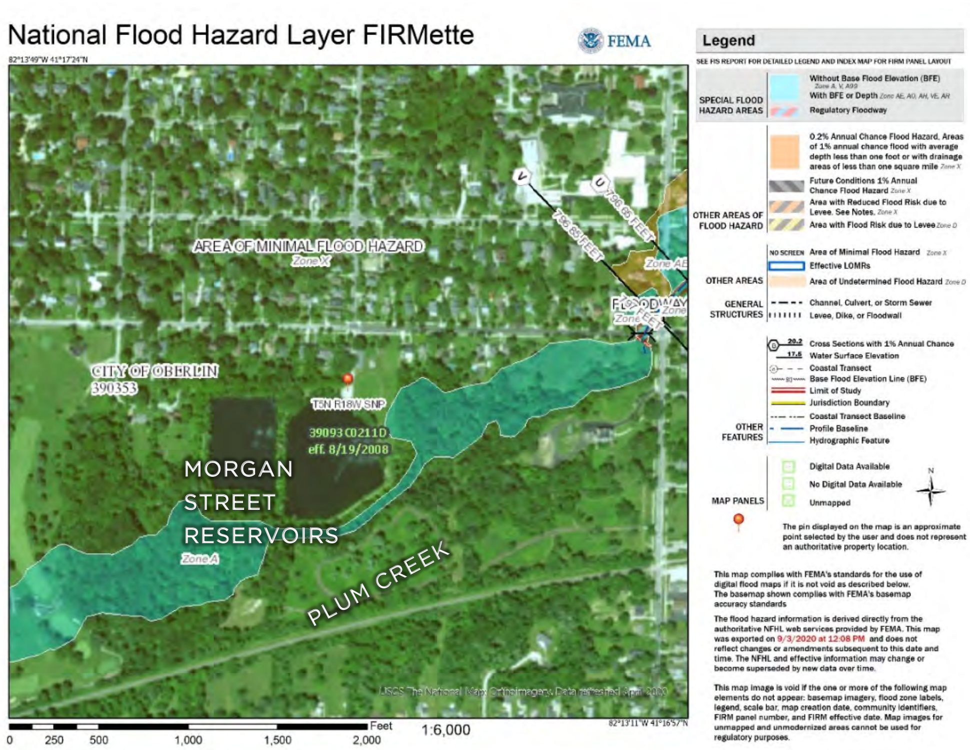


FIGURE 11 - FEMA FLOOD MAP OF AREA

HYDROLOGIC ANALYSIS

The original water supply for the Reservoirs came via pipe from the (now defunct) Kipton Reservoir on the east branch of the Vermilion River and a secondary conduit from the Kipton sandstone quarry, east of Kipton on SR511. After the site was decommissioned, it is believed that the inflow water sources included infiltration into the abandoned conduits, direct rainfall, very minimal runoff from bank side slopes, and possibly groundwater flow. Soil borings performed for this project identified groundwater elevations of approximately 795 & 796 feet, which is near the water elevation of Plum Creek. These borings were performed in November, when groundwater is typically at its lowest elevation. Further investigation during final design as part of the hydrologic modeling is needed to determine if groundwater greatly impacts the Reservoirs' and proposed wetland volume. There is an interconnecting pipe (at approximate elevation 812.35) nearer the south end of the adjoining embankment. Reservoir #1 has an overflow pipe (at approximate elevation 812.12) which drains to a catch basin near the NE corner of Reservoir #1 and from there to Plum Creek. Historically, the water level in Reservoir #2 was about 5' higher than the water level in Reservoir #1.

In early 2018, the normal water surface elevation of Reservoir No. 2 unexpectedly dropped by approximately five feet. The exact cause for this major shift in water level is unknown. Initial evaluations suggest that the shared embankment has been compromised by tree roots and burrowing rodents, among other possible causes. Following the 2018 exfiltration 'event', the Reservoirs' water levels have again normalized and seem to have been generally consistent since that time. Participants from the public meetings noted that they have never witnessed the Reservoirs overflowing the dam embankments.

As a part of this project the Reservoir's dams and banks were surveyed with limited survey points taken beneath the water surface. Based on this information, updated volumes of the Reservoirs were calculated. Reservoir No. 1 is estimated to currently enable the storage of 43 acre-feet of water. Due to this significant change in water level, the current estimated volume for Reservoir No. 2 is significantly smaller than the original estimated volume. In its compromised condition, Reservoir No. 2 is estimated to currently enable the storage of 18 acre-feet.

RESERVOIR 1		
	1916 ESTIMATE	CURRENT CALCULATED ESTIMATE
Surface Area (Acres)	4.0	4.09
Surface Elevation	809.8	807.5
Depth (Feet)	17-18	14-15
Estimated Avg. Depth (Feet)	11.5	10.5
Volume (Million Gallons)	15	14
Volume (Acre Feet)	46	43

TABLE 1 – RESERVOIR 1 ESTIMATED DATA

RESERVOIR 2		
	1916 ESTIMATE	CURRENT CALCULATED ESTIMATE
Surface Area (Acres)	2.7	2.39
Surface Elevation	814.0	806.7
Depth (Feet)	13-14	14-15
Estimated Avg. Depth (Feet)	11.4	7.5
Volume (Million Gallons)	10	5.9
Volume (Acre Feet)	30.7	18

TABLE 2 – RESERVOIR 2 ESTIMATED DATA

The combined estimated storage volume for the two reservoirs is over 50 acre-feet, both dam heights exceed 10 feet, and the dams share an earthen embankment. ODNR currently considers the two water bodies as one dam. This led to a discussion about possibly regulating the dams as two separate reservoirs. If one reservoir were to be altered in a way to provide exemption from ODNR dam requirements, the stability of the shared earthen embankment would be key. This prompted the decision to perform an embankment slope stability analysis on the shared earthen embankment.

EMBANKMENT SLOPE STABILITY

The design team included CTL Engineering (CTL) to investigate and analyze any deterioration and/or structural integrity issues with the earthen embankments and dams. CTL performed onsite geotechnical engineering exploration and analysis for the project in support of these efforts. The analysis considered the stability of the shared earthen embankment between Reservoir No. 1 and Reservoir No. 2 to assist in determining whether these reservoirs could be regulated separately. The analysis considered the possibility that Reservoir No. 2 may be permanently dewatered and/or removed. The analysis also considered the structural integrity of the southeast earthen dam of Reservoir No. 1 in compliance with ODNR requirements.

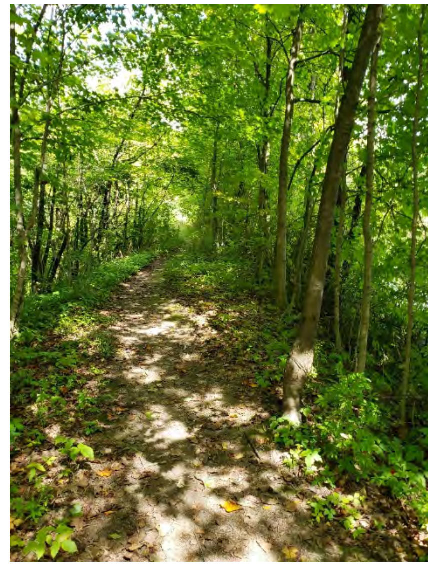


FIGURE 12 - SHARED EARTHEN EMBANKMENT BETWEEN THE RESERVOIRS

On November 5th, 2019, drillers extracted four, 30-foot deep soil tests on the site. Three of the borings were within the shared earthen embankment between the reservoirs and one was on the southeast corner of Reservoir No 1's earthen dam. The soil borings showed that most of the subsurface material within the earthen embankments/dams consisted of medium stiff to hard silty clay. Groundwater was generally encountered at elevations consistent with the bottom of the reservoirs.

The Slope Stability Analysis calculated the earthen embankment between the reservoirs has a factor of safety (FOS) of 1.06 under rapid draw down conditions and a FOS of 1.25 under steady state conditions. A FOS above 1.3 indicates a stable condition, while a FOS below 1.0 indicates a high probability of slope instability and/or occurring failures. Since the FOS falls into the area between 1.0 (instable) and 1.3 (stable), it is determined the reservoirs could not function as a single unit and therefore cannot be regulated as two separate reservoirs without significantly reinforcing the existing earthen embankment.

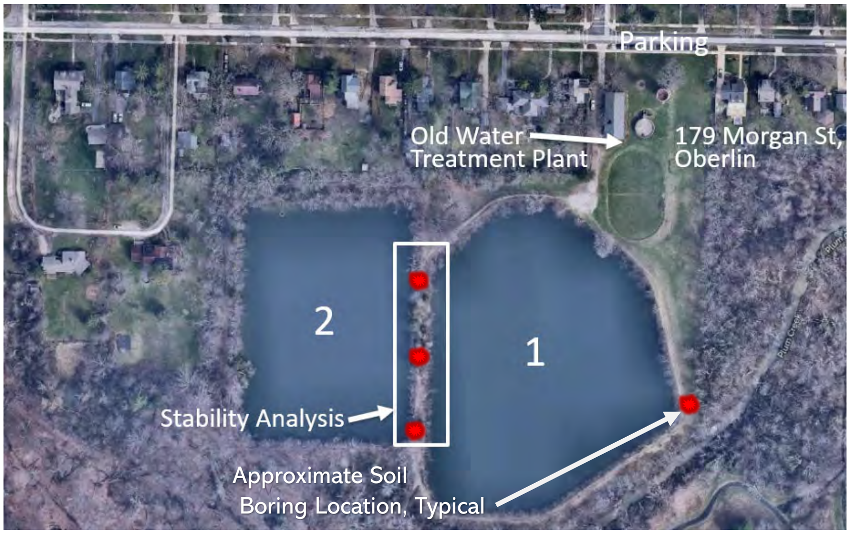


FIGURE 13 – GENERAL LOCATIONS OF PERFORMED SOIL BORINGS AND SLOPE STABILITY ANALYSIS

Further recommendations include avoiding rapid drawdown of Reservoir No. 2 and repairing all eroded areas along Reservoir No. 1. It is also recommended that after Reservoir No. 2 is drained, a perforated drain be installed along the west toe of slope. The full report, dated November 25, 2019 is included in Appendix C.

MEETINGS AND THE DECISION PROCESS

A rigorous planning and public facilitation process was intentionally performed to receive robust public input, include the client throughout each step of analysis and alternatives development, adequately address public concerns, and ultimately gain support from all stakeholders involved. Several meetings were held to enable this process. The following is a list of all meetings that occurred for the project:

CITY COUNCIL MEETING .... MAY 20TH, 2019
KICKOFF MEETING .... JUNE 18TH, 2019
ALTERNATIVES WORKSHOP .... AUGUST 14TH, 2019
CLIENT MEETING .... JANUARY 29TH, 2020
PUBLIC MEETING .... FEBRUARY 18TH, 2020
RECREATION COMMISSION .... APRIL 21ST, 2020
OPEN SPACE COMMISSION .... MAY 5TH, 2020
CITY COUNCIL WORK SESSION .... JUNE 15TH, 2020

At the City Council and Kickoff Meetings, the project outline, project updates, schedule, project goals, expected deliverables, and action items were discussed. Many of the initial action items were to prepare for the Alternatives Workshop.

FIGURE 14 - EDG PRESENTING AT THE ALTERNATIVES WORKSHOP

During the Alternatives Workshop, the design team presented the project to the public, including the site history, the site context, the ODNR inspection report and required remedial measures, and the planned project process. Following this presentation, the workshop format allowed the public to circulate to four different stations to provide input on: habitat/vegetation, historic character of the site, reservoir use, and trails/site circulation. By gathering this specific input, the design team was able to catalog the public's desire to preserve the site and to better utilize the space.

A summary of the most common responses received from the public includes:

Habitat/Vegetation

- Don't reduce the vegetation since it's crucial for the birds and wildlife
- Preserve the sitting spaces under the big old maple tree
- Increase natives and plant pollinator friendly species
- Keep the site as natural as possible

Historic Character

- Install interpretive signage about the history of the site as the first lime-soda softening water plant in the U.S.
- Provide public rentals, meeting space, and a warming space in the winter within the existing building
- Change the building into a nature center
- Don't allow the site for commercial use
- Add restrooms to the site

Reservoir Use

- No ODNR control while keeping both reservoirs
- Turn Reservoir No. 2 into a wetland
- Maintain the sledding hill on the east slope of Reservoir No. 1
- Keep or improve the beach at Reservoir No. 1
- Keep the reservoirs natural
- Develop an ice-skating rink over the historic settling basin east of Reservoir #1
- Keep the trees

Trails/Circulation

- Maintain the paths for pedestrian access and combine them with the Arboretum
- Keep the paths natural and do not add impervious surfaces
- Add wayfinding on the paths
- Do not add any additional parking
- Maintain the area for birding
- Allow Lorain County Metroparks to manage the site

A full list of cataloged comments is within Appendix D under "Alternatives Workshop Meeting Summary".

After the Alternative Workshop was complete, it was clear that additional geotechnical information was necessary to provide accurate information concerning possible alternate concepts going forward. A Geotechnical Study was performed at this time by CTL. The geotechnical information and analysis were outlined in the "Embankment Slope Stability" section above. The full Geotechnical Engineering Study can be found in Appendix C.

The design team then organized the public input received. As a part of responding to the public input, the following infographics were developed to graphically present the most frequent comments. The infographic broke each comment into ODNR compliant and exempt status. This framed each comment within the ODNR requirements to assist in clarifying the extensive restrictions that maintaining a regulatory dam entail. The infographics also helped summarize the design team's understanding of the public's comments.

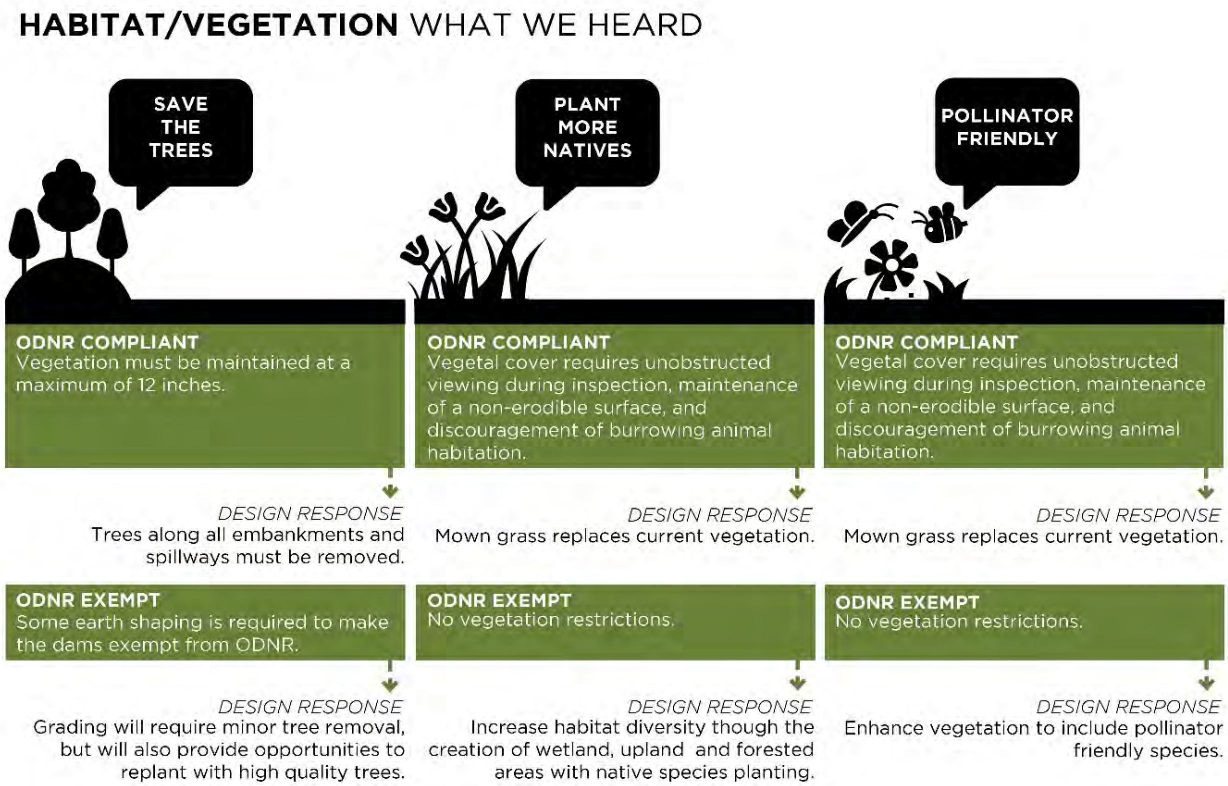


FIGURE 15 - HABITAT/VEGETATION INFOGRAPHIC

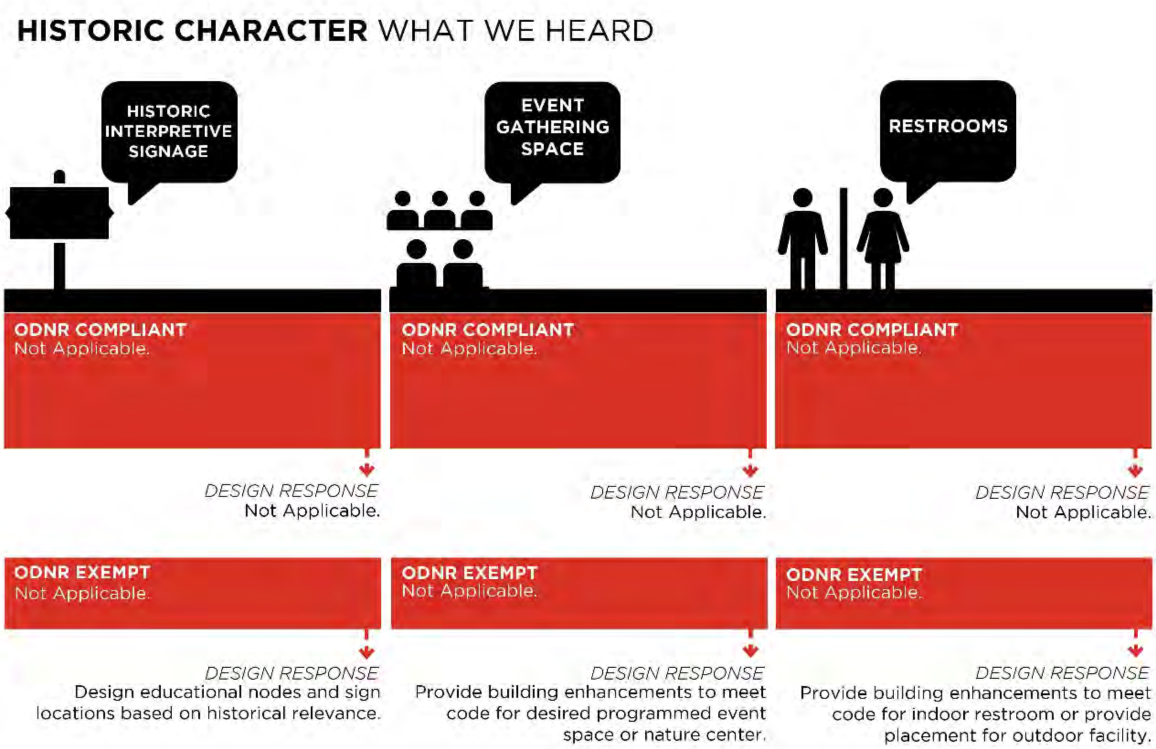


FIGURE 16 – HISTORIC CHARACTER INFOGRAPHIC

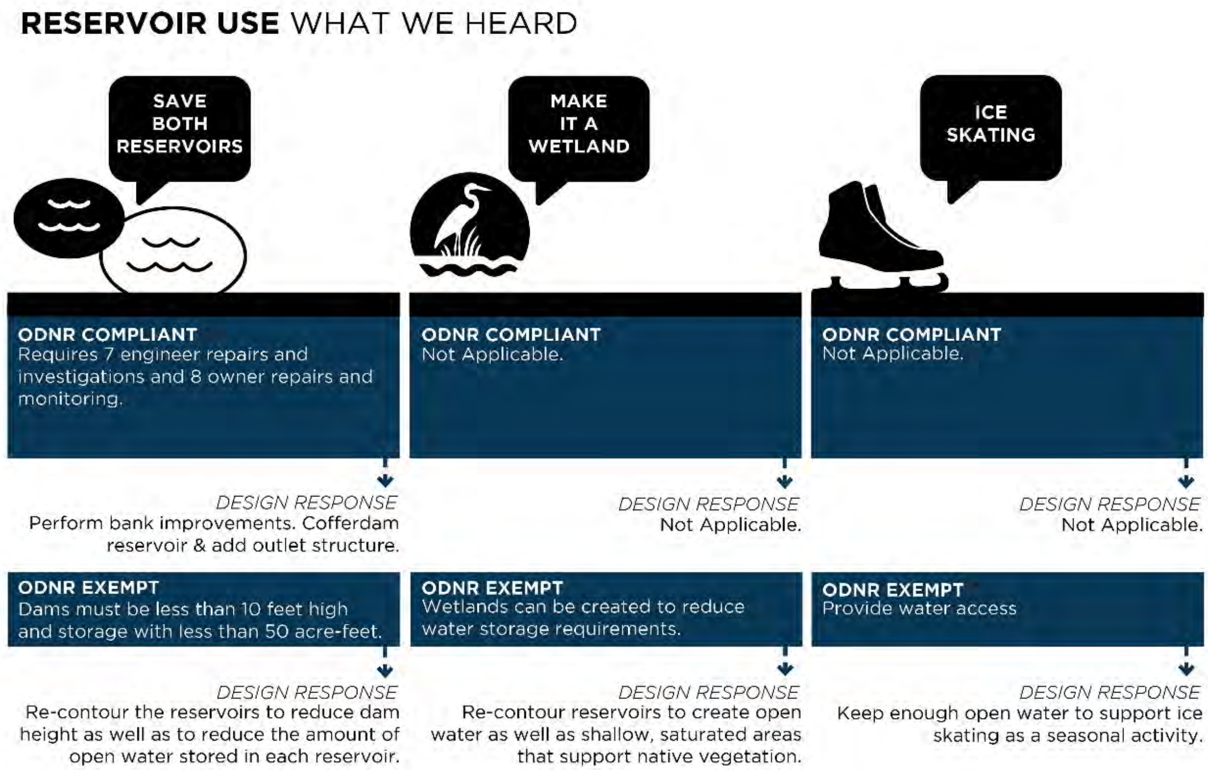


FIGURE 17 – RESERVOIR USE INFOGRAPHIC

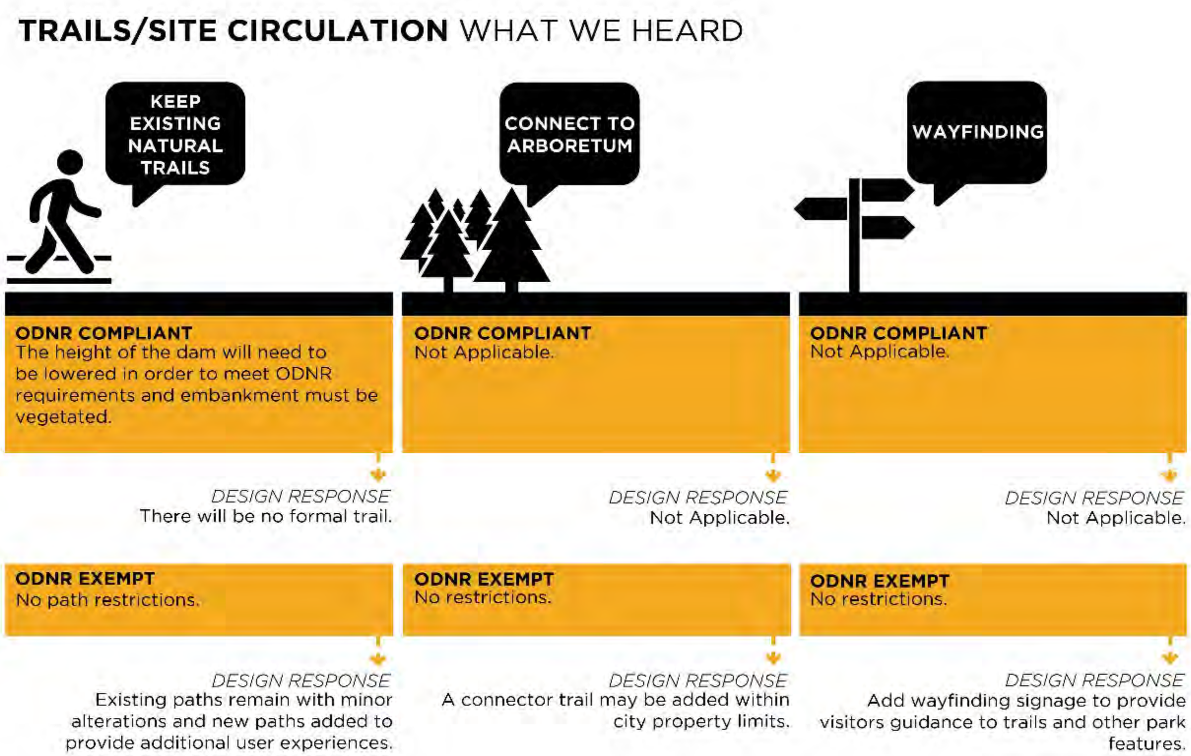


FIGURE 8 - TRAILS/SITE CIRCULATION INFOGRAPHIC

ALTERNATIVES

Upon completion of the Site Analysis, the design team began working on preliminary concepts. To fully consider the implications of regulatory compliance, one design concept was developed to meet ODNR requirements. Two alternatives were developed to modify the reservoir dams to become exempt from ODNR requirements for classified dams.

Several preliminary Alternative Concepts and General Cost Opinions were developed and eventually presented to the City at a Client Meeting held on January 2020. These alternatives, Concepts 1, 2, & 3, were developed based on the Site Analysis, current regulations, and input from the public engagement process, especially the Alternatives Workshop.

For this Alternatives Analysis, the two reservoirs were the primary focus. Changes to the historic water plant buildings, historic water settling area, and on-street parking were not considered within this study.
Based on City input, the preliminary concepts, were refined into three Primary Alternatives:

Alternative 1 – Meet Minimum ODNR requirements
Alternative 2 – One Exempt Reservoir & One Wetland
Alternative 3 – Stream Restoration & Wetlands (3B was eliminated due to trail bridge costs)

Each of these three alternatives were presented to the community during a Public Meeting in February 2020, the Recreation Commission in April 2020, the Open Space Commission in May 2020, and a City Council Work Session in June 2020. Comments were received at each meeting. The three alternatives are described in detail below.

Alternative 1 – Meet ODNR Requirements

This alternative includes major tree removal anywhere near the Reservoirs and repair of the earthen embankments. ODNR requires that no vegetation other than mown grass be grown on any reservoir embankment. Vegetation on embankments can cause instability by providing habitat for burrowing rodents and through the growth of roots. For this option, the only vegetation allowed to remain would be vegetation along the immediate bank of Plum Creek, some buffer vegetation along the eastern and northern property lines, and possibly two large trees within the existing green area at the northwest corner of Reservoir No. 1. All other vegetation would be removed and replanted with turf grass. This would significantly increase maintenance requirements of the site.

FIGURE 19 - ALTERNATIVE 1

Additionally, the current reservoir embankments lack a structured spillway. A spillway is a lower section of embankment that focuses water overflow during storm events. Additionally, both dams would require new outlet control structures with erosion protection on the embankments and spillways. To ensure the Reservoirs do not negatively affect the health, safety and welfare of current and future downstream structures, additional engineering studies and reports would need to be performed and approved by ODNR.

FIGURE 90 - ALTERNATIVE 2

Alternative 2 – Exempt Reservoir & Wetland

This alternative lowers the water level (less than 50 acre-feet) and portions of the embankment (to less than 10') around Reservoir No. 1 to allow this reservoir to be exempt from ODNR requirements. For Reservoir No. 2, the southern embankment would be substantially removed, and the bottom of the reservoir would be converted into a wetland. A portion of the removed embankment soil would be used to expand green space at the northeast corner of the wetland.

Grading within Reservoir No. 1 would be modest, including lowering the embankments at the northeast and southwest corners to ensure all embankments are under 10 feet in height. Reservoir No. 1's normal water level would be lowered by approximately three vertical feet to accommodate the lower embankment heights. A new outlet control structure would be installed to better control the water level. This would also slightly reduce the water pressure against the shared earthen embankment between the two reservoirs. Little to no grading is expected to occur along the exposed inside embankment slopes. The excess soil from lowering the embankments would be used to transform Reservoir No. 2 into a wetland.

Grading within Reservoir No. 2 would be more significant. The central bottom elevation of the existing reservoir would remain at nearly the same elevation. However, to create the wetland, significant fill would occur along the bottom perimeter of the basin to create a shelf around the constructed wetland. Additional fill would also be added at the west toe of the shared earthen embankment between the two reservoirs to provide additional stability to the embankment. A perforated drainpipe would be installed along the embankment to ensure any water seepage is collected and immediately drained away. In addition to utilizing soil from lowering the embankments within Reservoir No. 1, significant fill material would be obtained by partial removal of the southern earthen embankment of Reservoir No. 2. Some of this fill would be used to create a gently sloping green space at the northeast corner of the wetland to accommodate recreational activities. Preliminary calculations estimate that the cut and fill within the site can be balanced so that no soil would need to be brought onto the site or exported from the site. Amore detailed design will need to be developed to verify this preliminary assessment. Based on soil boring samples, it appears that the existing soil within the earthen embankments will be adequate to function as fill soil within the proposed wetland area.

The proposed wetland water surface elevation will be lower than Reservoir No. 2's water level. Although the exact hydrologic conditions remain to be determined, it is likely that water elevations in the constructed wetland will be controlled by surface run-off, rainfall and by groundwater levels. A new outlet control structure and overflow spillway will direct any excess water south, onto the floodplain area owned by Oberlin College. It is not estimated that outlet flows from the proposed wetland would be significant enough to create erosion issues in this area, however a more detailed design will need to be performed to verify this.

Although some vegetation would be initially removed where embankments are to be lowered or removed, the site would be significant revegetated throughout with both trees and native herbaceous plantings. The net gain of tree vegetation for this Alternative is estimated to be 24 percent above existing tree canopy.

Alternative 3 – Stream Restoration & Wetlands

FIGURE 10 - ALTERNATIVE 3

For this alternative, Reservoir No. 1 would be converted into a wetland, and with the development of a secondary overflow channel for Plum Creek routed through the southern portion of the original reservoir. Major portions of the southern embankment would be removed. Reservoir No. 2 would also be converted into a wetland, similar to Alternative 2.

Unlike Alternative 2, this alternative would require significant grading within Reservoir No. 1. The bottom of the existing reservoir would be raised approximately two to three feet and a shelf would be constructed around the perimeter of the proposed open water area of the wetland. A wetland outlet control structure would be installed to regulate the water level.

To build a secondary stream channel for Plum Creek, significant grading would be required to remove the earthen embankments of Reservoir No. 1 where the creek would come into and leave the original reservoir as well as excavation for the secondary creek bed itself. Significant fill will be gained from the removal of the earthen embankments and the excavation of the creek bed. Preliminary calculations estimate that the cut and fill within the site can be balanced so that no soil will need to be brought onto the site or exported from the site, however a detailed analysis would need to be performed for validation. As mentioned in Alternative 2, based on soil boring samples, it appears that the existing soil within the earthen embankments will be adequate to function as fill soil within the proposed wetland area.

This option would require significant enhancements to the excavated stream bed to accommodate the required creek bed material, erosion control measures, and habitat enhancements. In addition, considerable US Army Corp of Engineer (USACE) permitting would be required for the stream restoration work. It would also require coordination with Oberlin College as the original creek bed occurs on the College's property. Additional fluvial geomorphologic design would be required to ensure the new creek's bankful cross-sectional form, sinuosity, bed material size, and floodplain areas are adequately designed and constructed.

For Reservoir No. 2, all the grading and vegetation modifications would be the same as Alternative 2, with the exception of a small modification - a perforated pipe along the west toe of the shared embankment would not be needed as nearly all the water pressure from Reservoir No. 1 would be removed in this alternative.

Like Alternate 2, some vegetation would be initially removed where embankments are to be lowered or removed but the site would be significantly revegetated where the relocated creek enters and leaves the original reservoir area. Throughout the site, including the new wetland areas a mix of trees and native herbaceous plantings would be installed. The net gain of tree canopy cover for this alternative is estimated to be 33 percent over current tree canopy for the site.

Additional exhibits showing anticipated areas where trees are to remain, be removed, and be replaced are in Appendix E.

PREFERRED ALTERNATIVE

A Public Meeting was held in February 2020 to present the alternatives to the community and receive the public's input. There was little to no public support for Alternative #1. The public supported both Alternatives #2 and #3 but with a preference towards Alternative #2 due to its lower cost and its greater sensitivity to the historical context and more recent uses of the site. After the Public Meeting, the concepts were further refined to address the overall changes in tree cover and other comments. The finalized Concept Alternatives were then presented to the Recreation Commission in April, the Open Space Commission in May, and finally the City Council in June. At the June meeting, the City Council unanimously adopted Alternative 2.

The following image depicts a side-by-side comparison of the three alternatives and their initial cost, operation and maintenance cost. , ODNR jurisdiction after modification, water quality, tree inventory, biological habitat, historic character, active recreation, and passive recreation are all compared below:

	ALT 1 Two Reservoirs	ALT 2 Reservoir & Wetland	ALT 3 Wetland Stream & Wetland
Initial Cost	$550K	$300K	$550K
O&M Cost	HIGHER	LOWER	LOWER
ODNR Jurisdiction	YES	NO	NO
Water Quality	GOOD	BETTER	BEST
Tree Inventory	-50%	+26%	+35%
Biological Habitat	GOOD	BETTER	BEST
Historic Character	BEST	GOOD	POOR
Active Recreation	BEST	GOOD	POOR
Passive Recreation	GOOD	GOOD	GOOD

Environmental DesignGroup The community impact people. CITY OF OBERLIN • Live • Learn • Lead •

CIVIL ENGINEERING / LANDSCAPE ARCHITECTURE / PLANNING / SURVEYING / ENVIRONMENTAL SERVICES / CONSTRUCTION MANAGEMENT

FIGURE 22 - ALTERNATIVES COMPARISON

Alternative 2 provides the best balance between active and passive recreation, ecological benefit and cost while maintaining the historic character of Reservoir No. 1.

COST ESTIMATES

To assist in comparing the three alternatives, an Opinion of Probable Construction Costs (OPCC) was developed for each alternative. An Association for the Advancement of Cost Engineering International (AACE) Class 4 construction cost estimate was prepared for each Alternative's conceptual design with best available costing information. Class 4 estimates are generally prepared based on limited information and have an accuracy range of -15% to -30% on the low side and +20% to +50% on the high side. They are typically used for project screening, determination of feasibility concept evaluation and preliminary budget approval. The original cost estimates presented to the public and council meeting are shown within Figure 21. After the initial cost estimates were presented, the three alternatives Class 4 estimates were further analyzed and are shown below.

Alternative 1 – Meet Minimum ODNR requirements

Total OPCC: **$680,000** (Range: $480,000 - $1,000,000)

Cost estimate includes the following items:

- Geotechnical Investigation, Inundation Study, & EAP
- Mobilization
- Clearing, Demolition & Removal
- Coffer Dam & Drain Lake

- Excavation & Export Soil from Site
- Outlet Control Structures
- Owner Repairs
- Topsoil, Planting, Seeding & Erosion Control
- Design, Permitting, Legal, etc.

Alternative 2 – One Exempt Reservoir & One Wetland (Preferred Alternative)

Total OPCC: **$430,000** (Range: $300,000 - $645,000)

Cost estimate includes the following items:
- Geotechnical Investigation (Shared Berm)
- Mobilization
- Clearing, Demolition & Removal
- Excavation
- Outlet Control Structures
- Topsoil, Planting, Seeding & Erosion Control
- Design, Permitting, Legal, etc.

Alternative 3 – Stream Restoration & Wetlands

Total OPCC: **$650,000** (Range: $460,000 - $975,000)

Cost estimate includes the following items:
- Mobilization
- Clearing, Demolition & Removal
- Excavation
- Outlet Control Structures
- Stream Restoration
- Topsoil, Planting, Seeding & Erosion Control
- Design, Permitting, Legal, etc.

WETLAND RESTORATION AND MAINTENANCE

Alternative 2, the Preferred Alternative, would allow for restoration of palustrine wetland habitat consisting of open water, emergent, and wet meadow plant communities in and around the near margins of the former reservoir basins, transitioning to scrub-shrub and forested wetland as one moves further up the slope. The depth of water and hydric qualities of the soil will determine the types of communities present, as shown in the below diagram:

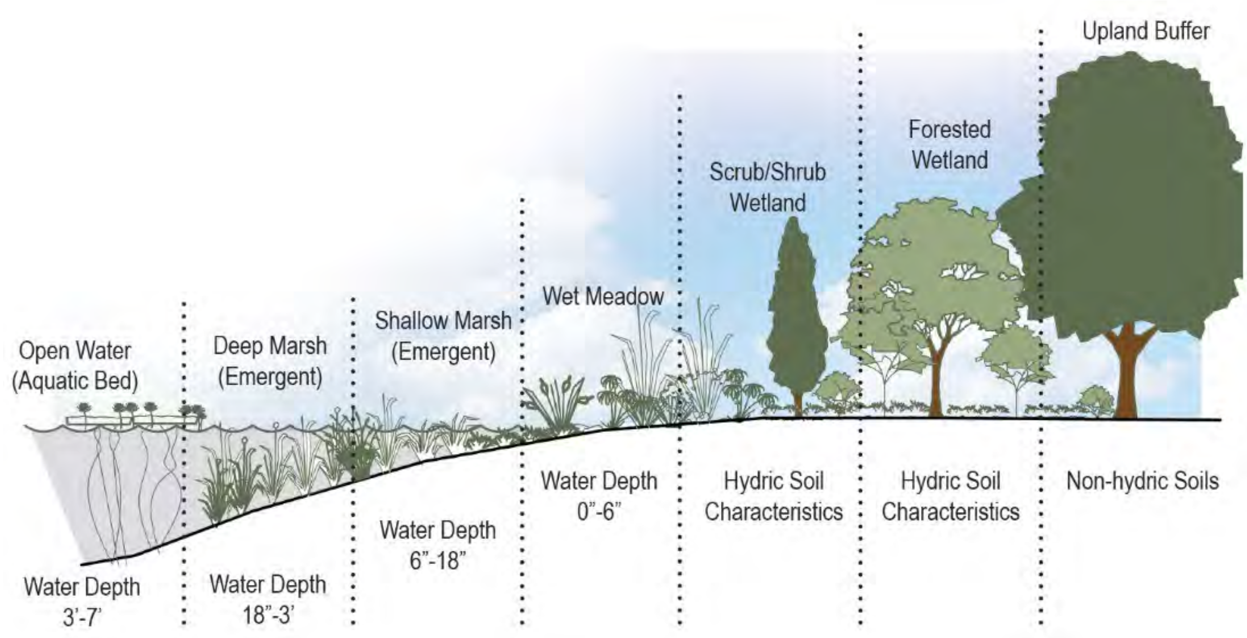


FIGURE 23 - WETLAND PLANT COMMUNITIES (IMAGE SOURCE: HTTP://GREATRIVERSGREENWAY.ORG)

The following are examples of characteristic native Ohio species found in each wetland plant community that could be used for the restoration efforts as part of a functional and aesthetically pleasing landscape:

Open Water Wetland Plant Species

- Nymphaea odorata (Fragrant Water-Lily)
- Nuphar lutea ssp. advena (Yellow Pond-Lily)
- Nelumbo lutea (American Lotus)

Emergent and Wet Meadow Wetland Plant Species

Forbs

- Caltha palustris (Marsh Marigold)
- Chelone glabra (Turtlehead)
- Iris versicolor (Blue Flag Iris)
- Iris virginica (Southern Blue Flag Iris)
- Lobelia cardinalis (Cardinal Flower)
- Lobelia siphilitica (Great Blue Lobelia)
- Mimulus ringens (Monkeyflower)
- Persicaria amphibia (Water Smartweed)
- Pontederia cordata (Pickerel Weed)
- Sagittaria latifolia (Common Arrowhead)
- Solidago riddellii (Riddell's Goldenrod)
- Sparganium americanum (American Bur-reed)
- Symphyotrichum ericoides (White Heath Aster)

- Symphyotrichum puniceum (Purplestem Aster)
- Symplocarpus foetidus (Skunk Cabbage)
- Tradescantia ohiensis (Ohio Spiderwort)
- Zizia aurea (Golden Alexanders)
- Asclepias incarnata (Swamp Milkweed)
- Eupatorium perfoliatum (Boneset)
- Filipendula rubra (Queen of the Prairie)
- Helianthus divaricatus (Woodland Sunflower)
- Hibiscus moscheutos (Swamp Mallow)
- Liatris spicata (Spiked Blazing Star)
- Symphyotrichum novae-angliae (New England Aster)
- Verbena hastata (Blue Vervain)
- Veronicastrum virginicum (Culver's Root)
- Amorpha fruticosa (False Indigo)

Grasses, Sedges, and Rushes

- Calamagrostis canadensis (Bluejoint Grass)
- Elymus virginicus (Virginia Wild Rye)
- Glyceria striata (Fowl Manna Grass)
- Cinna arundinacea (Wood-reed)
- Scirpus cyperinus (Wool-Grass)
- Spartina pectinata (Prairie Cord Grass)
- Carex crinita (Drooping Sedge)
- Carex frankii (Frank's Sedge)
- Carex gracillima (Graceful Sedge)
- Carex lacustris (Lake Sedge)
- Carex lurida (Bottlebrush Sedge)
- Carex stricta (Tussock Sedge)
- Scirpus atrovirens (Green Bulrush)
- Juncus effusus (Soft Rush)

Ferns

- Onoclea sensibilis (Sensitive Fern)
- Pteridium aquilinum (Bracken Fern)
- Equisetum hyemale (Horsetail Rush)

Shrub-Scrub and Forested Wetland Plant Species

Shrubs

- Rosa palustris (Swamp Rose)
- Cornus amomum (Silky Dogwood)
- Cornus racemosa (Gray Dogwood)
- Cornus sericea (Red-Osier Dogwood)
- Amelanchier arborea (Downy Serviceberry)
- Amelanchier laevis (Allegheny Serviceberry)
- Asimina triloba (Paw-Paw)
- Cephalanthus occidentalis (Buttonbush)

- Cercis canadensis (Eastern Redbud)
- Lindera benzoin (Spicebush)
- Ilex verticillata (Winterberry)
- Physocarpus opulifolius (Ninebark)
- Salix discolor (Pussy Willow)
- Salix sericea (Silky Willow)
- Sambucus canadensis (Common Elderberry)

Trees

- Nyssa sylvatica (Blackgum)
- Quercus macrocarpa (Bur Oak)
- Gymnocladus dioicus (Kentucky Coffee Tree)
- Quercus palustris (Pin Oak)
- Celtis occidentalis (Hackberry)
- Quercus bicolor (Swamp White Oak)
- Juglans nigra (Black Walnut)
- Acer rubrum (Red Maple)
- Aesculus glabra (Ohio Buckeye)
- Juniperus virginiana (Eastern Redcedar)

Wetland Restoration Management and Maintenance

Successful wetland restorations rely upon the establishment of healthy plant communities. Short-term maintenance goals, therefore, should prioritize monitoring the planted areas during the establishment period and looking for issues such as invasive species encroachment or general plant loss. Ideally, no more than 10% of the wetland area should be bare ground. While some loss of plant species is acceptable, the plant material may need to be recalibrated and a different species installed if more than 20% of a single species is lost, as open ground provides opportunity for invasive species to take over. Common invasive species in wetland restorations are *Phragmites australis* (common reed), *Phalaris arundinacea* (reed canary grass), *Lythrum salicaria* (purple loosestrife), and *Typha angustifolia* (narrowleaf cattail). These species can rapidly colonize and outcompete new wetland plantings but are significantly easier to control and eradicate if early detection and swift action are taken. Plantings should be inspected monthly during the growing season in at least the first year to check if establishment of any planted material is taking place and to quickly identify and control invasive species. After the first year, if establishment is occurring and invasive species are under control, vegetation monitoring and any needed invasive spot treatment can go down to once or twice a year. It may take a few years for an emergent wetland community to fully establish and diversify, and shrub-scrub and forest communities may take longer than that.

