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A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

Chapter 6

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Introduction

This section discusses the primary issues of concern and existing conditions for the Mill Pond and dam as well as five planning level alternatives and one optional add-on alternative that were evaluated as potential solutions to address these issues. These planning level alternatives were developed based on the management objectives for the Mill Pond and dam as described in Chapter 5. A full summary of the current conditions at the Mill Pond and dam was presented in Chapter 4.

Existing Conditions

The Mill Pond dam is located on Oak Creek in the City of South Milwaukee, about a mile upstream of the Oak Creek confluence with Lake Michigan. The dam is 14 feet in height and is constructed of concrete and dolomitic masonry. As described in Chapter 4, the dam was inspected by WDNR staff and repairs are required for the dam sluice gate system. This system allows the Mill Pond to be drained for dam structure maintenance.

Sediment transported by the stream has filled the Mill Pond since dredging was last completed in 1990. As discussed in Chapter 4, as of 2015, the Mill Pond had accumulated roughly 37,700 cubic yards (CY) of sediment (in place) as compared to the original 1930s design. Sedimentation has also created islands above the pond surface. Chapter 4 discusses existing pond conditions in more detail.

In the last ten years, the warming house on the southern bank of the Mill Pond has undergone significant structural renovation and landscaping improvements. There is strong community interest in utilizing the warming house for additional recreational and educational purposes.

Hydraulic Model Development

A more detailed hydraulic model of the Mill Pond and dam area was created for this planning effort using the US Army Corps of Engineers HEC-RAS software to better understand the hydraulic conditions in the Mill Pond and dam area. In Fall 2016, Commission staff updated the current effective FEMA model of the Oak Creek watershed for a MMSD facility planning effort.[1] This model update included road structure replacements and a refinement of a divided flow area about a mile upstream of the Mill Pond that were not accounted for in the previous model. In 2020, this model was further refined by replacing the rating curve representation of the Mill Pond dam with a structural feature for the dam, and by incorporating newer 2015 bathymetry data from the City of Racine Public Health Department for the bottom of the Mill Pond.[2] This updated hydraulic model provided a means to evaluate current conditions for the Mill Pond and dam and to develop and compare the proposed planning level alternatives.

The Wisconsin DNR (WDNR) has categorized the Mill Pond dam as a small dam, thus the dam spillway capacity requirements of Chapter NR 333 of the *Wisconsin Administrative Code* do not apply. Nevertheless,

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[1] *SEWRPC Staff Memorandum*, MMSD 2050 Facilities Plan – SEWRPC Floodplain Analyses, *November 29, 2017.*

[2] *L. Turner, A. Koski, and J. Kinzelman,* An Assessment of the Mill Pond Dam Impoundment – Oak Creek Watershed, *City of Racine Public Health Department Laboratory, January 2017.*

the existing spillway capacity of the Mill Pond dam was evaluated for this plan using the updated hydraulic model. Currently, the dam spillway capacity is approximately 675 cubic feet per second (cfs), which is less than the 50-percent-annual-probability (2-year recurrence interval) event. Although the requirements of NR 333 do not apply, it would be desirable to increase the spillway capacity of the Mill Pond dam to decrease the overland flow around the abutment of the dam for large storm events.

Issues of Concern

As previously discussed, the Mill Pond dam was inspected by WDNR staff and repairs are required for the dam sluice gate system. This system allows the Mill Pond to be drained for dam structure maintenance.

The Mill Pond has accumulated a substantial amount of sediment over time. Although the pond had water depths of seven to nine feet following its construction in the 1930s, the pond now has water depths of one to two feet. This accumulated sediment has caused a number of other problems for the area related to water quality as discussed in detail in Chapter 4. High water temperatures have been measured in the pond, especially in the northern lobe. Pond temperatures regularly exceed water temperatures recorded upstream and downstream of the pond, suggesting that the Mill Pond itself as the cause of warmer temperatures. This is a concern both for species in the Mill Pond and for downstream sections of Oak Creek which serve as a coldwater fishery for species such as trout and salmon. Contaminants present in water and sediment samples in the Mill Pond include metals and PCBs. The entire Oak Creek watershed is also considered impaired for chloride and phosphorus. Additionally, dissolved oxygen supersaturation has been found to occur in the Mill Pond, particularly in the northern lobe. This indicates that large fluctuations in dissolved oxygen concentrations occur in the pond, a situation detrimental to fish and aquatic organisms living in the pond.

Currently, the Mill Pond dam acts as a complete barrier to native fish passage. The height of the dam and water surface elevations during flood events exceed the leaping ability of all potential migratory fish. The only species that may be able to climb the downstream face of the dam is the invasive sea lamprey. There is no record of this species being observed climbing the Mill Pond dam or in the upstream Oak Creek watershed.

The current effective FEMA floodplain mapping shows a 1-percent-annual-probability (100-year recurrence interval) water surface elevation of around 617.9 feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29), which is high enough to flood the Oak Creek Parkway to the north and east of the Mill Pond (see Figure 6.Mill-FloodExist).

The current state of the Mill Pond limits its recreational functionality and value to desirable aquatic life. Historically, the Mill Pond had been used for ice skating and boating, however the pond is currently too shallow to be used for these purposes. The current Mill Pond also has limited recreational value for fishing due to its shallow depths and poor water quality.

Historical Restoration Planning Effort

In 2004, the Friends of the Mill Pond and Oak Creek Watercourse worked with Milwaukee County Parks System staff to develop a conceptual design for restoring the Mill Pond area. This effort, known as the "Mill Pond Renaissance Project", was proposed to be used by the Parks System to apply for restoration grants. The park design proposed creating a meander in the creek flow that would lead to a lagoon just upstream of the dam, which could be used for ice skating (see Figure 6.Mill-FOMPplan). The plan involved building a peninsula off the south bank to be used as a picnic area, which connected to Oak Creek Parkway via a pedestrian bridge. The plan recommended environmental improvements such as stabilizing eroding banks and planting native vegetation. The plan also included recreational features like a gazebo, extra lighting features, a trail loop around the pond, and a parking lot in the southeast corner of the pond area.

The Mill Pond Renaissance Project provided some insight into the community's priorities for the project area in the early 2000s. Unfortunately, some features included in this plan are not feasible. The main peninsula feature would not be possible due to confining the Oak Creek floodway in this area (see Figure 6.Mill-FloodExist), which would cause additional and potentially substantial flooding upstream of the Mill Pond. The proposed parking lot fill area would cover the dam sluice gate inlet and render it nonfunctional. The additional lighting would encourage night use and adversely impact nocturnal species in the Oak Creek parkway. Both of these impacts are considered undesirable by Milwaukee County.

Planning Level Alternatives

Introduction

Five planning level alternatives and one optional add-on alternative have been developed as potential solutions to address concerns and improve conditions in the Mill Pond and dam area. The first four alternatives maintain the Mill Pond dam structure, while the fifth alternative removes the dam and restores the Oak Creek channel. An optional emergency spillway and dam abutment extension design that would increase the spillway flow capacity was also evaluated for those alternatives that maintain the dam structure.

This section first discusses the design and cost assumptions used to develop the alternatives and planning levels costs. Then each alternative is described including details such as major construction components, maintenance requirements, and a planning level cost estimate.

Design and Cost Assumptions

The Mill Pond and dam alternatives incorporate assumptions regarding sediment quality, sediment dewatering, fish passage, habitat and recreational improvements, and cost. The sections below describe the resource characteristic, design, and cost assumptions used to develop the planning level alternatives for the Mill Pond and dam area.

<u>Sediment Quality</u>

The planning level construction cost estimates included in this plan assume that the sediment in the Mill Pond is not severely contaminated. The presence of contaminated sediment could dramatically increase construction and maintenance costs due to the need to haul the dredged material a longer distance to a landfill site that accepts contaminated fill. To determine if the Mill Pond sediment is contaminated, all the alternative cost estimates include sediment core sampling. **Sediment core sampling is recommended at up to five locations depending on the areal extent of dredging required for each alternative.** For the planning level cost estimate, it is assumed the sediment core sampling would be done during the winter when the ice is at least a foot thick to support the soil core machinery. This method is considered the least expensive option to complete sediment core sampling.

<u>Sediment Dewatering</u>

All five planning level alternatives include dewatering the Mill Pond area, allowing the accumulated sediment to dewater in place, and then either mechanically moving it within the Mill Pond area or hauling it off-site. Following sediment removal, the repaired sluice gate and/or an upstream bypass pump and pipe would be used to dewater the pond and maintain dry conditions during construction.

If dewatering the sediment in place is not feasible before hauling off-site, it may be necessary to move the dredged sediment to another location for additional dewatering. One option would be to use a nearby section of the Oak Creek Parkway to stage sediment dewatering bags. This would disrupt traffic so a potential alternative site located just south of the Mill Pond dam on a parcel owned by the City of South Milwaukee was also investigated. Using this site would require hauling sediment to the site, filling dewatering bags with the sediment, and piping the water back to Oak Creek. This method would require permission from one private landowner (Chicago & Northwestern Transportation Company) and coordination between the City and the County to lay the pipe between this dewatering site and the pond. This option was not included in the cost estimates for this plan, but **it is recommended that the City keep this parcel vacant in the event it needs to be used for future sediment dewatering.**

Fish Passage

Commission staff evaluated the potential to add a fish passage channel, or fishway, to allow fish to migrate past the dam for those alternatives where the dam remains. Ideally, the downstream end of a fishway should be just downstream of a dam, as fish swimming upstream will congregate there due to the turbulence of water over the dam. Since some fish may not swim far into dark enclosures, a fishway design should also have an open top along as much of its length as possible to allow natural lighting.

Due to the close proximity of the Mill Pond dam to the Mill Road bridge and the sluice gate system, constructing an open top fishway outlet immediately downstream of the Mill Pond dam was considered infeasible. An alternative fishway design was investigated that had an outlet farther downstream of the dam in a natural pool. Based on recent fishway designs in the Region, the fishway would need to have a slope of two percent or less to accommodate the swimming abilities of regional fish species during normal flow conditions in Oak Creek. Furthermore, a sufficiently large flow volume would need to pass through this fishway to attract fish, and channel conditions downstream of the dam must be modified to help assure that migrating fish find the fishway entrance. The only feasible alignment for a potential fish passage structure with a two percent slope was on the south side of the Mill Pond, as shown in Figure 6.Mill-Fishpassage. The fishway outlet is located at the pool just downstream of the dam. The fishway runs approximately 900 feet upstream and ties into the existing bottom of the pond. This alignment has a total invert elevation drop of 18 feet. For this evaluation, it was assumed that the fishway consisted of a box culvert with the top face removed, with a short, covered box culvert section for the reach passing under Mill Road.