Long-term wetland management, upon establishment of the native plant communities, relies upon the ecological principles of succession and edges. As a wetland matures over time, plant communities may alter and shift, such as becoming denser with emergent or shrub species. The edges, or boundaries where the communities change (such as from emergent to shrub-scrub), can either be abrupt or gradual. Gradual, intergraded habitat builds more resiliency into the landscape, but as the edges become more blurred, communities will begin to shift. If this natural shift and gradational succession is desired, then vegetation management should be minimal and largely hands-off aside from periodic monitoring and control for invasive species. If there are areas where passive management is not desired, however, various scheduled active management activities such as mowing can maintain those locations in a certain stage of succession. An example of this would be annual mowing in a meadow in late summer or fall to maintain it as a dominant community of perennial forbs and prevent the succession of shrub-scrub habitat into the area, or harvesting of aquatic vegetation as needed to maintain an area of open water.

Wetlands are dynamic systems and portions may dry up over the summer, exposing mudflats for seasonal grasses to germinate on and provide food and habitat for many species of wildlife through the summer and fall. Water level fluctuation is a normal and natural characteristic of wetlands and can create shifts in plant composition and habitat that may last several seasons or more. Again, active management is necessary to maintain a wetland in a specific stage of ecological succession.

CONCLUSION

In conclusion, the City should move forward with the detailed design for the Preferred Alternative. At the same time, the City should apply for grant funding to help offset project budget costs. This document can be used in part for these grant applications.

APPENDIX A

REPORT OF THE OBERLIN
WATER WORKS BOARD - 1916

Report of the Oberlin Water Works Board

Report of the Oberlin Water Works Board

There exists among the citizens of Oberlin much misunderstanding and mystery, not to say prejudice, concerning the matter of the water supply. It is therefore the purpose of this report to explain as frankly as possible just what the present status is, and to show, if possible, what should be done in the future to remedy present defects and shortcomings.

Source of Our Water Supply

As is known to most of our citizens, our water comes from the east branch of Vermilion River one mile south of Kipton, and is conveyed to us underground through a vitreous conduit. This has been our source of supply since 1887.

The larger part of the supply is what would be termed surface water, coming from the farms bordering on the river. A certain amount undoubtedly comes from springs, and even the drainage water, except in times of freshet, now comes mainly through underdrains, and so might almost be classed as spring water.

The land in the immediate neighborhood of the intake, extending upstream for half a mile and covering a tract of about 160 acres, belongs to the village of Oberlin, and is known as the "Water-Works Farm." Much of this land is covered with a young forest, and is protected from contamination. The total water-shed area above the intake is about 10 square miles. In this region contamination may occur, although the State Board of Health backs us in protecting our supply if specific cases are known. The fact is, we have had little trouble from this source, although careful attention is regularly paid to the matter of bacterial content. A count is taken every day in the office of our County Health Officer, Dr. W. A. McIntosh.

At times the water as it comes from the river is very muddy, but this feature is not so bad as it looks, for the mud settles out on standing and in so doing carries down countless numbers of bacteria.

Coming as it does, through a soil of glacial drift filled with limestone pebbles, the water is very hard, so hard indeed that, without softening, it would be intolerable for washing purposes.

The Dam and Intake

The original dam at the Kipton end of the conduit was a very small affair, crossing only the channel of the river, and impounding the water to a height of perhaps two feet only. This dam gave considerable trouble by filling with mud and turning the same into the conduit and also by its liability to a washout every time a freshet came. Moreover, being so low, this dam did not conserve any of the water in times of abundance but allowed all the excess to escape, so that in dry time we often suffered from serious shortage. To correct these difficulties a larger and more permanent dam was constructed, which makes use of the excess coming in time of freshet. The new dam has been in operation about two years and is giving perfect satisfaction. It is located about 50 yards further up-stream than the old one, and at a point where the river bottom is somewhat narrower than at the old site. It is constructed of earth, and stretches across the whole bottom land at an elevation of about 15 feet above the bottom of the river channel. At one end is a concrete spill-way, so placed that the water will pass over it before reaching the top of the dam, and thus preventing the latter from being washed away. A new channel leads from the spill-way to a point near the site of the old dam, leaving the old channel just below the dam nearly empty.

Directly in the river channel on the upstream side of the dam is a concrete intake box about four feet square furnished with an iron grating of about one-inch mesh intended to prevent any sizable object from entering the conduit. Passing from this through the base of the dam is a 12 inch iron pipe which leads the water into a second concrete box, and directly facing this pipe on the opposite side of the box is the entrance to the conduit leading to Oberlin.

A weir of variable height is placed at one side of this second box parallel to the conduits. The entering water rises until it overflows the weir, the excess passing away into the river channel. In this way a definite head is maintained which may be made as much as four feet by increasing the height of the weir. A head greater than this cannot be maintained because the conduit below this point is provided with lamp holes leading to the surface of the ground, and too great a head will cause the water to well over the top of these in cases where they happen to be rather shallow.

As an extra precaution the pipe leading from the intake to the weir box is provided with a valve which can be so set as to allow the conduit to take all the water passing through and not allow any of it to pass over the weir. This makes it possible to conserve the supply in a dry time.

The bottom of the spill-way in the dam is placed at an elevation four feet above the top of the weir at its maximum height, and when the water is up to this level it covers an area of perhaps three acres above the dam at an average depth of about five feet, giving a reserve of perhaps 6 million gallons. This reserve is sufficient for 18 days use if no further supply came in, which, of course, is not the case.

Most of the underbrush and rubbish have been cleared from the region thus covered, but still more work needs to be done, particularly about the edges of the reservoir where the water is shallow. There is no danger, however, of the region becoming overgrown with water plants for the water does not remain over it much of the time during warm weather. The statement has been made that "we are now drawing our supply of water from a swamp," but this is no more true now than it ever has been. The fact is that a considerable proportion of the water-shed outside our control is of a more or less swampy nature. The bacterial count shows that the purity of the water has not been affected by the impounding effect of the Kipton dam. The only noticeable effect has been a marked increase in the amount of water coming into our reservoirs, a thing very much to be desired. It is a significant fact in this connection that we have had no shortage of water all through the extremely dry fall and early winter of 1922 when many towns in this vicinity have had to endure something approaching a water famine.

The Pipe-Line

The pipe-line, or conduit, bringing the raw water from the Kipton dam to Oberlin has at various times been the subject of heated conversation and of "scientific investigation". At present other matters occupy our attention but the pipe-line still continues to bring our water.

This conduit consists of vitreous pipe except for a short section of wooden pipe and for the points where it passes beneath the streams in its path, where it is of cast-iron. Beginning at the Kipton end, the first one-fourth mile is 14-inch wooden pipe. Following this are four miles of 10-inch; then one-fourth mile of 8-inch; and the last half mile is 12-inch, all vitreous pipe. The 14-inch pipe was laid in the fall of 1922, and replaces a part of the old 10-inch pipe. The 12-inch pipe at the Oberlin end was laid in 1916. This is a replacement of 8-inch pipe. The 8-inch section is laid on a steeper grade than the rest of the conduit, and for this reason will carry as much water as the 10-inch section. The replacements with larger pipe look towards a possible larger consumption of water, and if necessity arises the whole conduit will be so replaced. It is true, of course, that even the partial replacements lower the total friction in the conduit and therefore increases the flow of water.

The total fall from the Kipton dam to the Oberlin reservoir, when the latter is full, is about 25 feet. The line was so laid as to make the fall as uniform as possible and everywhere down-grade, except where passing under the streams. This tends to prevent settling of mud and consequent obstruction.

The sections of iron pipe leading under the streams are in the form of downward curves, called "siphons". The longest of these, passing under the river near the Kipton dam, is provided at its lowest point with a removable cap to permit cleaning. This cleaning of the iron siphons is necessitated mainly by the accumulation of barnacle-like deposits. The other siphons probably need cleaning for the same reason, but unfortunately they were not provided with caps. Deposits of this kind do not seem to form on the vitreous pipe.

At frequent intervals along the conduit, lamp holes are provided, which permit of observation of flow, cleaning, etc.

The conduit delivers the water at the Oberlin reservoir simply by gravity, without pumpage, and at an average rate of about 300,000 gal. per day of 24 hours (the rate of consumption). During a time of high water, when the head at the Kipton end can be kept at its maximum (4 ft.) the line delivers faster than this as is evidenced by the rapid filling of our reservoirs.

The Storage Reservoirs

We have two storage reservoirs. The west reservoir, put into operation eight years ago, holds 10 million gallons. The east, or old reservoir holds 15 million gallons. The two combined therefore hold enough water, when full, to supply the town for 80 days, if no further supply were obtained in the meantime. The water from Kipton enters the west reservoir through the "well" located at its north-west corner, the purpose of which is to permit closing and draining the end of the conduit. The high-level point in this reservoir is 4 feet above that of the old one, and consequently the water can flow from one to the other by gravity. The line connecting the two reservoirs passes through the dividing embankment near the south end, and is provided with a valve which permits the flow of water to be controlled. The water is usually allowed to flow directly from the one reservoir to the other but in time of freshet when it is very muddy it is first allowed to settle in the west reservoir. Connecting pipes in the vicinity of the pumping station are so arranged that water may be taken directly from the Kipton pipe-line, or from either of the reservoirs. Ordinarily it is taken from the old one.

The Softening Process

Before describing the softening process it may be of historical interest to note that the softening plant at Oberlin was the first municipal plant of its kind in the United States. It was first put into operation in 1903. Most cities filter their water, but softening is usually not attempted, even though it may be badly needed. Columbus has a plant like ours, which in 1914 was softening about 20 million gallons of water per day.

The hardness of our water as it comes from the river is caused mainly by the presence in it of the bicarbonates and sulphates of calcium and magnesium. All these substances possess the property of forming insoluble compounds with soap. When soap is added, therefore, a curdling or precipitation occurs, and no lather will be formed until all the calcium and magnesium are precipitated.

When hard water is boiled the calcium bicarbonate is changed to the normal carbonate (chalk), which happens to be nearly insoluble in water, and so precipitates out. This part of the hardness which is removed by boiling is called "temporary hardness". Calcium and magnesium sulphate and magnesium bicarbonate are not rendered insoluble by boiling, and therefore constitute what is termed "permanent hardness".

The hardness of water is stated in terms of the number of grams of calcium carbonate contained in one million grams of water. This is usually spoken of as "parts per million". It is recognized, of course, that the hardness does not occur entirely in the form of calcium carbonate, but this method of statement automatically translates the other forms (sulphate, bicarbonates, and magnesium salts) into the equivalent amount of this form, and has the advantage of uniformity and simplicity. The effect on soap is just the same as it would be if the hardness were all in this form.

The degree of hardness varies widely, depending on the weather conditions. When rain is abundant or snow is melting the hardness of the water runs as low as 180 parts per million. In a dry time the salts become more concentrated, and the hardness runs high. For example during the fall and early winter of 1922 the hardness has run as high as 570 parts per million. According to Professor F. F. Jewett's weather report the total precipitation for the months of August, September, October and November has been 5.47 inches, while the 30-year average for this same period is 10.57 inches. This is sufficient to account for the extreme hardness of the water.

In the softening process used here in Oberlin the aim is to convert the calcium and magnesium into the most insoluble forms and thus cause them to precipitate out. In the case of the calcium this insoluble form is the carbonate; for magnesium it is the hydroxide (the same form as is seen in the so-called "milk of magnesia"). The process of accomplishing this is slightly complicated but can be understood without any great knowledge of chemistry. It has been found that when calcium bicarbonate is brought in contact with an equivalent amount of calcium hydroxide (hydrated, or slaked, lime) the two forms unite completely to form the normal carbonate (chalk) which, being nearly insoluble, falls out as a precipitate. The magnesium salts (bicarbonate and sulphate) react with the calcium hydroxide, to form magnesium hydroxide, calcium carbonate, and calcium sulphate. The first two of these, being insoluble, precipitate out, leaving the calcium sulphate in solution with that which is already in the water. To remove the calcium sulphate sodium carbonate (soda ash) is added, which changes it to calcium carbonate and leaves in the water an equivalent amount of sodium sulphate (Glauber's salt) which does not make the water hard and does not have any other undesirable effect.

To sum up then: slaked lime is added to remove calcium bicarbonate and all the magnesium; soda ash is added to remove the calcium sulphate; and all the materials put in combine with all the materials in the water to form insoluble compounds, and these drop out as a precipitate — all except Glauber's salt.

We say all of the compounds formed drop out. This is not quite true, for the calcium carbonate is soluble in the water to the extent of about 50 parts per million and the magnesium hydroxide to the extent of bout 9 parts per million. Fifty-nine parts per million, therefore, represents the best we can do with the lime-soda softening process, and it is usually not advisable to attain quite this degree of softness because of the danger of introducing an excess of the lime and soda, which, of course, would be as objectionable as the original hardness.

We should also note in tnis connection that with the hardness prevailing in the raw water during the latter part of 1922 (over 500 parts per million) we have found it very difficult to make the treated water as soft as usual. Over this situation some of our good citizens have expressed themselves in no very complimentary terms, and have made it perfectly plain to the Board that problems like this are to be solved before they appear. It has been suggested that the reason for this partial failure of the process is the fact that the water in the storage reservoir is too low to run into the mixing trough with sufficient violence for complete mixing, but this cannot be true, since we use the same volume of water each day, no matter how low it is; and, moreover, it has even been found advantageous to overtreat a portion of the water and then mix this with untreated water.

It is understood, of course, that the process of softening must be constantly controlled by chemical tests in order that the amount of chemicals added shall not be too little or too great. These control tests are made by noting the degree of alkalinity of the water, and by determining directly the amount of calcium and magnesium salts left in solution. Further details can scarcely be given in this report, but we may say that alkalinity tests are made at the treating plant and in Dr. McIntosh's office every day, while the complete analysis is made at the latter place every two weeks. Complete analyses are also made at Severance Chemical Laboratory at frequent intervals by a member of the Board. This should be sufficient to show that the process is constantly under careful control.

The mechanical side of the softening process consists in the following: Inside the pumping station the soda ash is dissolved in water, and the lime mixed with water to form what is usually called "milk of lime". These chemicals are conducted to the west side of the settling basin back of the station, where they meet the water as it flows in from the reservoir. To secure perfect mixing with the chemicals the water thus treated flows through a baffled trough around the rim of the basin and enters the south section of the basin itself on the opposite side. From that point it flows slowly around a series of baffles, passes through an opening in the central dividing wall, and then around another series of baffles to the north end of the basin. At this point the water enters a conduit leading to the filters.

The completion of the reaction between the water and the added chemicals does not occur instantly by any means: it takes time, and this is particularly true in cold weather when all chemical action is delayed. Furthermore, the substances precipitated, being very finely divided, do not settle out at once, but tend to remain suspended for a considerable length of time. When the plant was constructed in 1903 our daily consumption of water was 165,000 gal. The total capacity of the basin is 660,000 gal., enough to allow four days' settling at that time. Our present consumption is 300,000 gal. Hence at present the water can settle only two days before entering the filters. For this reason neither the chemical reactions nor the settling have quite completed themselves before this happens. The filters remove the suspended matter, of course and they also allow time for slightly furthering the chemical reactions; but with present conditions there occurs a considerable amount of after-precipitation in the mains. This has caused trouble and will always cause trouble until provision is made for longer settling.

It should not be reasoned, however, that because our present time of settling is one-half the original time the reactions are only half completed. The reactions proceed rapidly at first, and much more slowly towards the end. Two days' settling gives a result about 95 per cent as good as four days'. According to some experiments which have been conducted along this line, the absolute completion of the reactions would require in cold weather perhaps six days. After this length of time there should be no after-precipitation and consequently no filling up of the mains.

The materials precipitated from the water accumulate at the bottom of the basin, and must be removed at rather frequent intervals. For this purpose a vent is provided leading to Plum creek. During high water the sludge is run out and thus carried away. It may be of interest to note that with the present degree of hardness in the raw water (over 500 parts per million) we are precipitating in the basin over a ton of materials per day.

The Filters

The filters are located in the large well-house directly east of the station. This well is 19 feet deep. Reaching across it about half way down is a false bottom, and upon this the filters rest. The filtering material consists of fine excelsior of poplar wood packed into four separate compartments or segments of the filter room. The water passes upward through the filters and then downward into the bottom of the well, whence it is pumped into the mains. The filters are washed at regular intervals by passing the water through them in the reverse direction, the construction permitting one to be washed while the others are in operation.

These filters were designed by A. E. Kimberly, formerly assistant engineer of the State Board of Health and correspond in principle to a similar set at Owensburg, Ky., which had been in successful operation for several years previous to our installation.

Filters of the excelsior type remove

solid particles from the water by a process of adsorption, not by a straining action. This means that the solid particles simply attach themselves to the projecting wood fibers. A filter of fine sand or paper strains out the particles. The filters originally installed in our plant were of the sand type. With them there was a marked tendency for the sand grains to become cemented together into solid blocks by the after-deposit from the water. Due to the same source the sand particles rapidly grew in size. Either of these effects made the filters less and less effective. Hence our change to the excelsior type. It is probably true that a sand filter at its best is superior to the excelsior filter, but in any case where after-precipitation occurs the sand filter is never at its best after the day of installation. It might be contended, of course, that it would be better to have the after-precipitation in the filters than in the mains, but the fact is that this occurs just as well with the excelsior filter, as with the sand filter, and neither type prevents the further deposition in the mains. This can be prevented, as noted above, only by using such a large settling basin that the reactions may be completed before the filters are reached

It should be noted in this connection that the tendency to form deposits in hot-water coils is not a result of the softening process at all. The raw water will do the same thing in a much more marked degree. The softened water is bound to do this because, as indicated above, the softening process cannot remove all the lime or magnesium salts. It is, of course, true however, that the more complete the softening is, the less the deposit will be. This deposit has the disgusting tendency of breaking loose at intervals and running out with the hot water, making it appear as if sand or gravel had gotten into the mains, which is an impossibility. We would like to suggest that the tendency to form these deposits in hot water coils may be largely avoided by connecting the cold end of the coil up somewhat above the bottom of the tank so as to prevent the sediment from being carried into the coil.

Chlorination and Bacterial Count

As noted above, a bacterial count is taken on both the raw and the treated water every day. The count on the raw water varies greatly, ranging from perhaps 100 to 800 per cubic centimeter. The count on the treated water as it comes from the filters averages about 5 per cubic centimeter, often showing none at all. Of the bacteria thus found scarcely any can ever be identified as harmful. This means simply that our treated water is perfectly safe so far as disease germs are concerned. This great reduction in the bacterial count comes as a by-product of the softening process. The bacteria are simply entangled in the precipitated matter and carried down to the bottom of the settling basin.

However, as a special precaution the State Board of Health ask us to chlorinate the water as it enters the mains. This is done by means of a chlorinating machine which feeds chlorine into the water at a definite and known rate. The amount used is about 1 pound for each 300,000 gal. Stated in the usual way, this amounts to about 0.3 parts per million.

It is interesting to note that the bacterial count is not lowered by this introduction of chlorine. For this reason the Board doubts seriously the advisability of using chlorine, but the State Board of Health insists that it be done. Another reason why we would prefer not to use chlorine is the freakish effect it has on the taste of the water. In spite of the fact that the rate of addition is practically uniform, as our records show, we sometimes have the effect of what seems to be an overdose. Although these times have been very infrequent and not even noticeable to all people, they have called forth some vigorous protests, which are no doubt well justified.

Station and Pumps

The original pumping plant consisted of two large steam units so arranged that the water could be run either into the stand pipe, or, in case of fire, directly into the mains. The stand pipe is of sufficient height (75 feet when full) to maintain a pressure of about 35 lbs. in the mains. These pumps had been in use for over 30 years and had, of course, become badly worn, allowing a good deal of slippage.

In 1921 one of these pumps was removed, and in its place was installed a motor driven centrifugal of modern type. This has a capacity of 600 gal. per minute under a pressure of 56 lb. The motor is of 50 horse power, and is run by current drawn from the line of the Cleveland & Southwestern Co. This unit now does all the work of pumping our water for daily consumption; although before the installation of the new main it was necessary during certain periods of the day to use the remaining steam pump in addition. It is kept running in the daytime except for short intervals when the consumption is low. During these intervals and in the night, standpipe pressure alone is used.

The second steam pump has been kept in commission to aid the centrifugal pump in case of fire, and to give higher pressure for domestic use when needed. This has necessitated keeping up steam at all times, which, of course, has meant considerable expense. Besides this the pump was badly in need of repairs, which the Board did not think it wise to make on such an old piece of machinery. Hence during the summer of 1922 another centrifugal, driven by a gasoline motor, has been installed.

The new engine is a Sterling, 6-cylinder, giving at 1200 revolutions per minute 180 horse power, and at 1750 revolutions 245 horse power. Every precaution has been taken to insure the starting of the engine when it is needed, and according to the experience of others who are using the same type, no trouble need be expected from this source. The attached pump is of the same type as the other centrifugal, only very much larger. At 1,350 revolutions per minute it delivers 1,500 gallons of water per minute under a pressure of 100 lbs., and at less than the full speed and power of the engine will give a pressure of 125 lbs., which is more than we care to apply to our mains and service pipes.

To insure a thorough knowledge of the construction and operation of the new engine our engineer, Mr. Schickler, went to the factory and saw the complete assembling of the parts.

It should be stated that our reason for installing a gasoline motor on the new pump was the danger involved in relying entirely on the electrical service, which might fail us in time of dire need.

It is the plan of the board to remove the second steam unit, although at present it is still connected with the main and can be used.

The pumping station and other property on the grounds are in fairly good repair. The baffles and mixing trough in the settling basin were repaired during the summer; also the inside of the station and the house adjoining were painted. The replacement of pumps inside the station has left the floor in a badly mutilated condition, but after the remaining steam pump is removed it is planned to put this in good repair Removal of the old steam boilers will give shop room for repair of meters, and possibly storage room for other apparatus.

Mains and Pressure

Due to the after-precipitation of lime from the softening process the mains in the vicinity of the pumping station have gradually become coated on the inside with a more or less soft deposit. This has so greatly reduced their carrying capacity as to endanger the safety of the town in case of a bad fire, particularly in the business section. To correct this two courses were available. One was to have the old mains cleaned out, which can be done; the other was to put in a new and larger main. Considering the smallness of the old mains (none larger than 8 inch, and some as small as 4 inch) the Board decided that adequate protection could be secured only by leaving the old mains all in, having them cleaned, of course, and adding a new main of larger size. Consequently, during the summer of 1922 a new main was put in, and is now in operation. This main is 10-inch, and so has a carrying capacity nearly 60 per cent greater than the largest of the old ones. Its course is down Cedar from the station to West College, and then east to Professor. It connects with the old mains at all the street intersections except Forest. The old mains have not yet been cleaned out, but this will be done as soon as the services of the company doing this work can be secured.

It is interesting to note that where the old mains were cut the deposit was mostly very soft and easily removed. Also the amount of the deposit grew rapidly less as the distance from the station increased. At the corner of Professor and West College, where the last cut was made, the deposit was not more than a quarter-inch thick It is appreciated, however, that even a deposit of this thickness cuts down the capacity of a 6-inch pipe by one-sixth—probably more than this, considering friction due to the roughness of the deposit. In the vicinity of the station the deposit is perhaps over half an inch thick. This is sufficient to cut down the capacity of an 8-inch main by about one-fourth.

The installation of the new main has had a marked effect on the pressure throughout the town. A test made by the fire department on Jan. 2, 1923, satisfied them and those who witnessed the test that the pressure is now adequate for safety to all sections of the town.

The Financial Situation

Several recommendations have been made in this report looking to further improvements in our water-works system, and the question will be asked: "Why are these improvements not made at once"? In reply we may say that before the installation of the new pump and the new main the Board already had on its hands a deficit of about $4000, due partly to other improvements already made and partly to extremely high prices paid for chemicals and other supplies during the war. The new pump and main were installed at a total cost of about $15000. The Board therefore feels that it must be somewhat conservative in making further improvements, so long as these are not of such a nature that their omission endangers the water-works property or the safety of the town.

THE OBERLIN WATER-WORKS BOARD

W. H. Chapin, Sec.

APPENDIX B

DAM SAFETY INSPECTION REPORT – SEPTEMBER 18, 2018

ODNR DAM SAFETY FACT SHEETS

DAM SAFETY INSPECTION REPORT

OBERLIN WATERWORKS UPGROUND NO. 1&2

FILE NUMBER: 1221-018

INSPECTED: SEPTEMBER 18, 2018

LORAIN COUNTY

CLASS II

2045 MORSE ROAD, BUILDING B-3
COLUMBUS, OHIO 43229-6693
WWW.DNR.STATE.OH.US

Dam Safety
Legal Obligations and Responsibilities in Ohio

In accordance with Ohio Revised Code (ORC) Section 1521.062, the owners of dams must monitor, maintain, and operate their dams safely. Negligence of owners in fulfilling these responsibilities can lead to the development of extremely hazardous conditions to exterior residents and properties. In the event of a dam failure, dam owners can be subject to liability claims and potential criminal charges.

The Chief of the Division of Water Resources has the responsibility to ensure that human life, health, and property are protected from the failure of dams. Conducting periodic safety inspections and working with dam owners to maintain and improve the overall condition of Ohio dams are vital aspects of achieving this purpose.

Representatives of the Chief conducted this inspection to evaluate the condition of the dam and its appurtenances under authority of Ohio Revised Code Section 1521.062. This inspection does not take the place of the owner's responsibility for performing dam inspections, nor does it provide any guarantee of the safety of the dam.

In accordance with Ohio Administrative Code (OAC) Rule 1501:21-21-03, the owners of dams must implement all remedial measures listed in the enclosed report.

Table of Contents

Required Remedial Measures

The requirements listed below are based on observations made during inspection, calculations performed, and requirements of the Ohio Administrative Code (OAC). A checklist noting all observations made during the inspection is included as an appendix of this report. References to right and left in this report are oriented as if you were standing on the dam crest, looking exterior.

Engineer Repairs and Investigations

The owner must retain the services of a registered professional engineer to address the following items. Plans, specifications, investigative reports, and other supporting documentation, as necessary, must be submitted to the Division of Water Resources for review and approval prior to construction. The owner must complete these items and implement all engineered plans for improvement within 5 years unless otherwise stated. A record of all repairs should be included in the operation, maintenance, and inspection manual. Please refer to the fact sheets included in the Dam Safety Fact Sheet Booklet for additional information.

1. In accordance with OAC Rule 1501:21-13-03 (D), every upground reservoir shall have an overflow or other device to preclude overfilling of the reservoir during normal filling operation. Prepare plans and specifications to install an overflow or other device. See Discussion Item #1 included in this section for additional information. **This item has been noted previously and the appropriate time period for completion has already been exceeded. The owner must complete this item immediately.**

2. The embankment crest alignment must be uniform. Perform a survey of the entire embankment and appurtenant structures, including existing and abandoned conduits and drains and, as necessary, prepare plans and specifications for the correction of any problems. The survey must include topographic contours of the entire embankment. Submit the completed survey to the Division. **This item has been noted previously and the appropriate time period for completion has already been exceeded. The owner must complete this item immediately.**

3. In accordance with OAC Rule 1501:21-13-07, the maximum operating pool must be lowered and/or a request for a freeboard variance with supporting justification must be submitted to the division. Additionally, the reservoir pool level must be monitored weekly until the pool is lowered below the maximum operating pool level. This item should be completed in coordination with Item #1 above. See Discussion Item #2 of this section for additional information.

4. The unused and abandoned piping must be removed or properly abandoned. Prepare plans and specifications for removal or abandonment. The condition of the unused and abandoned piping must be monitored quarterly until repairs can be made. See Discussion Item #4 included in this section for additional information.

5. Seepage from the dam must be controlled to prevent stability and maintenance problems. Investigate the sudden drop in pool level in Reservoir No. 2 and determine the cause. As necessary, prepare plans and specifications for the collection, control, and/or monitoring of the seepage. Until repairs can be made, the pool level must be monitored weekly. See the "Seepage Through Earthen Dams" fact sheet for additional information.

6. This dam must have a device to permit draining of the reservoir within a reasonable period of time in accordance with OAC Rule 1501:21-13-06. Prepare plans and specifications for the installation of such a device. An alternate plan may be considered in lieu of installing a lake drain device. However, the alternate plans must be detailed in an Operation, Maintenance, and Inspection manual for this dam. Contact the Division of Water Resources for further discussion.

7. This dam must have a dam failure inundation study and map included in an Emergency Action Plan (EAP) in accordance with OAC Rule 1501:21-21-04. A registered professional engineer must prepare the inundation map and Section IV (Emergency Detection, Evaluation, and Classification) of the EAP. It is recommended that your engineer contact the Division of Water Resources prior to undertaking the engineering study for the inundation map. The inundation study and supporting calculations, including computer modeling, must be submitted to the Division of Water Resources for review and approval. See the additional information in the Owner Dam Safety Program section of this report for additional information. See Discussion Item #5 included in this section for additional information.

OWNER REPAIRS AND MONITORING

The dam owner must address the items below as part of the required dam maintenance. The owner may perform the work or hire a contractor. Repair activities should be documented in the Operation, Maintenance, and Inspection Manual (OMI). Please refer to the fact sheets included in the Dam Safety Fact Sheet Booklet for additional information.

The monitoring items in this section must also be incorporated in the OMI. Information in the OMI must include inspection frequency, method of assessing the condition, and documentation of observations. See the Owner Dam Safety Program section of this report for additional information regarding an OMI.

Owner Repairs

1. Remove the trees and brush from the entire embankment. Seed all disturbed areas to establish a proper grass cover. See the "Trees and Brush" fact sheet for additional information.

2. Install a staff gauge to facilitate accurate monitoring of the pool level. Please note that the graduations should extend below the normal pool level to allow monitoring during drawdowns. See Discussion Item #3 included in this section for additional information.

3. Seed the bare areas on the embankment to establish a proper grass cover. See the "Ground Cover" fact sheet for additional information.

4. Repair the erosion on the crest and interior slopes. See the "Ground Cover" fact sheet for additional information.

5. Repair the rodent burrows on the entire embankment. See the "Rodent Control" fact sheet for additional information.

6. Repair the footpaths on the crest. See the "Ground Cover" fact sheet for additional information.

7. Remove the obstructions from the emergency overflow catch basin.

Monitoring Items

8. Monitor the wet area on the southern exterior toe monthly for any signs of increased flow, muddy flow, or instability on or adjacent to the embankment. See the "Seepage Through Earthen Dams" fact sheet for guidance in monitoring the wet area and for additional information. Please note that repairs may be needed if this problem worsens.

Resolving all Engineering Repair and Investigation items as well as Owner Repair items listed in the sections above makes a dam eligible to receive a 15% discount off the annual fee for the dam. The Engineering items must be resolved as directed in this report. The Owner Repair items may be resolved by submitting a description of the repairs and photographs. There are no partial discounts available.

Owner Dam Safety Program

Assuring the safety of dams is a cooperative effort between owners, consultants and the Division of Water Resources - Dam Safety Program, with the most important role being that of the owner. The owners see the dam regularly and through their surveillance and monitoring, can detect changing and/or deteriorating conditions.

The scope of a particular owner's dam safety program should be commensurate with the size, type, and complexity of the owner's dam(s). There is no "one size fits all" dam safety program. At a minimum, the owner's dam safety program must include:

- A person (owner or owner's designated representative) responsible for dam safety (Dam Safety Officer) with the authority to maintain dam safety (clear designation of responsibility, oversight, and authority).
- Access to sufficient technical resources and expertise.
- A proactive and informed owner inspection and engineering evaluation program.
- Adequate on-site presence and/or remote monitoring capability.
- An approved Operation, Maintenance, and Inspection Manual that is kept up-to-date, requirements and recommendations followed, and proper records kept.
- An approved Emergency Action Plan that is kept up-to-date and is well coordinated with the local emergency management agencies.

Operation, Maintenance, and Inspection Manual (OMI)

A dam, like any other infrastructure, will change and deteriorate over time. Appurtenances such as gates and valves must be routinely exercised to ensure their operability. Inspection and monitoring of the dam identifies changing conditions and problems as they develop, and maintenance prevents minor problems from developing into major ones. Dam owners must have these procedures documented in an OMI.

1. Oberlin Waterworks Upground No. 1&2 does not have an OMI on file. Prepare an OMI and submit for approval. Guidelines for the preparation of this document can be found online at: http://water.ohiodnr.gov/safety/dam-safety#ADD.

Emergency Action Plan (EAP)

Despite efforts to provide sufficient structural integrity and to perform inspection and maintenance, dams can develop problems that can lead to failure. Early detection and appropriate response are crucial for maintaining the safety of the dam and downstream people and property. The ORC requires the owner to fully and promptly notify the Division of Water Resources of any condition which threatens the safety of the structure. A rapidly changing condition may be an indication of a potentially dangerous problem. The Division of Water Resources - Dam Safety Program can be contacted at 614/265-6731 during business hours or at 614/799-9538 after business hours. Dam owners must have emergency preparedness procedures documented in an EAP. All contact names and phone numbers in the EAP must be verified on an annual basis. Any revisions to the EAP must be submitted to the Division of Water Resources and the local county Emergency Management Agency (EMA).

1. Oberlin Waterworks Upground No. 1&2 does not have an approved Emergency Action Plan (EAP). Prepare an EAP and submit for approval. A registered professional engineer must prepare a dam failure inundation map and Section IV (Emergency Detection, Evaluation, and Classification) of the EAP. Guidelines for the preparation of this document can be found online at: http://water.ohiodnr.gov/safety/dam-safety#ADD. The fillable EAP is not appropriate for Oberlin Waterworks Upground No. 1&2 because of its downstream hazard potential.

Having an approved OMI and EAP on file with Division of Water Resources makes a dam eligible to receive a 10% discount off the annual fee charged to the dam.

Discussion Items

1. The elevation of an overflow device must be no more than 0.5 foot above the actual maximum operating pool level of the reservoir. Both reservoirs must have an overflow device. There is reportedly a 6-inch transfer pipe with valve in the common embankment between the two reservoirs; however, the valve must be removed or permanently disabled in the open position to allow for Reservoir No. 2 to overflow into Reservoir No. 1. If a device other than an overflow (e.g., an auto-shutoff for the inflow pumps) is used to preclude overfilling of the reservoir then the device must prevent the reservoir from rising 0.5 foot above the actual maximum operating pool level. Please note that in accordance with OAC Rule 1501:21-13-07, Class II upground reservoirs must have at least 5 feet of freeboard above the actual maximum operating pool level. See the "Freeboard and Overflow Protection" section for additional information.

2. In accordance with OAC Rule 1501:21-13-07, the minimum elevation of the crest of a Class II upground reservoir shall be at least 5 feet higher than the elevation of the actual maximum operating pool level unless otherwise approved by the Chief. A written request for a variance from this rule may be made to the chief if adequate justification is provided. The minimum

freeboard allowed under this variance would be not less than 3 feet. See the "Freeboard and Overflow Protection" section for additional information.

3. A staff gauge helps the owner more accurately document pool levels during flood events and during routine inspections. It is very helpful to correlate seepage through drains to pool level. Please note that the graduations/numbers should extend beneath the lake level so that lowering of the pool (should it be needed or desired) can be monitored. It should be positioned to allow easy reading from a safe location. An example of a staff gauge is shown below.

4. The deterioration of an old or unused pipe can lead to structural collapse or seepage along the pipe. As a result, piping can occur. Piping is when soil particles are carried out of the dam with the seepage, leaving voids in the embankment. Piping will lead to failure of the dam. Unused or old piping should be removed or properly abandoned in place. Abandoning in place requires the entire pipe to be filled with concrete or grout. Both alternatives must be completed under the supervision of a registered professional engineer.

5. As part of this inspection, the classification of the dam was evaluated according to the mandates of OAC Rule 1501:21-13-01. Based on field observations, it appears that there is potential a higher classification of the dam. A detailed study of the downstream hazard must be conducted prior to preparing plans and specifications for the repair of the dam. A detailed analysis of the downstream hazard is also required as part of the EAP for this dam. If the detailed analysis shows that there is no threat of loss of life due to failure of the dam, then the classification of the dam may remain as is.

Representatives of the Chief of the Division of Water Resources conducted this inspection to evaluate the condition of the dam and its appurtenances. The owner(s) of the dam must implement all remedial measures listed in the report.

1/11/2019

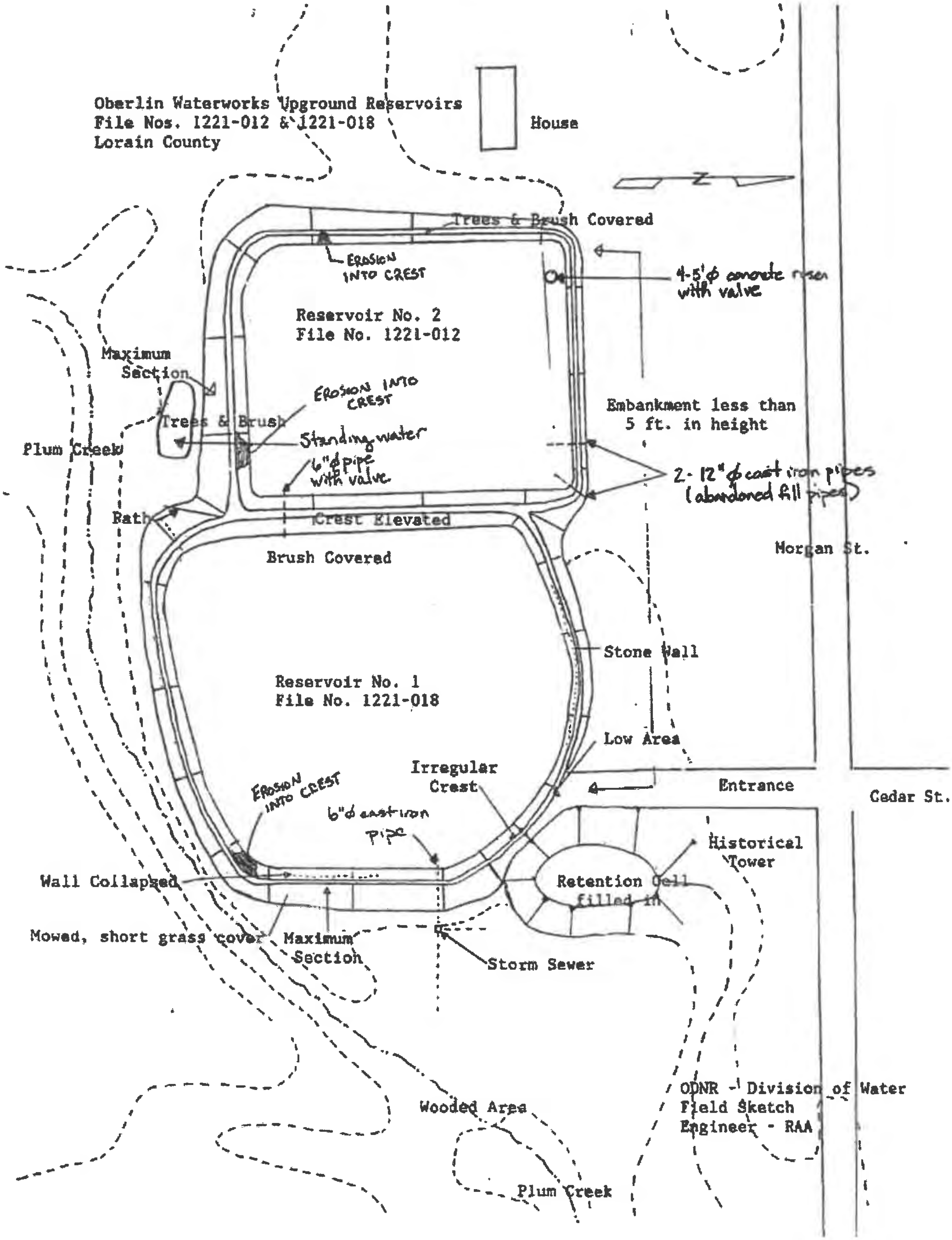
Keith Libben, P.E. Date
Project Manager
Dam Safety Program
Division of Water Resources

This inspection was performed pursuant to the authority granted to the Chief of the Division of Water Resources in ORC Section 1521.062.

1/11/19

Mia P. Kannik, P.E. Date
Program Manager
On behalf of Rodney J. Tornes, P.E.
Acting Chief
Division of Water Resources

SITE MAP


Oberlin Waterworks Upground Reservoirs
File Nos. 1221-012 & 1221-018
Lorain County
House
Trees & Brush Covered
EROSION INTO CREST
4-5'ϕ concrete riser with valve
Reservoir No. 2
File No. 1221-012
Maximum Section
EROSION INTO CREST
Trees & Brush
Standing water
6"ϕ pipe with valve
Embankment less than 5 ft. in height
2-12"ϕ cast iron pipes (abandoned fill pipes)
Plum Creek
Path
Crest Elevated
Brush Covered
Morgan St.
Stone Wall
Reservoir No. 1
File No. 1221-018
Low Area
Irregular Crest
EROSION INTO CREST
6"ϕ cast iron pipe
Entrance
Cedar St.
Historical Tower
Wall Collapsed
Retention Cell filled in
Mowed, short grass cover
Maximum Section
Storm Sewer
ODNR - Division of Water
Field Sketch
Engineer - RAA
Wooded Area
Plum Creek

PHOTOGRAPHS

	1. The east embankment along Reservoir No. 1.
	2. The north embankment along Reservoir No.1.
	3. One of multiple unused piping located within the embankment.

4. The old masonry riser in Reservoir No. 2.

5. Interior of the masonry riser.

6. Dense trees and brush covered the majority of the embankment.

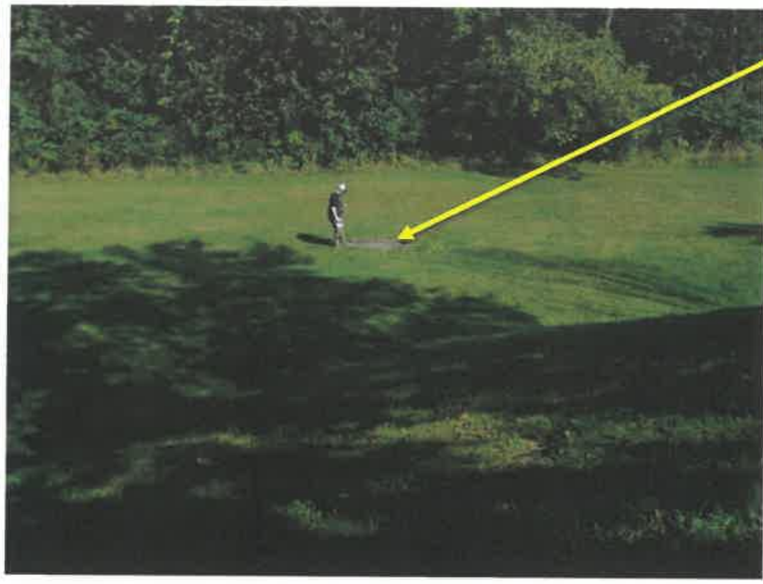
Notice the bare areas from the pedestrian footpath.

	7. Dense trees and brush obstructed visual inspection of the exterior slope.
	8. A concrete headwall was located along the southern exterior toe of Reservoir No. 2.
	9. The common embankment between the two reservoirs.

10. The embankment along Reservoir No. 1.

11. The east embankment along Reservoir No. 1.

12. The emergency overflow pipe located in Reservoir No. 1.

	13. The emergency overflow pipe catch basin located at the exterior toe of Reservoir No. 1.
	14. The interior of the catch basin in photograph no. 13. Notice the obstructions in the catch basin.

CLASSIFICATION

Oberlin Waterworks Upground No. 1&2

		Class
Height	11.5 ft	IV
Storage	60.6 ac-ft	III
Potential Downstream Hazard		II
	Final Class:	**II**

The classification of a dam is based on three factors:

- the dam's height,
- storage capacity, and
- potential downstream hazard.

HEIGHT AND STORAGE CRITERIA

Class	Height (ft)		Storage (ac-ft)
I	> 60		> 5000
II	> 40		> 500
III	> 25		> 50
IV	≤ 25		≤ 50
Exempt	< 10	and	< 50
Exempt	< 6	or	< 15

The height of the dam is the vertical distance from the top of dam (crest) elevation to the lowest point along the exterior toe. The storage capacity is the total volume of water that the dam can impound at the top of dam (crest) elevation. The potential downstream hazard consists of roads, buildings, homes, and other structures that would be damaged in the event of a dam failure. Potential for loss of life is also evaluated. Various dam failure scenarios must be considered, and they include failures when the dam is at normal pool level and failures during significant flood events. Each of the three factors is evaluated, and the final classification of the dam is based on the highest individual factor. Class I is the highest and Class IV is the lowest. The classification of a dam can change based on future development or other changes along the downstream channel or from changes made to the dam.

POTENTIAL DOWNSTREAM HAZARD

The following table shows the structures such as homes, businesses, roads, etc. that have been identified as part of the potential downstream hazard investigation. The letter in the table corresponds to the structure on the aerial photograph. The table is intended to establish or verify the appropriate classification in accordance with the OAC. It does not necessarily show all potential hazards or the full extent of inundation. Furthermore, in the event of dam failure, property owners in addition to those identified in the table should be made aware of the situation. This potential downstream hazard investigation is based on field observations, 2007 LiDAR data obtained from the Ohio Geographically Referenced Information Program, and aerial photography from Google.

Oberlin Waterworks Upground No. 1&2 Potential Downstream Hazard Classification

Hazard Class:	I	II					III		IV	—		Distance (ft)	
Potential Hazard	Probable loss of human life.	Loss of public water supply or wastewater treatment facility, release of health hazardous waste	Flooding of structure or high-value property	Damage to high-value or Class I, II, III dam or levee	Damage to major road (US or state route), disruption of only access to residential or critical facility area	Damage to railroad or public utility	Damage to rural building, not otherwise high-valued property, or Class IV dam or levee	Damage to local road (county and township)	Loss restricted mainly to the dam or agricultural, rural land	No hazard to structure noted	No hazard assessment; further investigation needed	Downstream - Dam to affected structure	Vertical - Streambed to base of affected structure
Morgan St.								A				1420	10
S. Professor St.								B				1600	12
Home			C									1850	8

Downstream Map

(See Next Page)


Legend
2-Foot Contour
10-Foot Contour
DOWNSTREAM HAZARD MAP
OBERLIN OLD UPGROUND RESERVOIR No. 1 & No. 2 DAM
File Number: 1221-018
DRAWN BY: DAN MURPHY
Date: 6/2/2014
NOTE: Contours as shown were determined from LiDAR data gathered in 2006 through the Ohio State Wide Imagery Program (OSIP)
0
300
600
Feet
N
E
S
W
A
B
C
S Main St
W Vine St
Morgan St
South St
S Professor St
Forest St
S Cedar St
S Prospect St

Freeboard and Overfilling Prevention for Upground Reservoirs

Unintentional misoperation/overfilling has caused reservoirs to fail throughout the nation and several incidents have occurred in Ohio. Three important factors for preventing overfilling are (1) establishing proper freeboard, (2) setting and monitoring the maximum operating pool, and (3) having an emergency overflow or pump shutoff.

Freeboard: OAC Rule 1501:21-13-07 requires that an upground reservoir have sufficient freeboard to prevent overtopping of the embankment crest. Freeboard is the elevation difference between the top of dam elevation and the maximum operating pool level. For Class II dams that are upground reservoirs, the minimum elevation of the embankment crest shall be at least 5 feet higher than the elevate on of the actual maximum operating pool level unless otherwise approved by the chief.

No reduction of freeboard has been granted for this upground reservoir. Therefore, the required freeboard for this Class II upground reservoir is 5 feet.

Maximum Operating Level: Although many reservoirs are designed to have fluctuating pool levels, there should be a designed maximum operating pool level that is established and not to be exceeded. During the inspection, the actual maximum operating pool level was determined from observations and discussion. The following table describes the reservoir operation based on information available to the division.

	Elevation in feet above msl
Top of Dam Elevation:	813.4
Ungated Overflow Elevation:	811.0
Designed Maximum Operating Pool Level:	Unknown
Actual Maximum Operating Pool Level:	811.0
Required Freeboard:	5 ft
Actual Operating Freeboard:	2.4 ft

The reservoir is not being operated with sufficient freeboard. The maximum operating pool must be lowered and/or a request for a freeboard variance must be submitted to the division with supporting justification.

Overflow/Pump Shutoff: In accordance with OAC Rule 1501:21-13-03, every upground reservoir shall have an overflow or other device to preclude overfilling the reservoir by more than ½ foot during normal filling operations.

Oberlin Waterworks Upground No. 1&2 has an emergency overflow at elevation 811.0 feet. The overflow consists of a 6-inch ungated pipe in the northeast corner of Reservoir No. 1. A 6-inch transfer pipe with a valve is reportedly located on the common embankment which would allow for overflow between the reservoirs; however, this pipe could not be located. This system is not acceptable for meeting this requirement.

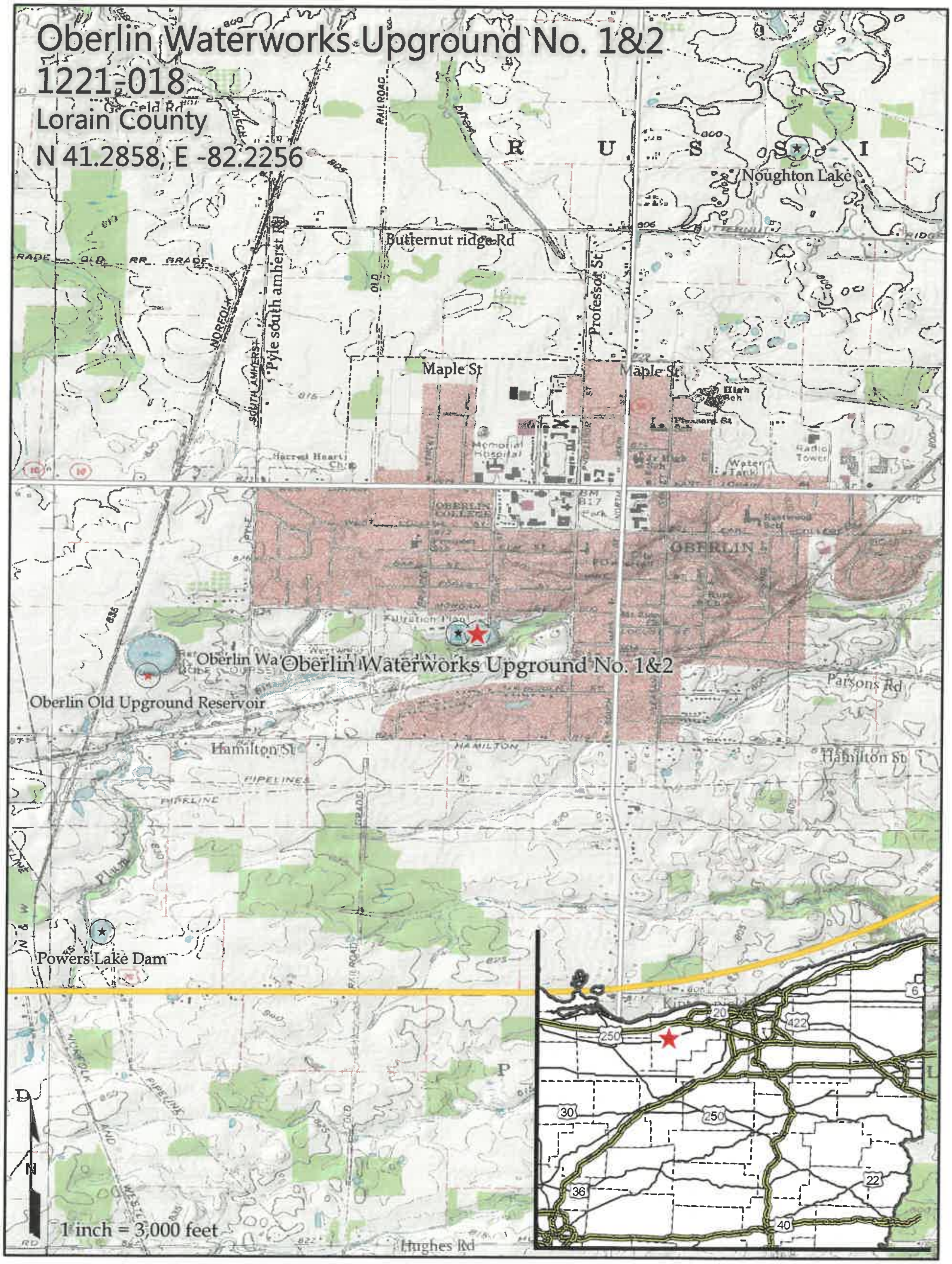
HISTORY

Oberlin Waterworks Upground No. 1&2

Unknown	Dam constructed.
July 24, 1985	Dam inventoried.
September 23, 1992	Dam safety inspection by the Division of Water Resources.
June 2, 2009	Dam safety inspection by the Division of Water Resources.
May 1, 2014	Dam safety inspection by the Division of Water Resources.
September 18, 2018	Dam safety inspection by the Division of Water Resources.

APPENDIX - LOCATION MAP, INVENTORY, INSPECTION CHECKLIST, OTHER AGENCIES

LOCATION MAP



Dam Inventory Sheet

Name: OBERLIN WATERWORKS UPGROUND NO. 1&2
File No: 1221-018
National #: OH01964
Reservoir:
Permit No.: N/A
Class (Ht-Vol): II (IV - III)

Owner Information

Owner: City of Oberlin
Owner Type: Public, Local
Address: Oberlin Water Treatment Plant
43885 Parsons Road
Multi-Dams: Yes: 3, Class I:1
Parcel No.:
City: Oberlin **State:** OH **Zip:** 44074
Contact: Bill Albrecht
Phone No.: 440/775-7290

Location Information

County: Lorain
Latitude Deg.: 41 **Min.:** 17 **Sec.:** 9
Township: Russia
Longitude Deg.: 82 **Min.:** 13 **Sec.:** 32
Stream: Plum Creek - Offstream
USGS Quad.: Oberlin
USGS Basin No.: 04110001

Design/Construction Information

Designed By:
Constructed By:
Completed: **Plan Available:** **At:**
Failure/Incident/Breach:

Structure Information

Purpose: Water Supply, Public
Type of Impound.: Upground
Type of Structure: Earthfill
Drainage Area (sq. miles): 0.01 **or (acres):** 7

Embankment Data

Length (ft): 2440
Upstream Slope: 2H:1V
Height (ft): 11.5
Downstream Slope: 3H:1V
Top Width (ft): 5
Volume of Fill (cub. yds.):

Spillway Outlet Works Data

Lake Drain: 10-IN-DIA CAST IRON PIPE AND PUMP STATION (INOPERABLE)
Principal: 6-IN-DIA WATER MAIN DISCHARGING TO STORM SEWER
Emergency: LOW NATURAL GROUND AT GRAVEL ACCESS RD & EMB INTERSECTION
Maximum Spillway Discharge (cfs): 1 **Design Flood:** 0.50 **Flood Capacity:** 0.5

Dam Reservoir Data	Elevation (ft-MSL)*	Area (acres)	Storage (acre-feet)
Top of Dam:	813.4	6.7	60.6
Emergency Spillway:	812.3	6.4	52
Principal Spillway:	811	6	43.5
Streambed:	803.2		
Foundation:			

*Elevations are not necessarily related to a USGS benchmark

Inspection Information

Inspection History:
9/18/2018 NTL
5/1/2014 DSM
6/2/2009 MPK
9/23/1992 RAA

Phase I:
Other Visits: 7/24/85 INV, 7/21/88 INV
Inspection Year: B

OBER

Operation Information/Remarks

CITY OF OBERLIN - OFFICE OF PUBLIC WORKS, 85 SOUTH MAIN STREET, OBERLIN, OH. PHONE (216)775-1531.

Emergency Action Plan: Not Approved **Format:** No Plan **OMI:** No
Last Entry: 10/9/2018

Dam Safety Inspection Checklist for Upground Reservoirs

Complete All Portions of This Section (Pre-inspection)

Name of Dam: Oberlin Waterworks Upground No. 1&2 Morgan st. — Lorain County

Date of Inspection: september 18, 2018

File Number: 1221-018

Class: II

Design Freeboard ($ELEV_{TOD}$-$ELEV_{NP}$): ? 2.4ft actual

Required Action	None	Mon.	Maint.	Eng.
Design Freeboard	☐	☐	☐	☒

Interview with Owner (at the site):

Owner/Representative present: (Yes, No) Name(s): John Doe, Bill Albrecht

Owner's Name(s): City of Oberlin

Address: Oberlin Water Treatment Plant, 43885 Parsons Road,

City: Oberlin State: OH Zip (+4): 44074

Contact Person: ~~Jerry Hade, Superintendent~~ Bill Albrecht Telephone: 440/775-7290 cell (440) 935-1744

Email Address:

Purpose of dam: Water Supply, Public

Owner's Dam Safety Program

Emergency Action Plan

EAP (document): Not Approved | No Plan Up-to-date? (yes, no) ☐ ☐ ☒ ☐

Exercised:

Downstream development: None

Security: None

Operation, Maintenance, and Inspection

OMI (document): No Up-to-date? (yes, no) ☐ ☐ ☒ ☐

Operation of drains/gates

All operable? (yes, no)

Norm./Emrg.drawdown: — Staff Gauge/Monitoring: None

Accessibility for operation: —

Ungated overflow or auto-shutoff? Lower cell has ungated overflow

How does reservoir operate (influ./efflu.): None

Maintenance

Frequency of mowing: None

Other maintenance: None

Inspection

Frequency and thoroughness of day-to-day and routine inspections: occasional visual

Frequency and thoroughness of event-driven inspections: none

Problems found during inspections: sudden drop in water level

Field Information

Freeboard (during inspection): varies Time: 3 (a.m. p.m.)

Site Conditions (temp., weather, ground moisture): 85°F, clear, dry

Inspection Party: Nathan Lieberum, Keith Libben, Melissa Monerey

Height: 11.5 feet (meas. / inv. o.k.) Norm. Pool Area: 6 Ac. (meas. / inv. o.k.)

Reservoirs no longer used for water supply. Water is not pumped into or out of the reservoirs. Parks dept. does the maintenance. There is a 6" diameter transfer pipe with valve between the two cells. There is a 6" cast-iron pipe in the NE corner of the east reservoir that is an emergency overflow. There are two abandoned 12" cast iron pipes in the NE corner of the west reservoir. There is also an abandoned riser and valve in the NW corner of the west reservoir (below the water	City Of Oberlin - Office Of Public Works, 85 South Main Street, Oberlin, Oh. Phone (216)775-1531.

Site Sketch

Interior Slope

☑ Gradient: 2H:1V

Typical Problems: wave erosion, trees & brush, surface erosion, ruts, rodent burrows, earth slides, cracks

	None	Monitor	Repair/Maint.	Engineer
Interior slope completely covered in trees and brush. Unable to fully inspect slope.			X	
Some erosion present			X	
Muskrat burrows observed			X	

Crest

☑ Width (ft): 5 ☑ Length (ft): 2440 ☑ Total Freeboard (ft): 2.40

Typical Problems: low areas, trees & brush, surface erosion, ruts, cracks

	None	Mon.	R./M.	Eng.
Crest varies in elevation				X
Bare soil footpath on much of the crest			X	

Exterior Slope

☑ Gradient: 3H:1V

Typical Problems: trees & brush, surface erosion, ruts, rodent burrows, earth slides, cracks, seepage

	None	Mon.	R./M.	Eng.
Trees and brush covering entire slope, unable to fully inspect			X	
Owners noted that the water level in the upper cell has dropped several feet. They suspect seepage. Given that seepage could not be located at the exterior toe, it is likely to be seeping through the common embankment with the lower cell.		X		X
Old headwall was located in the south exterior slope of the upper cell, unclear what the purpose or associated structure is. There are several unused pipes penetrating the embankment.				X

Required Action

Structures

Influent, Transfer, Effluent, Lake Drain

Typical Problems: Poor operating access, inoperable, deteriorated/missing components, outlet erosion/veg.

	None	Monitor	Rep./Maint.	Engineer
There is no operable influent or effluent lines, all unused lines penetrating the embankment should be properly abandoned.				X
6" Transfer pipe between upper and lower cells is reported to be operable. Valve should be left open and locked in that position as the only available overflow is in the lower cell.			X	X
No staff gauges			X	
No operable ~~obvious~~ lake drain				X

Overfilling Prevention

Emergency Overflow/Auto-shutoff

Typical Problems: Flowpath obstructed, material deterioration, erosion, too high, overgrown, undermining

	None	Mon.	R./M.	Eng.
6" overflow pipe in lower cell appeared in good condition, partially clogged at outlet in manhole.			X	X
Elevation of overflow is not in accordance with designed freeboard. A variance should be requested and/or the overflow altered.			X	X

Other

	None	Mon.	R./M.	Eng.

Failure Modes

	Assessed
Overfilling	
Sufficient info. has been gathered to evaluate design and operating freeboard.	✓
Sufficient info. has been gathered to evaluate design and performance of the emergency overflow or auto-shutoff.	✓
Seepage/Instability	
Sufficient info. has been gathered to evaluate the performance and monitoring of the internal drainage system.	✓

☑ All Field Data Gathered (inspector's initials): NTL | KRL

☑ Investigate Downstream Hazard

Agencies Associated with Dams and Lakes

The Division of Soil & Water Resources has the responsibility to ensure that human life, health, and property are protected from dam failures. The division provides fact sheets and dam safety information for dam owners on the division's web site: www.dnr.state.oh/water. Other governmental agencies are involved with the lakes and streams associated with dams, but have other responsibilities. Listed below are several relevant agencies that dam owners may be interested in contacting.

County Emergency Management Agency

County Emergency Management Agencies (EMAs) serve the public in disaster preparedness, public safety, and emergency management at the county level. County EMAs are responsible for coordinating relief efforts related to manmade and natural disasters. In the case of a dam emergency, the County EMA is one of the dam owner's first contacts.

Telephone: *440 329-5117*
State Web Site: http://ema.ohio.gov/index.aspx

Soil & Water Conservation District

County soil and water conservation districts (SWCDs) serve communities by providing assistance to urban and agricultural land users. SWCDs specialize in soil erosion prevention and water management. Some of services offered by county SWCD offices include survey and design of grassed waterways, erosion control structures, surface and subsurface drainage, farm ponds, and livestock waste management facilities. SWCDs also sponsor a number of information and education programs. In addition to these services, SWCDs may utilize assistance from the USDA Natural Resources Conservation Service (NRCS) for some technical matters.

http://www.dnr.state.oh.us/H_Nav2/OFFICESSWCDS/DistrictOffices/tabid/9093/Default.aspx
440-326-5800 - Telephone

Natural Resources Conservation Service

Since 1935, the Natural Resources Conservation Service (originally called the Soil Conservation Service) has provided leadership in a partnership effort to help America's private landowners and managers conserve their soil, water, and other natural resources. NRCS employees provide technical assistance based on sound science and suited to a customer's specific needs. NRCS provides financial assistance for many conservation activities.

Web Site: http://www.nrcs.usda.gov/

Division of Wildlife

The Division of Wildlife within the Ohio Department of Natural Resources manages fish and wildlife of the state. The division offers assistance in stream improvement and pollution investigations and provides fishery information and publications on pond stocking. Information regarding pest and rodent control can be obtained by visiting the division website or by contacting the regional office. The Division of Wildlife should be contacted before starting any construction activity where loss of aquatic life is anticipated.

330-644-2293 - District Office 3
http://ohiodnr.com/Home/ContactUs/tabid/18270/Default.aspx *- Web Site*

Ohio Environmental Protection Agency

The Ohio Environmental Protection Agency (EPA) establishes environmental guidance and enforcement standards for the state. In particular, the Division of Surface Water provides assistance for matters pertaining to rivers, lakes, and streams in Ohio. The Division of Surface Water can provide information and assistance in developing best management practices for the control of point and non-point pollution sources and spills. Suspected pollution spills can be reported directly by using the Ohio EPA Spill Hotline at 1-800-282-9378.

District Office Northeast: *330-963-1200*
State Web Site: http://www.epa.state.oh.us/

OSU Extension

The Ohio State University (OSU) Extension utilizes knowledge and research developed by the Ohio Agricultural Research and Development Center, Ohio State, and other land-grant universities to assist communities, businesses, and individuals. In addition to a wide variety of community leadership and agricultural services for all ages, county OSU Extension offices offer information and assistance in agricultural water resource conservation and management, farm pond management, and safety, Ohio hydrologic cycles and non-point source pollution management. Information regarding dry hydrant fire protection and legal liabilities associated with farm ponds in Ohio can be found on the extension website.

330-263-3831 *- Extension Region: North East*
http://extension.osu.edu/locate-an-office *- Web Site*

Division of Water Resources
Rodney J. Tornes, Acting Chief
2045 Morse Road/Building B-3
Columbus, Ohio 43229
614-265-6620
dswc@dnr.state.oh.us

January 11, 2019

City of Oberlin
Bill Albrecht
Oberlin Water Treatment Plant
43885 Parsons Road
Oberlin, OH 44074

RE: Oberlin Waterworks Upground No. 1&2 and Oberlin Upground Reservoir
File Number: 1221-018 and 1221-001
Lorain County

Dear Mr. Albrecht:

Thank you for allowing Keith Libben, Nathan Lieberum, and Melissa Menerey of the Division of Water Resources to conduct safety inspections of Oberlin Waterworks Upground No. 1&2, and Oberlin Upground Reservoir on September 18, 2018. These inspections were conducted by representatives of the Chief of the Division of Water Resources under the provisions of Ohio Revised Code Section (ORC) 1521.062 to evaluate the conditions of the dams and their appurtenances. The Chief has the responsibility to ensure that human life, health, and property are protected from dam failures. Conducting periodic safety inspections and working with dam owners to maintain and improve the overall condition of Ohio dams are vital aspects of achieving this purpose. A copy of the laws and administrative rules for dam safety is available on the division's web site or by request. I have enclosed guidelines for preparing an operation, maintenance, and inspection manual and guidelines for preparing an emergency action plan.

The enclosed inspection reports were generated based on available information and are hereby provided for your use and study. Listed in the reports are several repair, maintenance, and monitoring items that as a dam owner you are required by law to perform. Completion of these required items will improve the safety and overall conditions of the dams. The Chief must approve any plans for modifications or repairs to these dams. Modifying or repairing a dam includes, but is not limited to, installing or replacing a spillway pipe or a portion of a spillway, raising the embankment crest elevation, raising the normal pool level, and placement of fill and/or piping in an open channel spillway. Following approval of the engineered plans, all necessary repairs must be implemented by the owner under the supervision of a registered professional engineer.

Please be advised that you may qualify for a reduced-interest loan to make required repairs or develop an EAP through the Dam Safety Loan Program administered by the Ohio Water

Development Authority (OWDA). To find out about this program, please contact the OWDA at 614/466-5822.

It is the Division's understanding that you are the owner(s) of these dams. If you are not an owner of these dams, or believe that there are additional owners of the dams not addressed in this communication, please contact our office. Please note that ORC Section 1521.062 requires a dam owner to notify the Chief of the Division of Water Resources in writing of a change in ownership of a dam prior to the exchange of the property.

To gain information that will help improve the inspection program, a short survey has been developed and is enclosed. Please complete the survey and return it in the self-addressed envelope provided. Your feedback is important.

Your cooperation in improving the overall conditions of these dams is appreciated. Please contact Keith Libben at 614/265-6761 if you have any questions.

Sincerely,

Mia P. Kannik, P.E.
Program Manager
Dam Safety Program
Division of Water Resources

MPK:krl

cc: Rob Hillard, City Manager, City of Oberlin
Jeff Baumann, Public Works Director, City of Oberlin

Enclosures

Ohio Department of Natural Resources

Division of Water Resources

DAM SAFETY FACT SHEETS

Information for Dam Owners

Table of Contents

These fact sheets and more information are also available on our website:
http://water.ohiodnr.gov/safety/dam-safety

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 02–63

Remediation Alternatives

The Division of Water Resources, Dam Safety Program, has the statutory responsibility to ensure that human life, health, and property are protected from dam failures. The program regulates dams meeting certain height and storage criteria based on the provisions of the Ohio Revised Code (ORC) and Ohio Administrative Code (OAC). These criteria are listed in the ORC and OAC and in the Division of Water Resources's Construction Permit and Dam Classification fact sheets. For all dams meeting these criteria, the program regulates their construction, operation, and repair to ensure that dams meet the required safety standards set forth in the ORC and OAC.

When the program finds that a dam has been constructed without a permit or that an existing dam does not meet the required safety standards, the Division of Water Resources directs the owner to bring the dam into compliance. For a dam built without a construction permit, the owner would receive a letter that directs the owner to obtain a construction permit by following the construction permit requirements listed in the OAC and ORC. For an existing dam, the owner would receive a dam safety inspection report that lists required remedial measures. The owner must accomplish all of these required remedial measures. As alternatives to obtaining a construction permit or to accomplishing the required remedial measures listed in the inspection report, the owner may (a) remove the dam, (b) breach the dam, (c) modify the height of the dam to make it exempt from all or a portion of the construction permit and periodic inspection requirements, or (d) modify the purpose of the structure so that it does not meet the definition of a dam. Additional information about each of these alternatives is listed below.

Remove the Dam

Description: Dam removal consists of complete removal of the dam embankment to restore the original relief of the site. Removing the dam alleviates the need to obtain a construction permit or to accomplish the required remedial measures listed in the inspection report.

Requirements: The following items must be prepared by a registered professional engineer and submitted to the Division of Water Resources for review and approval: a plan for lowering the lake level, construction plans and specifications for removing the embankment, plans and specifications for controlling sediment in the impoundment, a description of erosion protection in the breach and dam embankment foundation areas, and a construction schedule. Other items may be required in certain circumstances. It is the responsibility of the owner to hire a qualified registered professional engineer.

Breach the Dam

Description: A breach is defined as an opening in a dam that prevents the dam from impounding a significant amount of water (see photograph). A breach extends from the upstream side of the embankment to the downstream side and typically has mild side slopes. A dam breach could be considered partial removal of a dam. Breaching the dam alleviates the need to obtain a construction permit or to address the required remedial measures listed in the inspection report.

Photograph of dam breach from downstream. White line shows former dam crest.

Requirements: The following items must be prepared by a registered professional engineer and submitted to the Division of Water Resources for review and approval: a plan for lowering the lake level, construction plans and specifications for constructing the breach, plans and specifications for controlling sediment in the impoundment, calculations or justification for sizing the breach, a description of erosion protection in the breach area, and a schedule for construction. Other items may be required in certain circumstances. It is the responsibility of the owner to hire a qualified registered professional engineer.

Modify the Height of the Dam

Description: Reducing the height of a dam reduces the dam's storage volume. This can make the dam exempt from the construction permit and periodic inspection requirements of the ORC or change the classification of the structure. Refer to the ORC for a complete description of the height and storage volume criteria. In summary, a dam is exempt from the construction permit and periodic inspection requirements when (a) it is not more than 6 feet high, or (b) it has not more than l5 acre-feet of storage volume at the top of dam elevation, or (c) it is not more than 10 feet high and has not more than 50 acre-feet of storage volume at the top of dam elevation. For reference, a dam that is 15 feet high and impounds a 2.5-acre lake has a storage volume of about 15 acre-feet. Modifying the dam to meet the above criteria alleviates the need to obtain a construction permit or to accomplish the required remedial measures listed in the inspection report.

The classification of a dam is based on three factors: the dam's height, storage capacity, and potential downstream hazard. Each factor is evaluated, and the final classification of the dam is based on the highest individual factor (Class I being the highest and Class IV being the lowest). When the classification based on downstream hazard is lower than the classification based on height and storage capacity, it is possible for the final classification of the dam to be changed if the height of the dam is reduced. In addition, reducing the height of a dam could change the potential impact of a dam failure on the downstream area, and thereby change the hazard classification. Changing the classification could alleviate the need to accomplish some or all of the required remedial measures listed in the inspection report. It should also be noted that Class IV dams do not require a construction permit; however, they do require submittal of the preliminary design report to the Division of Water Resources for approval.

Requirements: The following items must be prepared by a registered professional engineer and submitted to the Division of Water Resources for review and approval: a plan for lowering the lake level, detailed storage volume calculations, construction plans and specifications for lowering the dam crest, and supporting justification and calculations showing that the modified dam will operate safely. Other items such as a dam failure analysis may be required in certain circumstances. It is the responsibility of the owner to hire a qualified registered professional engineer.

Modify the Purpose of the Structure

Description: In accordance with OAC Rule 1501:21-3-01, the definition of a dam is "any artificial barrier together with any appurtenant works, which either does or may impound water or other liquefied material…A fill or structure intended solely for highway or railroad use that does not permanently impound water or other liquefied material as determined by the Chief is not considered a dam." It is possible to modify the dam so that it no longer meets the definition above. For example, draining the lake and installing a culvert at the streambed elevation or modifying the existing spillway to be a culvert may be acceptable. This alleviates the need to obtain a construction permit or to address the required remedial measures listed in the inspection report.

Requirements: The following items must be prepared by a registered professional engineer and submitted to the Division of Water Resources for review and approval: a plan for lowering the lake level, construction plans and specifications for the modification, plans and specifications for controlling sediment in the impoundment, calculations or justification for design, and a schedule for construction. Other items may be required in certain circumstances. It is the responsibility of the owner to hire a qualified registered professional engineer.

As a temporary measure, the lake level of a dam may be lowered and maintained at a lower level. A lower lake level makes the dam safer by reducing water pressure on the dam and its foundation, reducing the volume of water that would be released during a failure, and providing more flood storage capacity. Maintaining the lake at a lower lake level could allow for a less stringent time schedule for obtaining a construction permit, accomplishing required remedial measures, or modifying the size of the dam.

Other local, state, and federal approval may be required for the construction activities listed above. It is recommended that the owner contact the Ohio Environmental Protection Agency, Division of Surface Water - 401 Certification at (614) 644-2001, the local floodplain administrator, and the U.S. Army Corps of Engineers district office.

For additional information please contact:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Fact Sheet 96–39

Dam Safety: Annual Fee

Catastrophic dam failures have cost thousands of lives and millions of dollars in property damage throughout the United States. The Ohio state government established the dam safety program to protect lives, health and property from damages due to catastrophic dam failures. The program provides this protection by requiring review and approval for the design and construction of new and repaired dams, inspecting existing dams, and responding to dam safety emergencies. In Ohio, the Ohio Department of Natural Resources, Division of Water Resources has the responsibility to regulate dam safety.

The dam safety program benefits both the owners of dams and residents in downstream areas. Owners receive periodic safety inspections of their dams, technical assistance during emergency situations, information on maintenance and operational procedures, and references for the preparation of emergency action plans. Downstream residents receive additional protection from catastrophic failure of the upstream dam.

The Ohio General Assembly established the dam safety program in 1963, and until 1987, all funding for the program came from the General Revenue Fund. In 1987, the General Assembly placed a share of the cost of the program on the owners of dams and they created the dam safety annual fee. Funds collected from the annual fee are placed in a dam safety fund and are used to fund a portion of the staffing, operational and equipment expenses of the dam safety program. By law, the fees collected can only be used for these purposes.

Owners of class I, II and III dams must pay an annual fee. Section 1501:21-13-01 of the Ohio Administrative Code and Section 1521.062 of the Ohio Revised Code explain of how dams are classified. Division of Water Resources Fact Sheet 94-29, Classification of Structures also offers an explanation of the classification system in an easy-to- read format. The amount of the fee for each dam is based on its height, length, total storage volume, and classification. As stated in Section 1501:21-24-01 of the Ohio Administrative Code, the annual fee shall be as follows:

(1) For any dam classified as a class I dam under rules adopted by the Chief of the Division of Water Resources under section 1521.06 of the Revised Code, three hundred dollars plus ten dollars per foot of height of dam, eight cents per foot of length of the dam and eight cents per-acre foot of water impounded by the dam;

(2) For any dam classified as a class II dam under those rules, ninety dollars plus six dollars per foot of height of dam, eight cents per foot of length of the dam and eight cents per-acre foot of water impounded by the dam;

(3) For any dam classified as a class III dam under those rules, ninety dollars plus four dollars per foot of height of the dam, eight cents per foot of length of the dam, and eight cents per-acre foot of volume of water impounded by the dam.

The height of a dam is the vertical height, to the nearest foot, as determined by the division under section 1521.062 of the Revised Code. The total storage volume impounded by the dam is the total volume of water or other liquefied material impounded when the pool level is at the top of the dam immediately before it is overtopped, to the nearest acre-foot with a maximum of seven thousand acre-feet, as determined by the division.

Under the compliant dam discount program, the Chief may reduce the amount of the annual fee that an owner of a dam is required to pay if the owner is in compliance with section 1521.062 of the Revised Code and has developed an emergency action plan pursuant to standards established in rules adopted under this section. The Chief shall not discount an annual fee by more than twenty-five per cent of the total annual fee that is due. In addition, the Chief shall not discount the annual fee that is due from the owner of a dam who has been assessed a penalty under this section.

The Division of Water Resources mails the annual fee invoices each year in May. Payment is due on or before June 30, and there is a 60 day grace period. The penalty for late payment is 10 percent of the fee plus interest at the rate of 0.5% per month from the due date until the date of payment. Delinquent fees are referred to the Attorney General for collection.

Sample Calculation:

class I dam

height = 32 feet
length = 500 feet
total storage volume = 1000 ac-ft

annual fee = $300.00 + ($10.00/ ft)(32 ft) + ($0.08 ft)(500 ft) + ($0.08/ac-ft)(1000 ac-ft)

= $300.00 + $320 + $25 + $50

= $695.00

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources

Division of Water Resources

Fact Sheet

Fact Sheet 94–29

Dam Safety : Classification of Structures

Classification of dams is defined in the Ohio Administrative Code (OAC), Section 1501:21-13-01. Dams which are exempt from the Ohio Department of Natural Resources, Division of Soil and Water Resources jurisdiction are defined in Ohio Revised Code, Section 1521.06. The classification system divides dams which are under the jurisdiction of the Division into four classes, Class I, II, III, and IV. The chief of the Division determines the class of a dam during the preliminary design review for a new structure (OAC Rule 1501:21-5-02) and/or during the periodic inspection of existing structures (OAC Rule 1501:21-21-01). Classification of dams is necessary to provide proper design criteria and to ensure adequate safety factors for dams according to the potential for downstream damage should the dam fail. Please note that the classification is not an indication of the condition of a dam.

The classification system for dams in Ohio was modeled after the Federal Guidelines for Dam Safety established in 1979. The following parameters are the governing criteria for the classification: (See illustration on back)

1. Height of dam - defined as the vertical dimension as measured from the natural streambed at the downstream toe of a dam to the elevation of the top of the dam.

2. Storage volume - defined as the total volume impounded when the pool level is at the top of the dam immediately before it is overtopped.

3. Potential downstream hazard - defined as the resultant downstream damage should the dam fail, including probable future development.

The classification criteria are outlined in OAC Rule 1501:21-13-01 and summarized in the following list:

Height of Dam

Class I	—	greater than 60 feet
Class II	—	greater than 40 feet
Class III	—	greater than 25 feet
Class IV	—	less than or equal to 25 feet

Storage Volume

Class I	—	greater than 5000 acre-feet
Class II	—	greater than 500 acre-feet
Class III	—	greater than 50 acre-feet
Class IV	—	less than or equal to 50 acre-feet

(1 Acre foot equals about 326,000 gallons)

Potential Downstream Hazard

Class I — probable loss of life.

Class II — health hazard, flood water damage to homes, businesses, industrial structures (no loss of life envisioned), damage to state and interstate highways, loss of public utilities, railroads, downstream dams, only access to residential areas.