The conceptual fishway design shown in Figure6.Mill-Fishpassage would be difficult to construct and exceedingly expensive. It would not function well as a fishway given that the inlet and outlet would both be located far from the Mill Pond dam where fish are unlikely to congregate. Therefore, a fish passage design element was not included for alternatives where the dam remains.

Habitat and Recreational Improvements

Commission staff evaluated multiple terrestrial habitat and recreational features for the Mill Pond and dam alternatives. The recreational features investigated included boating, fishing piers, fishing access points, and additional walking paths. Terrestrial habitat features reviewed were vegetated terraces or benches and vegetation along the restored Mill Pond shoreline.

The only recreational features that were included in the proposed Mill Pond and dam alternatives were fishing access points and one new walking path. Boating is prohibited for ponds in the Milwaukee County Park System per Milwaukee County Code of Ordinances 47.13. Fishing piers were deemed to be infeasible as they would be difficult to access and maintain, would catch debris, and would be unsafe during flood events. There were limited opportunities for additional walking paths that would reach new terrain and be a reasonable distance from the current walking paths. With the existing configuration of Mill Pond, a walking path along the south side of the Mill Pond west of the warming house was determined to be infeasible due to the existing natural steep slopes present in that area. One additional walking path was included in this area as part of the fifth alternative in which dam removal provided sufficient space to the northwest of the warming house.

Vegetated floodplain or bench areas in the Mill Pond area were incorporated into the alternatives as appropriate. Plantings in these vegetated areas were assumed to consist of Wisconsin-native prairie and wetland plant species. It was determined that placing tall vegetation along the restored Mill Pond shoreline area would not be feasible for any of the alternatives. The was due to the desire to maintain sight lines to the Mill Pond area and warming house, as well as difficulties with establishing and maintaining this vegetation in high foot traffic areas, and the proximity of the shoreline to the existing sidewalk along the Oak Creek Parkway.

The Mill Pond and dam evaluation found evidence that natural springs may be present in the northern lobe of the pond. Where placing fill was proposed in the northern lobe as part of the Mill Pond and dam alternatives, no additional work or features were included in the planning level cost estimates to accommodate flows from the natural springs. Once an alternative is selected and construction begins, placement of French drains or a layer of clean sand may be required to facilitate flows from the natural springs.

Planning Level Costs

All items included in the planning level cost estimates for the Mill Pond and dam alternatives represent year 2019 dollars. Construction pricing was obtained chiefly from R.S. Means Heavy Construction Cost Data[3]; a 2015 AECOM cost estimate prepared for the County for the sluice gate repair[4]; and information from recent projects conducted by the Wisconsin Department of Transportation, the Minnesota Department of Transportation, and other local organizations. The planning level cost estimates also include a contingency of 35 percent to represent the costs for minor construction features, engineering design, and permitting. Permitting may include a dredging permit or a dam abandonment and removal permit from the WDNR as appropriate. A permit from the U.S. Army Corps of Engineers may also be required for construction of the selected alternative.

Dredging and hauling costs assume a volume of sediment with a 25 percent expansion factor to account for decompaction during mechanical excavation. A dredging and hauling cost of $100 per CY was used to develop the planning level cost estimates. This value was derived from the bids for the recent Estabrook dam removal and the AECOM cost estimate for the sluice gate repair. [5,6]

Sediment core sampling was assumed to occur during winter with a foot or more of ice thickness which should be sufficient for safe core sampling. It was assumed that the core samples would extend to the anticipated depth of dredging plus two feet and that a lab sample would be taken every two feet along the core length. A recommended list of contaminants that the samples should be tested for was developed based on guidance given in Chapter NR 347 of the *Wisconsin Administrative Code* (see Table 6.Mill-1). Chemical analysis costs for sample testing were provided by the Wisconsin State Lab of Hygiene. It should be noted that WDNR reserves the authority to waive testing for contaminants of minimal concern for the project site and to add additional testing parameters based on site-specific concerns. The planning level cost per sediment core sample for all the required constituents is included in Table 6.Mill-1.

The planning level cost estimate for each alternative also includes operation and maintenance costs for the next 50 years. The planning level operation and maintenance costs for the five alternatives include future

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[3]*R.S. Means Company, Inc.,* RSMeans Heavy Construction Cost Data, *23rd Annual Edition, 2009* and *30th Annual Edition, 2016.*

[4]*AECOM,* Milwaukee County Department of Parks, Recreation & Culture Mill Pond Dam Slide Gate Rehabilitation, Mill Road & Oak Creek Parkway, South Milwaukee, Wisconsin, *May 7, 2015. (This document is included in Appendix Dam)*

[5] Stacy Hron, WDNR, email correspondence dated July 29, 2020 for Estabrook dam removal bid worksheet.

[6] *AECOM 2015,* op. cit.

sediment dredging, vegetation maintenance, and dam inspections as appropriate. For alternatives with the dam remaining, it was assumed that re-dredging would be necessary about every 20 years based on the frequency of previous efforts by Milwaukee County. It was assumed that vegetation maintenance would be conducted during the first five years after completing construction for vegetation to become established. The alternatives where the dam remains also include a cost for dam inspections every ten years. While this is not a requirement, periodic inspection is a good practice to ensure the integrity of the dam structure and related infrastructure are maintained. Future maintenance costs were developed using an average Construction Cost Index factor and then calculated to present worth costs using an interest rate of 3.375 percent.

The five planning level alternatives and one optional add-on alternative developed for this plan are outlined below. Alternatives 1 through 4 retain the Mill Pond dam, while Alternative 5 removes the dam and restores the Oak Creek channel to a more natural configuration. The discussion below describes major construction components, maintenance requirements, and the planning level cost estimate for each alternative.

- Alternative 1 – Sluice Gate Repair
- Optional Spillway Enhancements – optional addition to Alternatives 1, 2 or 3
- Alternative 2 – Partial Pond Restoration
- Alternative 3 – Full Pond Restoration
- Alternative 4 – Bypass Channel, Dam Lowering, and Pond Restoration
- Alternative 5 – Dam Removal and Channel Restoration

Alternative 1 – Sluice Gate Repair

<u>Description and Main Features</u>

Alternative 1 represents the minimum work that must be done to bring the Mill Pond dam into compliance with the WDNR repair order. This alternative retains the Mill Pond dam and fixing the broken sluice gate as outlined in the construction plan developed by AECOM for Milwaukee County in 2015.[7] This plan includes

[7] *AECOM 2015,* op. cit.

adding a control gate structure, a new culvert between the existing gate structure and the new one, clearing the intake pipe of sediment, and dredging approximately 10 feet of sediment that currently buries the inlet pipe (see Figure 6.Mill-Alt1). The area dredged around the inlet required a five-foot horizontal to one-foot vertical (5:1) slope to promote sediment stability. Dredging would be completed by installing a sheet pile cofferdam, pumping water from within the cofferdam, and mechanically dredging in dry conditions. Once the sluice gate repair was completed, the cofferdam would be removed.

Major Construction Components

- SLUICE GATE REPAIR
  - Place cofferdam and dewater
  - Dredge and haul away approximately 1,200 CY of sediment
  - Clear existing intake pipe of sediment
  - Install new lift gate and control structure, new 2.5-ft diameter connection pipe

Maintenance Requirements

After the repairs are completed for Alternative 1, it is recommended that the sluice gate be opened, allowing water to flow through the gate at least once annually per guidance from the WDNR. For the purpose of developing planning level costs, it was assumed that dredging around the sluice gate inlet of half the volume initially dredged (600 CY) would be required once every 20 years. Half of the original dredge volume was assumed because regular operation of the sluice gate should flush some sediment from the intake area.

Planning Level Costs

The major construction components for Alternative 1 are listed above. The planning level cost estimate also includes the cost of collecting and analyzing one sediment core sample from the vicinity of the sluice gate inlet (see Figure 6.Mill-Alt1). The total estimated present worth cost for construction and maintenance of Alternative 1 is $542,000 (2019 dollars). A summary for all the planning level costs can be found in Table 6.Mill-2. The full planning level cost estimate tabulation for Alternative 1 can be found in Appendix 6.MillPond.

Optional Spillway Capacity Enhancements

Description and Main Features

As previously discussed, the Mill Pond dam spillway capacity is less than that needed to pass the 50-percent-annual-probability (2-year recurrence interval) flow event. When the capacity of the dam is exceeded, flood flows bypass the dam and go around the abutments of the dam structure which could destabilize the dam.

To accommodate larger storm events, two optional enhancements are described below to increase the spillway capacity of the Mill Pond dam. These enhancements could be added to Alternatives 1, 2, or 3 to improve safety at the dam and downstream on Oak Creek.

An optional emergency spillway with the configuration shown on Figure 6.Mill-Optional was evaluated to increase spillway capacity. The emergency spillway design includes a concrete weir to the north of the Mill Pond dam. The top of the emergency spillway would be set to a slightly higher elevation than the top of the existing dam (611.75 ft NGVD29) allowing baseflows to continue to flow over the Mill Pond dam. Water that flows over the emergency spillway would drop approximately ten feet through a concrete structure to a large rectangular box culvert. The emergency spillway culvert would discharge through an outlet on the north bank of the Creek downstream of the dam. This outlet includes a riprap-lined channel for erosion protection. The combination of this emergency spillway plus the existing dam would convey flows approximately equal to the 10-percent-annual-probability (10-year recurrence interval) event (1,420 cfs) before flows would bypass the abutments of the Mill Pond dam. The emergency spillway includes a grate at the inlet weir to prevent debris from clogging the culvert and a grate at the outlet for safety.

The Mill Pond dam spillway capacity could also be increased by extending the dam abutments to convey more flow over the current dam spillway (see Figure 6.Mill-Optional). Extending the abutments would increase the spillway capacity of the dam to about 1,050 cfs, between the 50-percent-annual-probability (2-year recurrence interval) event and the 10-percent-annual-probability (10-year recurrence interval) events. If both the emergency spillway and abutment extension designs were implemented, the dam would be able to safely convey the 2-percent-annual-probability (50-year recurrence interval) event (1,940 cfs).

<u>Major Construction Components</u>

- EMERGENCY SPILLWAY
  - Concrete weir 50 feet long with crest elevation of 612.0 NGVD29
  - Concrete drop structure to 200-foot long, 8-foot by 12-foot concrete box culvert
  - Concrete end section at outlet
  - Riprap armoring at outfall area
  - Inlet and outlet grates

- ABUTMENT EXTENSIONS
  - Concrete abutment extensions for total length of 37 feet

Planning Level Costs

The major construction components for the Optional Spillway Enhancements are listed above. No maintenance requirements for this alternative are included in the planning level cost estimate, although the inlet grate for the emergency spillway would require periodic inspection, maintenance, and removal of debris when necessary. The total estimated present worth cost for construction of the Optional Spillway Enhancements is $736,000. This includes $733,500 for the emergency spillway and $2,500 for the abutment extensions. Detailed planning level cost estimates for the Optional Spillway Enhancements can be found in Appendix 6.MillPond.