Class III — damage to low value non-residential structures, local roads, agricultural crops and livestock

Class IV — losses restricted mainly to the dam

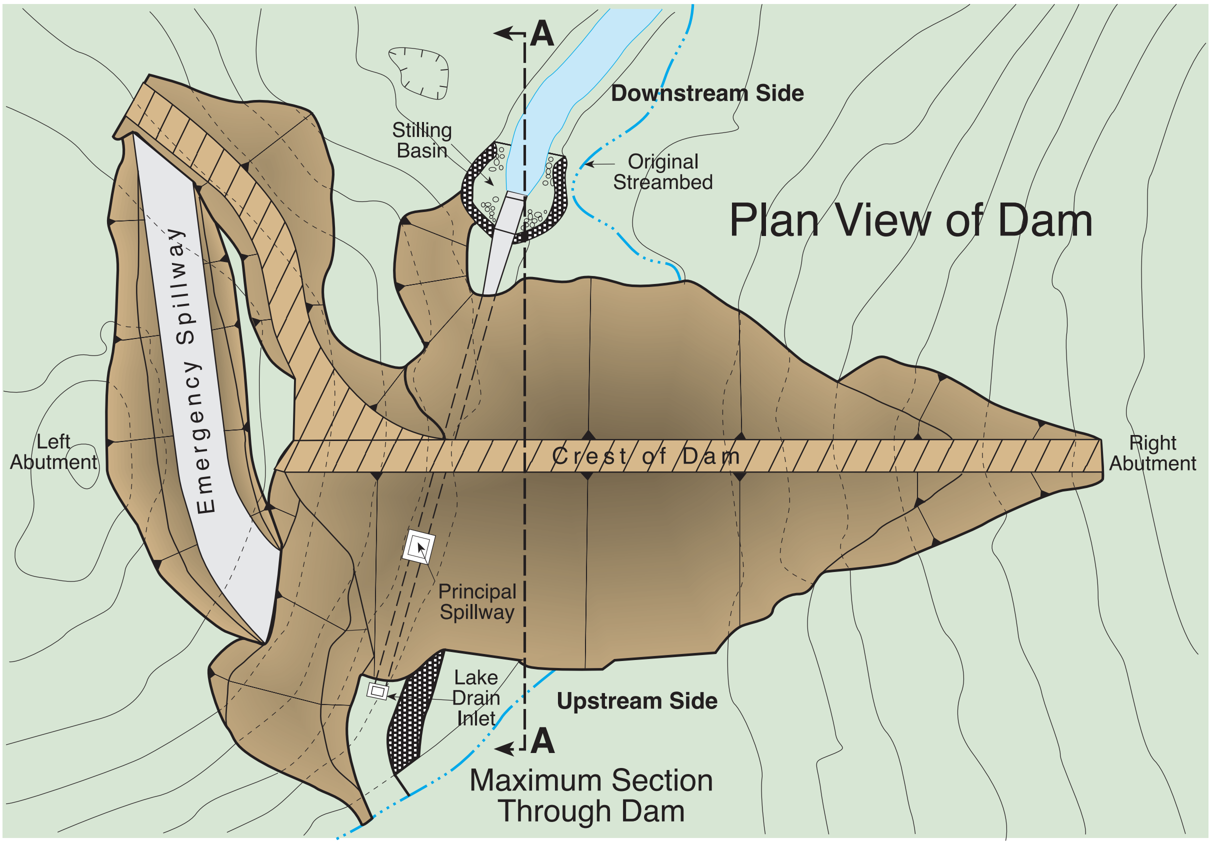
Each dam is evaluated on the preceding criteria and placed in the highest class that any one of these criteria might meet. The Division, in accordance with the ORC Section 1521.062 and OAC Rule 1501:21-13-01 (C), has the right to reclassify any dam as a result of a change in circumstances not in existence at the time of the initial classification.

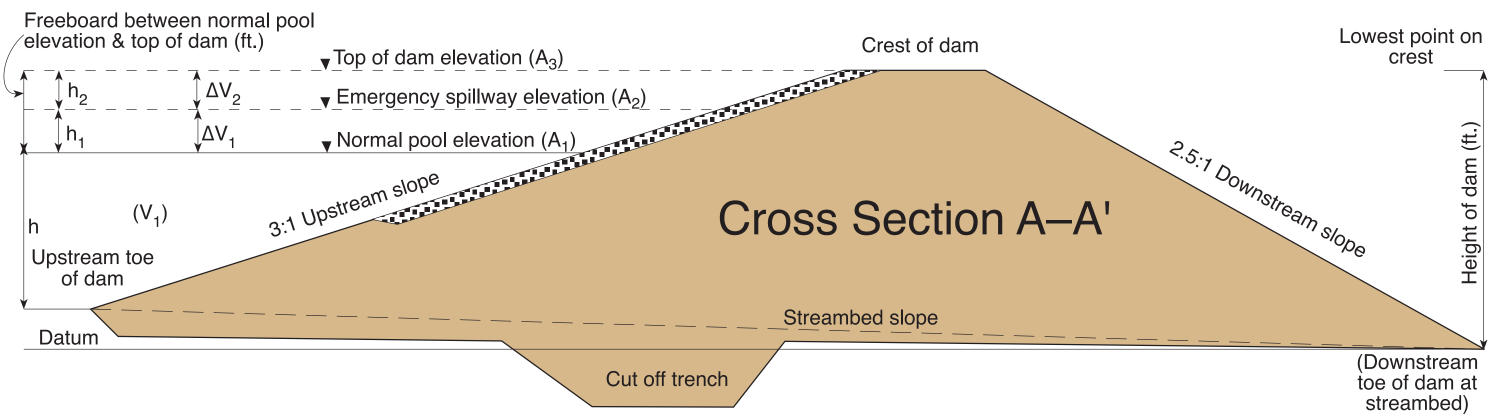
A dam is exempt from the state's authority under ORC Section 1521.062 if it is 6 feet or less in height regardless of total storage; less than 10 feet in height with not more than 50 acre-feet of total storage, or not more than 15 acre-feet of total storage regardless of height.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538





$$V_{TOD} = V_1 + \Delta V_1 + \Delta V_2$$

V_{TOD} = Storage volume of lake pool when at top of dam

V_1 = Storage volume at normal pool elevation: $\frac{h}{3} A_1$

ΔV_1 = Incremental volume between normal pool and emergency spillway elevation: $\frac{h_1}{3}(A_1 + A_2 + \sqrt{A_1 A_2})$

ΔV_2 = Incremental volume between emergency spillway and top of dam elevation: $\frac{h_2}{3}(A_2 + A_3 + \sqrt{A_2 A_3})$

A_1 = Lake surface area at normal pool elevation

A_2 = Lake surface area at emergency spillway elevation

A_3 = Lake surface area at top of dam elevation

Fact Sheet 94–30

Dam Safety: Earth Dam Failures

Owners of dams and operating and maintenance personnel must be knowledgeable of the potential problems which can lead to failure of a dam. These people regularly view the structure and, therefore, need to be able to recognize potential problems so that failure can be avoided. If a problem is noted early enough, an engineer experienced in dam design, construction, and inspection can be contacted to recommend corrective measures, and such measures can be implemented.

IF THERE IS ANY QUESTION AS TO THE SERIOUSNESS OF AN OBSERVATION, AN ENGINEER EXPERIENCED WITH DAMS SHOULD BE CONTACTED.

Acting promptly may avoid possible dam failure and the resulting catastrophic effect on downstream areas. Engineers from the Division of Water Resources, Dam Safety Program of the Department of Natural Resources are available at any time to inspect a dam if a serious problem is detected or if failure may be imminent. Contact the division at the following address and telephone number:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Since only superficial inspections of a dam can usually be made, it is imperative that owners and maintenance personnel be aware of the prominent types of failure and their telltale signs. Earth dam failures can be grouped into three general categories: overtopping failures, seepage failures, and structural failures. A brief discussion of each type follows.

Overtopping Failures

Overtopping failures result from the erosive action of water on the embankment. Erosion is due to uncontrolled flow of water over, around, and adjacent to the dam. Earth embankments are not designed to be overtopped and therefore are particularly susceptible to erosion. Once erosion has begun during overtopping, it is almost impossible to stop. A well vegetated earth embankment may withstand limited overtopping if its crest is level and water flows over the crest and down the face as an evenly distributed sheet without becoming concentrated. **The owner should closely monitor the reservoir pool level during severe storms. If the dam is close to overtopping or is overtopping, the Division of Water Resources, Dam Safety Program must be contacted immediately. The owner should also initiate the Emergency Action Plan for the dam.**

Seepage Failures

All earth dams have seepage resulting from water permeating slowly through the dam and its foundation. Seepage must be controlled in both velocity and quantity. If uncontrolled, it can progressively erode soil from the embankment or its foundation, resulting in rapid failure of the dam. Erosion of the soil begins at the downstream side of the embankment, either in the dam proper or the foundation, progressively works toward the reservoir, and eventually develops a direct connection to the reservoir. This phenomenon is known as "piping." Piping action can be recognized by an increased seepage flow rate, the discharge of muddy or discolored water, sinkholes on or near the embankment, or a whirlpool in the reservoir. Once a whirlpool (eddy) is observed on the reservoir surface, complete failure of the dam will probably follow in a matter of minutes. As with overtopping, fully developed piping is virtually impossible to control and will likely cause failure.

Seepage can cause slope failure by creating high pressures in the soil pores or by saturating the slope. The pressure of seepage within an embankment is difficult to determine without proper instrumentation. A slope which becomes saturated and develops slides may be showing signs of excessive seepage pressure.

Structural Failures

Structural failures can occur in either the embankment or the appurtenances. Structural failure of a spillway, lake drain, or other appurtenance may lead to failure of the embankment. Cracking, settlement, and slides are the more common signs of structural failure of embankments. Large cracks in either an appurtenance or the embankment, major settlement, and major slides will require emergency measures to ensure safety, especially if these problems occur suddenly.

Conclusions

If these types of failure situations occurs, the lake level should be lowered, the appropriate state and local authorities notified, and professional advice sought. **If the observer is uncertain as to the seriousness of the problem, the Division of Water Resources should be contacted immediately.**

The three types of failure previously described are often interrelated in a complex manner. For example, uncontrolled seepage may weaken the soil and lead to a structural failure. A structural failure may shorten the seepage path and lead to a piping failure. Surface erosion may result in structural failure.

Minor defects such as cracks in the embankment may be the first visual sign of a major problem which could lead to failure of the structure. The seriousness of all deficiencies should be evaluated by someone experienced in dam design and construction. A qualified professional engineer can recommend appropriate permanent remedial measures.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–53

Dam Safety: Embankment Instabilities

The dam embankment and any appurtenant dikes must safely contain the reservoir during normal and flood conditions. Cracks, slides, and depressions are signs of embankment instability and should indicate to the owner that maintenance or repair work ma y be required. When one of these conditions is detected, the owner must retain an experienced professional engineer to determine the cause of the instability. A rapidly changing condition or the sudden development of a large crack, slide, or depression indicates a very serious problem, and the Dam Safety Program should be contacted immediately. A professional engineer must investigate these types of embankment stability problems because a so-called "home remedy" may cause greater and more serious damage to the embankment and eventually result in unneeded expenditures for unsuccessful repairs.

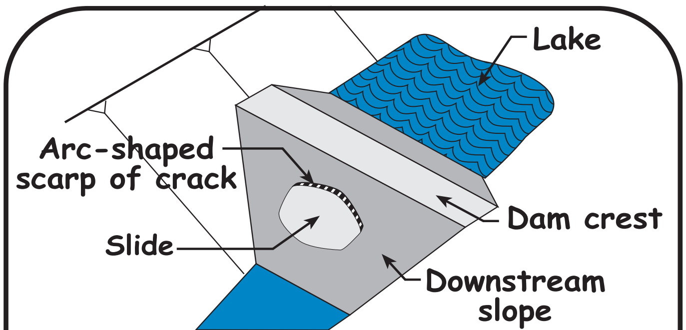
Cracks

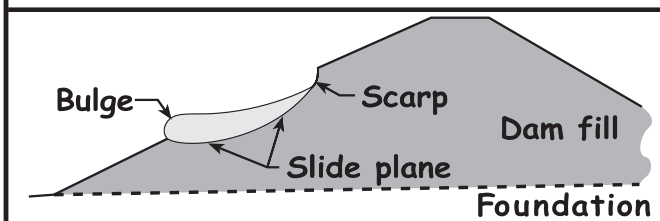
Short, isolated cracks are commonly due to drying and shrinkage of the embankment surface and are not usually significant. They are usually less than 1 inch wide, propagate in various directions, and occur especially where the embankment lacks a healthy grass cover. Larger (wider than 1 inch), well-defined cracks may indicate a more serious problem. There are generally two types of these cracks: longitudinal and transverse. Longitudinal cracks extend parallel to the crest of the embankment and may indicate the early stages of a slide on either the upstream or downstream slope of the embankment. They can create problems by allowing runoff to enter the cracks and saturate the embankment which in turn can cause instability of the embankment. Transverse cracks extend perpendicular to the crest and can indicate differential settlement within the embankment. Such cracks provide avenues for seepage through the dam and could quickly lead to piping, a severe seepage problem that will likely cause the dam to fail.

If the owner finds small cracks during inspection of the dam, he/she should document the observations, and seal the cracks to prevent runoff from saturating the embankment. The documentation should consist of detailed notes (including the location, length, approximate elevation, and crack width), photographs, sketches, and possibly monitoring stakes. The crack must then be monitored during future inspections. If the crack becomes longer or wider, a more serious problem such as a slide may be developing. Large cracks indicate serious stability problems. If one is detected, the owner should contact the Dam Safety Program and/or retain an engineer to investigate the crack and prepare plans and specifications for repairs. When muddy flow discharges from a crack, the dam may be close to failure. The emergency action plan should be initiated immediately and the Dam Safety Program contacted.

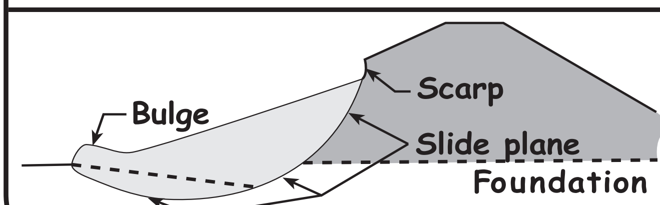
Slides

A slide in an embankment or in natural soil or rock is a mass movement of material. Some typical characteristics of a slide are an arc-shaped crack or scarp along the top and a bulge along the bottom of the slide (see drawing). Slides may develop because of poor soil compaction, the gradient of the slope being too steep for the embankment material, seepage, sudden drawdown of the lake level, undercutting of the embankment toe, or saturation and weakening of the embankment or foundation.





Shallow Slide Cross Section



Deep-seated Slide Cross Section

Slides can be divided into two main groups: shallow and deep-seated. Shallow slides generally affect the top 2 to 3 feet of the embankment surface. Shallow slides are generally not threatening to the immediate safety of the dam and often result from wave erosion, collapsed rodent burrows, or saturated top soil. Deep-seated slides are serious, immediate threats to the safety of a dam. They can extend several feet below the surface of the embankment, even below the foundation. A massive slide can initiate the catastrophic failure of a dam. Deep-seated slides are the result of serious problems within the embankment.

Small slides can be repaired by removing the vegetation and any unsuitable fill from the area, compacting suitable fill and adding topsoil to make the embankment uniform, and establishing a healthy grass cover. If a shallow or deep-seated slide is discovered, the Dam Safety Program should be contacted and an engineer retained to investigate the slide. Plans and specifications may need to be prepared for its repair depending on the findings of the investigation.

Depressions

Depressions are sunken areas of the abutment, toe area, or embankment surface. They may be created during construction, or may be caused by decay of buried organic materials, thawing of frozen embankment material, internal erosion of the embankment, or settlement (consolidation) of the embankment or its foundation. To a certain degree, minor depressions are common and do not necessarily indicate a serious problem. (An embankment with several minor depressions may be described as hummocky.) However, larger depressions may indicate serious problems such as weak foundation materials, poor compaction of the embankment during construction, or internal erosion of the embankment fill.

Depressions can create low areas along the crest, cracks through the embankment, structural damage to spillways or other appurtenant structures, damage to internal drainage systems, or general instability of the embankment. They can also inhibit maintenance of the dam and make detection of stability or seepage problems difficult.

The owner should monitor depressions during the regular inspection of the dam. All observations should be documented with detailed notes, photographs, and sketches. Minor depressions can be repaired by removing the vegetation and any unsuitable fill from the area, adding fill and then topsoil to make the embankment uniform, and finally establishing a healthy grass cover. An engineer should be retained to investigate large depressions or settlement areas. Plans and specifications may need to be prepared for its repair depending on the findings of the investigation.

Importance of Inspection

Stability problems can threaten the safety of the dam and the safety of people and property downstream. Therefore, stability problems must be detected and repaired in a timely manner. The entire embankment should be routinely and closely inspected for cracks, slides, and depressions. To do this thoroughly, proper vegetation must be regularly maintained on the embankment. Improper or overgrown vegetation can inhibit visual inspection and maintenance of the dam. Accurate inspection records are also needed to detect stability problems. These records can help determine if a condition is new, slowly changing, or rapidly changing. A rapidly changing condition or the sudden development of a large crack, slide, or depression indicates a very serious problem, and the Dam Safety Program must be contacted immediately.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 94–31

Dam Safety: Seepage Through Earthen Dams

Contrary to popular opinion, wet areas down stream from dams are not usually natural springs, but seepage areas. Even if natural springs exist, they should be treated with suspicion and carefully observed. Flows from ground-water springs in existence prior to the reservoir would probably increase due to the pressure caused by the pool of water behind the dam.

All dams have some seepage as the impounded water seeks paths of least resistance through the dam and its foundation. Seepage must, however, be controlled to prevent erosion of the embankment or foundation or damage to concrete structures.

Detection

Seepage can emerge anywhere on the downstream face, beyond the toe, or on the downstream abutments at elevations below normal pool. Seepage may vary in appearance from a "soft," wet area to a flowing "spring." It may show up first as an area where the vegetation is lush and darker green. Cattails, reeds, mosses, and other marsh vegetation often become established in a seepage area. Another indication of seepage is the presence of rust-colored iron bacteria. Due to their nature, the bacteria are found more often where water is discharging from the ground than in surface water. Seepage can make inspection and maintenance difficult. It can also saturate and weaken portions of the embankment and foundation, making the embankment susceptible to earth slides.

If the seepage forces are large enough, soil will be eroded from the foundation and be deposited in the shape of a cone around the outlet. If these "boils" appear, professional advice should be sought immediately. Seepage flow which is muddy and carrying sediment (soil particles) is evidence of "piping," and will cause failure of the dam. Piping can occur along a spillway and other conduits through the embankment, and these areas should be closely inspected. Sinkholes may develop on the surface of the embankment as internal erosion takes place. A whirlpool in the lake surface may follow and then likely a rapid and complete failure of the dam. Emergency procedures, including downstream evacuation, should be implemented if this condition is noted.

Seepage can also develop behind or beneath concrete structures such as chute spillways or headwalls. If the concrete structure does not have a means such as weep holes or relief drains to relieve the water pressure, the concrete structure may heave, rotate, or crack. The effects of the freezing and thawing can amplify these problems. It should be noted that the water pressure behind or beneath structures may also be due to infiltration of surface water or spillway discharge.

A continuous or sudden drop in the normal lake level is another indication that seepage is occurring. In this case, one or more locations of flowing water are usually noted downstream from the dam. This condition, in itself, may not be a serious problem, but will require frequent and close monitoring and professional assistance.

Control

The need for seepage control will depend on the quantity, content, and location of the seepage. Reducing the quantity of seepage that occurs after construction is difficult and expensive. It is not usually attempted unless the seepage has lowered the pool level or is endangering the embankment or appurtenant structures. Typical methods used to control the quantity of seepage are grouting or installation of an upstream blanket. Of these methods, grouting is probably the least effective and is most applicable to leakage zones in bedrock, abutments, and foundations. These methods must be designed and constructed under the supervision of a professional engineer experienced with dams.

Controlling the content of the seepage or preventing seepage flow from removing soil particles is extremely important. Modern design practice incorporates this control into the embankment through the use of cutoffs, internal filters, and adequate drainage provisions. Control at points of seepage exit can be accomplished after construction by installation of toe drains, relief wells, or inverted filters.

Weep holes and relief drains can be installed to relieve water pressure or drain seepage from behind or beneath concrete structures. These systems must be designed to prevent migration of soil particles but still allow the seepage to drain freely. The owner must retain a professional engineer to design toe drains, relief wells, inverted filters, weep holes, or relief holes.

Monitoring

Regular monitoring is essential to detect seepage and prevent dam failure. Knowledge of the dam's history is important to determine whether the seepage condition is in a steady or changing state. It is important to keep written records of points of seepage exit, quantity and content of flow, size of wet area, and type of vegetation for later comparison. Photographs provide invaluable records of seepage.

All records should be kept in the operation, maintenance, and inspection manual for the dam. The inspector should always look for increases in flow and evidence of flow carrying soil particles, which would indicate that a more serious problem is developing. Instrumentation can also be used to monitor seepage. V-notch weirs can be used to measure flow rates, and piezometers may be used to determine the saturation level (phreatic surface) within the embankment.

Regular surveillance and maintenance of internal embankment and foundation drainage outlets is also required. The rate and content of flow from each pipe outlet for toe drains, relief wells, weep holes, and relief drains should be monitored and documented regularly. Normal maintenance consists of removing all obstructions from the pipe to allow for free drainage of water from the pipe. Typical obstructions include debris, gravel, sediment, and rodent nests. Water should not be permitted to submerge the pipe outlets for extended periods of time. This will inhibit inspection and maintenance of the drains and may cause them to clog.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–54

Dam Safety: Ground Cover

The establishment and control of proper vegetation are an important part of dam maintenance. Properly maintained vegetation can help prevent erosion of embankment and earth channel surfaces, and aid in the control of groundhogs and muskrats. The uncontrolled growth of vegetation can damage embankments and concrete structures and make close inspection difficult.

Grass vegetation is an effective and inexpensive way to prevent erosion of embankment surfaces. If properly maintained, it also enhances the appearance of the dam and provides a surface that can be easily inspected. Roots and stems tend to trap fine sand and soil particles, forming an erosion-resistant layer once the plants are well established. Grass vegetation may not be effective in areas of concentrated runoff, such as at the contact of the embankment and abutments, or in areas subjected to wave action.

Common Problems

Bare Areas

Bare areas on an embankment are void of protective cover (e.g. grass, asphalt, riprap etc.). They are more susceptible to erosion which can lead to localized stability problems such as small slides and sloughs. Bare areas must be repaired by establishing a proper grass cover or by installing other protective cover. If using grass, the topsoil must be prepared with fertilizer and then scarified before sowing seed. Types of grass vegetation that have been used on dams in Ohio are bluegrass, fescue, ryegrass, alfalfa, clover, and redtop. One suggested seed mixture is 30% Kentucky Bluegrass, 60% Kentucky 31 Fescue, and 10% Perennial Ryegrass. Once the seed is sown, the area should be mulched and watered regularly.

Erosion

Embankment slopes are normally designed and constructed so that the surface drainage will be spread out in a thin layer as "sheet flow" over the grass cover. When the sod is in poor condition or flow is concentrated at one or more locations, the resulting erosion will leave rills and gullies in the embankment slope. The erosion will cause loss of material and make maintenance of the embankment difficult. Prompt repair of the erosion is required to prevent more serious damage to the embankment. If erosion gullies are extensive, a registered professional engineer may be required to design a more rigid repair such as riprap or concrete. Minor rills and gullies can be repaired by filling them with compacted cohesive material. Topsoil should be a minimum of 4 inches deep. The area should then be seeded and mulched. Not only should the eroded areas be repaired, but the cause of the erosion should be addressed to prevent a continued maintenance problem.

Footpaths

Paths from animal and pedestrian traffic are problems common to many embankments. If a path has become established, vegetation in this area will not provide adequate protection and a more durable cover will be required unless the traffic is eliminated. Gravel, asphalt, and concrete have been used effectively to cover footpaths. Embedding railroad ties or other treated wood beams into an embankment slope to form steps is one of the most successful and inexpensive methods used to provide a protected pathway.

Vehicle Ruts

Vehicle ruts can also be a problem on the embankment. Vehicular traffic on the dam should be discouraged especially during wet conditions except when necessary. Water collected in ruts may cause localized saturation, thereby weakening the embankment. Vehicles can also severely damage the vegetation on embankments. Worn areas could lead to erosion and more serious problems. Ruts that develop in the crest should be repaired by grading to direct all surface drainage into the impoundment. Bare and eroded areas should be repaired using the methods mentioned in the above sections. Constructed barriers such as fences and gates are effective ways to limit access of vehicles.

Improper Vegetation

Crown vetch, a perennial plant with small pink flowers, has been used on some dams in Ohio but is not recommended (see Figure 1). It hides the embankment surface, preventing early detection of cracks and erosion. It is not effective in preventing erosion.

Vines and woody vegetation such as trees and brush also hide the embankment surface preventing early detection of cracks and erosion. Tall vegetation also provides a habitat for burrowing animals. All improper vegetation must be removed from the entire embankment surface. Any residual roots that are larger than 3 inches in diameter must be removed. All roots should be removed down to a

Figure 1: Crown Vetch (Source: http://www.vg.com)

depth of at least 6 inches and replaced with a compacted clay material; then 4 inches of topsoil should be placed on the disturbed areas of the slope. Finally, these areas must be seeded and mulched to establish a proper grass cover.

Maintenance

Embankments, areas adjacent to spillway structures, vegetated channels, and other areas associated with a dam require continual maintenance of the vegetal cover. Removal of improper vegetation is necessary for the proper maintenance of a dam, dike or levee. All embankment slopes and vegetated earth spillways should be maintained with a maximum grass height of 12 inches. Reasons for proper maintenance of the vegetal cover include unobstructed viewing during inspection, maintenance of a non-erodible surface, discouragement of burrowing animal habitation, and aesthetics.

Common methods for control of vegetation include the use of weed trimmers or power brush-cutters and mowers. Chemical spraying to kill small trees and brush is acceptable if precautions are taken to protect the local environment. Some chemical spraying may require proper training prior to application. Additional information can be found on the Trees and Brush Fact Sheet.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 94–28

Dam Safety: Trees and Brush

The establishment and control of proper vegetation is an important part of dam maintenance. Properly maintained vegetation can help prevent erosion of embankment and earth channel surfaces, and aid in the control of groundhogs and muskrats. The uncontrolled growth of vegetation can damage embankments and concrete structures and make close inspection difficult.

Trees and Brush

Trees and brush should not be permitted on embankment surfaces or in vegetated earth spillways. Extensive root systems can provide seepage paths for water. Trees that blow down or fall over can leave large holes in the embankment surface that will weaken the embankment and can lead to increased erosion. Brush obscures the surface limiting visual inspection, provides a haven for burrowing animals, and retards growth of grass vegetation. Tree and brush growth adjacent to concrete walls and structures may eventually cause damage to the concrete and should be removed.

Stump Removal & Sprout Prevention

Stumps of cut trees should be removed so vegetation can be established and the surface mowed. Stumps can be removed either by pulling or with machines that grind them down. All woody material should be removed to about 6 inches below the ground surface. The cavity should be filled with well-compacted soil and grass vegetation established.

Stumps of trees in riprap cannot usually be pulled or ground down, but can be chemically treated so they will not continually form new sprouts. Certain herbicides are effective for this purpose and can even be used at water supply reservoirs if applied by licensed personnel. For product information and information on how to obtain a license, contact the Ohio Department of Agriculture at the following address:

Ohio Department of Agriculture
Pesticide Regulation
8995 E. Main Street
Reynoldsburg, Ohio 43068
Telephone Number (614) 728-6201

These products should be painted, not sprayed, on the stumps. Other instructions found on the label should be strictly followed when handling and applying these materials. Only a few commercially available chemicals can be used along shorelines or near water.

Embankment Maintenance

Embankments, areas adjacent to spillway structures, vegetated channels, and other areas associated with a dam require continual maintenance of the vegetal cover. Grass mowing, brush cutting, and removal of woody vegetation (including trees) are necessary for the proper maintenance of a dam, dike, or levee. All embankment slopes and vegetated earth spillways should be maintained with a maximum grass height of 12 inches. Aesthetics, unobstructed viewing during inspections, maintenance of a non-erodible surface, and discouragement of groundhog habitation are reasons for proper maintenance of the vegetal cover.

Methods used in the past for control of vegetation, but are now considered unacceptable, include chemical spraying, and burning. More acceptable methods include the use of weed whips or power brush-cutters and mowers. Chemical spraying to first kill small trees and brush is acceptable if precautions are taken to protect the local environment.

It is important to remember not to mow when the embankment is wet. It is also important to use proper equipment for the slope and type of vegetation to be cut. Also, always follow the manufacturer's recommended safe operation procedures.

Any other questions, comments, concerns, or fact sheet requests, should be directed to the Division of Water Resources at the following address:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–52

Dam Safety: Upstream Slope Protection

Slope protection is usually needed to protect the upstream slope against erosion due to wave action. Without proper slope protection, a serious erosion problem known as "beaching" can develop on the upstream slope.

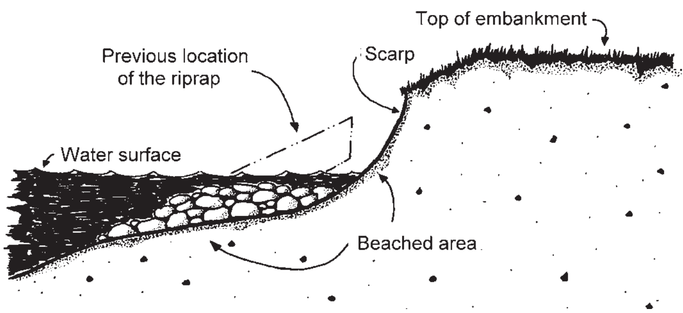


Figure 1 - Beaching

The repeated action of waves striking the embankment surface erodes fill material and displaces it farther down the slope, creating a "beach." The amount of erosion depends on the predominant wind direction, the orientation of the dam, the steepness of the slope, water level fluctuations, boating activities, and other factors. Further erosion can lead to cracking and sloughing of the slope which can extend into the crest, reducing its width. When erosion occurs and beaching develops on the upstream slope of a dam, repairs should be made as soon as possible. However, an erosion scarp less than 1 foot high may be stable and not require repair.

The upstream face of a dam is commonly protected against wave erosion by placement of a layer of rock riprap over a layer of bedding and a filter material. Other material such as concrete facing, soil-cement, fabri-form bags, slush grouted rocks, steel sheet piling, and articulated concrete blocks can also be used. Vegetative protection combined with a berm on the upstream slope can also be effective.

Rock Riprap

Rock riprap consists of a heterogeneous mixture of irregular shaped rocks placed over gravel bedding and a sand filter or geotextile fabric. The smaller rocks help to fill the spaces between the larger pieces forming an interlocking mass. The filter prevents soil particles on the embankment surface from being washed out through the spaces (or voids) between the rocks. The maximum rock size and weight must be large enough to break up the energy of the maximum anticipated wave action and hold the smaller stones in place. If the rock size is too small, it will eventually be displaced and washed away by wave action. If the riprap is sparse or if the filter or bedding material is too small, the filter material will wash out easily, allowing the embankment material to erode. Once the erosion has started, beaching will develop if remedial measures are not taken. Technical Release No. 69 developed by the USDA, Natural Resources Conservation Service can be used to help design engineers develop a preliminary or detailed design for riprap slope protection.

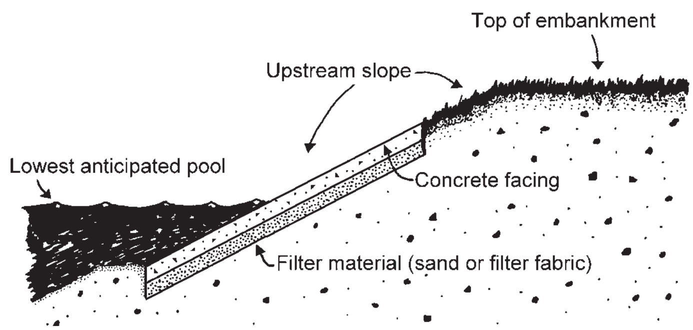


Figure 2 - Rock Riprap

The dam owner should expect some deterioration (weathering) of riprap. Freezing and thawing, wetting and drying, abrasive wave action, and other natural processes will eventually break down the riprap. Its useful life varies with the characteristics of the stone used. Stone for riprap should be rock that is dense and well cemented. In Ohio, glacial cobbles or boulders, most limestone, and a few types of sandstone are acceptable for riprap. Most sandstones and shales found in Ohio do not provide long-term protection. Due to the high initial cost of rock riprap, its durability should be determined by appropriate testing procedures prior to installation. Vegetative growth within the slope protection is undesirable because it can displace stone and disturb the filter material. Heavy undergrowth prevents an adequate inspection of the upstream slope and may hide potential problems. For additional information, see the "Trees and Brush" fact sheet.

Sufficient maintenance funds should be allocated for the addition of riprap and the removal of vegetation. Severe erosion or reoccurring problems may require a registered professional engineer to design a more effective slope protection.

Vegetated Wave Berm

Vegetated wave berms dissipate wave energy and protect the slope from erosion. Berms are constructed on the upstream slope at the normal pool level and should be no less than 20 feet wide. This method of slope protection will not work well where the water surface fluctuates regularly from normal pool. If improper or sparse vegetation is present, the wave berm may not adequately dissipate the wave energy, allowing erosion and beaching to develop on the upstream slope. Technical Release No. 56 developed by the USDA, Natural Resources Conservation Service provides design and layout information.

The vegetation on the wave berm should be monitored regularly to verify adequate growth. Sufficient funds should be allocated for the regular maintenance of the vegetation. Severe erosion or reoccurring problems may require a registered professional engineer to design a more effective slope protection.

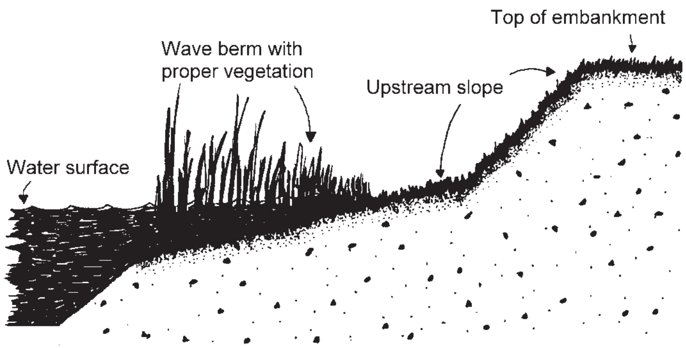


Figure 3 - Vegetated wave berm

Concrete Facing

Concrete facing can be used if severe wave action is anticipated, however, settlement of the embankment must be insignificant to insure adequate support for the concrete facing. A properly designed and constructed concrete facing can be expensive. This slope protection should extend several feet above and below the normal pool level. It should terminate on a berm or against a concrete curb or header. Granular filter or filter fabric (geotextile) is required under the concrete facing to help reduce the risk of undermining.

As with any type of slope protection, problems will develop if the concrete facing has not been properly designed or installed. Concrete facing often fails because the wave action washes soil particles from beneath the slabs through joints and cracks. This process is known as undermining, which will continue until large voids are created. Detection of voids is difficult because the voids are hidden. Failure of the concrete facing may be sudden and extensive. Concrete facing should be monitored for cracks and open joints. Open joints should be sealed with plastic fillers and cracks should be grouted and sealed. For additional information, see the "Problems with Concrete Materials" fact sheet.

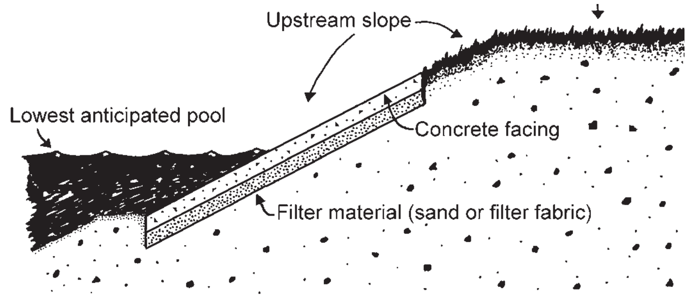


Figure 4 - Concrete facing

Inspection and Monitoring

Regular inspection and monitoring of the upstream slope protection is essential to detect any problems. It is important to keep written records of the location and extent of any erosion, undermining, or deterioration of the riprap, wave berm or other slope protection. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem, and the Dam Safety Program should be contacted immediately. All records should be kept in the operation, maintenance, and inspection manual for the dam.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 94–27

Dam Safety: Rodent Control

Rodents such as the grounhog (woodchuck), muskrat, and beaver are attracted to dams and reservoirs, and can be quite dangerous to the structural integrity and proper performance of the embankment and spillway. Groundhog and muskrat burrows weaken the embankment and can serve as pathways for seepage. Beavers may plug the spillway and raise the pool level. Rodent control is essential in preserving a well-maintained dam.

Groundhog

The groundhog is the largest member of the squirrel family. Its coarse fur is a grizzled grayish brown with a reddish cast. Typical foods include grasses, clover, alfalfa, soybeans, peas, lettuce, and apples. Breeding takes place during early spring (beginning at the age of one year) with an average of four or five young per litter, one litter per year. The average life expectancy is two or three years with a maximum of six years.

Occupied groundhog burrows are easily recognized in the spring due to the groundhog's habit of keeping them "cleaned out." Fresh dirt is generally found at the mouth of active burrows. Half-round mounds, paths leading from the den to nearby fields, and clawed or girdled trees and shrubs also help identify inhabited burrows and dens.

When burrowing into an embankment, groundhogs stay above the phreatic surface (upper surface of seepage or saturation) to stay dry. The burrow is rarely a single tunnel. It is usually forked, with more than one entrance and with several side passages or rooms from 1 to 12 feet long.

Groundhog Control

Control methods should be implemented during early spring when active burrows are easy to find, young groundhogs have not scattered, and there is less likelihood of damage to other wildlife. In later summer, fall, and winter, game animals will scurry into groundhog burrows for brief protection and may even take up permanent abode during the period of groundhog hibernation.

Groundhogs can be controlled by trapping or shooting. Groundhogs will be discouraged from inhabiting the embankment if the vegetal cover is kept mowed.

Muskrat

The muskrat is a stocky rodent with a broad head, short legs, small eyes, and rich dark brown fur. Muskrats are chiefly nocturnal. Their principal food includes stems, roots, bulbs, and foliage of aquatic plants. They also feed on snails, mussels, crustaceans, insects, and fish. Usually three to five litters, averaging six to eight young per litter, are produced each year. Adult muskrats average one foot in length and three pounds in weight. The life expectancy is less than two years, with a maximum of four years. Muskrats can be found wherever there are marshes, swamps, ponds, lakes and streams having calm or very slowly moving water with vegetation in the water and along the banks.

Muskrats make their homes by burrowing into the banks of lakes and streams or by building "houses" of bushes and other plants. Their burrows begin from 6 to 18 inches below the water surface and penetrate the embankment on an upward slant. At distances up to 15 feet from the entrance, a dry chamber is hollowed out above the water level. Once a muskrat den is occupied, a rise in the water level will cause the muskrat to dig farther and higher to excavate a new dry chamber. Damage (and the potential for problems) is compounded where groundhogs or other burrowing animals construct their dens in the embankment opposite muskrat dens.

Muskrat Control

Barriers to prevent burrowing offer the most practical protection to earthen structures. A properly constructed riprap and filter layer will discourage burrowing. The filter and riprap should extend at least 3 feet below the water line. As the muskrat attempts to construct a burrow, the sand and gravel of the filter layer caves in and thus discourages den building. Heavy wire fencing laid flat against the slope and extending above and below the water line can also be effective. Eliminating or reducing aquatic vegetation along the shoreline will discourage muskrat habitation. Where muskrats have inhabited the area, trapping is usually the most practical method of removing them from a pond.

Eliminating a Burrow

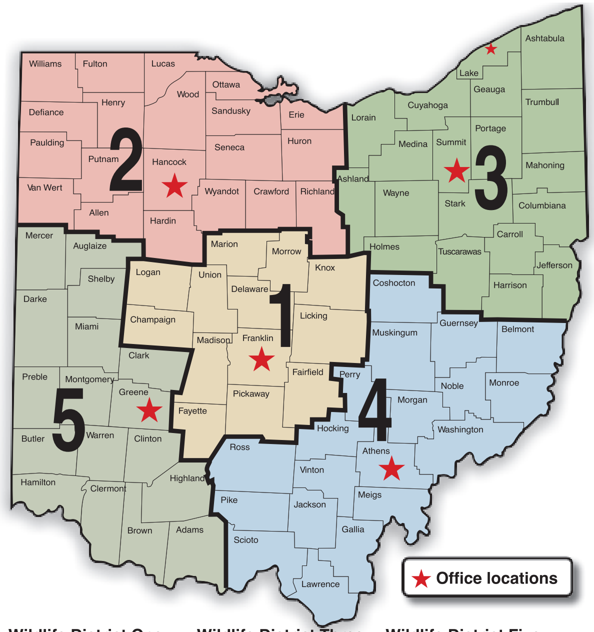
The recommended method of backfilling a burrow in an embankment is mud-packing. This simple, inexpensive method can be accomplished by placing one or two lengths of metal stove or vent pipe in a vertical position over the entrance of the den. Making sure that the pipe connection to the den does not leak, the mud-pack mixture is then poured into the pipe until the burrow and pipe are filled with the earth-water mixture. The pipe is removed and dry earth is tamped into the entrance. The mud-pack is made by adding water to a 90 percent earth and 10 percent cement mixture until a slurry or thin cement consistency is attained. All entrances should be plugged with well-compacted earth and vegetation re-established. Dens should be eliminated without delay because damage from just one hole can lead to failure of a dam or levee.

Beaver

Beaver will try to plug spillways with their cuttings. Routinely removing the cuttings is one way to alleviate the problem. Trapping beaver may be done by the owner during the appropriate season; however, the nearest ODNR, Division of Wildlife, District Office or state wildlife officer should be contacted first.

Hunting and Trapping Regulations

Because hunting and trapping rules change from year to year, ODNR, Division of Wildlife authorities at one of the following offices should be consulted before taking any action.



Wildlife District One
1500 Dublin Road
Columbus, Ohio 43215
Phone: (614) 644-3925
FAX (614) 644-3931

Wildlife District Three
912 Portage Lakes Drive
Akron, Ohio 44319
Phone: (330) 644-2293
FAX (330) 644-8403

Wildlife District Five
1076 Old Springfield Pike
Xenia, Ohio 45385
Phone: (937) 372-9261
FAX (937) 376-3011

Wildlife District Two
952 Lima Avenue
Findlay, Ohio 45840
Phone: (419) 424-5000
FAX (419) 422-4875

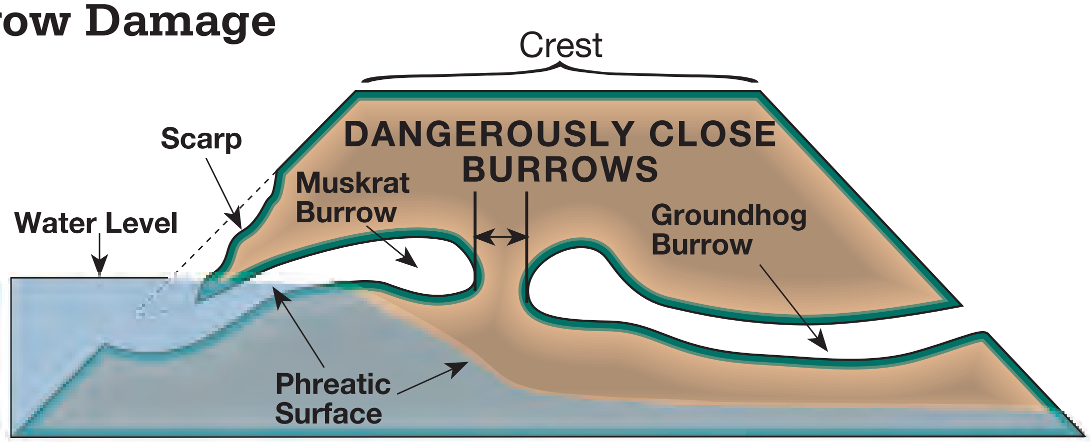
Wildlife District Four
360 E. State Street
Athens, Ohio 45701
Phone: (740) 589-9930
FAX (740) 589-9999

In Fairport Harbor
1190 High Street
Fairport Harbor, Ohio 44077
Phone: (440) 352-4199
FAX (440) 352-4199

Additional questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Rodent Burrow Damage



Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 93–26

Dam Safety: Lake Drains

A lake drain is a device to permit draining a reservoir, lake or pond. Administrative Rule 1501:21-13-06 requires that all Class I, Class II and Class III dams include a lake drain.

Types of Drains

Common types of drains include the following:

- A valve located in the spillway riser.
- A conduit through the dam with a valve at either the upstream or downstream end of the conduit.
- A siphon system (Often used to retrofit existing dams).
- A gate, valve or stoplogs located in a drain control tower.

Uses of Drains

The following situations make up the primary uses of lake drains:

Emergencies: Should serious problems ever occur to threaten the immediate safety of the dam, drains may be used to lower the lake level to reduce the likelihood of dam failure. Examples of such emergencies are as follows: clogging of the spillway pipe which may lead to high lake levels and eventually dam overtopping, development of slides or cracks in the dam, severe seepage through the dam which may lead to a piping failure of the dam, and partial or total collapse of the spillway system.

Maintenance: Some repair items around the lake and dam can only be completed or are much easier to perform with a lower than normal lake level. Some examples are: slope protection repair, spillway repairs, repair and/or installation of docks and other structures along the shoreline, and dredging the lake.

Winter Drawdown: Some dam owners prefer to lower the lake level during the winter months to reduce ice damage to structures along the shoreline and to provide additional flood storage for upcoming spring rains. Several repair items are often performed during this winter drawdown period. Periodic fluctuations in the lake level also discourage muskrat and beaver habitation along the shoreline. Muskrat burrows in earthen dams can lead to costly repairs.

Common Maintenance Problems

Common problems often associated with the maintenance and operation of lake drains include the following:

- Deteriorated and bent control stems and stem guides.
- Deteriorated and separated conduit joints.
- Leaky and rusted control valves and sluice gates.
- Deteriorated ladders in control towers.
- Deteriorated control towers.
- Clogging of the drain conduit inlet with sediment and debris.
- Inaccessibility of the control mechanism to operate the drain.
- Seepage along the drain conduit.
- Erosion and undermining of the conduit discharge area because the conduit outlets significantly above the elevation of the streambed.
- Vandalism.
- Development of slides along the upstream slope of the dam and the shoreline caused by lowering the lake level too quickly.

Operation and Maintenance Tips

A. All gates, valves, stems and other mechanisms should be lubricated according to the manufacturer's specifications. If you do not have a copy of the specifications and the manufacturing company can not be determined, then a local valve distributor may be able to provide assistance.

B. The lake drain should be operated at least twice a year to prevent the inlet from clogging with sediment and debris, and to keep all movable parts working easily. Most manufacturers recommend that gates and valves be operated at least four times per year. Frequent operation will help to ensure that the drain will be operable when it is needed. All valves and gates should be fully opened and closed at least twice to help flush out debris and to obtain a proper seal. If the gate gets stuck in a partially opened position, gradually work the gate in each direction until it becomes fully operational. Do not apply excessive torque as this could bend or break the control stem, or damage the valve or gate seat. With the drain fully open, inspect the outlet area for flow amounts, leaks, erosion and anything unusual.

C. All visible portions of the lake drain system should be inspected at least annually, preferably during the periodic operation of the drain. Look for and make note of any cracks, rusted and deteriorated parts, leaks, bent control stems, separated conduit joints or unusual observations.

D. A properly designed lake drain should include a headwall near the outlet of the drain conduit to prevent undermining of the conduit during periods of flow. A headwall can be easily retro-fitted to an existing conduit if undermining is a problem at an existing dam. A properly designed layer of rock riprap or other slope protection will help reduce erosion in the lake drain outlet area.

E. Drain control valves and gates should always be placed upstream of the centerline of the dam. This allows the drain conduit to remain depressurized except during use, therefore reducing the likelihood of seepage through the conduit joints and saturation of the surrounding earth fill.

F. For accessibility ease, the drain control platform should be located on shore or be provided with a bridge or other structure. This becomes very important during emergency situations if high pool levels exist.

G. Vandalism can be a problem at any dam. If a lake drain is operated by a crank, wheel or other similar mechanism, locking with a chain or other device, or off-site storage may be beneficial. Fences or other such installations may also help to ward off vandals.

H. The recommended rate of lake drawdown is one foot or less per week, except in emergencies. Fast drawdown causes a build-up of hydrostatic pressures in the upstream slope of the dam which can lead to slope failure. Lowering the water level slowly allows these pressures to dissipate.

Monitoring

Monitoring of the lake drain system is necessary to detect problems and should be performed at least twice a year or more frequently if problems develop. Proper ventilation and confined space precautions must be considered when entering a lake drain vault or outlet pipe. Items to be considered when monitoring a lake drain system include the stem, valve, outlet pipe and related appurtenances. Monitoring for surface deterioration (rust), ease of operation, and leakage is important to maintain a working lake drain system. If the stem or valve appears to be inoperable because of deterioration or if the operability of the lake drain system is in question, because the valve does not completely close (seal) and allows an excessive amount of leakage, then a registered professional engineer or manufacturer's representative should be contacted. Photographs along with written records of the monitoring items performed provide invaluable information. For further information on evaluating the condition of the lake drain system see the "Spillway Conduit System Problems", "Problems with Metal Materials", "Problems with Plastic (Polymer) Materials", and "Problems with Concrete Materials" fact sheets.

Conclusion

An operable lake drain accomplishes the following:

1. Makes for a safer dam by providing a method to lower the lake level in an emergency situation.
2. Allows the dam owner to have greater control of the lake level for maintenance, winter drawdown and emergency situations.
3. Meets the requirements of the Ohio Dam Safety Laws.

Any other questions, comments concerns, or fact sheet requests, should be directed to the Division of Water Resources at the following address:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 95–38

Dam Safety: Design and Maintenance of Trashracks
for Pipe and Riser Spillways

The principal spillway for dams in the State of Ohio can be one of several designs. The proper operation of these spillways is an important part of maintaining the overall safety of the dam. Pipe and riser, drop inlet spillways are susceptible to obstruction and damage by floating debris such as leaves, branches, and logs. One device used to ensure that these spillways operate correctly is a trashrack. Trashracks are designed to keep trash and other debris from entering the spillway and causing damage.

Common problems

Trashracks usually become plugged because the openings are too small or the head loss at the inlet causes material and sediment to settle out and accumulate. Small openings will cause debris such as twigs and leaves to accumulate on the trashrack bars. This buildup will cause progressively larger debris to accumulate against the trashrack bars. Ultimately, this will result in the complete blockage of the spillway inlet.

Pipe and riser spillways can also become blocked by a build up of debris in the spillway. This type of blockage occurs when no trashrack is in place, or if the openings are too large.

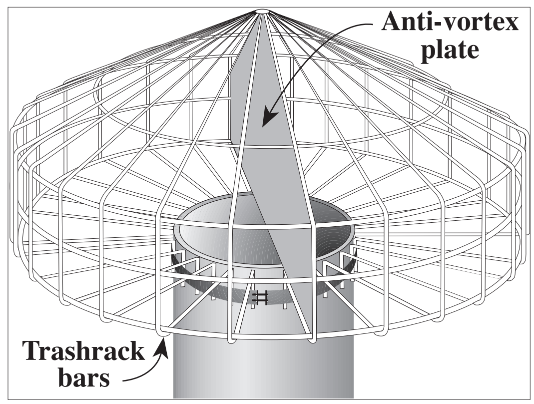
In many spillway systems, the size of the outlet conduit is smaller than the size of the inlet. Therefore, it is incorrect to assume that debris which passes through the inlet will not obstruct the flow through the outlet. Large debris, such as logs and tree limbs, can become lodged in the transitions in the spillway. This reduces the capacity of the spillway and could cause damage. An obstructed outlet pipe can be a major problem because removal of large debris from inside the spillway can be very difficult.

A partially blocked spillway reduces the capacity of the spillway and may also create a higher than normal pool level. The combination of these two factors can dramatically reduce the discharge/storage capacity of the dam. A reduction in the discharge/storage capacity of a dam increases the likelihood that the dam will be overtopped during a severe storm event. Overtopping for even a short period of time can cause damage to the embankment and possibly failure of the dam. If the dam has an emergency spillway, a blocked principal spillway will cause more frequent flows in the emergency spillway. Since emergency spillways are usually grass lined channels designed for infrequent flows of short duration, serious damage is likely to result.

Trashrack design

A well-designed trashrack will stop large debris that could plug the conduit but allow unrestricted passage of water and smaller debris. The larger the outlet conduit, the larger the trashrack opening should be. In the design of a trashrack

Common Trashrack & Anti-Vortex Design



the openings should be sized so that they measure one-half the nominal dimension of the outlet conduit. For example, if the outlet pipe is 18 inches in diameter, the trashrack openings should be the effective equivalent of 9 inches by 9 inches; if the outlet conduit is 3 feet by 5 feet, the trashrack openings should be the effective equivalent of 18 inches by 18 inches. This rule applies up to a maximum trashrack opening of two feet by two feet. For an outlet conduit with a nominal dimension of 12 inches or less, the trashrack openings should be at least 6 inches by 6 inches. This prevents large debris from passing through the inlet and blocking the outlet conduit while allowing smaller debris (leave, sticks, etc.) to flush through the spillway system. Another important design criteria is that the trashrack should be securely fastened to the inlet. The connection must be strong enough to withstand the hydrostatic and dynamic forces exerted on the trashrack during periods of high flow.

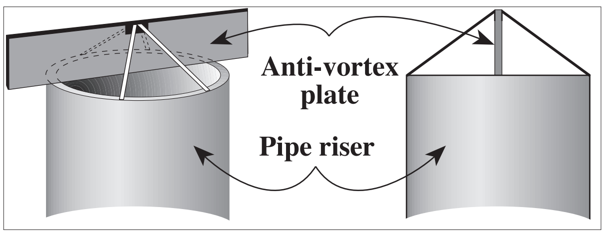
Fish protection

Many owners are concerned about losing fish through trashracks that have large openings. If this is a concern, a metal plate surrounding the riser or drop inlet which extends above and below the normal pool level should be installed. See Figure on back of sheet. On the bottom of the plate, a metal screen should be attached and connected to the riser pipe. The solid plate at the water level will prevent the fish and floating debris from passing over the crest of the riser. The underwater screen will keep the fish from moving under the metal plate and through the spillway. The underwater screen will not become blocked because most of the debris floats on the water surface. If this design is used, the area between the inside of the cylinder and the outside of the riser must be equal to or greater than the area inside the riser.

Anti-vortex devices

An anti-vortex device can easily be incorporated into most trashrack designs. A common anti-vortex device is a flat metal plate which is placed on edge and attached to the inlet of the spillway. See Figure below. The capacity of the spillway will be increased by equipping the trashrack with an anti-vortex plate. The anti-vortex plate increases capacity by preventing the formation of a flow inhibiting vortex during periods of high flow.

Basic Anti-Vortex Plate Design



Maintenance

Maintenance should include periodic checks of the trashrack for rusted and broken sections and repairing as needed. Trashracks should be checked frequently during and after storm events to ensure they are functioning properly and to remove accumulated debris. Extreme caution should be used when attempting to remove accumulated debris during periods of high flow.

Conclusion

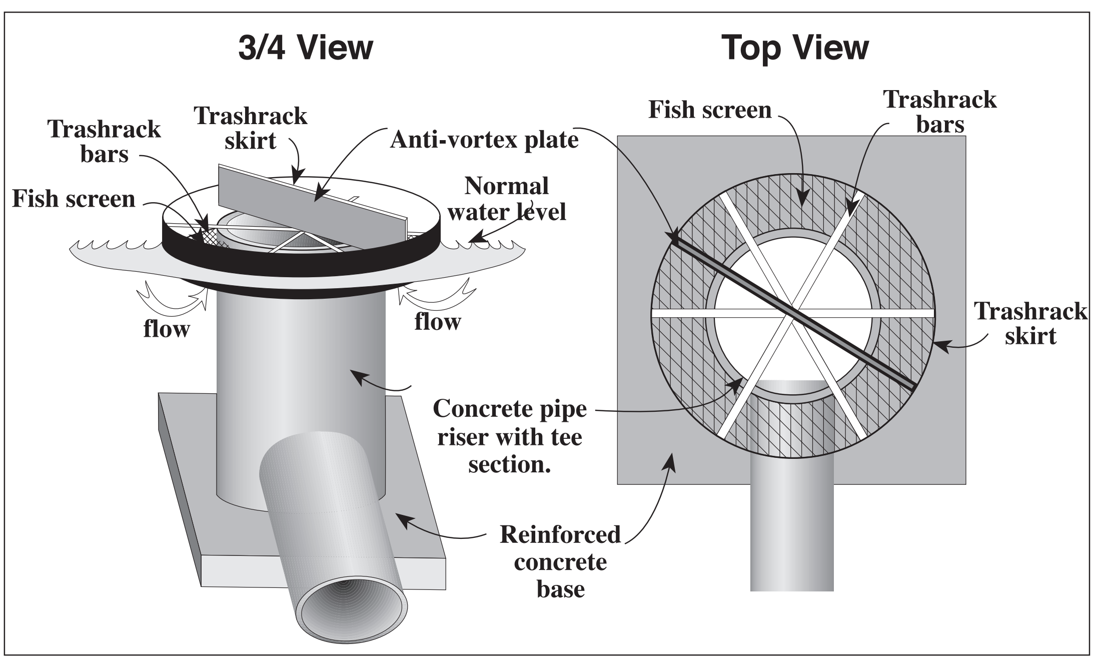
The benefits of a properly designed and maintained trashrack include the following:

1. Efficient use of the existing spillway system that will maintain the design discharge/storage capacity of the dam and prevent overtopping.
2. Prevention of costly maintenance items such as the removal of debris from the spillway, repair or replacement of damaged spillway components, and the repair of erosion in emergency spillway.
3. A reduction in the amount of fish lost through the spillway system if a fish screen is used.

Any questions, comments, concerns, or fact sheet requests should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Trash Rack Design With Fish Protector Screen



Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–55

Dam Safety: Spillway Conduit System Problems

Many dams have conduit systems that serve as principal spillways. These conduit systems are required to carry normal stream and small flood flows safely past the embankment throughout the life of the structure. Conduits through embankments are difficult to construct properly and can be extremely dangerous to the embankment if problems develop after construction. Conduits are usually difficult to repair because of their location within the embankment. Also, replacing conduits requires extensive excavation. In order to avoid difficult and costly repairs, particular attention should be directed to maintaining these structures. The most common problem noted with spillway conduit systems is undermining of the conduit. This condition typically results from water leaking through pipe joints, seepage along the conduit or inadequate energy dissipation at the conduit outlet. The typical causes of seepage and water leaking through pipe joints include any one or a combination of the following factors: loss of joint material, separated joints, misalignment, differential settlement, conduit deterioration, and pipe deformation. Problems in any of these areas may lead to failure of the spillway system and possibly dam failure.

Undermining

Undermining is the removal of foundation material surrounding a conduit system. Any low areas or unexplained settlement of the earthfill in line with the conduit may indicate that undermining has occurred within the embankment. As erosion continues, undermining of a conduit can lead to displacement and collapse of the pipe sections and cause sloughing, sliding or other forms of instability in the embankment. As the embankment is weakened, a complete failure of the conduit system and, eventually failure of the dam may occur.

Seepage along the conduit from the reservoir can occur as a result of poor compaction around the conduit. If seepage control devices have not been installed, the seepage may remove foundation material from around the conduit and eventually lead to undermining.

In addition, undermining can occur as the result of erosion due to inadequate energy dissipation or inadequate erosion protection at the outlet. This undermining can be visually observed at the outlet of a pipe system and can extend well into the embankment. In this case, undermining can lead to other conduit problems such as misalignment, separated joints and pipe deterioration. An extensive discussion on outlet erosion control as it relates to undermining of the pipe outlet can be found in the "Outlet Erosion Control Structures" fact sheet.

Installation of seepage control devices is required as a preventative measure to control seepage along the conduit and undermining. Regular monitoring of conduit systems must include visual observation and notation of any undermining or any precursors. These precursors usually include pipe deformation, misalignment and differential settlement, pipe deterioration, separated joints and loss of joint material.

Pipe deformation

Pipe deformations are typically caused by external loads that are applied on a pipe such as the weight of the embankment or heavy equipment. Collapse of the pipe can cause failure of the joints and allow erosion of the supporting fill. This may lead to undermining and settlement. Pipe deformation may reduce or eliminate spillway capacity. Pipe deformation must be monitored on a regular basis to ensure that no further deformation is occurring, that pipe joints are intact and that no undermining or settlement is occurring.

Separated joints and loss of joint material: Joint Deterioration

Conduit systems usually have construction and/or section joints. In almost every situation, the joints will have a water stop, mechanical seal and/or chemical seal to prevent leakage of water through the joint. Separation and deterioration can destroy the watertight integrity of the joint. Joint deterioration can result from weathering, excessive seepage, erosion or corrosion. Separation at a joint may be the result of a more serious condition such as foundation settlement, undermining, structural damage or structural instability. Deterioration at joints includes loss of gasket material, loss of joint sealant and spalling around the edges of joints. Separation of joints and loss of joint material allow seepage through the pipe. This can erode the fill underneath and along the conduit causing undermining, which can lead to the displacement of the pipe sections. Separated pipe joints can be detected by inspecting the interior of the conduit. A regular monitoring program is needed to determine the rate and severity of joint deterioration. Joint separations should be monitored to determine if movement is continuing.

Conduit Deterioration

Deterioration of conduit material is normally due to the forces of nature such as wetting and drying, freezing and thawing, oxidation, decay, ultra-violet light, cavitation and the erosive forces of water. Deterioration of pipe materials and joints can lead to seepage through and along the conduit and eventually failure of conduit systems. Additional information on deterioration can be found on the "Problems with Concrete Materials", "Problems with Metal Materials", and "Problems with Plastic (Polymer) Materials" fact sheets.

Differential Settlement

Removal or consolidation of foundation material from around the conduit can cause differential settlement. Inadequate compaction immediately next to the conduit system during construction would compound the problem. Differential settlement can ultimately lead to undermining of the conduit system. Differential settlement should be monitored with routine inspections and documentation of observations.

Misalignment

Alignment deviations can be an indication of movement, which may or may not be in excess of design tolerances. Proper alignment is important to the structural integrity of conduit systems. Misalignment can be the direct result of internal seepage flows that have removed soil particles or dissolved soluble rock. Misalignment can also result from poor construction practices, collapse of deteriorated conduits, decay of organic material in the dam, seismic events or normal settlement due to consolidation of embankment or foundation materials. Excessive misalignment may result in other problems such as cracks, depressions, slides on the embankment, joint separation and seepage. Both the vertical and horizontal alignment of the conduit should be monitored on a regular basis.

Monitoring and Repair

Frequent inspection is necessary to ensure that the pipe system is functioning properly. All conduits should be inspected thoroughly once a year. Conduits that are 24 inches or more in diameter can be entered and visually inspected with proper ventilation and confined space precautions. Small inaccessible conduits may be monitored with video cameras. The conduits should be inspected for misalignment, separated joints, loss of joint material, deformations, leaks, differential settlement and undermining. Problems with conduits occur most often at joints, and special attention should be given to them during the inspection. The joint should be checked for separation caused by misalignment or settlement and loss of joint-filler material. The outlet should be checked for signs of water seeping along the exterior surface of the conduit. Generally, this is noted by water flowing from under the conduit and/or the lack of foundation material directly beneath the conduit. The embankment surface should be monitored for depressions or sinkholes. Depressions or sinkholes on the embankment surface above the spillway conduit system develop when the underlying material is eroded and displaced. Photographs along with written records of the monitoring items performed provide invaluable information.

Effective repair of the internal surface or joint of a conduit is difficult and should not be attempted without careful planning and proper professional supervision. Various construction techniques can be applied for minor joint repair and conduit leakage, but major repairs require a plan be developed by a professional engineer experienced in dam spillway construction.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 98–49

Dam Safety: Open Channel Spillways

(Earth and Rock)

Open channels are often used as the emergency spillway and sometimes as the principal spillway for dams. A principal spillway is used to pass normal inflows, and an emergency spillway is designed to operate only during large flood events, usually after the capacity of the principal spillway has been exceeded. For dams with pipe conduit principal spillways, an open channel emergency spillway is almost always required as a backup in case the pipe becomes clogged. Open channels are usually located in natural ground adjacent to the dam and can be vegetated, rock-lined, or cut in rock.

Design

Flow through an emergency spillway does not necessarily indicate a problem with the dam, but high velocity flows can cause severe erosion and result in a permanently lowered lake level if not repaired. Proper design of an open channel spillway will include provisions for minimizing any potential erosion. One way to minimize erosion is to design a flatter channel slope to reduce the velocity of the flow. Earthen channels can be protected by a good grass cover, an appropriately designed rock cover, concrete or various types of erosion control matting. Rock-lined channels must have adequately sized riprap to resist displacement and contain an appropriate geotextile fabric or granular filter beneath the rock. Guide berms are often required to divert flow through open channels away from the dam to prevent erosion of the embankment fill. If an open channel is used for a principal spillway, it must be rock-lined or cut in rock due to more frequent or constant flows.

Ohio Administrative Code Rule 1501:21-13-04 requires that the frequency of use for an earth (grass-lined) emergency spillway be less than:

- Once in 50 years for Class I dams;
- Once in 25 years for Class II dams; and
- Once in 10 years for Class III dams.

Maintenance

Maintenance should include, but not be limited to, the following items:

- **Grass-covered channels should be mowed at least twice per year to maintain a good grass cover and to prevent trees, brush and weeds from becoming established.** Poor vegetal cover can result in extensive and rapid erosion when the spillway flows. Repairs can be costly. Reseeding and fertilization may be necessary to maintain a vigorous growth of grass. One suggested seed mixture is 30% Kentucky Bluegrass, 60% Kentucky 31 Fescue, and 10% Perennial Ryegrass.

- **Trees and brush must be removed from the channel.** Tree and brush growth reduces the discharge capacity of the spillway channel. This increases the lake level during large storm events which can lead to overtopping and failure of the dam.

- **Erosion in the channel must be repaired quickly after it occurs.** Erosion can be expected in the spillway channel during high flows, and can also occur as a result of rainfall and runoff, especially in areas of poor grass cover. Terraces or drainage channels may be necessary in large spillway channels where large amounts of rainfall and runoff may concentrate and have high velocities. Erosion of the side slopes may deposit material in the spillway channel, especially where the side slopes meet the channel bottom. In small spillways, this can significantly reduce the discharge capacity. This condition often occurs immediately after construction before vegetation becomes established. In these cases, it may be necessary to reshape the channel to provide the necessary capacity.

- **All obstructions should be kept out of the channel.** Open channel spillways often are used for purposes other than passage of flood flows. Among these uses are reservoir access, parking lots, boat ramps, boat storage, pasture and cropland. Permanent structures (buildings, fences, etc.) should not be constructed in these spillways. If fences, bridges or other such structures are absolutely necessary, they should cross the spillway far enough upstream or downstream from the control section so that they do not interfere with the flow. Construction of any structures in or across the channel requires prior approval from the Division of Water Resources.

• **Weathering of rock channels can be a serious problem and is primarily due to freeze/thaw action.** Deterioration due to the effects of sun, wind, rain, chemical action and tree root growth also occurs. Weathered rock is susceptible to erosion and displacement during high flows; therefore, rock channels are often designed with 1 to 3 feet of earth with a grass cover over the rock surface to help insulate the rock from the effects of freeze/thaw action.

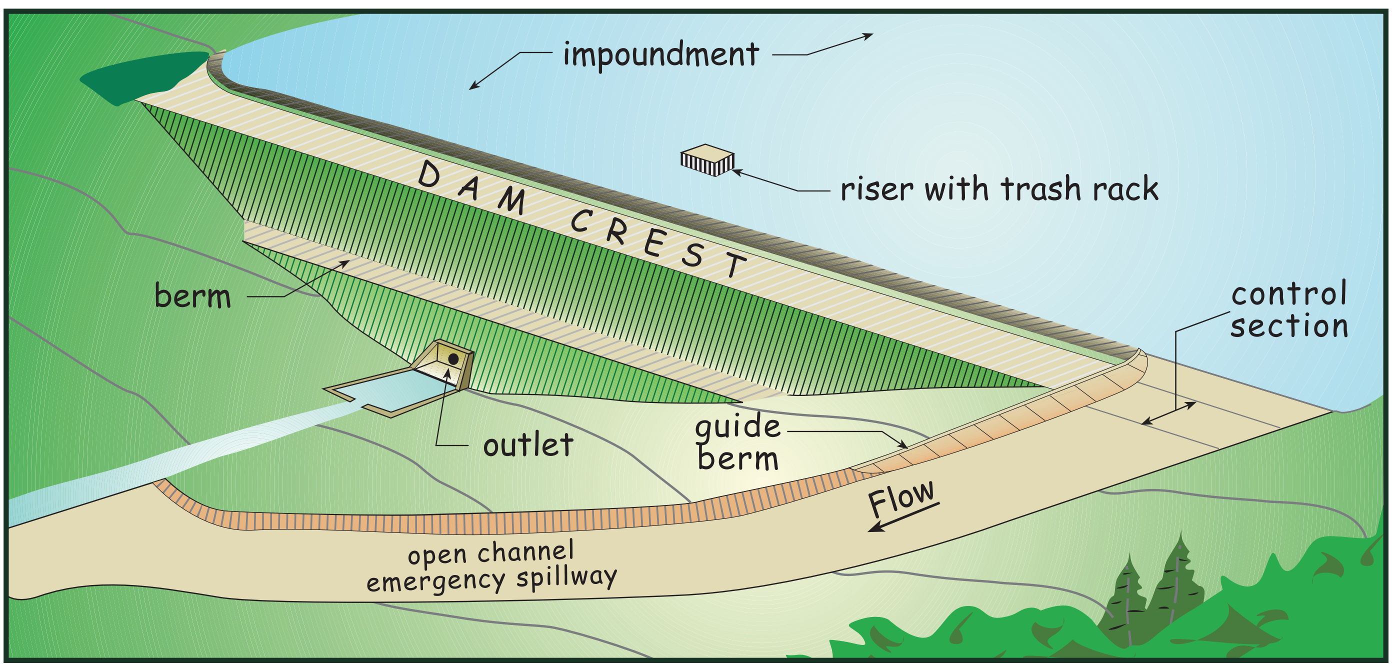
Monitoring

Open channel spillways should be monitored for erosion, poor vegetal cover, growth of trees and brush, obstructions, and weathering and displacement of rock. Monitoring should take place on a regular basis and after large flood events. It is important to keep written records of observations. Photographs provide invaluable records of changing conditions. All records should be kept in the operation, maintenance, and inspection manual for the dam.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Downstream View of Open Channel Spillway



Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–59

Dam Safety: Open Channel Spillways
(Concrete Chutes and Weirs)

Concrete chutes and weirs are used for principal spillways and emergency spillways. The principal spillway is used to pass normal flows, and the emergency spillway provides additional flow capacity during large flood events. If the principal spillway for a dam is a concrete weir and/or chute, the flow capacity may be large enough that an emergency spillway is not needed. Unlike grass-lined channel spillways that should always be located on natural ground, a concrete weir or chute may be located on the dam, but must be properly designed so that the integrity of the dam is not endangered.

The main components of a concrete chute spillway are the inlet structure, control section, discharge channel, and outlet erosion control structure. The inlet structure conveys water to the control section. The control section is the highest point in the channel and regulates the outflow from the reservoir. It is usually located on or near the crest of the dam. The control section may consist of a concrete weir or may simply be the most elevated slab in the floor of the chute. The discharge channel is located downstream of the control section and conveys flow to the outlet erosion control structure. This structure is designed to dissipate most of the erosive energy of the flow before it enters the downstream channel.

Overall Design and Safety Considerations

Alignment

For good hydraulic performance, abrupt changes should be avoided. This applies to sudden changes in vertical elevation of the chute floor, abrupt widening or narrowing of the chute, and sharp turns in the chute. Anything that will abruptly disrupt or change the direction of the flow in the chute will reduce flow capacity and will place more stress on the concrete. The best performance is obtained when the distribution of flow is even across the channel.

Settlement and Movement

Abnormal settlement, heaving, deflections, and lateral movement of the sidewalls or floor slabs of the spillway can occur. Movements are usually caused by a loss of underlying material, excessive settlement of the fill, or the buildup of water pressure behind or under the structure. Any abnormal settlement, heaving, deflections or lateral movement in the concrete spillway should be immediately investigated by a registered professional engineer knowledgeable about dam safety. As necessary, plans and specifications for repair to the spillway should also be promptly developed and implemented by a registered professional engineer.

The concrete sidewalls and floor of the chute must have enough strength to withstand water loads, soil/fill loads, uplift forces, weathering, and abrasion. The forces of weathering, movement of abrasive materials by water flowing in the spillway, or cavitation may cause surface defects or more serious concrete deterioration. The freeze-thaw cycle is the most damaging weathering force acting on exposed concrete. The concrete's durability and resistance to weathering and deterioration will be determined by the concrete mix, age of the concrete, and proper sealing of the joints. Typical problems with concrete structures include scaling, spalling, honeycombing, bugholes, and popouts. Please refer to the "Problems with Concrete Materials" fact sheet for further explanation of these problems and more details about concrete durability and design. Plans and specifications for repair of structural cracks, or other structural problems, should be developed and implemented by a registered professional engineer so that the integrity of the spillway and/or embankment is not jeopardized.

Undermining

Undermining of the chute may occur at any point along its length. The chute may become undermined at the inlet and/or outlet due to an inadequate cutoff wall or erosion protection. Erosion beneath and alongside the spillway may also be caused by seepage and inadequate drainage. Undermining and erosion will lead to settlement of the undermined portions of the chute. If the concrete spillway is located on the embankment, undermining and collapse of portions of the chute will jeopardize the safety of the dam. If the spillway is located in the abutment, erosion and lowering of the lake level may result. A registered professional engineer should be hired to develop plans and specifications to repair undermining of the chute.

Cutoff Wall and Endwall

A cutoff wall should be placed at the entrance to the concrete chute to prevent the flow approaching and entering the chute from flowing beneath and undermining the floor slabs. Undermining of the chute can cause cracking and collapse of the slabs as the underlying material is eroded away. In addition, a cutoff wall is necessary at the downstream end of the chute in order to prevent undermining by flows exiting the chute and entering the downstream channel. The cutoff wall or endwall should be founded on bedrock or have adequate support to provide stability and prevent undermining of the wall itself.

Outlet Erosion Control Structure

The discharge at the outlet may exit the chute at a high velocity. Based on the anticipated velocity, energy, and volume of flow, a structure may be needed to protect the spillway and/or dam from erosion and undermining. Please refer to the "Outlet Erosion Control Structures" fact sheet for more detailed information.

Seepage

The rate and content of flow from weep holes and relief drains must be monitored and documented regularly. Muddy flow may indicate erosion of fill material along the spillway or piping through the embankment. The presence of soil particles or muddy flow from the drains indicates that the filter or underdrainage is not functioning properly and is allowing the migration of soil particles from the embankment. Sudden increases in flow, or muddy flow from the drains should be immediately investigated by a registered professional engineer in order to determine the cause and severity of the problem. Plans and specifications to properly control the seepage and repair the drain(s) and embankment should also be developed and carried out under the direction of a registered professional engineer.

In addition to monitoring the amount of flow, normal maintenance consists of removing all obstructions from drain holes and pipes to allow free drainage. Typical obstructions include debris, gravel, sediment and rodent nests. Water should not be permitted to submerge the pipe outlets for extended periods of time. This will inhibit inspection and maintenance and may cause the drains to clog. Also see the "Seepage Through Earthen Dams" fact sheet for more information.

Underdrainage and Weep Holes

Weep holes, relief drains and underdrains must be included with the concrete chute to relieve excessive water pressure or infiltration from behind the walls and floor. The drainage system for the chute should consist of correctly placed and sized drainage holes, perforated pipes, and filter and bedding materials, such as sand and gravel. Seepage can occur through the dam, along the contact between the embankment and the concrete chute, or through open joints and cracks. Uncontrolled seepage flow along the structure can erode the underlying fill material (undermining) which may cause cracking or buckling of the slabs. Excessive pressure behind the walls and floor of the chute can cause cracking and heaving of the concrete. The freeze-thaw cycle can increase the amount of stress and strain on the concrete and can also cause heaving, cracking and additional serious damage to the structure. Weep holes, relief drains, and underdrainage for a concrete chute spillway should be designed by a registered professional engineer.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources

Division of Water Resources

Fact Sheet

Fact Sheet 99–51

Dam Safety: Outlet Erosion Control Structures

(Stilling Basins)

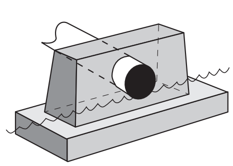
Water moving through the spillway of a dam contains a large amount of energy. This energy can cause erosion at the outlet which can lead to instability of the spillway. Failure to properly design, install, or maintain a stilling basin could lead to problems such as undermining of the spillway and erosion of the outlet channel and/or embankment material These problems can lead to failure of the spillway and ultimately the dam. A stilling basin provides a means to absorb or dissipate the energy from the spillway discharge and protects the spillway area from erosion and undermining. An outlet erosion control structure such as a headwall/endwall, impact basin, United States Department of the Interior, Bureau of Reclamation Type II or Type III basin, baffled chute, or plunge pool is considered an energy dissipating device. The performance of these structures can be affected by the tailwater elevation. The tailwater elevation is the elevation of the water that is flowing through the natural stream channel downstream during various flow conditions.

A headwall/endwall, impact basin, Type II or Type III basin, and baffled chute are all constructed of concrete. Concrete structures can develop surface defects such as minor cracking, bugholes, honeycombing, and spalling. Concrete structures can have severe structural defects such as exposed rebar, settlement, misalignment and large cracks. Severe defects can indicate structural instability.

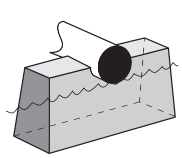
Headwall/Endwall

A headwall/endwall located at or close to the end of the discharge conduit will provide support and reduce the potential for undermining. A headwall/endwall is typically constructed of concrete, and it should be founded on bedrock or have an adequate foundation footing to provide support for stability. A headwall/endwall can become displaced if it is not adequately designed and is subject to undermining. Displacement of the headwall/endwall can lead to separation of the spillway conduit at the joints which could affect the integrity of the spillway conduit.

Headwall



Endwall

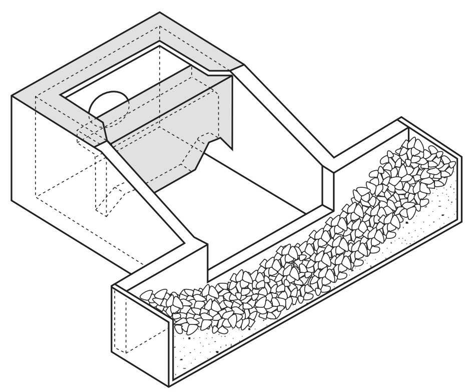


If a concrete structure develops the structural defects mentioned in the opening paragraphs, or if the discharge spillway conduit does not have a headwall/endwall, then a registered professional engineer should be contacted to evaluate the stability of the outlet.

Impact Basin

A concrete impact basin is an energy dissipating device located at the outlet of the spillway in which flow from the discharge conduit strikes a vertical hanging baffle.

Impact Basin

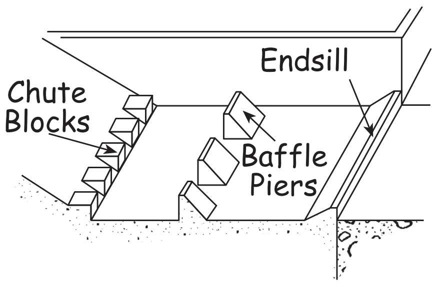


Discharge is directed upstream in vertical eddies by the horizontal portion of the baffle and by the floor before flowing over the endsill. Energy dissipation occurs as the discharge strikes the baffle, thus, performance is not dependent on tailwater. Most impact basins were designed by the United States Department of Agriculture, Natural Resources Conservation Service and the United States Department of Interior, Bureau of Reclamation. If any of the severe defects that are referenced in the opening paragraphs are observed, a registered professional engineer should be contacted to evaluate the stability of the outlet.

U.S. Department of Interior, Bureau of Reclamation Type II and Type III Basins

Type II and Type III basins reduce the energy of the flow discharging from the outlet of a spillway and allow the water to exit into the outlet channel at a reduced velocity. Type II energy dissipators contain chute blocks at the upstream end of the basin and a dentated (tooth-like) endsill. Baffle piers are not used in a Type II basin because of the high velocity water entering the basin.

Type III Basin

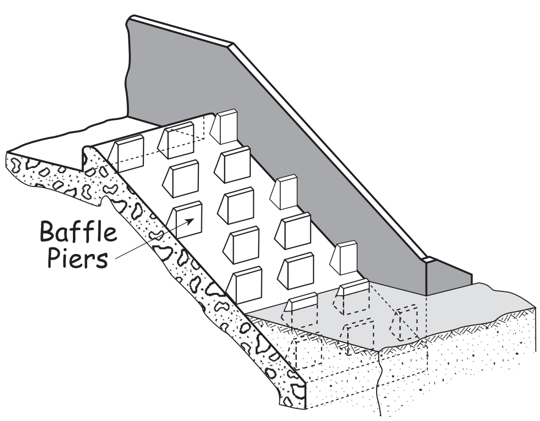


Type III energy dissipators can be used if the entrance velocity of the water is not high. They contain baffle piers which are located on the stilling basin apron downstream of the chute blocks. Located at the end of both the Type II and Type III basins is an endsill. The endsill may be level or sloped, and its purpose is to create the tailwater which reduces the outflow velocity. If any of the severe defects associated with concrete structures are observed, a registered professional engineer should be contacted to evaluate the stability of the basin.

Baffled Chute

Baffled chutes require no initial tailwater to be effective and are located downstream of the control section. Multiple rows of baffle piers on the chute prevent excessive acceleration of the flow and prevent the damage that occurs from a high discharge velocity. A portion of the baffled chute usually extends below the streambed elevation to prevent undermining of the chute. If any of the severe problems associated with concrete that are referenced in the opening paragraphs are observed, a registered professional engineer should be contacted to evaluate the stability of the outlet.

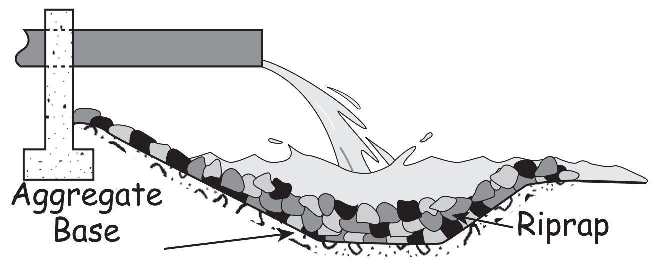
Baffeled Chute Basin



Plunge Pool

A plunge pool is an energy dissipating device located at the outlet of a spillway. Energy is dissipated as the discharge flows into the plunge pool. Plunge pools are commonly lined with rock riprap or other material to prevent excessive erosion of the pool area. Discharge from the plunge pool should be at the natural streambed elevation. Typical problems may include movement of the riprap, loss of fines from the bedding material and scour beyond the riprap and lining. If scour beneath the outlet conduit develops,

Plunge Pool



the conduit will be left unsupported and separation of the conduit joints and undermining may occur. Separation of the conduit joints and undermining may lead to failure of the spillway and ultimately the dam. A registered professional engineer should be contacted to ensure that the plunge pool is designed properly.