Alternative 2 – Partial Pond Restoration

Description and Main Features

Alternative 2 includes fixing the dam sluice gate and the associated dredging as described in the description of Alternative 1 and dredging the southeastern lobe of the Mill Pond to bottom elevations similar to the original Mill Pond after dam construction in the 1930s (see Figure 6.Mill-Alt.2A). This alternative would retain the Mill Pond dam. Alternative 2 would create pond depths of up to seven to nine feet.

Two variations of Alternative 2 were evaluated for disposal of dredged sediment. Under the first variation, all dredged sediment would be hauled off-site (see Figure 6.Mill-Alt.2A). Under the second variation, it was assumed the dredged sediment would be suitable to use to fill in the northern lobe of the Mill Pond. This area would be restored with seeded vegetation in the floodfringe area (see Figure 6.Mill-Alt.2B). The fill area was designed to not impact the Oak Creek floodplain. Placing dredged material in this area may enhance the ability of wetland vegetation to survive and would reduce sediment haul volumes by as much as 10,000 CY. It may be required to place a soil cap over this fill to reduce human contact potential. The placement of a soil cap is not included in the planning level cost estimate for Alternative 2B. Under both sub-alternatives, a pervious pavement platform would be constructed along the eastern bank of the pond to the north of the dam to provide access for recreational fishing.

Should Alternative 2 be implemented, investigations will need to be conducted to determine whether a safety barrier should be placed near the dam spillway to warn ice skaters of the dam face. This investigation and such a barrier are not included in the planning level cost estimate. Alternative 2 also includes repair of the sluice gate system as described in Alternative 1. It is recommended to repair the sluice gate first, so the sluice gate can be used to dewater the Mill Pond prior to the sediment mechanical dredging for Alternative 2.

Major Construction Components

- SLUICE GATE REPAIR (see Alternative 1)

- DREDGE SOUTHERN POND LOBE
  - Dewater with sluice gate and cofferdam/piping around site
  - Dredge approximately 12,200 CY of sediment
  - Haul away 12,200 CY (Alternative 2A) or 2,200 CY (Alternative 2B) of sediment

- FILL NORTHERN POND LOBE (ALTERNATIVE 2B)
  - Floodway area filled to maximum elevation of 611.7 ft NGVD29
  - Floodfringe area filled to maximum elevation of 613.7 ft NGVD29
  - Floodfringe Bank area planted with native vegetation

- RECREATIONAL ENHANCEMENTS
  - Create approximately 1.7 acres of open water or skating area
  - One pervious pavement platform for fishing

Maintenance Requirements

As for Alternative 1, the sluice gate should be opened, allowing water to flow through the gate at least once annually per WDNR guidance. For the purpose of developing planning level costs, it was assumed that dredging the entire volume initially dredged (13,400 CY) for Alternative 2 would be required once every 20 years. The entire volume was assumed because the restored Mill Pond area is small. The vegetation that would be planted in the floodfringe area for Alternative 2B would also require maintenance until desired species are firmly established. The planning level cost estimate for Alternative 2B includes vegetation maintenance for the first five years after construction.

Planning Level Costs

The major construction components for Alternative 2 are listed above. The planning level cost estimate also includes collection and chemical analysis of two sediment core samples (see Figure 6.Mill-Alt2A). The total estimated present worth cost for construction and maintenance of Alternative 2A is $5,351,000 (2019 dollars) and for Alternative 2B is $4,315,000 (2019 dollars). A summary of the planning level costs can be found in Table 6.Mill-2. Detailed planning level cost estimates for Alternatives 2A and 2B can be found in Appendix 6.MillPond.

Alternative 3 – Full Pond Restoration

Description and Main Features

Alternative 3 involves fixing the sluice gate of the dam and associated dredging as described in the description of Alternative 1 and dredging the accumulated sediment in the entire Mill Pond area to recreate the original 1930s condition (see Figure 6.Mill-Alt3). This alternative retains the Mill Pond dam and creates pond depths of up to seven to nine feet over a larger area than Alternative 2. Two pervious pavement platforms would be installed along the north and east bank of the pond to provide access for recreational fishing.

As with Alternative 2, investigations will need to be conducted to determine whether a safety barrier should be placed near the dam spillway to warn ice skaters of the dam face. This item is not included in the planning level cost estimate. In this alternative, the sluice gate system would be repaired as described in Alternative 1. It is recommended to repair the sluice gate first, so the sluice gate can be used to dewater the Mill Pond prior to the sediment mechanical dredging for Alternative 3.

Major Construction Components

- SLUICE GATE REPAIR (see Alternative 1)

- DREDGE POND AREA
  - Dewater with sluice gate and cofferdam/piping around site
  - Dredge and haul away approximately 46,000 CY of sediment

- RECREATIONAL ENHANCEMENTS
  - Create approximately 5.7 acres of open water or skating area
  - Two pervious pavement platforms for fishing

Maintenance Requirements

As with Alternative 1, the sluice gate should be opened, allowing water to flow through the gate at least once annually per guidance from the WDNR. Under Alternative 3 it was assumed that half of the volume initially dredged (23,600 CY) would be required every 20 years. For the area to be restored, this volume of dredging is reasonable as compared to the assumed volume of maintenance dredging for Alternative 2.

Planning Level Costs

The major construction components for Alternative 3 are listed above. The planning level cost estimate also includes collection and chemical analysis of five sediment core samples (see Figure 6.Mill-Alt3). The total estimated present worth cost for construction and maintenance of Alternative 3 is $12,410,000 (2019 dollars). A summary of the planning level costs can be found in Table 6.Mill-2. Detailed planning level cost estimates for Alternative 3 can be found in Appendix 6.MillPond.

Alternative 4 – Bypass Channel, Dam Lowering, and Pond Restoration

Description and Main Features

Alternative 4 includes fixing the dam sluice gate and associated dredging as described in the description of Alternative 1, diverting lower flows into a bypass channel around the Mill Pond, and restoring the remaining portion of pond (see Figure 6.Mill-Alt4). Low flows less than the 50-percent-annual-probability (2-year recurrence interval) event convey the majority of sediment load for Oak Creek. Routing these flows around the pond will significantly reduce sediment accumulation in the restored Mill Pond. Under this alternative the remaining Mill Pond area would be dredged to a maximum depth of about six feet. The Mill Pond dam would be retained, but the dam crest would be lowered by approximately two feet.

Alternative 4 involves diverting Oak Creek low flows up to the 99-percent-annual-probability (1-year recurrence interval) event (387 cfs) through a trapezoidal rock-lined channel. This channel would run along the northern edge of the project area and connect to a culvert that bypasses the Mill Pond dam on the north side (see Figure 6.Mill-Alt4). An inlet weir would be built at the upstream end of the Mill Pond. This weir would allow Oak Creek flows greater than approximately 80 cfs to also enter the restored pond. The section of the bypass channel near the existing island in the pond would have a smaller cross section with additional rock lining to provide enough capacity and armoring to convey the flow through this narrow area. The bypass channel would be separated from the Mill Pond by a berm which would have a clay core to prevent seepage flow between the bypass channel and the restored Mill Pond. The bypass berm may also provide additional locations for fishing access.

The downstream end of the bypass channel would discharge over a weir which would be covered by a grate with an opening at the base to allow free flow. A large concrete drop structure and culvert would be installed downstream of this weir. The culvert would convey flow under Mill Road, discharging into the Creek through an outlet located downstream of the Mill Pond dam on the north bank. Rock armoring would be placed at the outlet of the culvert for erosion protection. The configuration of this portion of Alternative 4 is shown on Figure 6.Mill-Alt4detail. The bypass weir and culvert would also function as an emergency spillway for the dam. Hydraulic modeling indicated that events larger than the 2-percent-annual-probability (50-year recurrence interval) event would flow over the berm between the restored pond and the bypass channel. Alternative 4 includes lowering the Mill Pond dam crest to provide adequate hydraulic conditions at the inlet weir for the bypass channel. With the dam lowering and bypass culvert, the total spillway capacity for Alternative 4 would be between the 1-percent-annual-probability (100-year recurrence interval) and 0.2-percent-annual-probablity (500-year recurrence interval) events.

As discussed above, the planning level design for Alternative 4 includes a bypass channel for Oak Creek baseflows. This would mean that the restored pond for Alternative 4 would only see flows from Oak Creek during flow events larger than approximately 80 cfs. Review of Oak Creek flow data at the USGS gage at 15th Avenue from years 2011, 2014, and 2017, which were selected as flow data that approximated a typical year, showed that on average the pond would receive flow during 30 days per year over ten different events. An option to supplement flows to the pond would be to pump City water into the Alternative 4 restored pond during baseflow times. This pumping option is not included in the planning level cost estimate for Alternative 4.

As with Alternatives 2 and 3, the need for a safety barrier at the dam spillway to warn ice skaters of the dam face should be investigated. This item is not included in the planning level cost estimate. In this alternative, the sluice gate system would be repaired as described in Alternative 1. It is recommended to repair the sluice gate first, so the sluice gate can be used to dewater the Mill Pond prior to the sediment mechanical dredging for Alternative 4.

<u>Major Construction Components</u>

- SLUICE GATE REPAIR (see Alternative 1)

- DREDGE POND AREA
  - Dewater with sluice gate and cofferdam/piping around site
  - Dredge and haul away approximately 44,000 CY of sediment

- LOWER DAM
  - Lower dam crest by 1.75 feet (610.0 ft NGVD)

- INLET WEIR TO POND
  - Concrete weir with top elevation of 613.4 ft NGVD29 and five-foot wide notch with invert of 610.6 ft NGVD29

- BYPASS CHANNEL AND EARTHEN BERM
  - Rock armored and grass lined trapezoidal channel
  - Channel around pond 10 feet wide at bottom with 3:1 side slopes and rock lining for lower 1.5 feet of side slope. Channel around natural island 7.4 feet wide with 2:1 side slopes and rock lining for 4.75 feet of depth.
  - Bypass berm with a top elevation of 613.0 ft NGVD29
  - Earthen berm has 3:1 side slopes and a clay core, planted with native vegetation

- BYPASS CULVERT SYSTEM
  - Concrete weir 10 feet wide with invert elevation of 606.25 ft NGVD29
  - Concrete drop structure to 8-ft diameter concrete culvert, 190 feet long under Mill Road
  - Rock armoring at outlet
  - Inlet and outlet grates with two-foot high opening at bottom to prevent clogging

- RECREATIONAL ENHANCEMENTS
  - Create approximately 3.5 acres of open water or skating area
  - Bypass berm for additional access to restored Mill Pond

<u>Maintenance Requirements</u>

As with Alternative 1, the sluice gate should be opened, allowing water to flow through the gate at least once annually per WDNR guidance. The inlet grate for the bypass culvert will require periodic inspection and be cleaned of debris when necessary. For the purpose of developing planning level cost, it was assumed that dredging a quarter of volume initially dredged (11,000 CY) would be required every 20 years. A quarter of the entire volume was assumed as the bypass channel should divert a large portion of the sediment around the Mill Pond for Alternative 4. The vegetation planted on the earthen berm would also require maintenance until desired species become established. The planning level cost estimate includes vegetation maintenance for the first five years after construction.