Additional information about related topics can be found on the following fact sheets: "Inspection of Concrete Structures," "Spillway Conduit System Problems," "Open Channel Spillways (Concrete Chutes and Weirs)," and "Problems with Concrete Materials."

Any questions, comments, concerns, or fact sheet requests should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–57

Dam Safety: Problems with Metal Materials

Corrosion is a common problem for spillway conduits and other metal appurtenances. Corrosion is the deterioration or breakdown of metal because of a reaction with its environment. Exposure to moisture, acidic conditions, or salt will accelerate the corrosion process. Acid runoff from strip-mined areas will cause rapid corrosion of metal conduits. In these areas, conduits made of less corrodible materials such as concrete or plastic should be used. Soil types also factor into the amount of corrosion. Clayey soils can be more corrosive than sandy soils since they are poorly drained and poorly aerated. Silts are somewhere in between clays and sands. Some examples of metal conduits include ductile iron, smooth steel, and corrugated metal. Corrugated metal pipe is not recommended for use in dams since the service life for corrugated metal is only 25 to 30 years, whereas the life expectancy for dams is much longer. In areas of acidic water, the service life can be much less. Therefore, corrugated metal spillway conduits typically need to be repaired or replaced early in the dam's design life, which can be very expensive.

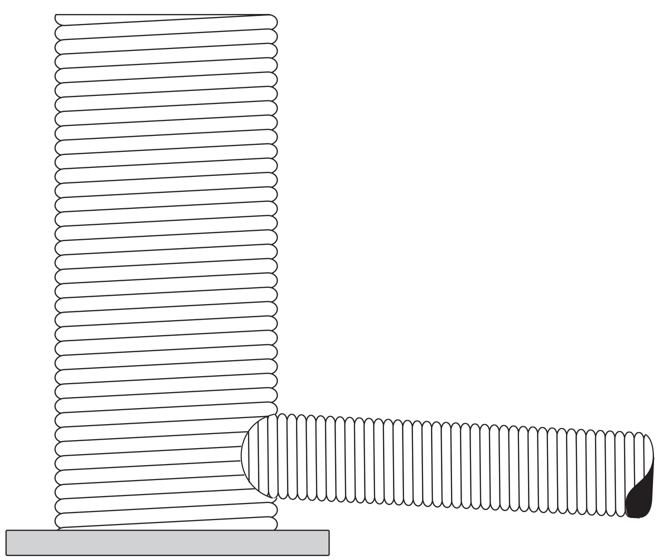


Figure 1 – Example of a corrugated metal pipe and riser spillway.

Conduit coating is an effective way of controlling corrosion of metal conduits if used properly. It is relatively inexpensive and extends the life of the conduit. Some examples of coatings include cement-mortar, epoxy, aluminum, or polyethylene film. Asphalt (bituminous) coatings are not recommended since their service life is usually only one or two years. Coatings must be applied to the conduit prior to installation and protected to ensure that the coating is not scratched off. Coatings applied to conduits in service are generally not very effective because of the difficulty in establishing an adequate bond.

Corrosion can also be controlled or arrested by installing cathodic protection. A metallic anode such as magnesium (or zinc) is buried in the soil and is connected to the metal conduit by wire. Natural voltage current flowing from the magnesium (anode) to the conduit (cathode) will cause the magnesium to corrode and not the conduit. However, sufficient maintenance funds should be allocated for the regular inspection of this active system.

If corrosion is allowed to continue, metal conduits will rust out. The spillway must be repaired before water flows through the rusted out portion of the conduit and erodes the fill material of the embankment. Continued erosion can lead to failure of the dam. Sliplining can be an economical and effective method of permanently restoring deteriorated spillways. During sliplining, a smaller diameter pipe is inserted into the old spillway conduit and then grout is used to fill in the void between the two pipes. If sliplining the spillway is not feasible, the lake may need to be drained and a new spillway must be installed. A registered professional engineer must be retained to develop and submit plans and specifications for any major modifications such as spillway sliplining or replacement.

Corrosion of the metal parts of the operating mechanisms such as lake drain valves and sluice gates can be effectively treated by keeping these parts lubricated and /or painted. If the device has not been operated in several years, a qualified person (i.e. manufacturer's representative or registered professional engineer) should inspect it to determine its operability. Caution must be used to prevent the mechanism from breaking. A registered professional engineer may be needed to prepare plans and specifications for repair if the device is determined to be inoperable.

Regular inspection and monitoring is essential to detect any problems with metal materials. Coatings on metal pipes should be inspected for scratched and worn areas. The inspector should also look for corrosion inside the spillway conduit. Proper ventilation and confined space precautions must be considered when entering the spillway conduit system. If using cathodic protection, regular inspections are required to verify that the system is working properly. It is important to keep written records of the amount of surface rust, pitting, and corrosion on any metal surface. Areas of thin metal should be monitored more frequently and repaired or replaced if they rust out. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem, and the Dam Safety Program should be contacted immediately. All records should be kept in the operation, maintenance, and inspection manual for the dam.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–58

Dam Safety: Problems with Plastic (Polymer) Materials

Plastics are often used as spillway and lake drain pipes in dam construction and repair. The most common plastic pipes are high-density polyethylene (HDPE) and polyvinyl chloride (PVC). The advantages of using plastic pipe include excellent abrasion resistance, chemical corrosion resistance, low maintenance, and long life expectancy. Naturally occurring chemicals in soils will not degrade plastic pipe and cause it to rot or corrode. Plastic pipes are also much easier to handle and install compared to heavier concrete and steel pipes.

Plastic pipes are considered flexible, and they get their strength from the material and the surrounding backfill whereas rigid pipes, such as concrete, get their strength from the material and the pipe structure. Backfill around plastic pipes must be properly compacted and in full contact with the pipe. It is important to take special care in the haunch area to prevent the pipe from lifting off the subgrade and disrupting vertical alignment. Symmetric backfilling is also required to prevent the pipe from being out of lateral alignment.

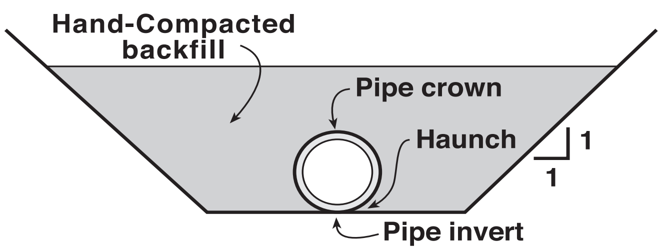


Figure 1 - Cross-section of plastic pipe in trench

When designing a new spillway system, a registered professional engineer will be required to specify the correct type of pressurized plastic pipe that can be used. The pipe must be able to withstand the pressures from the weight of the embankment without crushing or buckling. The joints must also be watertight. Not all plastic pipe will meet these requirements.

As with other plastic materials, ultraviolet light degradation can be a problem. Photo-degradation can cause plastic to become brittle and crack. Carbon black is the most effective additive to enhance the photo-degradation resistance of plastic materials. Pipes containing carbon black can be safely stored outside in most climates for many years without damage from ultraviolet exposure. Plastic pipes can be affected by liquid hydrocarbons such as gasoline and oil. If hydrocarbons come in contact with plastic pipe, they will permeate the pipe wall causing swelling and loss of strength. However, if the hydrocarbons are removed, the effects are reversible.

Regular inspection and monitoring is essential to detect any problems with plastic materials. Plastic pipes should be inspected for deformation and cracking. The inspector should also look at the interior condition of the spillway pipe. Proper ventilation and confined space precautions must be considered when entering the spillway pipe system. It is important to keep written records of pipe dimensions to note deformation and the length and width of cracks. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem, and the Dam Safety Program should be contacted immediately. All records should be kept in the operation, maintenance, and inspection manual for the dam.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 99–56

Dam Safety: Problems with Concrete Materials

Visual inspection of concrete will allow for the detection of distressed or deteriorated areas. Problems with concrete include construction errors, disintegration, scaling, cracking, efflorescence, erosion, spalling, and popouts.

Construction Errors

Errors made during construction such as adding improper amounts of water to the concrete mix, inadequate consolidation, and improper curing can cause distress and deterioration of the concrete. Proper mix design, placement, and curing of the concrete, as well as an experienced contractor are essential to prevent construction errors from occurring. Construction errors can lead to some of the problems discussed later in this fact sheet such as scaling and cracking. Honeycombing and bugholes can be observed after construction.

Honeycombing can be recognized by exposed coarse aggregate on the surface without any mortar covering or surrounding the aggregate particles. The honeycombing may extend deep into the concrete. Honeycombing can be caused by a poorly graded concrete mix, by too large of a coarse aggregate, or by insufficient vibration at the time of placement. Honeycombing will result in further deterioration of the concrete due to freeze-thaw because moisture can easily work its way into the honeycombed areas. Severe honeycombing should be repaired to prevent further deterioration of the concrete surface.

Bugholes is a term used to describe small holes (less than about 0.25 inch in diameter) that are noticeable on the surface of the concrete. Bugholes are generally caused by too much sand in the mix, a mix that is too lean, or excessive amplitude of vibration during placement. Bugholes may cause durability problems with the concrete and should be monitored.

Disintegration and Scaling

Disintegration can be described as the deterioration of the concrete into small fragments and individual aggregates. Scaling is a milder form of disintegration where the surface mortar flakes off. Large areas of crumbling (rotten) concrete, areas of deterioration which are more than about 3 to 4 inches deep (depending on the wall/slab thickness), and exposed rebar indicate serious concrete deterioration. If not repaired, this type of concrete deterioration may lead to structural instability of the concrete structure. A registered professional engineer must prepare plans and specifications for repair of serious concrete deterioration. For additional information, see the “Concrete Repair Techniques” fact sheet.

Disintegration can be a result of many causes such as freezing and thawing, chemical attack, and poor construction practices. All exposed concrete is subject to freeze-thaw, but the concrete’s resistance to weathering is determined by the concrete mix and the age of the concrete. Concrete with the proper amounts of air, water, and cement, and a properly sized aggregate, will be much more durable. In addition, proper drainage is essential in preventing freeze-thaw damage. When critically saturated concrete (when 90% of the pore space in the concrete is filled with water) is exposed to freezing temperatures, the water in the pore spaces within the concrete freezes and expands, damaging the concrete. Repeated cycles of freezing and thawing will result in surface scaling and can lead to disintegration of the concrete. Hydraulic structures are especially susceptible to freeze-thaw damage since they are more likely to be critically saturated. Older structures are also more susceptible to freeze-thaw damage since the concrete was not air entrained. In addition, acidic substances in the surrounding soil and water can cause disintegration of the concrete surface due to a reaction between the acid and the hydrated cement.

Cracks

Cracks in the concrete may be structural or surface cracks. Surface cracks are generally less than a few millimeters wide and deep. These are often called hairline cracks and may consist of single, thin cracks, or cracks in a craze/map-like pattern. A small number of surface or shrinkage cracks is common and does not usually cause any problems. Surface cracks can be caused by freezing and thawing, poor construction practices, and alkali-aggregate reactivity. Alkali-aggregate reactivity occurs when the aggregate reacts with the cement causing crazing or map cracks. The placement of new concrete over old may cause surface cracks to develop. This occurs because the new concrete will shrink as it cures. Surface cracks in the spillway should be monitored and will need to be repaired if they deteriorate further.

Structural cracks in the concrete are usually larger than 0.25 inch in width. They extend deeper into the concrete and may extend all the way through a wall, slab, or other structural member. Structural cracks are often caused by settlement of the fill material supporting the concrete structure, or by loss of the fill support due to erosion. The structural cracks may worsen in severity due to the forces of weathering. A registered professional engineer knowledgeable about dam safety must investigate the cause of structural cracks and prepare plans and specifications for repair of any structural cracks. For additional information, see the "Concrete Repair Techniques" fact sheet.

Efflorescence

A white, crystallized substance, known as efflorescence, may sometimes be noted on concrete surfaces, especially spillway sidewalls. It is usually noted near hairline or thin cracks. Efflorescence is formed by water seeping through the pores or thin cracks in the concrete. When the water evaporates, it leaves behind some minerals that have been leached from the soil, fill, or concrete. Efflorescence is typically not a structural problem. Efflorescence should be monitored because it can indicate the amount of seepage finding its way through thin cracks in the concrete and can signal areas where problems (i.e. inadequate drainage behind the wall or deterioration of concrete) could develop. Also, water seeping through thin cracks in the wall will make the concrete more susceptible to deterioration due to freezing and thawing of the water.

Erosion

Erosion due to abrasion results in a worn concrete surface. It is caused by the rubbing and grinding of aggregate or other debris on the concrete surface of a spillway channel or stilling basin. Minor erosion is not a problem but severe erosion can jeopardize the structural integrity of the concrete. A registered professional engineer must prepare plans and specifications for repair of this type of erosion if it is severe.

Erosion due to cavitation results in a rough, pitted concrete surface. Cavitation is a process in which subatmospheric pressures, turbulent flow and impact energy are created and will damage the concrete. If the shape of the upper curve on the ogee spillway is not designed close to its ideal shape, cavitation may occur just below the upper curve, causing erosion. A registered professional engineer must prepare plans and specifications for repair of this type of erosion if the concrete becomes severely pitted which could lead to structural damage or failure of the structure.

Spalling and Popouts

Spalling is the loss of larger pieces or flakes of concrete. It is typically caused by sudden impact of something dropped on the concrete or stress in the concrete that exceeded the design. Spalling may occur on a smaller scale, creating popouts. Popouts are formed as the water in saturated coarse aggregate particles near the surface freezes, expands, and pushes off the top of the aggregate and surrounding mortar to create a shallow conical depression. Popouts are typically not a structural problem. However, if a spall is large and causes structural damage, a registered professional engineer must prepare plans and specifications to repair the spalling.

Inspection and Monitoring

Regular inspection and monitoring is essential to detect problems with concrete materials. Concrete structures should be inspected a minimum of once per year. The inspector should also look at the interior condition of concrete spillway conduit. Proper ventilation and confined space precautions must be considered when entering a conduit. It is important to keep written records of the dimensions and extent of scaling, disintegration, efflorescence, honeycombing, erosion, spalling, popouts, and the length and width of cracks. Structural cracks should be monitored more frequently and repaired if they are a threat to the stability of the structure or dam. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem, and the Dam Safety Program should be contacted immediately. All records should be kept in the operation, maintenance, and inspection manual for the dam.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources

Division of Water Resources

Fact Sheet

Fact Sheet 94–33

Dam Safety: Inspection of Concrete Structures

Dams, dikes, and levees must not be thought of as part of the natural landscape, but as man-made structures which must be designed, inspected, operated, and maintained accordingly. Routine maintenance and inspection of dams and appurtenant facilities should be an ongoing process to ensure that structural failures do not occur which can threaten the overall safety of the dam. The information provided in this fact sheet pertains entirely to the inspection of concrete structures used at dams. The intention is to help dam owners become more aware of common problems that are typically encountered with concrete so that they can more readily address the seriousness of a particular condition whenever it arises.

Structural Inspections

Concrete surfaces should be visually examined for spalling and deterioration due to weathering, unusual or extreme stresses, alkali or other chemical attack, erosion, cavitation, vandalism, and other destructive forces. Structural problems are indicated by cracking, exposure of reinforcing bars, large areas of broken-out concrete, misalignment at joints, undermining and settlement in the structure. Rust stains that are noted on the concrete may indicate that internal corrosion and deterioration of reinforcement steel is occurring. Spillway floor slabs and upstream slope protection slabs should be checked for erosion of underlying base material otherwise known as undermining. Concrete walls and tower structures should be examined to determine if settlement and misalignment of construction joints has occurred.

What to Look For

Concrete structures can exhibit many different types of cracking. Deep, wide cracking is due to stresses which are primarily caused by shrinkage and structural loads. Minor or hairline surface cracking is caused by weathering and the quality of the concrete that was applied. The results of this minor cracking can be the eventual loss of concrete, which exposes reinforcing steel and accelerates deterioration. Generally, minor surface cracking does not affect the structural integrity and performance of the concrete structure.

Cracks through concrete surfaces exposed to flowing water may lead to the erosion or piping of embankment or foundation soils from around and/or under the concrete structure. In this case, the cracks are not the result of a problem but are the detrimental condition which leads to piping and erosion. Seepage at the discharge end of a spillway or outlet structure may indicate leakage of water through a crack. Proper underdrainage for open channel spillways with structural concrete floors is necessary to control this leakage. Flows from underdrain outlets and pressure relief holes should also be observed and measured. Cloudy flows may indicate that piping is occurring beneath or adjacent to the concrete structure. This could be detrimental to the foundation support.

Concrete surfaces adjacent to contraction joints and subject to flowing water are of special concern especially in chute slabs. The adjacent slabs must be flush or the downstream one slightly lower to prevent erosion of the concrete and to prevent water from being directed into the joint during high velocity flow. All weep holes should be checked for the accumulation of silt and granular deposits at their outlets. These deposits may obstruct flow or indicate loss of support material behind the concrete surfaces. Tapping the concrete surface with a hammer or some other device will help locate voids if they are present as well as give an indication of the condition and soundness of the concrete. Weep holes in the concrete are used to allow free drainage and relieve excessive hydrostatic pressures from building up underneath the structure. Excessive hydrostatic pressures underneath the concrete could cause it to heave or crack which increases the potential for accelerated deterioration and undermining. Periodic monitoring of the weep hole drains should be performed and documented on a regular and routine basis to ensure that they are functioning as designed.

Structural cracking of concrete is usually identified by long, single or multiple diagonal cracks with accompanying displacements and misalignment. Cracks extending across concrete slabs which line open channel spillways or provide upstream slope wave protection can indicate a loss of foundation support resulting from settlement, piping, undermining, or erosion of foundation soils. Piping and erosion of foundation soils are the result of inadequate underdrainage and/or cutoff walls. Items to consider when evaluating a suspected structural crack are the concrete thickness, the size and location of the reinforcing steel, the type of foundation, and the drainage provision for the structure.

Inspection of intake structures, trashracks, upstream conduits, and stilling basin concrete surfaces that are below the water surface is not readily feasible during a regularly scheduled inspection. Typically, stilling basins require the most regular monitoring and major maintenance because they are holding ponds for rock and debris, which can cause extensive damage to the concrete surfaces during the dissipation of flowing water. Therefore, special inspections of these features should be performed at least once every five years by either dewatering the structure or when operating conditions permit. Investigation of these features using experienced divers is also an alternative.

Preparing for an Inspection

Before an inspection of the dam's concrete facilities is performed, it is recommended that a checklist be developed that includes all the different components of the spillway and/or outlet works. The checklist should also include a space for logging any specific observations about the structure and the state of its condition. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem. If there are any questions as to the seriousness of an observation the Dam Safety Program, or a registered professional engineer experienced with dams, should be contacted.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov
Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Fact Sheet

Fact Sheet 94–32

Dam Safety: Concrete Repair Techniques

Concrete is an inexpensive, durable, strong and basic building material often used in dams for core walls, spillways, stilling basins, control towers, and slope protection. However, poor workmanship, construction procedures, and construction materials may cause imperfections that later require repair. Any long-term deterioration or damage to concrete structures caused by flowing water, ice, or other natural forces must be corrected. Neglecting to perform periodic maintenance and repairs to concrete structures as they occur could result in failure of the structure from either a structural or hydraulic standpoint. This in turn may threaten the continued safe operation and use of the dam.

Considerations

Floor or wall movement, extensive cracking, improper alignments, settlement, joint displacement, and extensive undermining are signs of major structural problems. In situations where concrete replacement solutions are required to repair deteriorated concrete, it is recommended that a registered professional engineer be retained to perform an inspection to assess the concrete's overall condition, and determine the extent of any structural damage and necessary remedial measures.

Typically, it is found that drainage systems are needed to relieve excessive water pressures under floors and behind walls. In addition, reinforcing steel must also be properly designed to handle tension zones and shear and bending forces in structural concrete produced by any external loading (including the weight of the structure). Therefore, the finished product in any concrete repair procedure should consist of a structure that is durable and able to withstand the effects of service conditions such as weathering, chemical action, and wear. Because of their complex nature, major structural repairs that require professional advice are not addressed here.

Repair Methods

Before any type of concrete repair is attempted, it is essential that all factors governing the deterioration or failure of the concrete structure are identified. This is required so that the appropriate remedial measures can be undertaken in the repair design to help correct the problem and prevent it from occurring in the future. The following techniques require expert and experienced assistance for the best results. The particular method of repair will depend on the size of the job and the type of repair required.

1. The Dry-Pack Method: The dry-pack method can be used on small holes in new concrete which have a depth equal to or greater that the surface diameter. Preparation of a dry-pack mix typically consists of about 1 part portland cement and 2 1/2 parts sand to be mixed with water. You then add enough water to produce a mortar that will stick together. Once the desired consistency is reached, the mortar is ready to be packed into the hole using thin layers.

2. Concrete Replacement: Concrete replacement is required when one-half to one square foot areas or larger extend entirely through the concrete sections or where the depth of damaged concrete exceeds 6 inches. When this occurs, normal concrete placement methods should be used. Repair will be more effective if tied in with existing reinforcing steel (rebar). This type of repair will require the assistance of a professional engineer experienced in concrete construction.

3. Replacement of Unformed Concrete: The replacement of damaged or deteriorated areas in horizontal slabs involves no special procedures other than those used in good construction practices for placement of new slabs. Repair work can be bonded to old concrete by use of a bond coat made of equal amounts of sand and cement. It should have the consistency of whipped cream and should be applied immediately ahead of concrete placement so that it will not set or dry out. Latex emulsions with portland cement and epoxy resins are also used as bonding coats.

4. Preplaced Aggregate Concrete: This special commercial technique has been used for massive repairs, particularly for underwater repairs of piers and abutments. The process consists of the following procedures: 1) Removing the deteriorated concrete, 2) forming the sections to be repaired, 3) prepacking the repair area with coarse aggregate, and 4) pressure grouting the voids between the aggregate particles with a cement or sand-cement mortar.

5. Synthetic Patches: One of the most recent developments in concrete repair has been the use of synthetic materials for bonding and patching. Epoxy-resin compounds are used extensively because of their high bonding properties and great strength. In applying epoxy-resin patching mortars, a bonding coat of the epoxy resin is thoroughly brushed onto the base of the old concrete. The mortar is then immediately applied and troweled to the elevation of the surrounding material.

Before attempting to repair a deteriorated concrete surface, all unsound concrete should be removed by sawing or chipping and the patch area thoroughly cleaned. A sawed edge is superior to a chipped edge, and sawing is generally less costly than mechanical chipping. Before concrete is ordered for placing, adequate inspection should be performed to ensure that (1) foundations are properly prepared and ready to receive the concrete, (2) construction joints are clean and free from defective concrete, (3) forms are grout-tight, amply strong, and set to their true alignment and grade, (4) all reinforcement steel and embedded parts are clean, in their correct position, and securely held in place, and (5) adequate concrete delivery equipment and facilities are on the job, ready to go, and capable of completing the placement without addition unplanned construction.

Concrete Use Guidelines

In addition to its strength characteristics, concrete must also have the properties of workability and durability. Workability can be defined as the ease with which a given set of materials can be mixed into concrete and subsequently handled, transported, and placed with a minimal loss of homogeneity. The degree of workability required for proper placement and consolidation of concrete is governed by the dimensions and shape of the structure and by the spacing and size of the reinforcement. The concrete, when properly placed, will be free of segregation, and its mortar is intimately in contact with the coarse aggregate, the reinforcement, and/or any other embedded parts or surfaces within the concrete. Separation of coarse aggregate from the mortar should be minimized by avoiding or controlling the lateral movement of concrete during handling and placing operations. The concrete should be deposited as nearly as practicable in its final position. Placing methods that cause the concrete to flow in the forms should be avoided. The concrete should be placed in horizontal layers, and each layer should be thoroughly vibrated to obtain proper compaction.

All concrete repairs must be adequately moist-cured to be effective. The bond strength of new concrete to old concrete develops much more slowly, and the tendency to shrink and loosen is reduced by a long moist-curing period.

In general, the concrete repair procedures discussed above should be considered on a relative basis and in terms of the quality of concrete that one wishes to achieve for their particular construction purpose. In addition to being adequately designed, a structure must also be properly constructed with concrete that is strong enough to carry the design loads, durable enough to withstand the forces associated with weathering, and yet economical, not only in first cost, but in terms of its ultimate service. It should be emphasized that major structural repairs to concrete should not be attempted by the owner or persons not experienced in concrete repairs. A qualified professional engineer experienced in concrete construction should be obtained for the design of large scale repair projects.

Crack Repair

The two main objectives when repairing cracks in concrete are structural bonding and stopping water flow. For a structural bond, epoxy injection can be used. This process can be very expensive since a skilled contractor is needed for proper installation. The epoxy is injected into the concrete under pressure, welding the cracks to form a monolithic structure. This method of repair should not be considered if the crack is still active (moving). For a watertight seal, a urethane sealant can be used. This repair technique does not form a structural bond; however, it can be used on cracks that are still active. Cracks should be opened using a concrete saw or hand tool prior to placing the sealant. A minimum opening of $^{1}/_{4}$ inch is recommended since small openings are hard to fill. Urethane sealants can be reapplied since they are flexible materials and will adhere to older applications. As previously noted, all of the factors causing cracking must be identified and addressed before repairing the concrete to prevent the reoccurrence of cracks.

Any other questions, comments concerns, or fact sheet requests, should be directed to:

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road
Columbus, OH 43229-6693
(614) 265-6731
dswc@dnr.state.oh.us
water.ohiodnr.gov

Emergency 24hr hotline: (614) 799-9538

Ohio Department of Natural Resources
Division of Water Resources
Dam Safety Program
2045 Morse Road, B-3
Columbus, Ohio 43229
Voice: 614/265-6731
E-mail: dswc@dnr.state.oh.us
Website: http://ohiodnr.gov/water
Emergency 24 hour hotline: 614/799-9538

Revised 8/2019

APPENDIX C

GEOTECHNICAL ENGINEERING REPORT –
NOVEMBER 25, 2019

GEOTECHNICAL ENGINEERING REPORT

SLOPE STABILIZATION
OBERLIN WATERWORKS UPGROUND #1 & 2RESERVOIRS
ODNR FILE NO. 1221-018
CEDAR STREET & MORGAN STREET
OBERLIN, LORAIN COUNTY, OHIO

CTL PROJECT NO. 19050024CLE

PREPARED FOR:

ENVIRONMENTAL DESIGN GROUP
450 GRANT STREET
AKRON, OHIO 44311

PREPARED BY:

CTL ENGINEERING, INC.
3085 INTERSATE PARKWAY
BRUNSWICK, OHIO 44212
www.ctleng.com

November 25, 2019

CTL
ENGINEERING INC.

Contents Page

I. PROJECT LOCATION AND DESCRIPTION

The project site is located near Cedar Street & Morgan Street, in Oberlin, Lorain County, Ohio. The site consists of two abutting reservoirs identified as Reservoir #1 and Reservoir #2. CTL understands that an alternative being investigated may be to eliminate reservoir number 2 and maintain reservoir number 1. However, the stability of the embankment around reservoir number 1 must be evaluated, specifically the west side embankment (Eastern dam) that separate the two reservoirs. This stability analysis between the reservoirs is also required for ODNR to consider regulating the reservoirs separately.

This report presents the results of a subsurface investigation, slope stability analysis, and recommendations for improvement along the embankment around reservoir number 1, specifically the west side embankment (Eastern dam) that separates the two reservoirs and near southeast corner of reservoir number 1.

II. SUBSURFACE EXPLORATION

Soil Borings

On November 5, 2019 DC drillers under the directions of CTL Engineering advanced four (4) soil test borings identified as B-01 to B-04 to the depths of 30 feet below existing grade. CTL Engineering, in collaboration with Environmental Design Group, selected the boring locations as shown approximately on the enclosed Boring Location Plan in Appendix A.

CTL Engineering field located the borings and obtained their respective surface elevations using provided Topographic Map. Contractors and design engineers should not rely on these elevations and any elevations stated in this report unless they are field verified prior to construction.

The drillers obtained soil samples at 2.5- foot interval in upper 10 feet and at 5-foot interval thereafter using Standard Penetration Tests (SPTs). The SPT consists of driving a 2.0-inch outside diameter (OD) split-spoon sampler 18 inches into the soil with an automatic 140-pound hammer falling 30 inches. The SPT hammer used for this project had an energy ratio of 75 percent in obtaining industry standard N-values (N_{60}-values).

The drilling crew visually classified the soil samples then secured them in glass jars and delivered them to accredited CTL laboratory for further testing and analysis. A CTL geologist reclassified the soil samples and performed laboratory testing on representative samples under the direction of the Geotechnical Engineer. The laboratory testing included moisture content, Atterberg limits, grain size distribution and unconfined compression.

The drilling, sampling, and soil testing was performed in accordance with standard geotechnical engineering practices and current ASTM procedures. Appendices B and C include the test boring records and laboratory test results, respectively.

III. FINDINGS

A. Visual Observations

Reservoir No. 1 consists of elevated earthen berms or embankments along the west, south, and east sides. The majorities of these earthen berms are wooded /covered with brush with the exception of the outer slopes of the east embankment where the terrain consisted of mowed grass. CTL did not notice any surface seepage along the toes of the east embankment. The south embankment is wooded and covered with brush and was not feasible to observe seepage if any.

The terrain along the south embankment and at the southeast corner of reservoir No. 1 beyond the earthen berm consisted of a narrow relatively mild graded plateau over a steep drop into Plum Creek. CTL noted ongoing natural erosion along the boundary between the creek and the reservoir. Based on visual observations during the reconnaissance, CTL did not notice slope failures of the existing embankments, we noted the erosion and the irregularities as stated in the ODNR Safety Inspection Report.

Photograph 1: Toe Erosion near Plum Creek at SE of Reservoir #1.

B. Site Geology

According to the United States Department of Agriculture (USDA), the project site consists of three major soil groups: Two variations of the Mahoning Silt Loam (MgA and MgB), and the Orrville Silt Loam (Or).

<u>MgA Typical Profile:</u>

Parent Material	: Till
Land form	: Till Plains
Slope	: 0 to 2 percent
Drainage class	: Somewhat poorly drained
Ap - 0 to 7 inches	: silt loam
Eg - 7 to 9 inches	: silt loam
Btg - 9 to 12 inches	: silty clay loam
Bt1 - 12 to 20 inches	: silty clay
Bt2 - 20 to 30 inches	: silty clay
BCt - 30 to 36 inches	: clay loam
C - 36 to 60 inches	: clay loam

<u>MgB Typical Profile:</u>

Parent Material	: Till
Land form	: Till Plains
Slope	: 2 to 6 percent
Drainage class	: Somewhat poorly drained
Ap - 0 to 7 inches	: silt loam
Eg - 7 to 9 inches	: silt loam
Btg - 9 to 12 inches	: silty clay loam
Bt1 - 12 to 20 inches	: silty clay
Bt2 - 20 to 30 inches	: silty clay
BCt - 30 to 36 inches	: clay loam
C - 36 to 60 inches	: clay loam

<u>Or Typical Profile:</u>

Parent Material	: Alluvium
Land form	: Flood Plains
Slope	: 0 to 2 percent
Drainage class	: Somewhat poorly drained
H1 - 0 to 8 inches	: silt loam
H2 - 8 to 42 inches	: silty clay loam
H3 - 42 to 60 inches	: silty clay

According to the Ohio Department of Natural Resources' Division of Geological Survey (SG-2 Maps), the project site consists of approximately 10 feet of Holocene-age alluvium sediments. These deposits are commonly organic, not compact, and can include a wide variety of textures from silt and clay to boulders. The alluvium deposits are followed by approximately 40 feet of Wisconsinan Till: unsorted mix of textures from clay to boulders that were deposited by several ice advances in the region. These deposits tend to contain higher amounts of clay near surface and decreases with depth. The till is followed by 20 feet of Wisconsinan sand and gravel, which may contain thin layers of silt and clay. The bedrock beneath the site consists of Mississippian and Devonian age shale and sandstone, but is primarily dominated by Mississippian Berea Sandstone.

The project site is located on the boundary of two physiographic regions: The Berea Headlands of the Till Plain, and The Berea Headlands of the Erie Lake Plain. According to the ODNR, these two regions are fairly similar: thin, clayey, medium-lime deposits underlain by resistant Berea Sandstone. The main difference being the parent material of each classification, is till or lacustrine.

According to ODNR's Mine Locator, there are no inactive or active underground mines in the approximate vicinity of the project site.

C. Subsurface Conditions

The surface material at the boring locations consisted of about 6 to 8 inches of gravel/topsoil. The subsurface material consisted of about 6 to 23 feet of fill comprised of medium stiff to hard silty clay. The natural soils are primarily consisted medium stiff to hard silty clay followed by medium dense to dense clayey silt.

The Standard Penetration Test (SPT) and moisture content values within the fill ranged mostly from 5 to 31 blows per foot (bpf) and from 9 to 23 percent respectively. The SPT values and moisture contents within natural deposits ranged from 5 to 62 blows per foot (bpf), and from 8 to 21 percent respectively. The Liquid Limits and Plasticity Index of the cohesive soils ranged from 22 to 41 percent and 6 to 20 percent respectively.

D. Ground Water

Groundwater was encountered during drilling in test borings B-01 and B-02 at a depth of approximately 18 feet (about elevation of 796 feet) and at completion in test borings B-02 and B-04 at depths of approximately 8.5 feet and 11 feet below the existing grades (about elevations of 805.5 feet and 795 feet) respectively. It should be noted that fluctuations in groundwater levels should be expected over time due to variations in precipitation, surrounding groundwater use, and the time of year, the measurements are determined. Static groundwater levels can only be determined through observations made in cased holes over relatively long periods.

IV. ANALYSIS & RECOMMENDATIONS

The conclusions and recommendations presented herewith are based on the data obtained from the field exploration, laboratory-testing programs, available information, provided

Topographic map, and slope stability analysis.

A. Slope Stability Analysis

One representative most critical slope section identified on the Boring Location Plan in Appendix A as A-A near bore hole 1 (B-01) was considered for the slope stability analysis. The slope stability analysis was performed using Slide 2018, a 2-dimentional limiting equilibrium program. The soil profile was based on soil borings performed on top of slope.

Random failure surfaces in the 100's were generated and analyzed in terms of factor of safety (FOS) against slope failure. The results indicated that the minimum Factor of Safety (FOS) values against global rotational failure was 1.06 under rapid draw down condition and 1.25 for steady state condition after emptying reservoir 2. The results of the slope stability analysis including soil data are summarized in Appendix D.

A FOS of 1.3 or greater for this project would be considered an indication of stable condition. A FOS of 1.0 or less would be an indication of high probability of slope instability and/or occurring failures.

The FOS determined for the existing conditions under rapid draw down condition indicates potentially unstable slope section. The minimum factor of safety determined under effective stress condition in a staged drawdown indicates a marginally acceptable stable slope after emptying reservoir 2.

The soil at boring B-4 at the southeast side of reservoir #1 is very stiff and does not pose potential for slope instability. Only continuous long-term erosion along Plum Creek may compromise the stability of the dam at this location.

B. Recommendations

- Rapid drawdown should be avoided when draining Reservoir #2. We recommend lowering Reservoir #2 water level in stages at one (1) foot interval per 10 days.

- Repair all eroded areas along Reservoir #1 by placing rock fills and aggregates. Monitor the erosion along the boundary between the Plum Creek and Reservoir #1 near the southeast corner and apply erosion control using Riprap when it becomes necessary.

- After draining Reservoir #2, evaluate the conditions along the toe and plan a contingency to install 4-inch perforated toe drains wrapped with filter fabric along the downstream toe of South half of the embankment to decrease pore pressure in the downstream face and improve stability of the west embankment of the remaining reservoir.

V. CHANGED CONDITIONS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year. In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided in this report, CTL Engineering should be notified so that our recommendations can modified, if required.

VI. TESTING AND OBSERVATION

During the design process, it is recommended that CTL Engineering work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

VII. CLOSURE

The report was prepared by CTL Engineering, Inc. (Consultant) solely for the use of the Client in accordance with an executed contract. The Client's use of or reliance on this report is limited by the terms and conditions of the contract and by the qualifications and limitations stated in the report. It is also acknowledged that the Client's use of and reliance of this report is limited for reasons which include: actual site conditions that may change with time; hidden conditions, not discoverable within the scope of the assessment, may exist at the site; and the scope of the investigation may have been limited by time, budget and other constraints imposed by the Client.

Neither the report, nor its contents, conclusions nor recommendations are intended for the use of any party other than the Client. Consultant and the Client assume no liability for any reliance placed on this report by such party. The rights of the Client under contract may not be assigned to any person or entity, without the consent of the Consultant which consent shall not be unreasonably withheld.

This geotechnical report does not address the environmental conditions of the site. The Consultant is not responsible for consequences or conditions arising from facts that were concealed, withheld, or not fully disclosed at the time the assessment was conducted.

To the fullest extent permitted by law, the Consultant and Client agree to indemnify and hold each other, and their officers and employees harmless from and against claims, damages, losses and expenses arising out of unknown or concealed conditions. Furthermore, neither the Consultant nor its employees shall be liable to the Owner in an amount in excess of the available professional liability insurance coverage of the Consultant. In addition, Client and Consultant agree neither shall be liable for any special, indirect or consequential damages of any kind or nature.

The Consultant's services have been provided consistent with its professional standard of care. No other warranties are made, either expressed or implied.

Respectfully Submitted,
CTL ENGINEERING, INC.

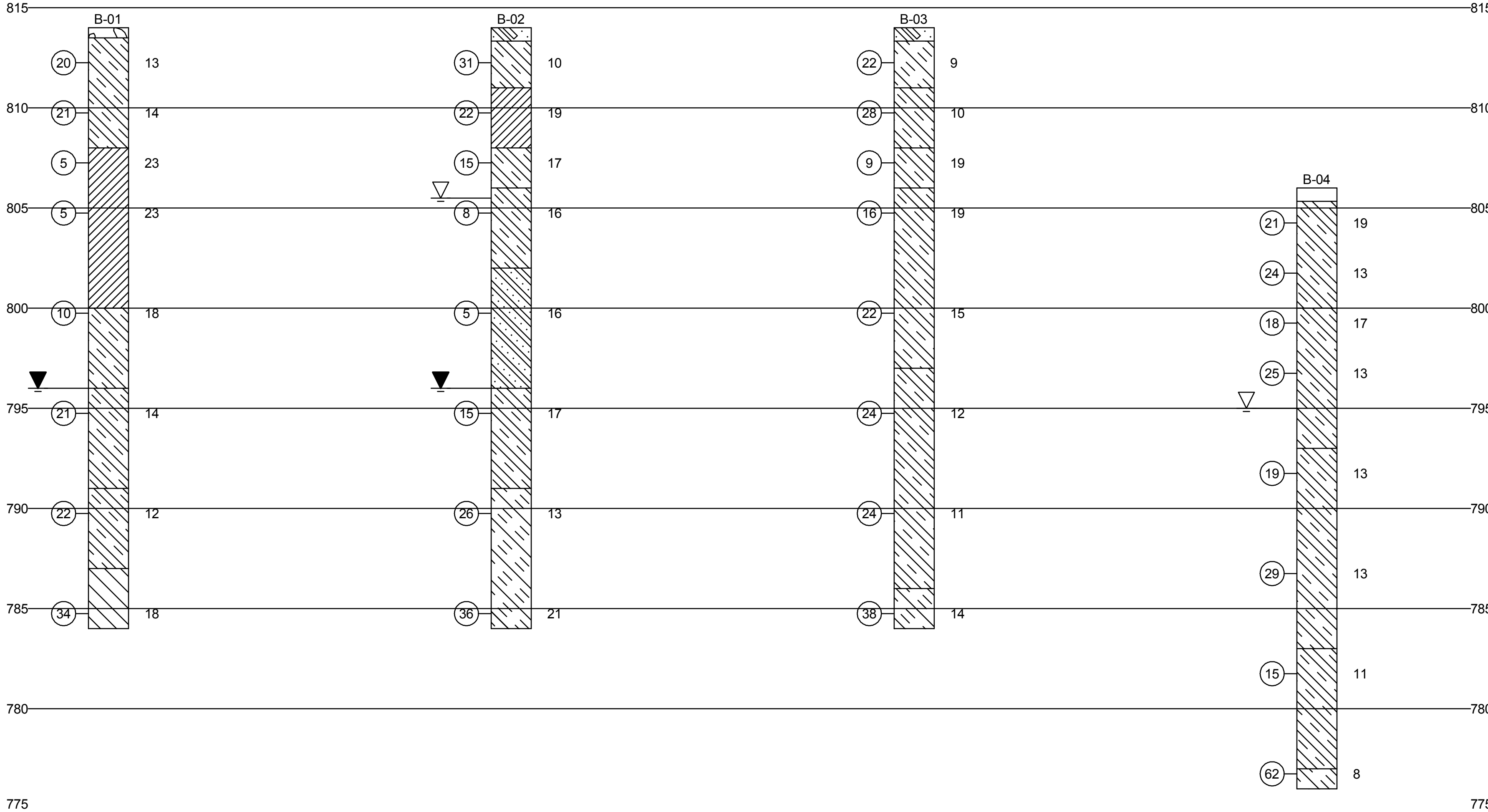
Nithya K Manikkam, Ph.D
Engineer in Training

Matthew Kairouz, P.E.
Project Engineer

APPENDIX A

- BORING LOCATION PLAN
- SOIL PROFILE

	SITE LOCATION MAP			
	Date 11/20/2019	EDG Oberlin Waterworks Upground Morgan St and S. Cedar St Oberlin, OH		
CTL ENGINEERING, INC. GEOTECHNICAL ENGINEERS TESTING * INSPECTION LABORATORY SERVICES	**Scale** None			
	Drawn By MK	**Reviewed By**	**Page** 1 of 1	**Project No.** 19050024CLE



TOPSOIL, ASPHALT, GW, GP, GW-GM, GW-GC, GP-GM, GP-GC, GM, GC, GC-GM, SW, SP, SW-SM, SW-SC, SP-SM, SP-SC, SM, SC, SC-SM, ML, CL, CL-ML, OL, CH, MH, OH, PT, SHALE, SILTSTONE, LIMESTONE, FILL

LEGEND

GROUND WATER DURING DRILLING

GROUND WATER AT COMPLETION OF DRILLING

GROUND WATER AT "N" HOURS AFTER COMPLETION

W — MOISTURE CONTENT IN PERCENT (w)

(N) — STANDARD PENETRATION IN BLOWS PER FOOT (N)

B-01

CTL ENGINEERING, INC.
CONSULTING ENGINEERS
3085 Interstate Parkway
Brunswick, Ohio 44212

SOIL PLAN/PROFILE		
DATE 11/20/2019	Environmental Design Group	
SCALE AS SHOWN	Oberlin Waterworks #1 & 2 Cedar & Morgan St, Oberlin, OH	
DRAWN BY MK	PAGE 1 OF 1	PROJECT NUMBER 19050024CLE

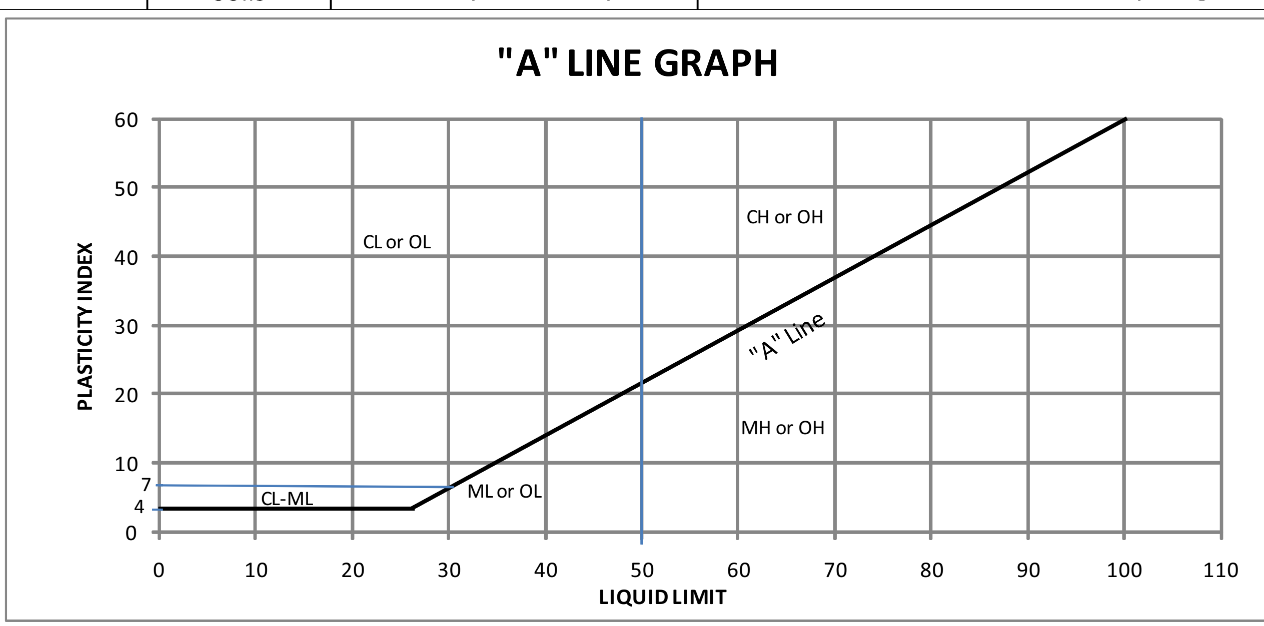
APPENDIX B

- TEST BORING RECORDS

SOIL DESCRIPTIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM

ASTM D 2487 and D 2488

Major Division			Group Symbol	Letter Symbol	Group Name*
Coarse Grained Soils Less Than 50 Percent Passing the # 200 Sieve	Gravel - Percent GRAVEL > percent SAND	Gravel with < 5% Fines		GW	Well Graded GRAVEL
				GP	Poorly Graded GRAVEL
		Gravel with Between 5 and 15% Fines		GW-GM	Well Graded GRAVEL with silt
				GW-GC	Well Graded Gravel with clay
				GP-GM	Poorly Graded GRAVEL with silt
				GP-GC	Poorly Graded GRAVEL with clay
		Gravel with ≥ 15% Fines		GM	Silty GRAVEL
				GC	Clayey GRAVEL
	Sand - Percent SAND ≥ percent GRAVEL	Sand with < 5% Fines		SW	Well Graded SAND
				SP	Poorly Graded SAND
		Sand with Between 5 and 15% Fines		SW-SM	Well Graded SAND with silt
				SW-SC	Well Graded SAND with clay
				SP-SM	Poorly Graded SAND with silt
				SP-SC	Poorly Graded SAND with clay
		Sand with ≥ 15% Fines		SM	Silty SAND
				SC	Clayey SAND
Fine Grained Soils 50 percent or more Passing the # 200 Sieve	SILT and CLAY	Liquid Limit Less Than 50		ML	SILT
				CL	Lean CLAY
				CL-ML	SILTY CLAY
				OL	Organic SILT, CLAY, or SILTY CLAY
		Liquid Limit 50 or Greater		MH	Elastic SILT
				CH	Fat CLAY
				OH	Organic SILT or CLAY
Highly Organic Soils				PT	Peat
* Additional Modifiers	Coarse Grained Soils	with silt or clay		5 to 12 % Silt or Clay by weight	
		Silty or Clayey		more than 12 % Silt or Clay by weight	
	Fine Grained Soils	with sand or gravel		15 to 29 % Sand or Gravel by weight	
		Sandy or Gravelly		30 % or more Sand or Gravel by weight	



SOIL DESCRIPTION

Descriptors for soil consistency used in this report are based upon the Standard Penetration Test (SPT), ASTM D 1587, with the penetration (N) values corrected to N_{60}, based upon the efficiency of the SPT Hammer used for the soil sampling.

Descriptors for both non-cohesive and cohesive soils are presented below, with the corresponding range of corrected penetration values.

NON-COHESIVE SOIL DESCRIPTION	CORRECTED PENETRATION VALUES BLOWS PER FOOT (BPF)
Very Loose	0 – 4
Loose	5 – 10
Medium Dense	11- 30
Dense	31 – 50
Very Dense	Over 50

COHESIVE SOIL DESCRIPTION	CORRECTED PENETRATION VALUES BLOWS PER FOOT (BPF)
Very Soft	0 – 1
Soft	2 – 4
Medium Stiff	5 – 8
Stiff	9 – 15
Very Stiff	16 –30
Hard	Over 30

Moisture term descriptors for both non-cohesive and cohesive soils are presented below.

NON-COHESIVE SOIL DESCRIPTION	MOISTURE TERMS	COHESIVE SOIL DESCRIPTION
Powdery	Dry	Powdery
Some Moisture	Damp	Below Plastic Limit
Damp to the Touch	Moist	Above Plastic, Below Liquid Limit
Free Water	Wet	Above Liquid Limit

CTL ENGINEERING INC

TEST BORING RECORD

CLIENT	: Environmental Design Group	BORING NO.:	B-01
PROJECT	: Oberlin Waterworks Upground #1 & 2 - ODNR File No. 1221-018	SHEET	1 OF 1
LOCATION	: Cedar Street & Morgan Street, Oberlin, OH - Lorain County	DATE STARTED	: 11-05-19
PROJECT NO.	: 19050024CLE	DATE COMPLETED	: 11-05-19

BORING					
ELEVATION	: 814.0 Feet	RIG TYPE	: Geo Probe	DRILLER	: DC
STATION	:	CASING DIA.	: 3.25	TEMPERATURE	:
OFFSET	:	CORE SIZE	: 2'-1/4"	WEATHER	:
DEPTH	: 30.0 Feet	HAMMER	: AUTO		
BORING METHOD:	HPR	ENERGY RATIO	: 75		

GROUNDWATER: Encountered at 18.0' At completion N/A Caved in at N/A

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
813.5		6" GRAVEL	0.5										
		Very stiff, brown, SILTY CLAY, trace to little gravel, plant roots, damp (FILL)		SS-1	6 7 9	20	56	13		9.0*			
	5			SS-2	7 7 10	21	100	14		9.0*			
808.0			6.0										
		Medium stiff, greyish brown, LEAN CLAY, some sand, trace gravel, moist (FILL)		SS-3	2 2 2	5	100	23		2.5*			
	10			SS-4	1 2 2	5	100	23		2.0*	32	17	15
				ST-1			72	17	139				
800.0			14.0										
	15	Stiff, brownish grey, SILTY CLAY, trace sand and gravel, moist (FILL)		SS-5	4 4 4	10	89	18		9.0*			
796.0			18.0										
	20	Very stiff, brownish grey, SILTY CLAY, some sand and gravel, moist (FILL)		SS-6	5 8 9	21	100	14		5.0*			
791.0			23.0										
	25	Very stiff, grey, SILTY CLAY, some gravel, damp		SS-7	8 8 10	22	89	12		9.0*			
787.0			27.0										
		Hard, grey, CLAY, little silt, moist											
784.0	30		30.0	SS-8	9 13 14	34	100	18		9.0*			
		End of boring @ 30ft											
	35												

ENGINEERING
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT : Environmental Design Group
PROJECT : Oberlin Waterworks Upground #1 & 2 - ODNR File No. 1221-018
LOCATION : Cedar Street & Morgan Street, Oberlin, OH - Lorain County
PROJECT NO. : 19050024CLE

BORING NO.: **B-02**
SHEET 1 OF 1
DATE STARTED : 11-05-19
DATE COMPLETED : 11-05-19

BORING			
ELEVATION : 814.0 Feet	RIG TYPE : Geo Probe	DRILLER : DC
STATION :	CASING DIA. : 3.25	TEMPERATURE :
OFFSET :	CORE SIZE : 2'-1/4"	WEATHER :
DEPTH : 30.0 Feet	HAMMER : AUTO	
BORING METHOD: HPR	ENERGY RATIO : 75	

GROUNDWATER: Encountered at 18.0' At completion 8.5' Caved in at N/A

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
813.3		8" GRAVEL, SAND, AND SILT	0.7										
811.0		Hard, light brown, SILTY CLAY, trace gravel, plant roots, damp (POSSIBLE FILL)	3.0	SS-1	8 12 13	31	100	10		9.0*			
808.0	5	Very stiff, brown, LEAN CLAY, little sand, plant roots, slightly organic, moist (POSSIBLE FILL)	6.0	SS-2	8 9 9	22	100	19		9.0*	41	21	20
806.0		Stiff, brown, SILTY CLAY, trace gravel, moist (POSSIBLE FILL)	8.0	SS-3	4 5 7	15	100	17		7.0*			
802.0	10	Medium stiff, brown, SILTY CLAY, little gravel, moist	12.0	SS-4	3 3 3	8	100	16		7.5*			
796.0	15	Medium stiff, greyish brown, SANDY LEAN CLAY, trace gravel, moist	18.0	SS-5	3 2 2	5	89	16		7.0*	33	18	15
791.0	20	Stiff, grey, SILTY CLAY, little gravel, moist	23.0	SS-6	3 5 7	15	100	17		9.0*			
	25	Medium dense to dense, grey, CLAYEY SILT, moist		SS-7	8 9 12	26	100	13		9.0*			
784.0	30		30.0	SS-8	8 12 17	36	100	21		9.0*			
		End of boring @ 30ft											
	35												

CTL ENGINEERING INC.
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 19050024CLE.GPJ CTL CORPORATE.GDT 11/22/19

TEST BORING RECORD

CLIENT : Environmental Design Group	BORING NO.: **B-03**
PROJECT : Oberlin Waterworks Upground #1 & 2 - ODNR File No. 1221-018	SHEET 1 OF 1
LOCATION : Cedar Street & Morgan Street, Oberlin, OH - Lorain County	DATE STARTED : 11-05-19
PROJECT NO. : 19050024CLE	DATE COMPLETED : 11-05-19

BORING ELEVATION : 814.0 Feet	RIG TYPE : Geo Probe	DRILLER : DC
STATION :	CASING DIA. : 3.25	TEMPERATURE :
OFFSET :	CORE SIZE : 2'-1/4"	WEATHER :
DEPTH : 30.0 Feet	HAMMER : AUTO	
BORING METHOD: HPR	ENERGY RATIO : 75	

GROUNDWATER: Encountered at N/A At completion N/A Caved in at N/A

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
813.3		8" GRAVEL, SAND, AND SILT	0.7										
811.0		Medium dense, light brown, CLAYEY SILT, trace gravel, plant roots, damp (FILL)	3.0	SS-1	7 7 11	22	100	9					
808.0	5	Very stiff, brown, SILTY CLAY, trace gravel, damp (FILL)	6.0	SS-2	8 10 12	28	67	10		9.0*			
806.0		Stiff, greyish brown, SILTY CLAY, moist	8.0	SS-3	2 3 4	9	89	19		5.0*			
	10	Very stiff, brown, SILTY CLAY, trace gravel, moist		SS-4	2 5 8	16	100	19		9.0*			
797.0	15		17.0	SS-5	6 7 11	22	100	15		9.0*			
	20	Very stiff, grey, SILTY CLAY, moist		SS-6	7 8 11	24	89	12		9.0*			
786.0	25		28.0	SS-7	8 8 11	24	100	11		9.0*			
784.0	30	Dense, grey, CLAYEY SILT, some sand, moist	30.0	SS-8	8 13 17	38	100	14					
	35	End of boring @ 30ft											

CTL ENGINEERING INC
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING RECORD

CLIENT	: Environmental Design Group	BORING NO.:	B-04
PROJECT	: Oberlin Waterworks Upground #1 & 2 - ODNR File No. 1221-018	SHEET	1 OF 1
LOCATION	: Cedar Street & Morgan Street, Oberlin, OH - Lorain County	DATE STARTED	: 11-05-19
PROJECT NO.	: 19050024CLE	DATE COMPLETED	: 11-05-19

BORING ELEVATION	: 806.0 Feet	RIG TYPE	: Geo Probe	DRILLER	: DC
STATION	:	CASING DIA.	: 3.25	TEMPERATURE	:
OFFSET	:	CORE SIZE	: 2'-1/4"	WEATHER	:
DEPTH	: 30.0 Feet	HAMMER	: AUTO		
BORING METHOD: HPR		ENERGY RATIO	: 75		

GROUNDWATER: Encountered at N/A ▽ At completion 11.0' Caved in at N/A

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	STRATUM DEPTH	SAMPLE NUMBER	SPT per 6"	N_{60}	RECOVERY (%)	MOISTURE CONTENT	TOTAL UNIT WEIGHT pcf	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI
805.3		8" CLAYEY SILTY TOPSOIL	0.7										
		Very stiff, brown, SILTY CLAY, moist (FILL)		SS-1	5 8 9	21	100	19		9.0*			
	5			SS-2	8 9 10	24	56	13		9.0*			
800.0		Very stiff, brown, SILTY CLAY, trace gravel, moist	6.0	SS-3	3 6 8	18	89	17		8.5*			
	10			SS-4	8 9 11	25	78	13		9.0*			
793.0		Very stiff, grey, SILTY CLAY, some sand, moist	13.0										
	15			SS-5	5 7 8	19	100	13		9.0*			
	20			SS-6	9 11 12	29	100	13		9.0*	22	16	6
783.0		Stiff, grey, SILTY CLAY, trace gravel, moist	23.0										
	25			SS-7	5 5 7	15	100	11		9.0*			
777.0		Very dense, grey, CLAYEY SILT, some gravel, damp	29.0	SS-8	20 23 27	62	89	8		9.0*			
776.0	30	End of boring @ 30ft	30.0										
	35												

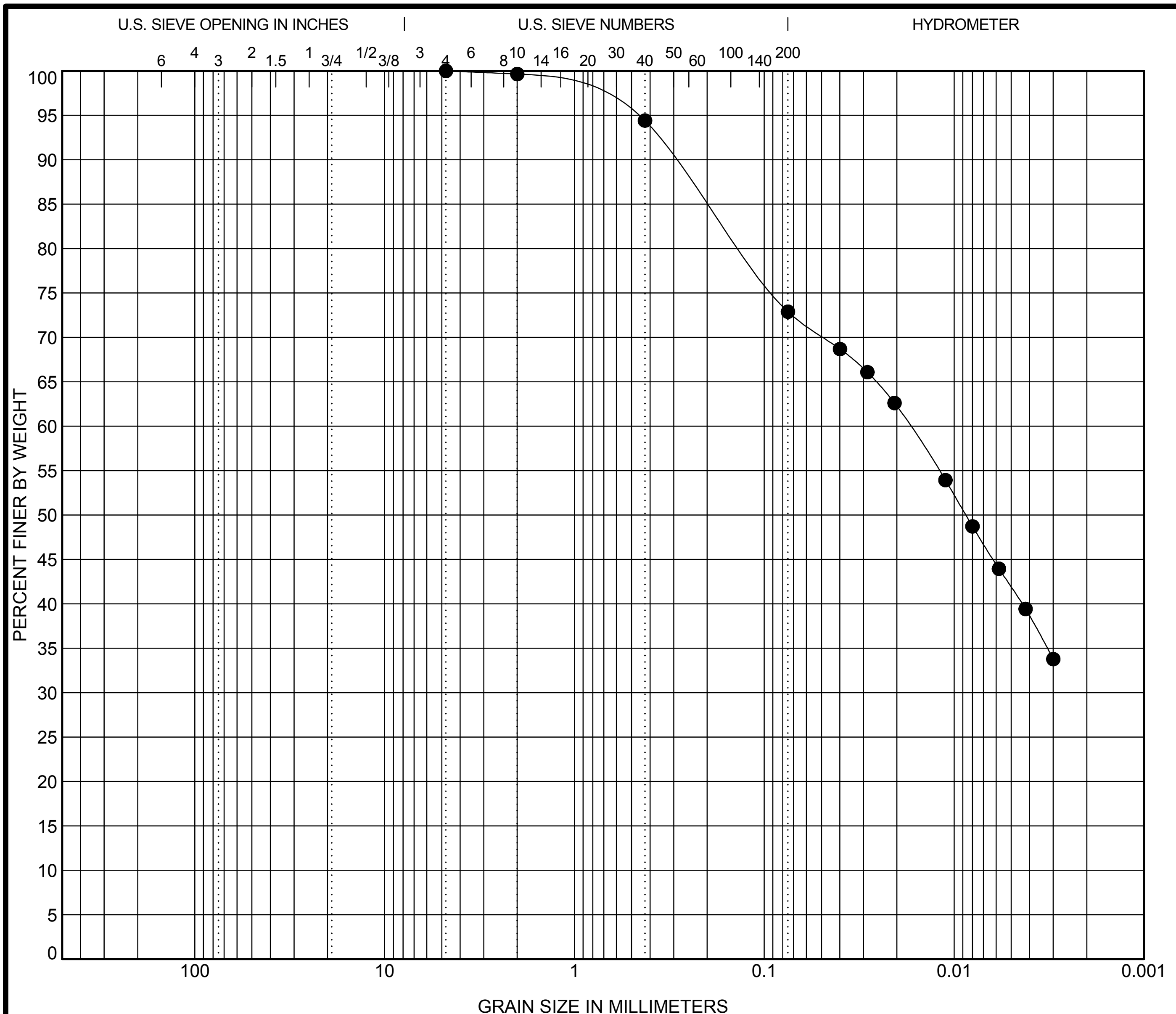
CTL ENGINEERING INC.
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling		SPT - Standard Penetration Test
HA - Hand Auger		N_{60} - Standard Penetration Normalized to 60% Drill Rod ER

TEST BORING/PIT RECORD 19050024CLE.GPJ CTL CORPORATE.GDT 11/22/19

APPENDIX C

- LABORATORY TEST RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
●	**B-01**	**SS-4**	**LEAN CLAY with SAND (CL)**	**23**	**32**	**17**	**15**		

	Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-01**	**SS-4**	**4.75**	**0.017**	**0.009**			**0**	**27**	**31**	**42**

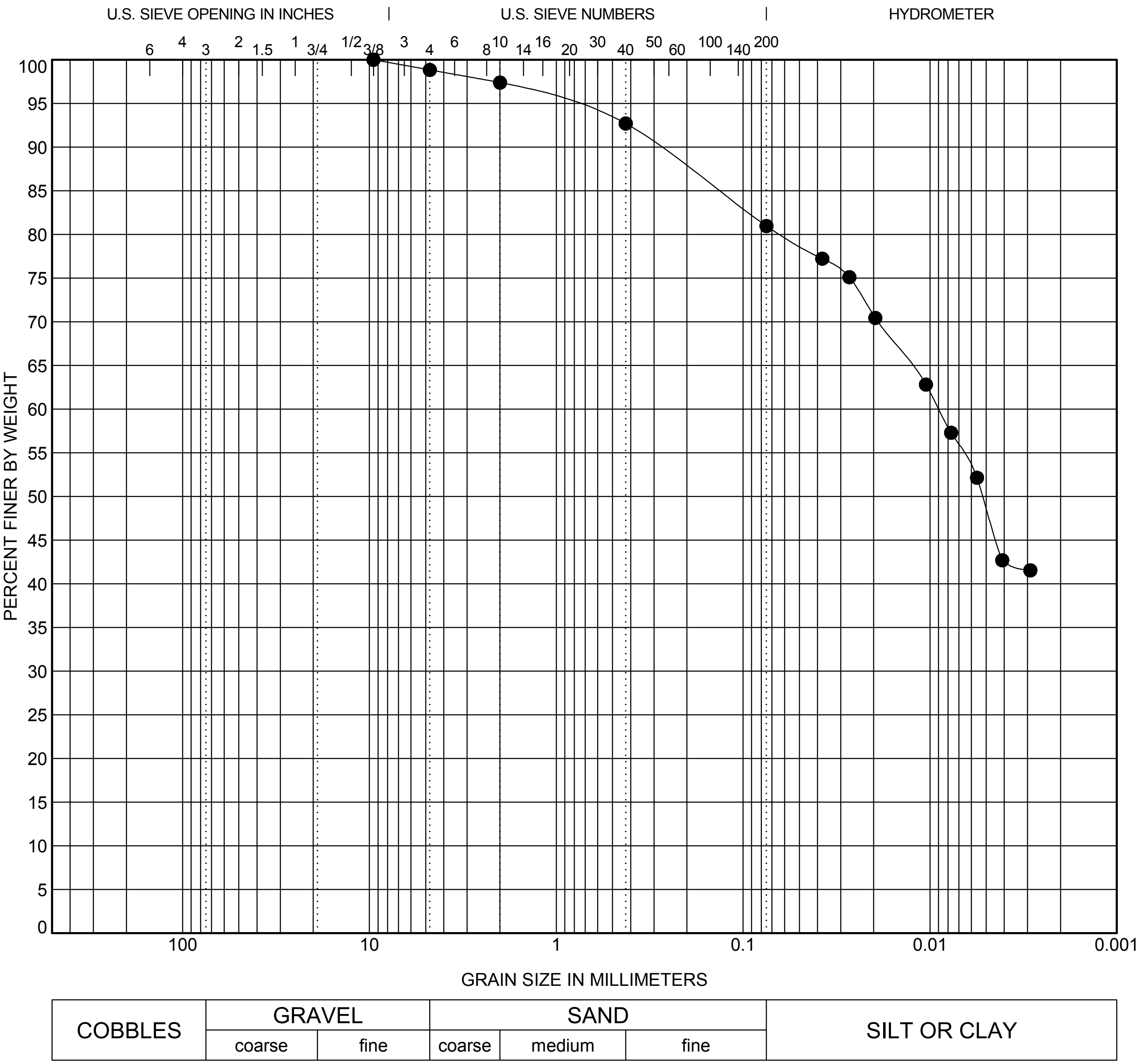
CTL Engineering
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

GRAIN SIZE DISTRIBUTION

Project: Oberlin Waterworks #1 & 2

Location: Cedar & Morgan St, Oberlin, OH

CTL Project Number: 19050024CLE



Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-02**	**SS-2**	**LEAN CLAY with SAND (CL)**	**19**	**41**	**21**	**20**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-02**	**SS-2**	**9.525**	**0.009**	**0.005**			**1**	**18**	**32**	**49**

CTLLAB GRAINSIZE 19050024CLE.GPJ CTL CORPORATE.GDT 11/20/19

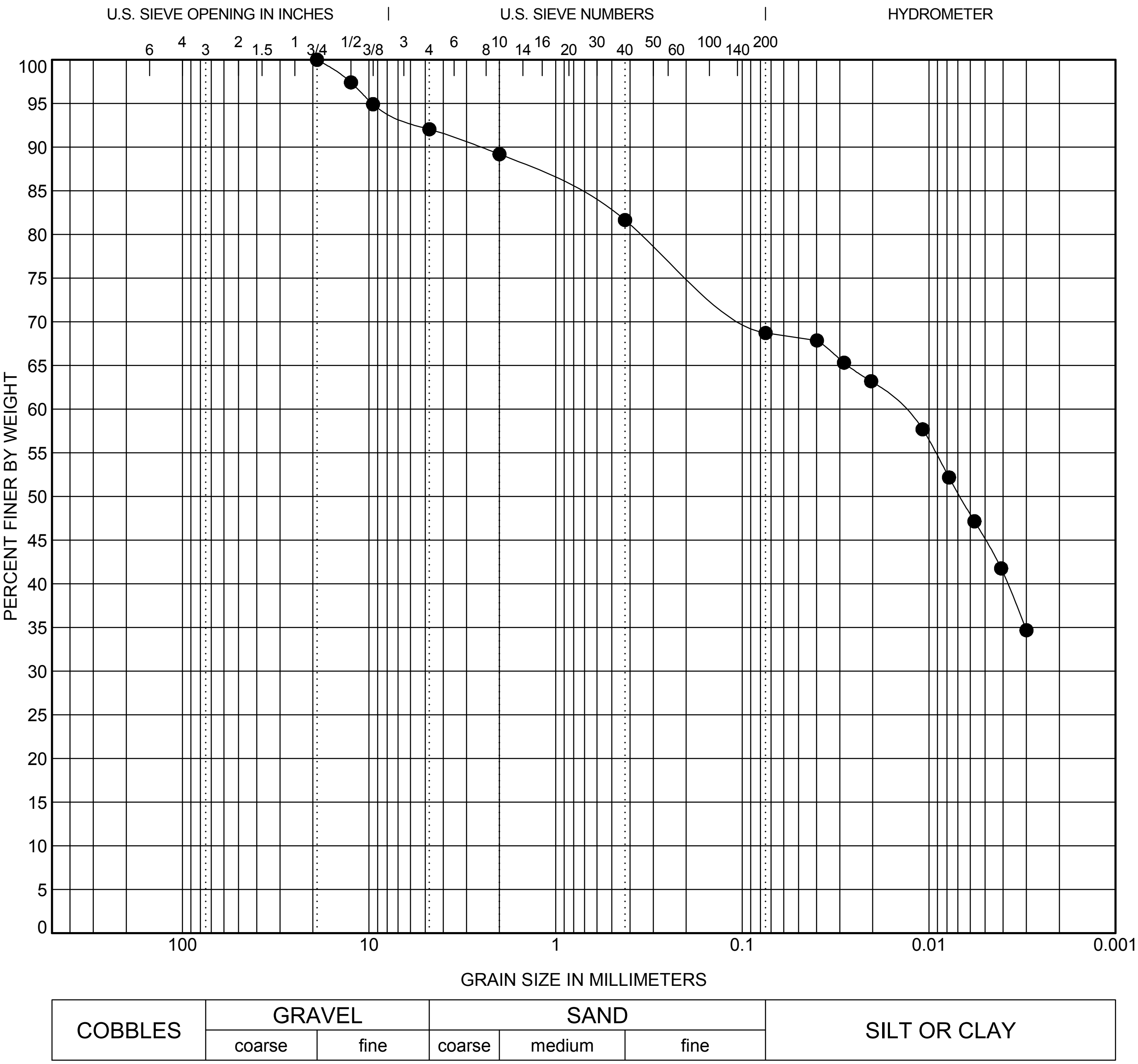
CTL Engineering
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

GRAIN SIZE DISTRIBUTION

Project: Oberlin Waterworks #1 & 2

Location: Cedar & Morgan St, Oberlin, OH

CTL Project Number: 19050024CLE



Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-02**	**SS-5**	**SANDY LEAN CLAY (CL)**	**16**	**33**	**18**	**15**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-02**	**SS-5**	**19**	**0.014**	**0.007**			**8**	**23**	**24**	**45**

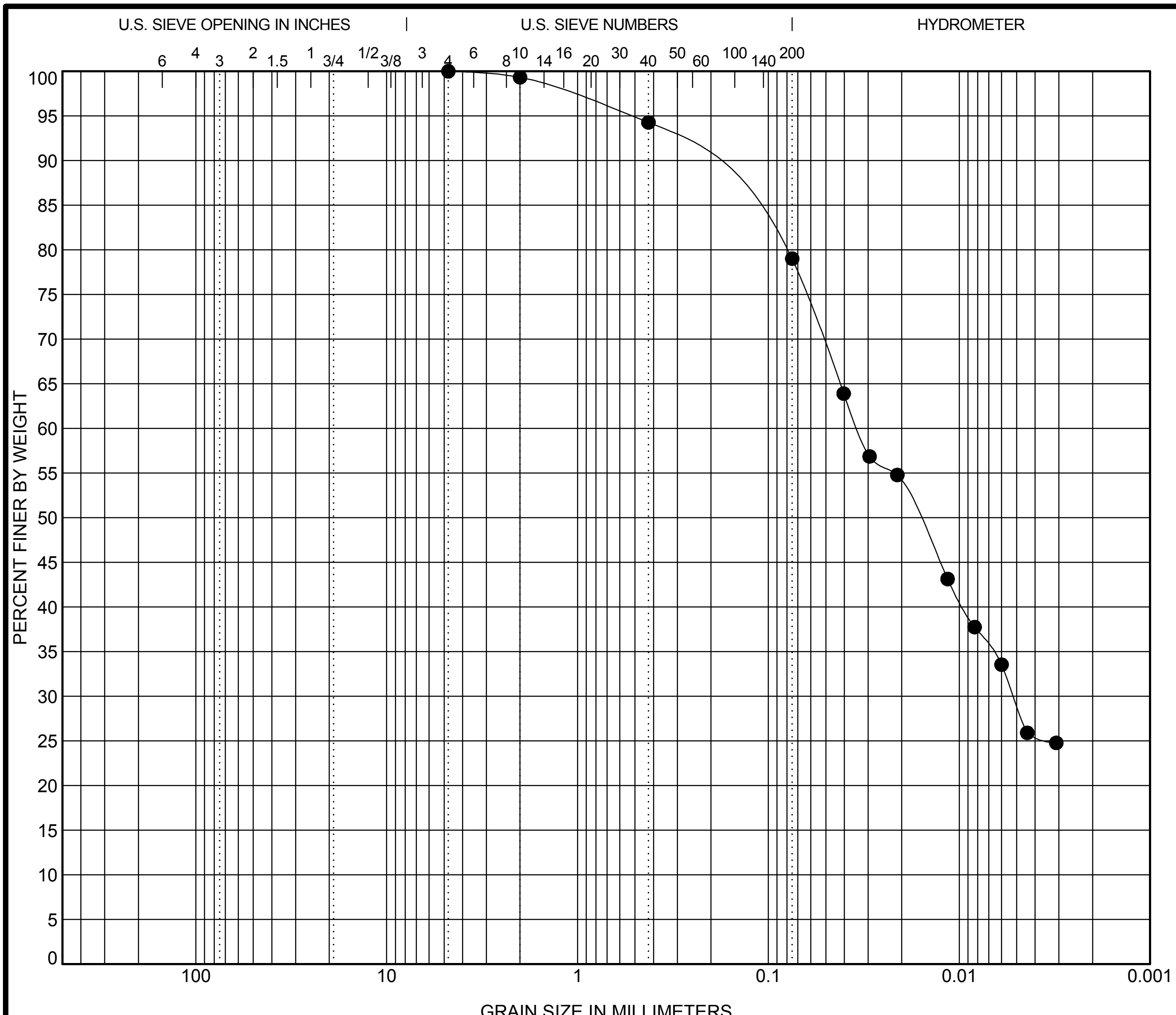
CTL Engineering
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

GRAIN SIZE DISTRIBUTION

Project: Oberlin Waterworks #1 & 2

Location: Cedar & Morgan St, Oberlin, OH

CTL Project Number: 19050024CLE



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen ID	Sample	Classification	%MC	LL	PL	PI	Cc	Cu
● **B-04**	**SS-6**	**SILTY CLAY with SAND (CL-ML)**	**13**	**22**	**16**	**6**		

Specimen ID	Sample	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-04**	**SS-6**	**4.75**	**0.034**	**0.016**	**0.005**		**0**	**21**	**50**	**29**

CTL Engineering
3085 Interstate Parkway
Brunswick, Ohio 44212
Telephone: 330-220-8900
Fax: 330-220-8944
Email: ctl@ctleng.com

GRAIN SIZE DISTRIBUTION

Project: Oberlin Waterworks #1 & 2

Location: Cedar & Morgan St, Oberlin, OH

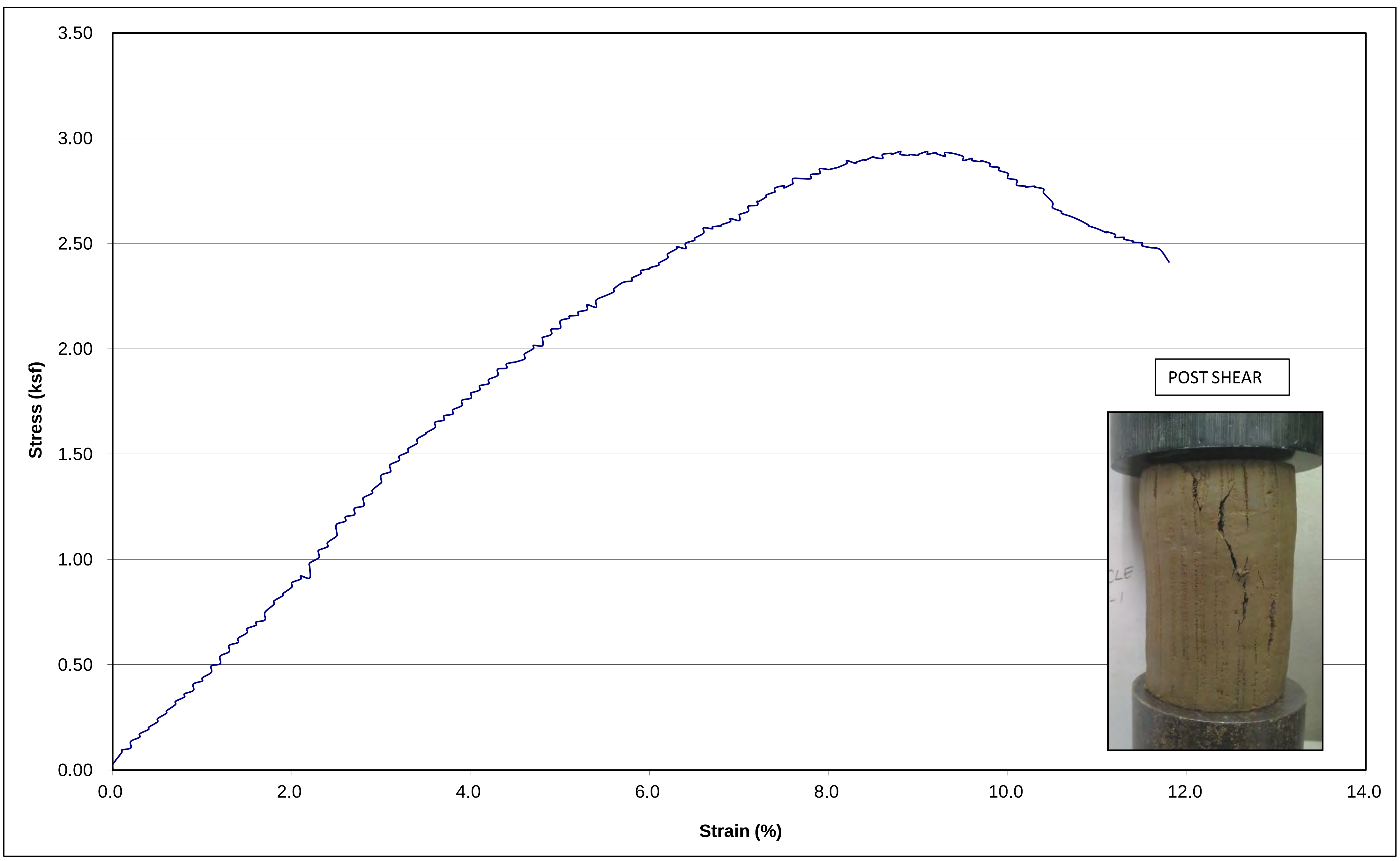
CTL Project Number: 19050024CLE

Unconfined Compression Test Results ASTM D 2166, D 5102	CTL ENGINEERING, INC. 2860 Fisher Road Columbus, Ohio 43204

Sample ID:	B-1, @10ft
Avg. Sample Height (in.):	3.99
Avg. Sample Diameter (in.):	1.88
Height-to-diameter ratio:	2.12
Ultimate Strength (ksf):	2.94
Shear Strength (Ksf):	1.47
Avg. Rate of Strain to Failure(%):	2.52
Strain at Failure (%):	8.80
Initial Dry Density (pcf):	118.77
Moisture Content (%):	17.1 (Obtained Post Shear)
Visual Description:	Brown SAndy LEAN CLAY (CL)
Hand Penetrometer (Ksf):	2.00
Sensitivity:	NA
Failure Type:	Diagonal Shear

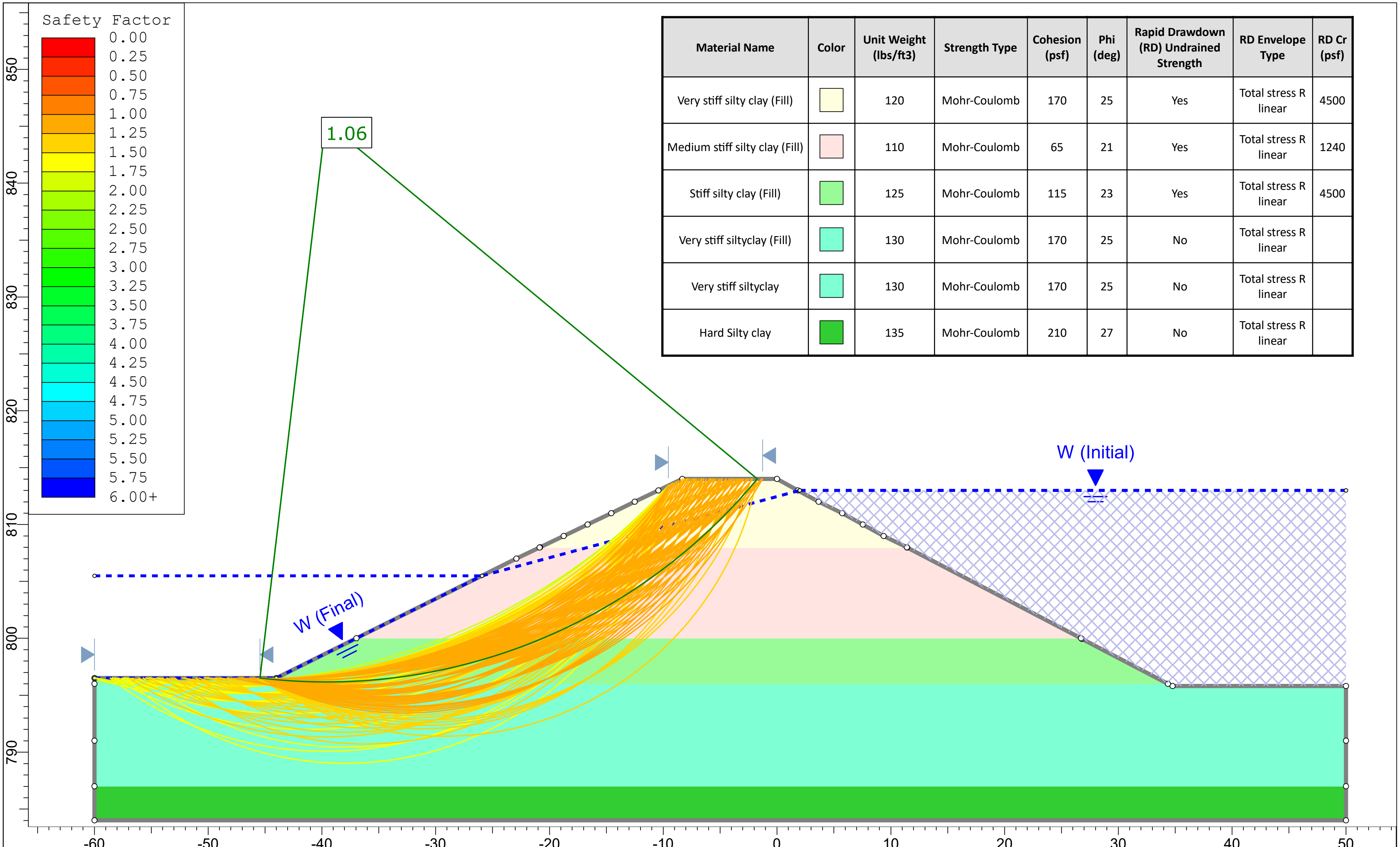
Client:	Environmental Design Group
Project:	Oberlin Waterworks Upgroud #1&2-ODOT
Location:	Cedar St & Morgan St.,Lorain Co.
Project No.	19050024CLE
Lab Code No.	19050795COL
Date Tested:	11/21/2019
Reviewed by:	SM