Planning Level Costs

The major construction components for Alternative 4 are listed above. The planning level cost estimate also includes collection and chemical analysis of five sediment core samples (see Figure 6.Mill-Alt4). The total estimated present worth cost for construction and maintenance of Alternative 4 is $10,331,000 (2019 dollars). A summary of the planning level costs can be found in Table 6.Mill-2. Detailed planning level cost estimates for Alternative 4 can be found in Appendix 6.MillPond.

Alternative 5 – Dam Removal and Channel Restoration

Description and Main Features

Alternative 5 includes removing the dam and recreating a naturalized Oak Creek channel in the Mill Pond area. As was discussed in Chapter 4, a portion of the original Oak Creek channel has been permanently buried under Mill Road, thus a new channel would need to be built. The Mill Pond area would be lowered to create a new Oak Creek channel that would contain a series of meandering riffles and pools to facilitate fish passage (see Figure 6.Mill-Alt5AB). Some features of the design might be similar to a channel restoration project completed by the Milwaukee Metropolitan Sewerage District on Underwood Creek in the City of Wauwatosa. The Underwood Creek project also included floodplain excavation and creation of a rock lined channel (see Figure 6.Mill-Alt5example).

Three variations of Alternative 5 were evaluated that included two different techniques to lower the Mill Pond area as well as two different shapes for the restored bank area. The sediment and soil removal techniques included combinations of dredging and hauling off-site, allowing sediment to be removed naturally by Oak Creek flows, and reworking the sediment and soil within the former pond area. The two different shapes for the restored bank area above the riffle pool complex included a large or small floodplain habitat area.

Under the Alternative 5A, all dredged sediment would be hauled off-site to create a large floodplain habitat area (see Figure 6.Mill-Alt5AB). Hauling all the material off-site would be required if the sediment and soils in the Mill Pond were found to be contaminated. An example of the proposed channel and floodplain cross section for Alternative 5A is shown on Figure 6.Mill-XS at the location indicated on Figure 6.Mill-AltAB. This cross section is oriented looking downstream, or to the southeast, and depicts the conceptual cross section for the Alternative 5 options relative to the existing Mill Pond bottom. Under the Alternative 5B, the large floodplain habitat area would be created by allowing a portion of the sediment removal to be achieved by gradually notching the dam and allowing the sediment to move downstream with Oak Creek flows. The remaining sediment removal for Alternative 5B would be achieved by earthwork onsite or hauling off-site.

The lowered floodplain for Alternatives 5A and 5B would become wet during above-average flow conditions for Oak Creek (flows above 25 cfs), creating a more wetland-like environment. The areas of fill for Alternative 5B were designed to not impact flood levels for the Oak Creek 1-percent-annual-probability (100-year recurrence interval) event.

Under Alternative 5C, the small floodplain habitat area would be created by allowing a portion of the sediment removal to be achieved by gradually notching the dam and allowing sediment to move downstream with Oak Creek flows (see Figure 6.Mill-Alt5C). The remaining sediment removal for Alternative 5C would be achieved by earthwork onsite or hauling off-site (see Figure 6.Mill-XS). The lowered floodplain in Alternative 5C would become wet at approximately the 50-percent-annual-probability (2-year recurrence interval) event (flows above 878 cfs). The areas of fill for Alternative 5C were designed to not impact flood levels for the Oak Creek 1-percent-annual-probability (100-year recurrence interval) event.

For all of the Alternative 5 options, the areas above the riffle pool complex would be restored with seeded native vegetation. Placing existing sediment material in the vegetated areas may enhance the ability of wetland and native vegetation to survive. The establishment of native vegetation will be especially important for Alternative 5C as flood velocities are higher in the small floodplain habitat area as compared to the large floodplain habitat for Alternatives 5A and 5B. Alternative 5C may also require additional erosion control features in the floodplain habitat area due to higher flood velocities. It may also be required to place a soil cap over the vegetated areas before seeding to reduce human contact potential. The placement of additional erosion control features or a soil cap is not included in the planning level cost estimates for Alternatives 5A, 5B, or 5C.

The updated hydraulic model was used to size the Oak Creek channel restoration which is the same for each of the Alternative 5 options. The hydraulic model estimated that the proposed riffle pool system would have a maximum flow velocity of about 4.6 feet per second (fps) near the former dam during normal Oak Creek flow conditions. The former dam location is the most constrained cross section for the Alternative 5 options, and thus it is the location with the highest flow velocity. The maximum prolonged swimming and swimming burst speeds of various migrating fish species found in southern Lake Michigan are shown in Table 6.Mill-3. Based upon these data, pike, salmon, trout, and most bass and sucker species would likely be able to pass through the Alternative 5 riffle pool system under normal flow conditions.

The restored channel bottom under each of the Alternative 5 options would drop approximately 11 feet over the length of the Mill Pond, in half-foot increments at each riffle to allow fish passage. The pools would provide resting areas for aquatic organisms and would have a maximum depth of about three feet. The restored channel would be armored with rounded stone, and large rock benches would anchor the riffles to ensure that they remain in place during higher flow events. All of the Alternative 5 options also include construction of a walking path to the northwest of the warming house.

As each of the Alternative 5 options eliminates the open water component of the previous alternatives, a potential location for a seasonal ice skating area was investigated. It was determined that a location in the vegetated floodplain habitat area just north of the warming house would be feasible (see Figure 6.Mill-Alt5skate). This area could be flooded using water from Oak Creek or the City water utility. This would provide approximately 0.3 acres of skating area. A trail with switchbacks leading down to the ice skating area would be necessary to make the site accessible. The skating area option and associated trail are not included in the planning level costs discussed below.

<u>Major Construction Components</u>

- DREDGE POND AREA (ALTERNATIVE 5A)
  - Dewater with pumping and cofferdam/piping around site
  - Dredge and haul away approximately 72,000 CY of sediment to create large floodplain habitat

- LOWER POND AREA (ALTERNATIVE 5B)
  - Dewater pond by notching dam in half-foot increments
  - Route streamflow during construction with cofferdam and pumping/piping around site
  - Create large floodplain habitat by allowing sediment to flow downstream and reworking a portion of remaining sediments
  - Dredge and haul away approximately 41,000 CY of sediment

- LOWER POND AREA (ALTERNATIVE 5C)
  - Dewater pond by notching dam in half-foot increments
  - Route streamflow during construction with cofferdam and pumping/piping around site
  - Create small floodplain habitat by allowing sediment to flow downstream and reworking a portion of remaining sediments
  - Dredge and haul away approximately 12,000 CY of sediment

- DAM REMOVAL

- ESTABLISH VEGETATION
  - Non-rock areas planted with native vegetation

- RIFFLE-POOL CHANNEL
  - Series of 22 riffle pools that drop 11 feet across project area, in half-foot steps
  - Each pool has a maximum depth of about three feet and a minimum length of about 50 feet
  - Each riffle has a minimum width of five feet
  - Channel lined with smooth boulders one to two feet in diameter
  - Channel riffles anchored with three-foot diameter boulders

Maintenance Requirements

The only maintenance requirement associated with the Alternative 5 options is vegetation maintenance. It is likely that some Oak Creek sediment would wash up onto the vegetated areas during flooding, but the volume deposited would probably be small enough to be incorporated into the floodplain bench habitat areas and would not require removal. The vegetation planted in the floodplain bench areas would require maintenance until desired species become established. The planning level cost estimate includes vegetation maintenance for the first five years after construction.

Planning Level Costs

The major construction components for the Alternative 5 options (5A, 5B, 5C) are listed above. The planning level cost estimate also included five sediment core samples (see Figure 6.Mill-Alt5AB). The total estimated present worth cost for construction and maintenance of Alternative 5A is $11,926,000 (2019 dollars), for Alternative 5B is $7,906,000 (2019 dollars), and for Alternative 5C is $4,772,000 (2019 dollars). A summary of the planning level costs can be found in Table 6.Mill-2. Detailed planning level cost estimates for Alternatives 5A, 5B, and 5C can be found in Appendix 6.MillPond.

Evaluation of Alternatives

The Mill Pond and Mill Pond dam planning level alternatives discussed above were evaluated based on their impact on flooding, environmental, and recreational components of the Mill Pond area. For each of these issues, the sections below first discuss the criteria used to evaluate the alternatives, then present the evaluation. A summary of the full evaluation is given in Table 6.Mill-4. This table presents a qualitative evaluation of positive (+) and negative (-) impacts as compared to existing conditions at the Mill Pond and dam.

Flooding

Impacts of the five proposed alternatives on flooding were evaluated. It was determined that a reduction in the flood elevation for the 1-percent-annual-probablity (100-year recurrence interval) floodplain upstream of the dam location as compared to existing conditions would constitute an improvement (see Figure 6.Mill-FloodExist). This reduction in flood elevation would be achieved by either increasing the spillway capacity or removing the dam. For the five proposed alternatives a reduction in the flood elevation will result a reduced areal extent for the 1-percent-annual-probability (100-year recurrence interval) floodplain.

As was previously discussed, Alternatives 1, 2 and 3 would not reduce the flood elevation upstream of the dam unless the optional spillway enhancements were included (see Figure 6.Mill-FloodAlt). The optional spillway enhancements to Alternatives 1, 2, and 3 would increase the overall Mill Pond dam spillway capacity as compared to existing conditions, lowering the 1-percent-annual-probability flood elevation by approximately 1.1 feet. This would reduce flooding on the Oak Creek Parkway. Alternative 4 would increase the overall spillway capacity significantly as compared to existing conditions, thus lowering the 1-percent-annual-probability flood elevation by approximately 2.5 feet. This would essentially eliminate flooding on the Oak Creek Parkway. Alternative 5 would lower the 1-percent-annual-probability flood elevation by up to 10.5 feet, which would significantly reduce the flooded area (see Figure 6.Mill-FloodAlt).

Environmental

The evaluation of the environmental impacts of the Mill Pond and dam alternatives was based on the effects of the alternatives on water quality, sedimentation, fish passage, and habitat. These four categories were evaluated individually.