ASTM D 4318	ASTM D 6913	
LL: N/A	Gravel (%): N/A	Silt(%): N/A
PL: N/A	Sand(%): N/A	Clay(%): N/A



APPENDIX D

- SLOPE STABILITY ANALYSES

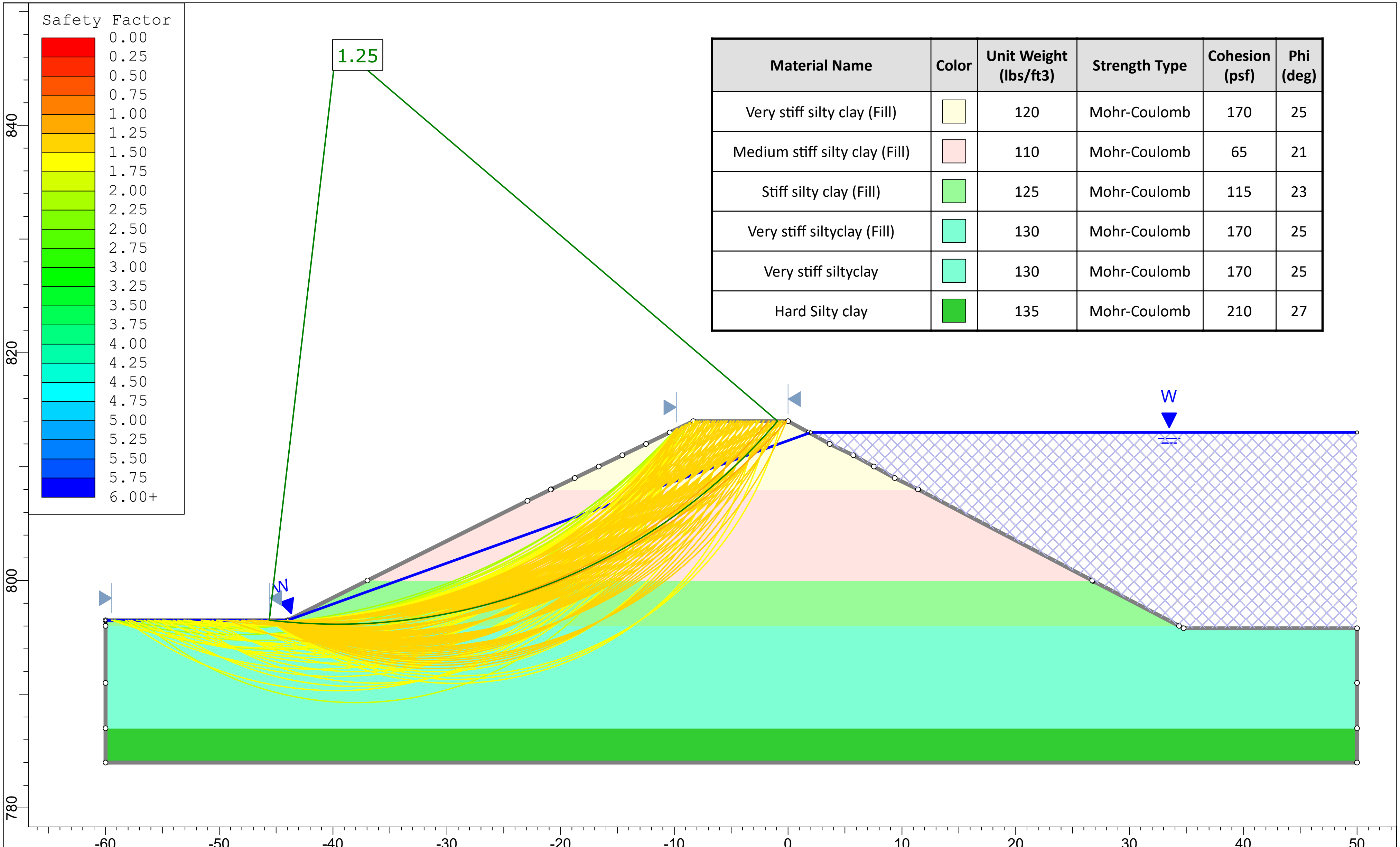


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Rapid Drawdown (RD) Undrained Strength	RD Envelope Type	RD Cr (psf)
Very stiff silty clay (Fill)		120	Mohr-Coulomb	170	25	Yes	Total stress R linear	4500
Medium stiff silty clay (Fill)		110	Mohr-Coulomb	65	21	Yes	Total stress R linear	1240
Stiff silty clay (Fill)		125	Mohr-Coulomb	115	23	Yes	Total stress R linear	4500
Very stiff siltyclay (Fill)		130	Mohr-Coulomb	170	25	No	Total stress R linear	
Very stiff siltyclay		130	Mohr-Coulomb	170	25	No	Total stress R linear	
Hard Silty clay		135	Mohr-Coulomb	210	27	No	Total stress R linear	

rocscience

SLIDEINTERPRET 8.026

Project	Oberlin dam		
Analysis Description	Center Embankment Section		
Drawn By NKM	*Scale* 1:140	*CTL Engineering*	
Date 11/22/2019		*Slope stability Rapid draw down*	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Very stiff silty clay (Fill)		120	Mohr-Coulomb	170	25
Medium stiff silty clay (Fill)		110	Mohr-Coulomb	65	21
Stiff silty clay (Fill)		125	Mohr-Coulomb	115	23
Very stiff siltyclay (Fill)		130	Mohr-Coulomb	170	25
Very stiff siltyclay		130	Mohr-Coulomb	170	25
Hard Silty clay		135	Mohr-Coulomb	210	27

rocscience

SLIDEINTERPRET 8.026

Project	Oberlin dam		
Analysis Description	Center Embankment Section		
Drawn By	NKM	*Scale* 1:140	*CTL Engineering*
Date	11/25/2019		*Slope stability Effective Stress Analysis*

APPENDIX D

KICKOFF MEETING SUMMARY – JUNE 18, 2019

ALTERNATIVE WORKSHOP MEETING SUMMARY – AUGUST 14, 2019

MEETING SUMMARY

To: Attendees

From: Julie Lawson, P.E., C.F.M.

Date: June 20, 2019

Subject: Kickoff Meeting – June 18, 2019

1. Attendees – Sign-in Sheet attached.
2. Project Update
   a) Field Survey – Field work is ongoing. Base map should be complete in the next week or two.
   b) Available Information – The City found historic documents regarding the original Water Works and has storm sewer mapping and information regarding localized flooding for the area. Dawn will send this information to EDG. An Oberlin Parks & Recreation Strategic Plan was completed 7 or 8 years ago and should be available on the City's website. EDG will download this plan. At this time there is no Stormwater Master Plan in place for the City.
3. Schedule
   a) Review of Preliminary Project Schedule – The preliminary project schedule attached was determined to be acceptable so that adequate information is available from the analysis when the City begins to work on their 2020 budget in September or October.
   b) Alternatives Workshop
      i) The Alternatives Workshop will be scheduled for Monday, July 15, 2019 from 4:30 p.m. to 6:30 p.m. in the Community Room at the Public Library. Jeff will secure the room at the library and confirm this date and time. Jeff will also invite Gary Fischer. The City will advertise this meeting. Participants will sign in and provide their addresses and e-mail addresses. The workshop will begin with a short presentation to explain the format for the evening then participants will rotate around four tables for 15 minutes at each table. Each table will have a specific topic such as the history of the reservoirs/site, the water depths of the reservoirs, vegetation/wildlife/habitat, and trails/circulation around the site. Each table will have a facilitator to record participants' comments. At the end of the rotations each facilitator will report to the audience a summary of what was heard at each table.
      ii) The Public Meeting will be scheduled for Monday, September 16, 2019, tentatively from 4:30 p.m. to 6:30 p.m. in the Council Chambers or in the Community Room at the Public Library depending on availability. EDG will present the alternatives analyzed and the preferred alternative identified. There will be time for questions and comments, which will be considered in the draft report.
4. Project Goals
   a) ODNR compliance
   b) Transform the site from infrastructure to a park
   c) Preserve the history of the site
   d) Include educational elements
   e) Identify key plants
   f) Preserve/enhance aquatic and woodland habitat
   g) Site safety

h) Reduce maintenance
i) Keep the site as passive recreational use
j) Investigate the feasibility of using the site for stormwater management
k) Include trail connectivity with Oberlin College trails adjacent to the site

5. Deliverables – As defined in the Contract.
6. Action Items
   a) Dawn will send historic documents, storm sewer documents, and flooding documents to EDG.
   b) EDG will download the Parks & Recreation Strategic Plan.
   c) Jeff will secure the room for the July 15 Alternatives Workshop and confirm the date, location, and time with all Kickoff Meeting attendees.
   d) Jeff will invite Gary Fischer to the July 15 Alternatives Workshop.
   e) The City will advertise the July 15 Alternatives Workshop.
   f) Jeff will secure a room for the September 16 Public Meeting and confirm the date, location, and time with all Kickoff Meeting attendees.
   g) The City will advertise the September 16 Public Meeting when appropriate.
   h) Julie will complete the meeting summary and distribute to all Kickoff Meeting attendees in the next few days.

PROJECT: CITY OF OBERLIN MORGAN STREET RESERVOIRS

SIGN-IN SHEET

Kickoff Meeting – June 18, 2019

INITIALS	NAME	ORGANIZATION	E-MAIL
B.A.	Albrecht, Bill	Oberlin, Water Department	walbrecht@cityofoberlin.com
[illegible]	Baumann, Jeff	Oberlin, Public Works Department	jbaumann@cityofoberlin.com
[illegible]	Ferro, Dawn	Oberlin, Engineering Division	dferro@cityofoberlin.com
KBH	Holmok, Katherine	Environmental Design Group	kholmok@envdesigngroup.com
JAL	Lawson, Julie	Environmental Design Group	jlawson@envdesigngroup.com
[illegible]	Love, Jon	Oberlin, Water Department	jlove@cityofoberlin.com
	Roberts, Randall	Oberlin, Engineering Division	rroberts@cityofoberlin.com
JS	Simms, Jon	Oberlin, Buildings & Grounds	~~jsimms~~@cityofoberlin.com jesimms

Environmental DesignGroup
The community impact people.

MEETING SUMMARY

From: Julie Lawson, P.E., C.F.M.

Date: June 20, 2019

Subject: Alternatives Workshop – August 14, 2019

1. Public Input
   a. Habitat/Vegetation
   b. Historic Character
   c. Reservoir Use
   d. Trails/Site Circulation
2. Attendees – Sign-in Sheet attached.

HABITAT/VEGETATION

Between Reservoirs		**Water**		**Others**		**Preferences**		**Miscellaneous**
Don't reduce vegetation (crucial for birds)	x4	Keep water moving to reduce water plants?		Preserve tree canopy/keep trees	x3	Increase Natives	x5	Late night partying in some areas at night, burning of trash
Reduce vegetation around reservoir #1 south trail so trail is wider & better maintained	x2	Too much vegetation in the water and matted algae on surface		Sitting spaces under big old oak	x3	Pollinator friendly	x4	Needs better city management
Reduce Vegetation				Get rid of poison ivy		Keep as natural as possible	x3	I love trees, but these trees are not special and will grow back if the embankment may have vegetation at all
				Protect turtles and fish		Get rid of muskrats	x2	Variety of water depth
				Keep higher dam for fishing		Don't disturb established ecosystem	x2	Question : Can poison ivy be preserved? Answer: It's bird food!
				Benches for sitting		Improve water quality	x2	Shave off height of walls and slope sides for wildlife habitat
						Save as much vegetation as possible	x2	
						Reduce Invasive	x2	
						Maintain vegetation		
						Make more parklike and attractive to wildlife		
						Choose between park or natural area		
						Long term management		

HISTORIC CHARACTER

Signage		**Building Use**		**General**		**Restrooms**		**Miscellaneous**	
Interpretive Signs (nature & history)	x8	Public rentals (event center)/ meeting place	x5	No commercial use; for educational use only	x4	Yes	x4	Skeptical that staff to operate rental options (skating, canoes, etc.) would be economically sustainable	x2
Entrance/welcome sign	x2	Warming house for skate rink	x4	Splash pad	x2	Self cleaning toilets open all the time		What were the characteristics prior to reservoirs?	
Exhibition of historic photos		Nature center	x4	Keep buildings to add to landscape				Do nothing! Good to have "ruins" in Oberlin to observe/ponder	
		Lease to business (design or professional offices or public works)	x2	Outdoor amphitheater in oval for concerts/plays				How about funding restoration of buildings by appealing state wide to citizens and seeking matching funds from larger donors?	
		Music venue	x2	Keep podium					
		Boat storage/rental	x2	Water filtration education; filter own water					
		No need for building	x2	Possible to climb inside tower; open on a schedule					
		Not for storage	x2	Skate rink					
		Scout cabin		Snack bar					
		No apartments or offices with daily use		Avant-garde playground					
		Art in round structure		Community garden					
		Art gallery		Observation tower					
		No to any rentals		Ping pong					
		No public use, nothing requiring staffing		Crafts					
		Game room		Star gazing (top of tower)					
				Historic tours					
				Farmers market					
				Community events					

RESERVOIR USE

Both/Either		**Reservoir #1**		**Reservoir #2**		**Beach**		**Other**		**Miscellaneous**	
No ODNR control	x8	Sledding hill on east slope	x5	Wetland	x5	Yes	X4	Keep natural	x6	Can redevelopment be tied to other city activity needs?	x2
Keep both	x6	Natural ice skating	x4	Reduce to 50 acres	x2	No	x1	Ice skating rink	x6	Reservoir #2 used mostly for skinny dippers	
Keep path between both reservoirs	x2	Lower to 10'	x3	Sports field		Yes, northeast corner	x1	Keep trees	x5	Quote from 92-year-old resident: water has never overflowed in either lake in my lifetime	
Reduce depth but keep surface area	x2	Keep	x2	Drain		Enforce no swimming in both		Protect birding areas		What will current users lose?	
Combine both reservoirs	x2	Boating		Spillway to creek				Public restrooms		If it gets cleaned up too much, will it become under utilized like other city parks	
Sailboat lessons		Maintain fishing		Tennis court				Rooms for public use		What about mosquitos in any plan, particularly, wetlands	
Kayak lessons		Add 1-2 docks		Fix banks				Nature center		Dam lowering negates fishing	
Lower dams								Build chimney swift tower		Often walk around reservoir #1 and down stairs to arboretum trails	
Reduce water to less than 50 acres								Carbon sink		Work closely with the college and arboretum space	
Save reservoir #1 over reservoir #2								Solar array		Put nature first - splash zones are for recreation	
								Minimize maintenance to save money		Never walked around reservoir #2, used to be fenced	
								Picnic areas		Keep its current character	
										Reduce width of trails as much as possible	

TRAILS/CIRCULATION

Trails		Materials		Signage		Parking		Other		Miscellaneous
Maintain paths for pedestrian access	x8	Keep it natural	x8	Wayfinding	x5	No additional Parking	x4	Maintain birding area	x6	Don't disturb the ecosystem that has developed. Just try and get rid of the muskrats
Combine with Arboretum	x7	No concrete, pavement, or asphalt	x5	Map of trails and entrance		Bike Parking		Lorain Co. Metroparks should manage	x4	Cut path (not trees) between reservoirs #1 & #2 down 1.5 feet
Keep trails	x5	Pave part so accessible	x2	Welcome and entrance sign				Bird observation structure	x2	Keep existing vegetation to reduce city noise
Open and safe	x3	Boardwalk for wetland	x2					Keep it narrow/ reduce width as much as possible	x2	Do a study to see to see how many people use it now
Clear old Plum creek trail	x2	Keep low maintenance	x2					Trails for nature viewing	x2	It should not have become so overgrown. Remove vegetation, especially poison ivy
Keep trees	x2	Packed limestone or cinders						Don't disturb ecosystem that has developed		This area - the combined reservoir & arboretum are crucial migratory bird habitat and nesting habitat, see www.ebird.org-hotspotOberlinCollege-oberlinarboretuim
Connect to Professor St.		Limestone						Get rid of poison ivy		
Trail on west side of reservoir #2 could be moved to bottom of embankment		Boardwalk around water so accessible						Stairs between arboretum and loop around #1 should be repaired/improved		
One scenic paved bike path connecting the rail-to-trail to Morgan St.								Vegetation between reservoirs #1 & #2 are most crucial to wildlife		
Bike trails								Build bridge if necessary		
Trails around reservoir should be wheelchair accessible										
Keep path between reservoirs										

PROJECT: CITY OF OBERLIN MORGAN STREET RESERVOIRS

SIGN-IN SHEET

Alternatives Workshop – August 14, 2019

NAME	ADDRESS	PHONE NUMBER	E-MAIL
Martin Ackermann	143 E. College St. # 419		martinnz@oberlin.net
Michael Garner	138 S. Main St Apt 402		oberlin Rec
Josie Gruber	643 Beech St Oberlin		josiepgruber@gmail.com
Kelley Singleton	260 OAK St. Oberlin		ksingleton@cityofoberlin.com
Heather Adelman	240 Elm St. Oberlin		hadelman@cityofoberlin.com
Rosa Hillard	205 Morgan St.		rosahillard1@gmail
Paul Kobulnicky	49 Spring St		PJKOBULNICKY@gmail.com
Amanda Manahan	Oberlin Heritage Center	440-774-1700	tourinfo@oberlinheritage.org
Linda Arbogast	69 S Main		larbogast@cityofoberlin
Ray English	93 ? Cedar		ray.english@oberlin.edu
melissa Stalnaker	323 Elm		melissastalnaker@hotmail.com
Kristin Peterson	65 Glenhurst Dr		Kpeterson@cityofoberlin.com

Environmental Design Group
The community impact people.

PROJECT: CITY OF OBERLIN MORGAN STREET RESERVOIRS

SIGN-IN SHEET

Alternatives Workshop – August 14, 2019

NAME	ADDRESS	PHONE NUMBER	E-MAIL
Elizabeth J. Meadows	343 S. Pleasant St.		ejmeadows1945@gmail.com
Melissa Reed	94 Kendal Dr		timberlost2@yahoo.com
Jennifer Reeves	69 S Main St		jreeves@cityofoberlin.com
Sylvan Long	223 Eastern Ave.		sylvan.long@gmail.com
Kate Pilacky	184 N. Main		kpilacky@wrlandconservancy.org
JEFF HOBBS	304 S. PROFESSOR		BETHANDJEFFANY@GMAIL.COM
Jeff Baumann	85 S. MAIN		jbaumann@cityofoberlin.com
John Bukovac	61 N. Park St		Jbukovac@lorainccc.edu
Maureen Simen	36 Morgan St		mtsimen@gmail.com
Jill Sawyer	55 S. Main St.		saysjill@gmail.com
Peter Thomas	166 S. Cedar St.		pjthomas@case.edu
Bill Kannen	131 E. College		bkannen@Hudson-Medical.com

Environmental DesignGroup
The community impact people.

PROJECT: CITY OF OBERLIN MORGAN STREET RESERVOIRS

SIGN-IN SHEET

Alternatives Workshop – August 14, 2019

NAME	ADDRESS	PHONE NUMBER	E-MAIL
Ginny Cesturo	251 Morgan		g.bcesturo@yahoo.com
Bob Cesturo	"		racesturo@gmail.com
WILLIAM ALBRECHT	OBERLIN WATER DEPARTMENT	440-775-7290	WALBRECHT@CITYOFOBERLIN.COM
Liz Schultz	Oberlin Heritage Center	440-774-1700	director@oberlinheritage.org
Maren McHen	Oberlin Heritage Center	440 774 1700	history@oberlinheritage.org
Bill + Mary Ann TROST	556 Morgan	440-775-0509	matrost@yahoo.com
Peter Comings	237 E College	440-941-6597	petercomings@gmail.com
Alison Ricker	83 S. Cedar	440 775 4582	aricker@oberlin.edu
TONY MEALY	328 SO. PROFESSOR		
CAMERON MILL	24 N PARK STREET	440 775 0352	
Mary Price	355 W College St.	440 320 6188	mary.ellen.price@gmail.com
ROB CALHOUN	249 ELM ST	440 935 2002	rob@calhoun.net

Environmental Design Group
The community impact people.

SIGN-IN SHEET

Alternatives Workshop – August 14, 2019

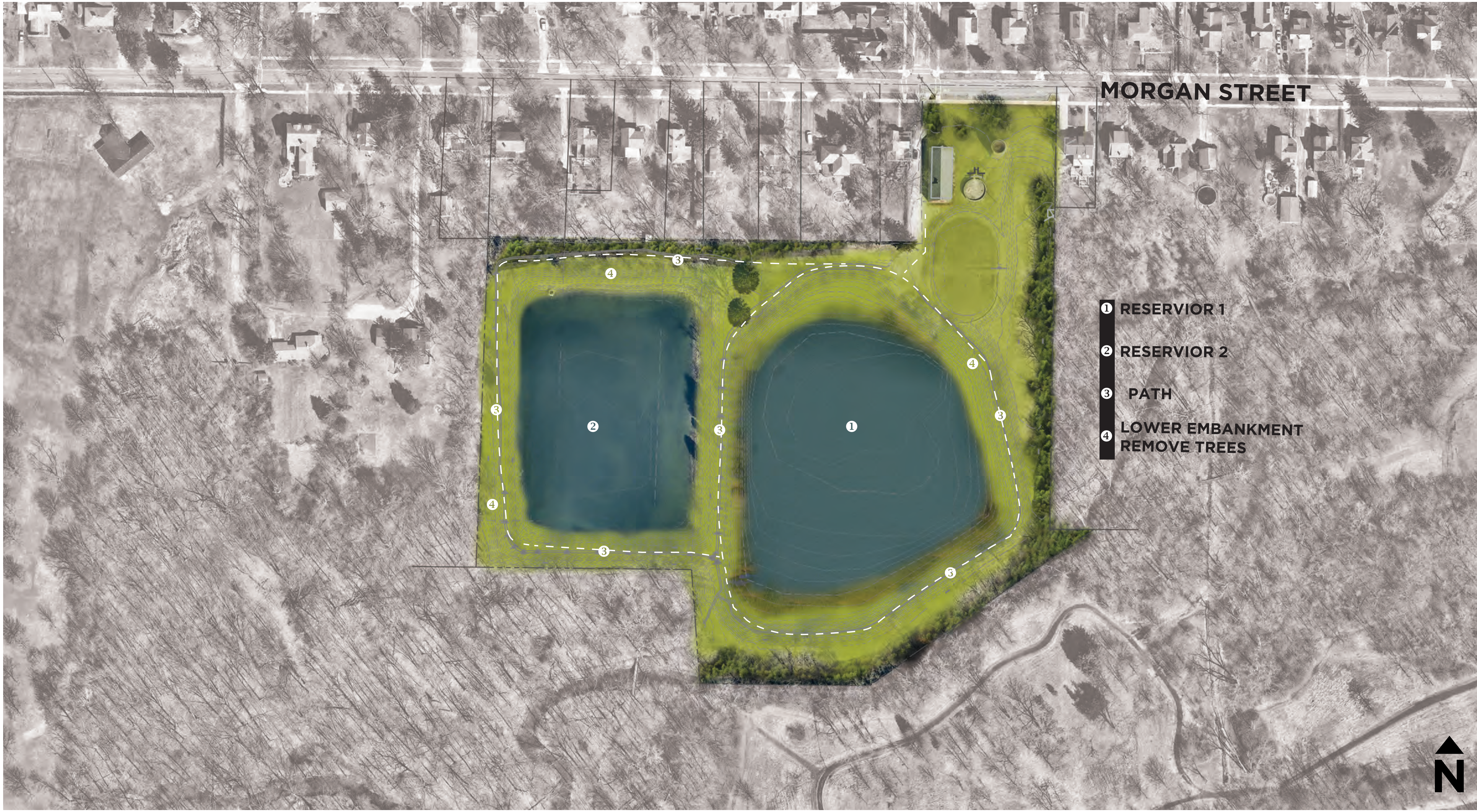
NAME	ADDRESS	PHONE NUMBER	E-MAIL
Jody Kannen	131 E College	330-472-9657	jodykannen@gmail.com
Holly Whitesid	24 N. Park	440 775 0352	h.whitesidel@mail.lorainccc.edu
Jutta Ittner	231 Morgan St	440 775 1975	ittner@case.edu
Michele Norton	179 Morgan St	216 409 9788	MKN8678@Gmail
Judy Laushman	42 North Cedar		jmlaushman@gmail
Chris Howell	275 Morgan St.	440-666-6809	chowell@oberlin.edu.

APPENDIX E

CONCEPT ALTERNATIVES EXHIBIT –
JANUARY 24, 2020

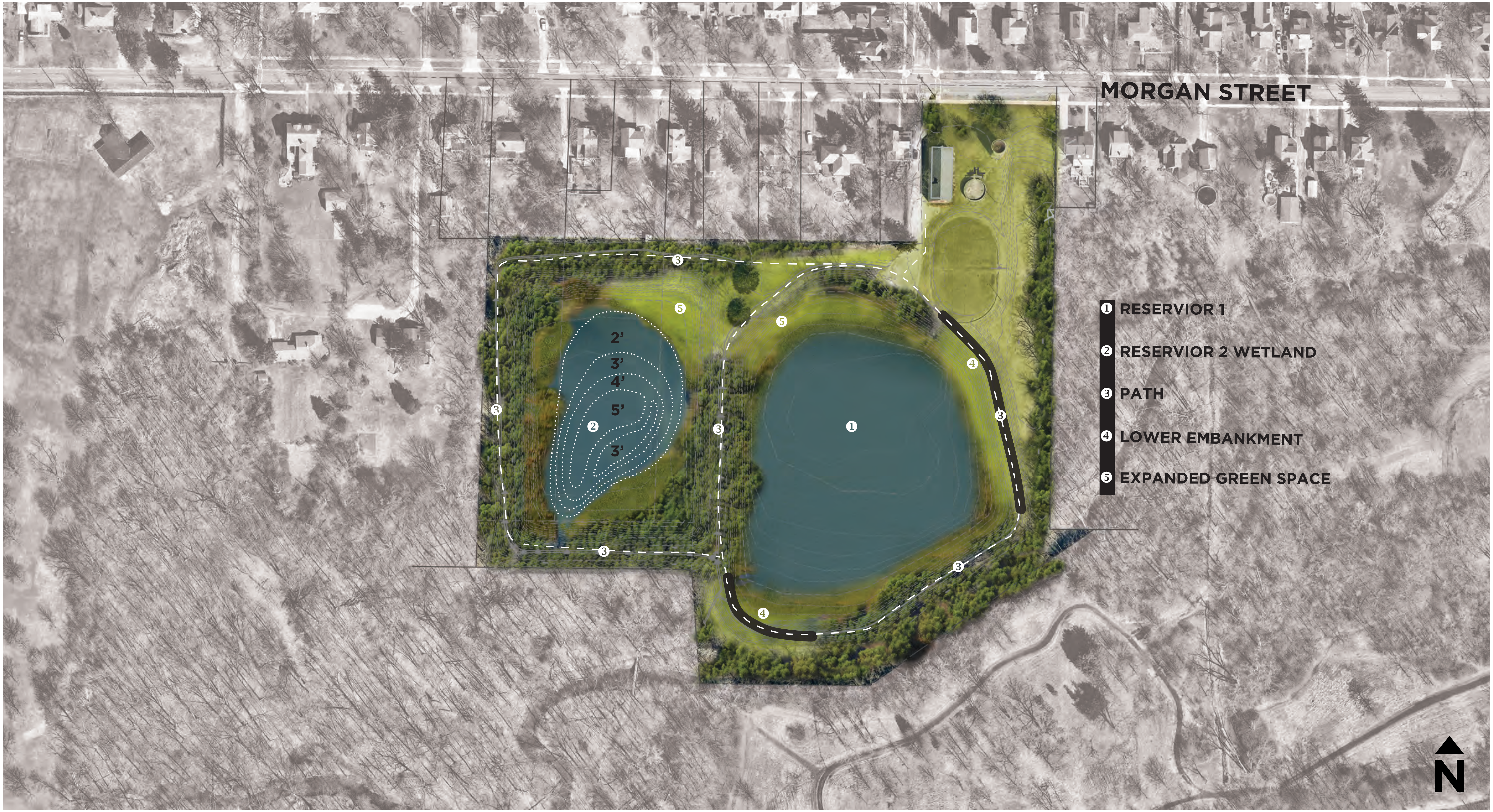
FINAL ALTERNATIVES EXHIBIT –
FEBRUARY 18, 2020

MORGAN STREET RESERVOIRS CONCEPT ALTERNATIVE 1



January 24, 2020

MORGAN STREET RESERVOIRS CONCEPT ALTERNATIVE 2



January 24, 2020

CITY OF OBERLIN · Live · Learn · Lead

Environmental Design Group
The community impact people.

MORGAN STREET RESERVOIRS CONCEPT ALTERNATIVE 3A

City of Oberlin · Live · Learn · Lead

Environmental Design Group — The community impact people.

January 24, 2020

MORGAN STREET RESERVOIRS CONCEPT ALTERNATIVE 3B

January 24, 2020

MORGAN STREET RESERVOIRS ODNR REGULATED RESERVOIRS

ALT 1

February 18, 2020

MORGAN STREET RESERVOIRS EXEMPT RESERVOIR & WETLAND

ALT 2

February 18, 2020

CITY OF OBERLIN Live · Learn · Lead

Environmental Design Group
The community impact people.

MORGAN STREET RESERVOIRS STREAM RESTORATION & WETLAND

ALT 3

February 18, 2020

CITY OF OBERLIN Live · Learn · Lead

Environmental Design Group
The community impact people.

MORGAN STREET RESERVOIRS ODNR REGULATED RESERVOIRS

ALT 1 - TREE INVENTORY

February 18, 2020

MORGAN STREET RESERVOIRS EXEMPT RESERVOIR & WETLAND

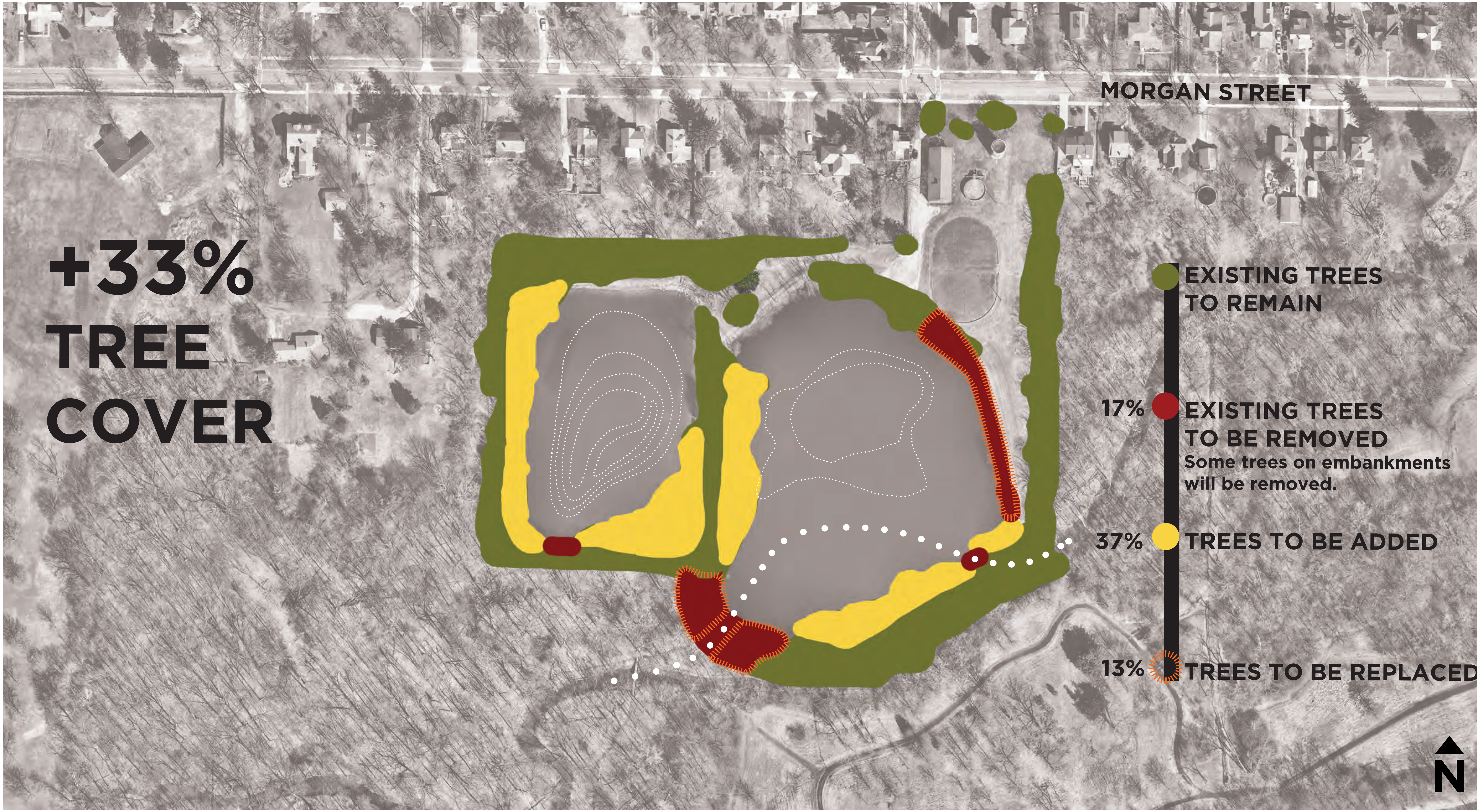
ALT 2 - TREE INVENTORY

February 18, 2020

CITY OF OBERLIN Live · Learn · Lead

Environmental Design Group The community impact people.

MORGAN STREET RESERVOIRS STREAM RESTORATION & WETLAND



ALT 3 - TREE INVENTORY

February 18, 2020

APPENDIX F

FUNDING OPTIONS

FUNDING OPTIONS

Funding for these proposed improvements may include Income Tax Capital and/or General Fund dollars from the City budget, a separate Park Levy or a Bond Issue for improvements, philanthropic donations, and/or grants. The site may also be eligible to become a wetlands mitigation bank.

Alternatives 2, the Preferred Alternative, proposes restoration of one of the two reservoirs to a natural wetland complex with potential for both passive and active park recreation. Under this alternative, there is potential to seek ecological restoration and/or park funding to enhance the project site and leverage additional dollars into the project. Below is a summary of potential funding sources that may be applicable to Alternative 2.

Great Lakes Restoration Initiative (U.S. EPA)

Funding Agency: U.S. Environmental Protection Agency

Funding Amount: projects funded range from $200,000 to $999,000. Grant will fund design and construction performed **after** grant awarded

Match Requirement: Not required, but match provides additional points for grant scoring. Design performed prior to application provides additional points in the grant application scoring.

Funding Timeframes: Request For Application (RFA) typically in late June/early July, deadline typically 30 days after RFA issue. Significant upfront documentation necessary to perform competitively for this national grant, including detailed cost estimates, drawings, calculations of ecological impacts (including background on surrounding ecological conditions) and identification of long term maintenance control. Support letters should be obtained from federal senators and US congressmen. Typically, announcements of winning application are 12-months from application deadline, with 3-years for implementation.

Funding Focus: Funding is allocated to five key focus areas: Toxic Substances and Areas of Concern, Invasive Species, Nonpoint Source Pollution Impacts on Nearshore Health, Habitats and Species, and Foundations for Future Restoration Actions. Habitats and Species focus of the GLRI grant would be applicable for funding portions of Alternative 3. **Project must be included in an approved Nonpoint Source Implementation Strategy (NPS-IS) Plan.** This project is in the Plum Creek Watershed (HUC12-041100010505), which does not currently have an approved NPS-IS plan.

Great Lakes Restoration Initiative (U.S. Forest Service)

Funding Agency: U.S. Forest Service through an agreement with U.S. EPA

Funding Amount: $50,000 to $300,000. Grant will fund design and construction performed **after** grant awarded

Match Requirement: 20% non-Federal cost share. Matching above the minimum provides additional points for grant scoring. Design performed prior to application provides additional points in the grant application scoring.

Funding Timeframes: Applications are due in June. Significant upfront documentation necessary to perform competitively for this national grant, including detailed cost estimates, drawings, calculations of ecological impacts (including background on surrounding ecological conditions) and identification of long term maintenance control. Support letters should be obtained from federal senators and US congressmen. Typically, announcements of winning application are 12-months from application deadline, with 3-years for implementation.

Funding focus: Funding is allocated to four key program areas: Forest Insect and Disease Mitigation, Reducing Runoff from Degraded Sites through Green Infrastructure, Protect and Restore Coastal Wetlands through Healthy Tree Cover, and Restore Resilient Riparian and Shoreline Forests. Funding supports native tree and shrub management and plantings to improve habitat within the Great Lakes Basin watershed. Restore Resilient Riparian and Shoreline Forests focus of this grant would be applicable for funding portions of Alternative 2.

ODNR Recreational Trails Program Grant

Funding Agency: Ohio Department of Natural Resources

Funding Amount: up to $150,000. Grant will fund design and construction performed **<u>after</u>** grant awarded.

Match Requirement: 20% state or local cost share (in-kind), with match above the minimum providing additional points for grant scoring on this extremely competitive grant program.

Funding Timeframes: Application deadline is typically February 1st. Typically, announcements of winning application are by November of the same year, with 18- months for implementation.

Funding Focus: Recreational trail and limited supporting facility development for publicly-owned property, including development of urban trail linkages, trail head and trailside facilities; maintenance of existing trails; restoration of trail areas damaged by usage; improving access for people with disabilities; acquisition of easements and property; development and construction of new trails; purchase and lease of recreational trail construction and maintenance equipment; and environmental and safety education programs related to trails.

Ohio EPA Section 319 Grants

Funding Agency: Ohio Environmental Protection Agency

Funding Amount: typical projects range from $150,000 to $400,000. Grant will fund design and construction performed **<u>after</u>** grant awarded. Design performed prior to application provides additional points in the grant application scoring.

Match Requirement: No match requirement last round; previous rounds required 40% non-Federal cost share. Match above the minimum provides additional points for grant scoring on this extremely competitive grant program.

Funding Timeframes: RFA typically in late January/early February, applications typically due approximately 30 days later. Typically, announcements of winning application are by June of the same year, with 3-years for implementation.

Funding Focus: Funds projects that restore Ohio streams, reduce nonpoint source pollutants such as nutrients, sediment, and bacteria, improve stream and riparian habitat and/or reverse the impacts of stream hydromodification. Improve stream and riparian habitat focus of this grant would be applicable for funding portions of Alternative 3. **Project must be included in an approved Nonpoint Source Implementation Strategy (NPS-IS) Plan.** This project is in the Plum Creek Watershed (HUC12-041100010505), which does not currently have an approved NPS-IS plan.

Natureworks Grant Program

Funding Agency: Ohio Department of Natural Resources

Funding Amount: Allocated by state to counties; Lorain County's typical allocation around $50,000, with the expectation of funding multiple projects.

Match Requirement: 25% local cost share which can include in-kind match. Match above the minimum provides additional points for grant scoring on this extremely competitive grant program.

Funding Timeframes: RFA for Round 27 postponed until June 1, 2021 due to uncertainty of funding for State fiscal years 2021-22. Typically, announcements of winning application are by October of the same year, with 3-years for implementation.

Funding Focus: Acquisition, development, or rehabilitation of active public park and recreation areas. This grant prefers to focus on new restrooms, shelters, playgrounds, active sports fields and premanufactured site amenity items installed on existing publicly owned parks. Upgrades to the existing onsite buildings, a picnic shelter, benches or an observation deck overlooking the wetland/pond would be very applicable proposed improvements for this fund.

Land and Water Conservation Fund

Funding Agency: National Park Service through Ohio Department of Natural Resources

Funding Amount: $50,000 to $500,000.

Match Requirement: 50% local cost share, including in-kind match. Match above the minimum provides additional points for grant scoring on this extremely competitive grant program. Design performed prior to application provides additional points in the grant application scoring.

Funding Timeframes: Applications due November 16th, 2020. Typically, announcements of winning application are by June of the following year, with 3-years for implementation.

Funding Focus: Acquisition, development and rehabilitation of recreational areas. Projects must be either development or acquisition. Eligible projects include picnic and support facilities, low impact development/green infrastructure and interpretive facilities in passive parks and nature preserves, amphitheaters, band shells, and visitor information centers, camping facilities and support facilities, swimming and water sports facilities, boating facilities, lake impoundments, outdoor game courts, sports fields and ranges, recreational trails and support facilities, limited redevelopment or renovation of existing facilities, and site architectural and/or engineering planning work directly related to site construction (must not exceed 15% of the total grant project cost).