It was assumed that water quality in the Mill Pond would improve as a result of either an increase in pond depth or an improvement of flow and sediment transport through the area because these changes would improve water temperatures and dissolved oxygen conditions. Alternative 1, with repair to the sluice gate only, would not improve water quality in the Mill Pond area. Alternatives 2 and 3 would improve water quality by increasing the depth of the Mill Pond. Alternative 4 would improve water quality in the Mill Pond by both increasing its depth and bypassing sediment past the pond area. The water quality improvement for Alternative 4 may be tempered by the reduction in baseflows to the pond area unless supplemental pumping is included. Alternative 5 would improve water quality by eliminating ponding and conveying Oak Creek flows downstream.

It was assumed that less sediment would accumulate in the Mill Pond under those alternatives that convey sediment past the Mill Pond dam area. Under Alternatives 1, 2, and 3, the Mill Pond will continue to accumulate sediment over time. Under Alternative 4, a large portion of sediment transported by Oak Creek would bypass the restored Mill Pond area, thus improving conditions in the Pond. Under Alternative 5, the majority of sediment would be conveyed past the pond area, which would also be an improvement for sediment conditions in the Mill Pond area.

Fish passage past the Mill Pond dam would only be improved under Alternative 5 in which the dam would be removed and the channel would be restored. As was discussed earlier in this section, it was determined that a fish passage channel would not be feasible for Alternatives 1, 2, 3, and 4 given the current constraints at the Mill Pond dam and Mill Road. Under Alternative 5, fish and aquatic species could move between Lake Michigan and the upper Oak Creek watershed, which would provide a variety of habitat and food sources and produce a more healthy native fishery. However, this would also allow invasive aquatic species and viral hemorrhagic septicemia (VHS) to more easily travel upstream. VHS is a deadly infectious fish disease that occurs in the Lake Michigan fishery. Overall, the free movement of fish and aquatic species would be considered a positive for Alternative 5.

The criteria used to evaluate habitat improvements for the alternatives were based on whether an implementation of an alternative would increase habitat area available to aquatic species through increases in Mill Pond depth or flow and whether it would increase habitat area available to terrestrial species. Alternative 1 would not provide any habitat improvements over existing conditions. Alternatives 2A and 3 would improve habitat for fish and aquatic species by increasing water depth in the Mill Pond. Alternative 2B would also add vegetated benches in the original Mill Pond area which would improve habitat for amphibians and terrestrial species. Alternative 4 would also improve habitat by increasing depths in the restored pond and creating a small area on the bypass channel berm for vegetation. Alternative 5 would improve flow conditions through the Mill Pond area significantly, increase the amount of terrestrial habitat, and improve the connections between that habitat and the restored Oak Creek channel.

Recreation

The Mill Pond and dam alternatives were evaluated based on their potential to improve recreational opportunities in the Mill Pond area. The main recreational opportunities evaluated included ice skating, fishing, use of the warming house, and viewing of the dam waterfall. As previously discussed, boating is prohibited on the ponds in the Milwaukee County Park System per Milwaukee County Code. The potential for adding walking paths to the alternatives was limited to a small additional walking path for Alternative 5 only, thus walking paths were not included in the following evaluation.

Improvements in opportunities for ice skating were assessed by comparing the restored pond areas available for skating under each alternative. However, it should be noted that the potential for ice skating also depends on having freezing temperatures for a long enough duration to achieve safe ice thickness. Alternative 1 would not modify the Mill Pond, thus it would not improve skating opportunities. Alternatives 2, 3, and 4 would increase the area available for ice skating, with Alternative 3 providing the largest skating area. Alternative 5 would eliminate the Mill Pond, diminishing opportunities for ice skating. If the small optional ice skating area discussed above were implemented as part of Alternative 5, this would provide a smaller area for skating than the other alternatives.

The impact of the five planning level alternatives on fishing opportunities were evaluated based on potential changes to pond conditions and connectivity to Lake Michigan. Increases in water depth, water quality, pond area, and reconnection to Lake Michigan were considered to provide improvements in fishing opportunities. Alternative 1 would not improve fishing conditions. Alternatives 2, 3, and 4 would improve fishing conditions in the Mill Pond to varying degrees, depending on the size and depth of the restored pond. Alternative 5 would also improve fishing conditions in the Mill Pond area because flow conditions would improve with the restored channel, aquatic organisms would be able to move through the Mill Pond area and have access to both Lake Michigan and the upstream Oak Creek watershed.

Additional demand for use of the warming house was evaluated based on the level of improved water quality, habitat, and recreational conditions in the Mill Pond area. It was assumed improved conditions would translate to additional people using the area. Alternative 1 would not improve conditions at the Mill Pond area, thus there would not be additional demand for use of the warming house. Alternative 2 restored a portion of the Mill Pond area which should slightly increase demand for use of the warming house. Alternatives 3, 4, and 5 improved the majority of the Mill Pond area, thus there should be a larger demand for use of the warming house.

The view of the waterfall would remain the same under Alternative 1,2, and 3, but it would be modified under Alternative 4. Because the bypass channel would convey the majority of Oak Creek baseflow, flows over the lowered dam under Alternative 4 may be intermittent during normal flows. This lack of flow over the dam could be mitigated by adding City water to the restored Alternative 4 pond.

Summary

Table 6.Mill-4 summarizes the evaluation of the Mill Pond and dam alternatives. It also includes a summary of the maintenance needs and planning level costs for each alternative.

Alternative 1 (sluice gate repair) would meet the requirements of the WDNR order for repairing the Mill Pond dam but would not improve conditions related to flooding, environmental concerns, or recreation as compared to existing conditions. Adding the optional emergency spillway and/or abutment extensions to Alternative 1 would reduce flooding impacts. Maintenance for Alternative 1 includes exercising the sluice gate, dam inspections, and periodic dredging, and the maintenance cost was low compared to the other alternatives. The total present worth planning level cost is $542,000 (2019 dollars) for Alternative 1. Including the optional emergency spillway and abutment extensions as part of Alternative 1 would add $736,000 (2019 dollars) to cost (see Table 6.Mill-4).

Alternative 2 (partial pond restoration) would include the sluice gate repair described in Alternative 1, thus it would also meet the requirements of the WDNR repair order for the Mill Pond dam. Alterative 2 would not improve flooding conditions as compared to existing conditions unless the optional emergency spillway and/or abutment extensions were added. Alternative 2A would improve environmental conditions and recreation to some degree with the smaller restored pond. Alternative 2B with the vegetated fill area would further improve environmental conditions. Maintenance for Alternative 2 includes exercising the sluice gate, dam inspections, vegetation maintenance (for Alternative 2B), and periodic dredging, and the maintenance cost was high compared to the other planning level alternatives. The total present worth planning level cost for Alternative 2A is $5,351,000 (2019 dollars) and for Alternative 2B is $4,315,000 (2019 dollars). Including the optional emergency spillway and abutment extensions would add $736,000 (2019 dollars) to the Alternative 2 costs (see Table 6.Mill-4).

Alternative 3 (full pond restoration) would include the sluice gate repair described in Alternative 1, thus it would also meet the requirements of the WDNR repair order for the Mill Pond dam. Alterative 3 would not improve flooding conditions as compared to existing conditions unless the optional emergency spillway and/or abutment extensions were included. Alternative 3 would improve environmental conditions and recreation within the larger restored pond. Maintenance for Alternative 3 includes exercising the sluice gate, dam inspections, and periodic dredging, and the maintenance cost was high compared to the other planning level alternatives. The total present worth planning level cost for Alternative 3 is $12,410,000 (2019 dollars). Including the optional emergency spillway and abutment extensions would add $736,000 (2019 dollars) to the Alternative 3 cost (see Table 6.Mill-4).

Alternative 4 (bypass channel, dam lowering, and pond restoration) would include the sluice gate repair described in Alternative 1, thus it would also meet the requirements of the WDNR repair order for the Mill Pond dam. Alternative 4 would reduce flooding conditions as compared to existing conditions. Alternative 4 would improve environmental conditions and recreation overall with the bypass channel and larger restored pond. Alternative 4 would have a negative impact on viewing of the waterfall. Maintenance for Alternative 4 includes exercising the sluice gate, dam inspections, vegetation maintenance, and periodic dredging, and the maintenance cost was medium compared to the other planning level alternatives. The total present worth planning level cost for Alternative 4 is $10,331,000 (2019 dollars) (see Table 6.Mill-4).

Alternative 5 (dam removal and channel restoration) would eliminate the need for the sluice gate repair. This alternative would meet the requirements of the WDNR repair order by removing the dam. Alterative 5 would considerably reduce flooding conditions as compared to existing conditions. Alternative 5 would improve environmental conditions and recreation overall with the restoration of the Oak Creek channel and floodplain. Alternative 5 would have a negative impact on the ability to ice skate in the former pond area, unless the optional small ice skating area is included. This also the only alternative that would restore fish passage between Lake Michigan and the Oak Creek watershed. Maintenance for Alternative 5 includes vegetation maintenance only, and the cost was low compared to the other planning level alternatives. The total present worth planning level costs for Alternative 5A is $11,926,000 (2019 dollars), Alternative 5B is $7,906,000 (2019 dollars), and Alternative 5C is $4,772,000 (2019 dollars) (see Table 6.Mill-4).

Recommended Actions

The alternatives for the Mill Pond and dam presented in this plan are planning-level conceptual alternatives. As summarized above, the planning level alternatives would improve conditions at the Mill Pond and dam to varying degrees for a wide range of costs. The decision regarding improvements to the Mill Pond and dam area ultimately rests with Milwaukee County as owner of the dam. An alternative or components of an alternative described in this plan will need to be refined based on environmental concerns, local input, maintenance requirements, and cost considerations. As part of this planning effort, one action is recommended and two other potential actions are offered in order to move closer to a preferred alternative for the Mill Pond and dam.

1. Sediment Core Sampling – **It is recommended that the County complete sediment core sampling and analysis for up to five locations in the project area at a planning level cost of $49,000 (2019 dollars).** This work will determine the level of sediment contamination and dredged material disposal

options, both of which will impact the cost and feasibility of the Mill Pond and dam alternatives presented in this plan.

2. Sediment Transport Analysis – The County should consider completing a sediment transport analysis as part of the refinement of alternatives for the Mill Pond area. This analysis would provide a better estimate of the amount of sediment being delivered to the area by Oak Creek, which would help clarify the frequency of maintenance dredging that would be required for Alternatives 1 through 4. The complexity of this analysis could range from a simple land-use based model to detailed sediment measurements. A basic modeling effort would include a literature review of the amount of bedload and sediment delivered by similar current land uses and streams, and subsequent completion of a model such as a Unit Area Load model for the Oak Creek watershed. Field measurement efforts could include mapping the sediment accumulation in the Mill Pond over a longer period of time (years), or actual sampling of sediment in Oak Creek upstream of the pond for at least a year. It is estimated that the cost to complete a sediment transport analysis would range from $10,000 to $75,000 (2019 dollars).

3. Sluice Gate Repair – If it is determined in the future that Alternative 5 (dam removal and channel restoration) should not be pursued, repairs to the sluice gate could be completed prior to selecting a preferred alternative as this would be necessary for any modification that does not fully remove the dam. The total present worth cost for Alternative 1 for the sluice gate repair was $542,000 (2019 dollars).

6.7 RECOMMENDED ACTIONS FOR PUBLIC AWARENESS AND PARTICIPATION IN WATERSHED RESTORATION ACTIVITIES

6.8 PRIORITY PROJECTS FOR IMPLEMENTATION

6.9 MEASURING PLAN PROGRESS AND SUCCESS

6.10 PLAN IMPLEMENTATION

6.11 REQUIRED TECHNICAL AND FINANCIAL ASSISTANCE

Community Assistance Planning Report No. 330

A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

Chapter 6

PLAN RECOMMENDATIONS

TABLES

Table 6.Mill-1
Sediment Core Tests and Associated Costs for Mill Pond Sediment

Soil Test	Cost per Sample (dollars)
Aroclors/Pesticides in Soil / Sediment (total PCBs, chlordane, dieldrin, endrin, DDT, DDE, aldrin, heptachlor, lindane, toxaphene)	700
Metals and Other Inorganic Chemicals (arsenic, barium, cadmium, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, selenium, zinc)	110
Nutrients (ammonia nitrogen, nitrate, total Kjeldahl nitrogen, total phosphorus)	210
Other Constituents (PAHs, oil and grease in solid, grain size, percent solids, total organic carbon, PFAS)	1,300
Total Cost	2,320

Sources: Section NR 347.06(6)(b)of the Wisconsin Administrative Code *and Wisconsin State Lab of Hygiene (2020 pricing)*

Table 6.Mill-2
Mill Pond and Dam Cost Summary

Alternative	Description	Core Sampling (Number of Sample Locations)[a]	Construction with 35 percent Contingency[a]	Ongoing Maintenance[a,b]	Total Present Worth Cost[a]
Alternative 1	Sluice Gate Repair[c]	$14,000 (1)	$329,000	$199,000	$542,000
Alternative 2A[d]	Partial Pond Restoration[c]	$24,000 (2)	$2,202,000	$3,125,000	$5,351,000
Alternative 2B[e]	Partial Pond Restoration and Fill[c]	$24,000 (2)	$1,147,000	$3,144,000	$4,315,000
Alternative 3	Full Pond Restoration[c]	$49,000 (5)	$6,897,000	$5,464,000	$12,410,000
Alternative 4	Bypass Channel, Dam Lowering, and Pond Restoration	$49,000 (5)	$7,658,000	$2,624,000	$10,331,000
Alternative 5A[f]	Dam Removal and Channel Restoration – Large Floodplain Habitat	$49,000 (5)	$11,816,000	$61,000	$11,926,000
Alternative 5B[g]	Dam Removal and Channel Restoration – Large Floodplain Habitat	$49,000 (5)	$7,796,000	$61,000	$7,906,000
Alternative 5C[h]	Dam Removal and Channel Restoration – Small Floodplain Habitat	$49,000 (5)	$4,662,000	$61,000	$4,772,000

[a] *All costs are in 2019 dollars*

[b] *Present worth maintenance costs included dam inspections and dredging for a 50-year period for Alternatives 1, 2, 3, and 4, and vegetation maintenance for a 5-year period for Alternatives 2B, 4, and 5.*

[c] *To improve safety, dam abutment extensions and an emergency spillway would add $736,000 to the total present worth costs.*

[d] *Alternative 2A includes the full amount of dredged sediment hauled off site.*

[e] *Alternative 2B includes a portion of the dredged material used as fill in the Mill Pond northern lobe and restored with vegetative seeding, with the remaining dredged material hauled off site.*

[f] *Alternative 5A has the full amount of material hauled off site, with no fill on site. This alternative will create a large floodplain habitat.*

[g] *Alternative 5B allows a portion of the sediment to naturally erode downstream, a portion to be used as fill in the northern lobe fringe area, with the remaining amount hauled off site. This alternative will create a large floodplain habitat.*

[h] *Alternative 5C allows a portion of the sediment to naturally erode downstream, a portion to be used as fill in the northern lobe fringe area, with the remaining amount hauled off site. This alternative will create a small floodplain habitat.*

Source: SEWRPC

Table 6.Mill-3
Swimming Speeds for Fish Passage

Fish Species	Prolonged Speed (feet per second)	Burst Speed (feet per second)
Smallmouth Bass	1.8-3.9[a]	3.6-7.8[a]
Longnose Sucker	2.5-5.0[b]	4.0-7.9[b]
Northern Pike	0.6-1.6[b]	5.0-13.0[c]
Brown Trout	2.3-7.5[b]	7.5-12.2[b]
Coho Salmon	3.4-10.6[b]	10.6-21.5[b]
Chinook Salmon	3.4-10.8[d]	10.8-22.4[d]
Steelhead Trout	4.6-13.7[b]	13.7-27.0[b]

[a] *Stephan Peake, An Evaluation of the Use of Critical Swimming Speed for Determination of Culvert Water Velocity Criteria for Smallmouth Bass, Transactions of the American Fisheries Society 133: 1472-1479, 2004 and Normandeau Associates, Inc., Claytor Hydroelectric Project Fish Entrainment and Impingement Assessment, Appalachian Power Company, R-20979.001, January 2009.*

[b] *Furniss, Michael, et al. "FishXing: Software and Interactive Learning for Fish Passage through Culverts." FishXing: Software and Learning Systems for Fish Passage through Culverts, 2.1, United State Fish & Wildlife Service, www.fs.fed.us/biology/nsaec/fishxing/index.html.*

[c] *Luther P. Aadland, Reconnecting Rivers: Natural Channel Design in Dam Removals and Fish Passage, Minnesota Department of Natural Resources, January 2010 and S.J. Peake, Swimming Performance and Behaviour of Fish Species Endemic to Newfoundland and Labrador: A Literature Review, Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2843, 2008.*

[d] *Gregory T. Ruggerone, Evaluation of Salmon and Steelhead Migration Through the Upper Sultan River Canyon Prior to Dam Construction, City of Everett, July 2006.*

Source: SEWRPC

Table 6.Mill-4
Mill Pond and Dam Alternatives Summary

Description	Flooding[a]		Environmental[a]				Recreation[a]				Level of Maintenance for Alternative	Total Present Worth Cost (2019 Dollars)[b]
	Flooding Impacts	Spillway Capacity (Percent-Annual-Probability)	Water Quality in Pond Area	Sediment Accumulation in Pond Area	Fish and Aquatic Species Passage at Dam	Habitat	Ice Skating	Fishing at Mill Pond	Use of Warming House	View of Waterfall		
Existing Condition	0	50%	0	0	0	0	0	0	0	0	--	NA
Alternative 1: Sluice Gate Repair	0[c]	50%[c]	0	0	0	0	0	0	+	0	low	542,000[d]
Alternative 2A: Partial Pond Restoration	0[c]	50%[c]	+	0	0	+	+	+	+	0	high	5,351,000[d]
Alternative 2B: Partial Pond Restoration and Fill	0[c]	50%[c]	+	0	0	++	+	+	++	0	high	4,315,000[d]
Alternative 3: Full Pond Restoration	0[c]	50%[c]	+	0	0	++	+++	++	++	0	high	12,410,000[d]
Alternative 4: Bypass Channel, Dam Lowering, and Pond Restoration	+	1% - 0.2%	+	+	0	++	++	++	++	-	medium	10,331,000
Alternative 5A/5B: Dam Removal and Channel Restoration – Large Floodplain Habitat	++	NA	+	++	+	++	-	++	++	NA	low	(5A) 11,926,000 (5B) 7,906,000
Alternative 5C: Dam Removal and Channel Restoration – Small Floodplain Habitat	++	NA	+	++	+	++	-	++	++	NA	low	4,772,000
Basis for Evaluation	Increase in outlet capacity and removal of dam will reduce flooding impacts.	Flow event that can be conveyed within the spillway. A lower % is a larger event with greater flow.	Increase in water depth, flow, and transport of sediment will improve water quality.	Only Alts 4 & 5 provide a way for sediment to move past the pond and dam area.	Elimination of structure in river will allow fish and aquatic species passage.	Increase in pond water depth, flow, and vegetation bench will create and improve habitat.	Increase in pond water depth and restored pond area will improve ice skating. Assumes Alt 5 does not include optional small ice skate area.	Increase in pond depth will improve fishing. Removal of dam will provide fishing opportunities for migratory species.	Demand would increase with level of restoration in Mill Pond area.	Lack of regular flow in Mill Pond for Alt 4 may eliminate waterfall effect at times.	Includes annually exercising the sluice gate, future dredging, dam inspections, and vegetation maintenance.	--

Note: NA means not applicable.

[a] *Alternatives are rated relative to the potential changes from the existing condition which is designated neutrally as "0". Positive (+) or negative (-) signs indicate a more positive or negative effect, respectively, on the issue of concern as compared to the existing condition. Additional positive (+) or negative (-) values are relative to the other alternatives in each column.*

[b] *Costs based on an interest rate of 3.375% and a project life of 50 years.*

[c] *Adding the optional emergency spillway and abutment extension to these alternatives would improve flooding impacts. Adding the optional emergency spillway and abutment extension increases the total spillway capacity to the 2%-annual-probability event (50-year recurrence interval event). Adding either the emergency spillway or the abutment extension individually would increase the spillway capacity to about the 10%-annual-probability event (10-year recurrence event.)*

[d] *Costs do not include the optional emergency spillway or abutment extensions. An additional $736,000 would be added to these costs for these items.*

Source: SEWRPC

Community Assistance Planning Report No. 330

A RESTORATION PLAN FOR THE OAK CREEK WATERSHED

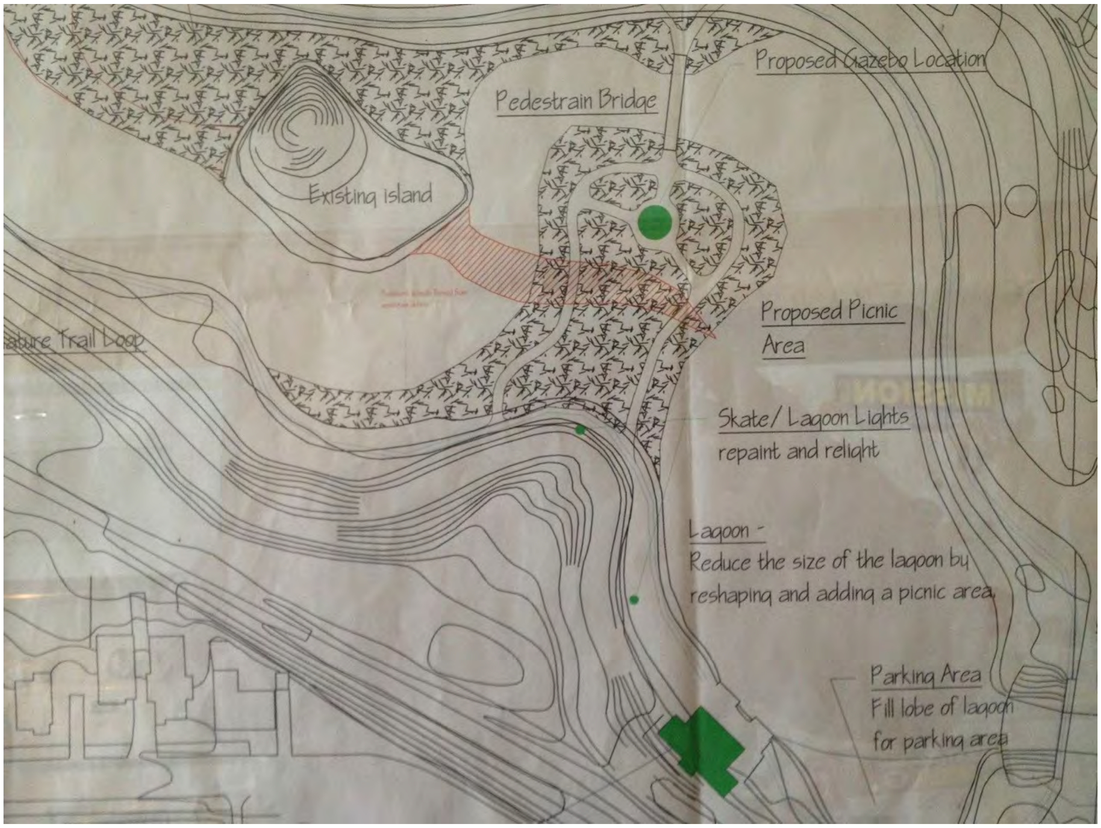
Chapter 6

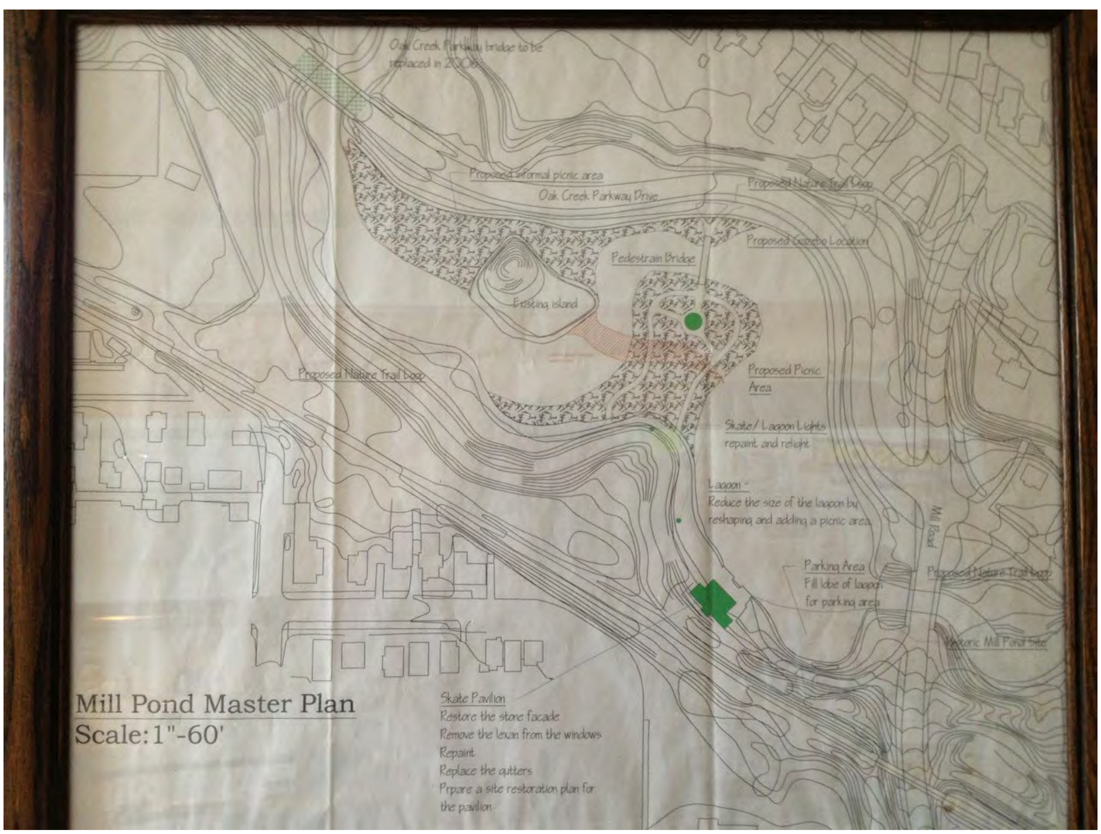
PLAN RECOMMENDATIONS

FIGURES

Figure 6.Mill-FloodExist
Existing Floodplain Conditions at Mill Pond

Figure 6.Mill-FOMPplan
2006 Master Plan from Friends of the Mill Pond





Source: Friends of the Mill Pond

Figure 6.Mill-Fishpassage Potential Fishway Analysis

Figure 6.Mill-Alt1
Alternative 1 – Sluice Gate Repair

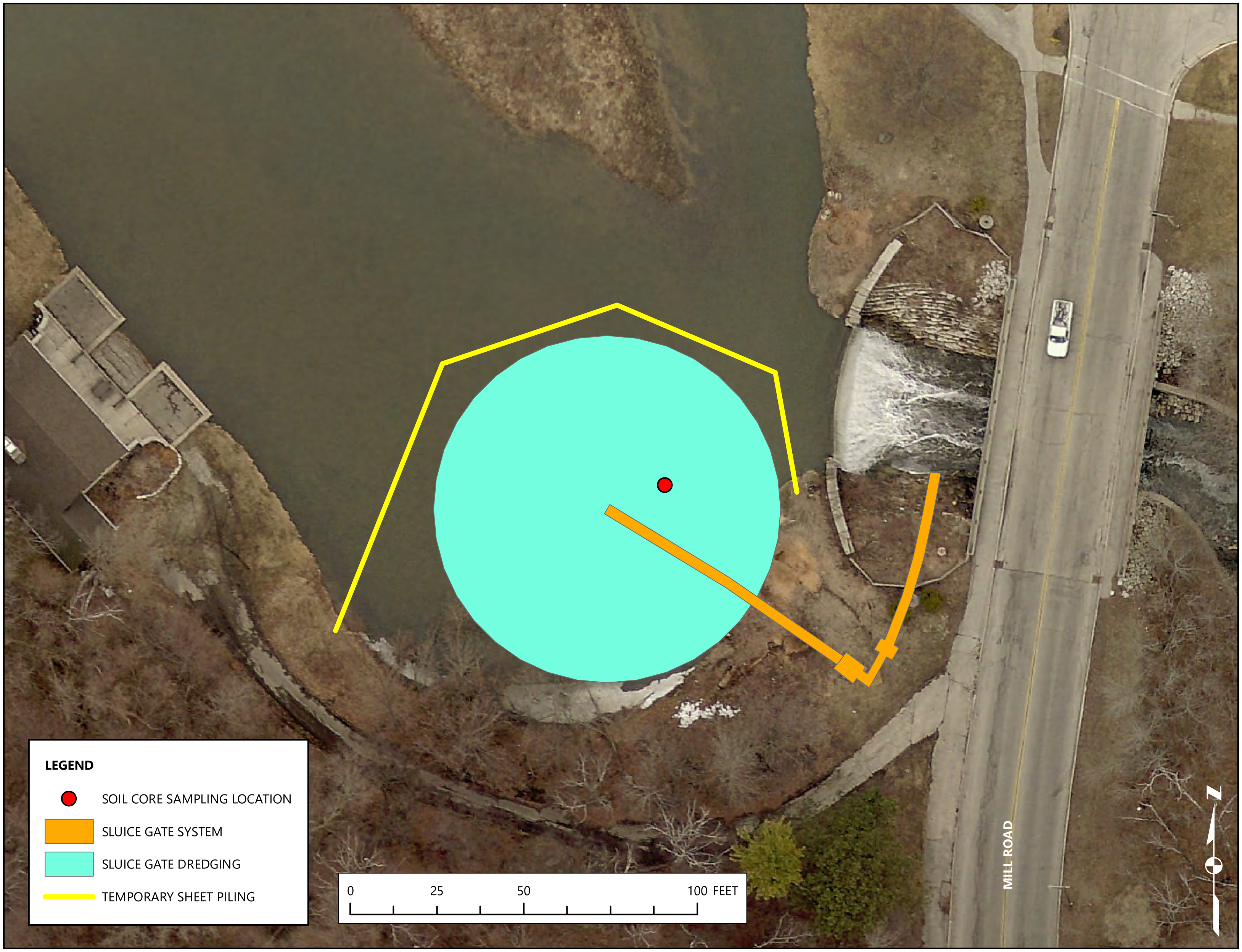


Figure 6.Mill-Optional
Optional Spillway Capacity Enhancements

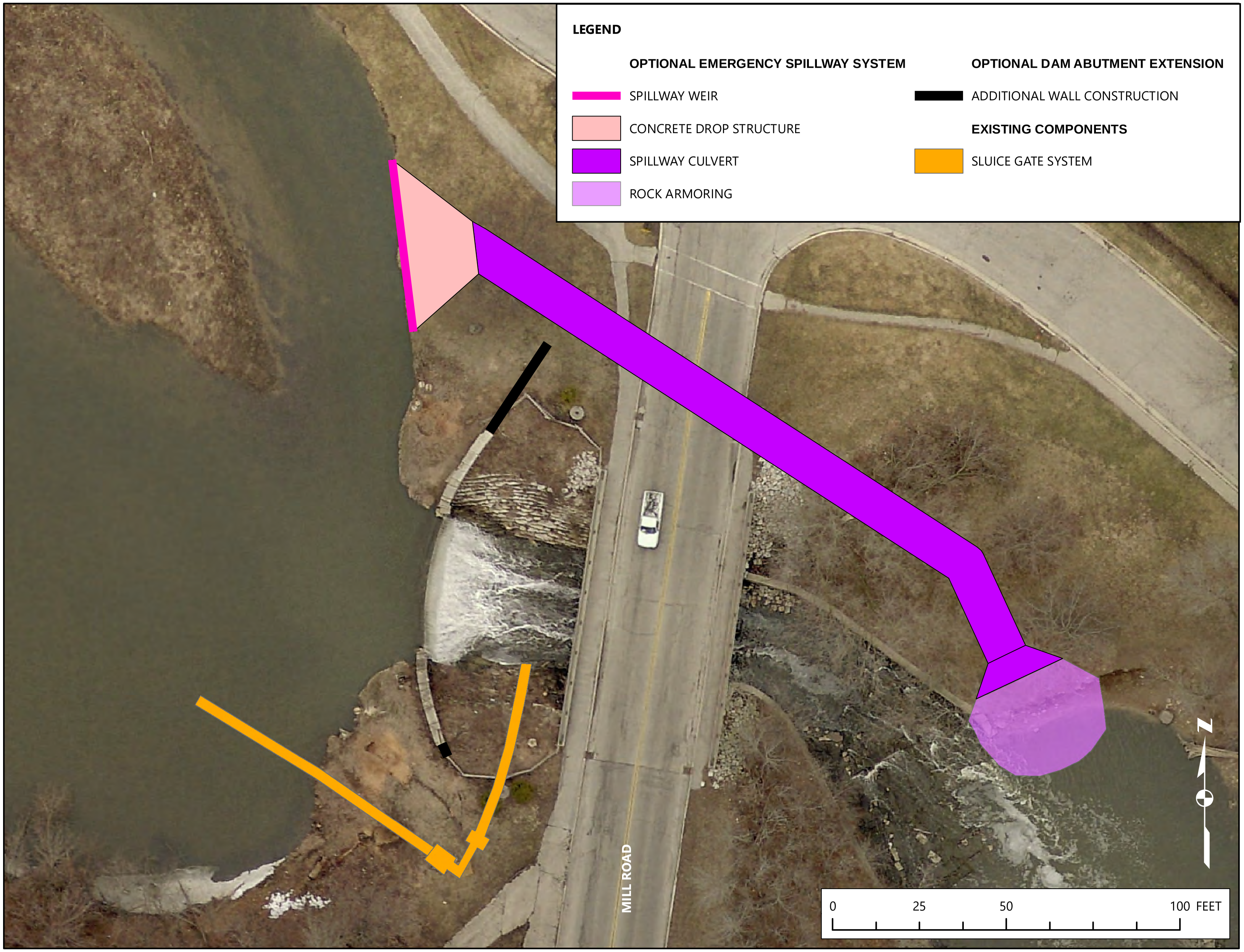


Figure 6.Mill-Alt2A
Alternative 2A – Partial Pond Restoration

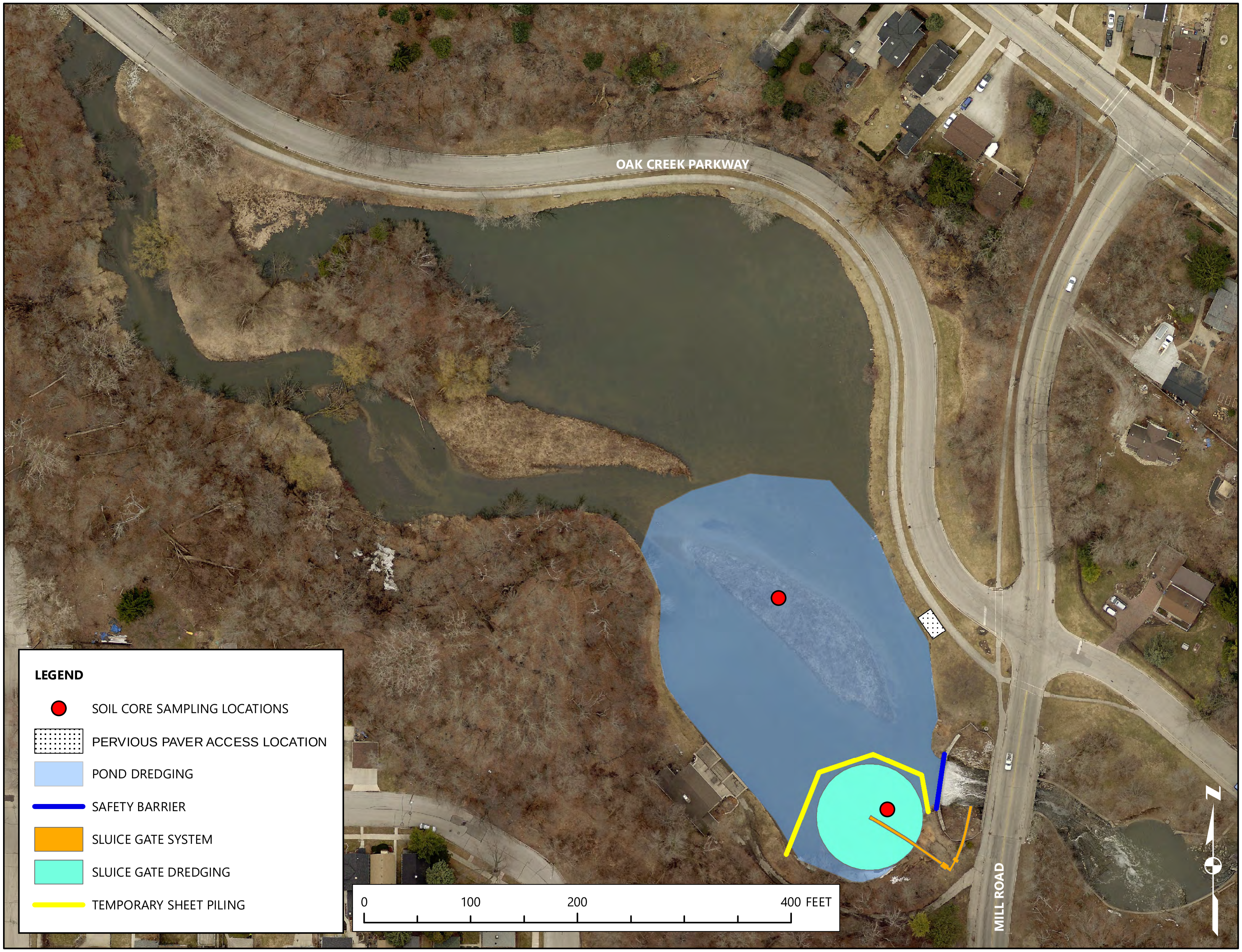


Figure 6.Mill-Alt2B
Alternative 2B – Partial Pond Restoration and Fill

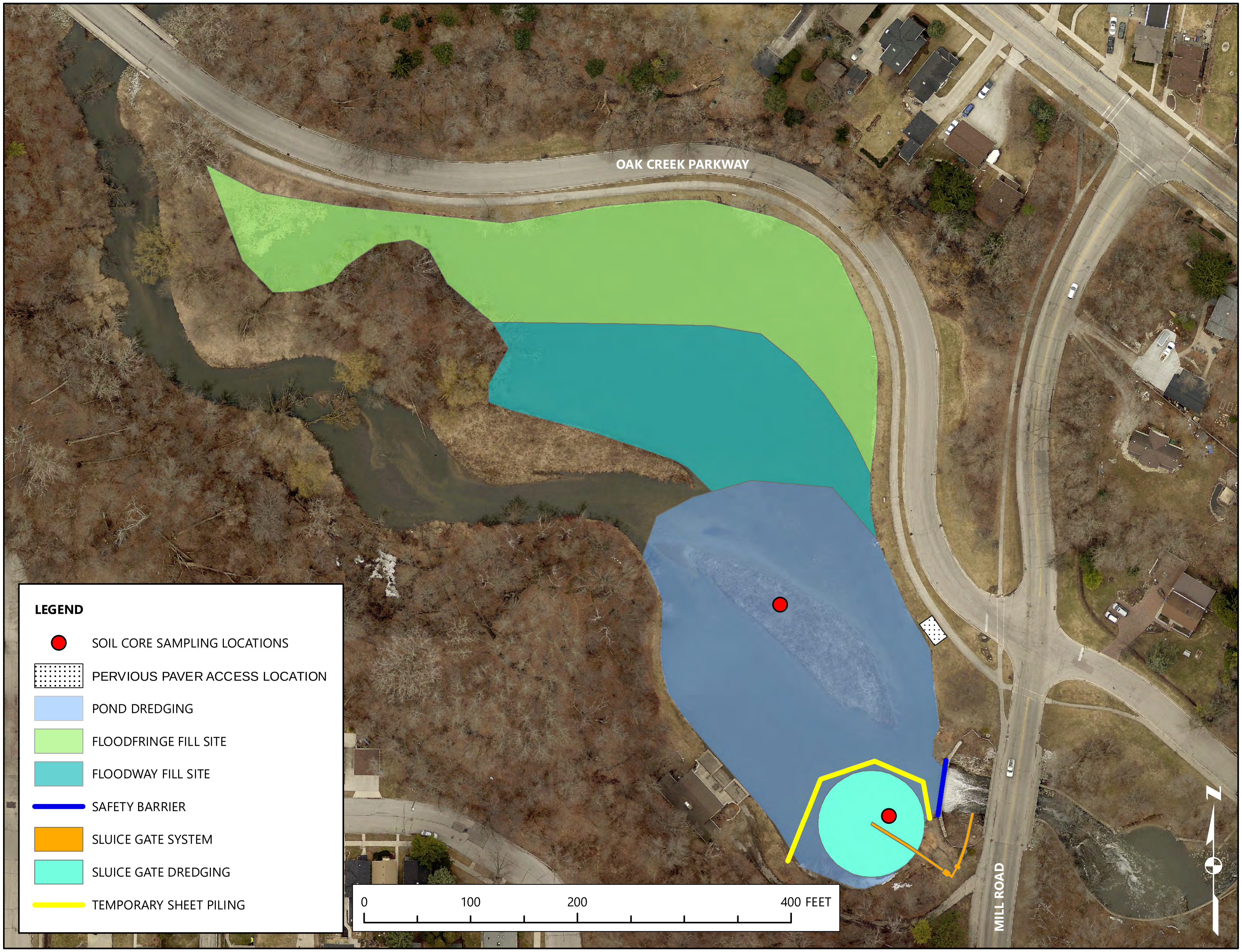


Figure 6.Mill-Alt3
Alternative 3 – Full Pond Restoration

Figure 6.Mill-Alt4
Alternative 4 – Bypass Channel, Dam Lowering, and Pond Restoration

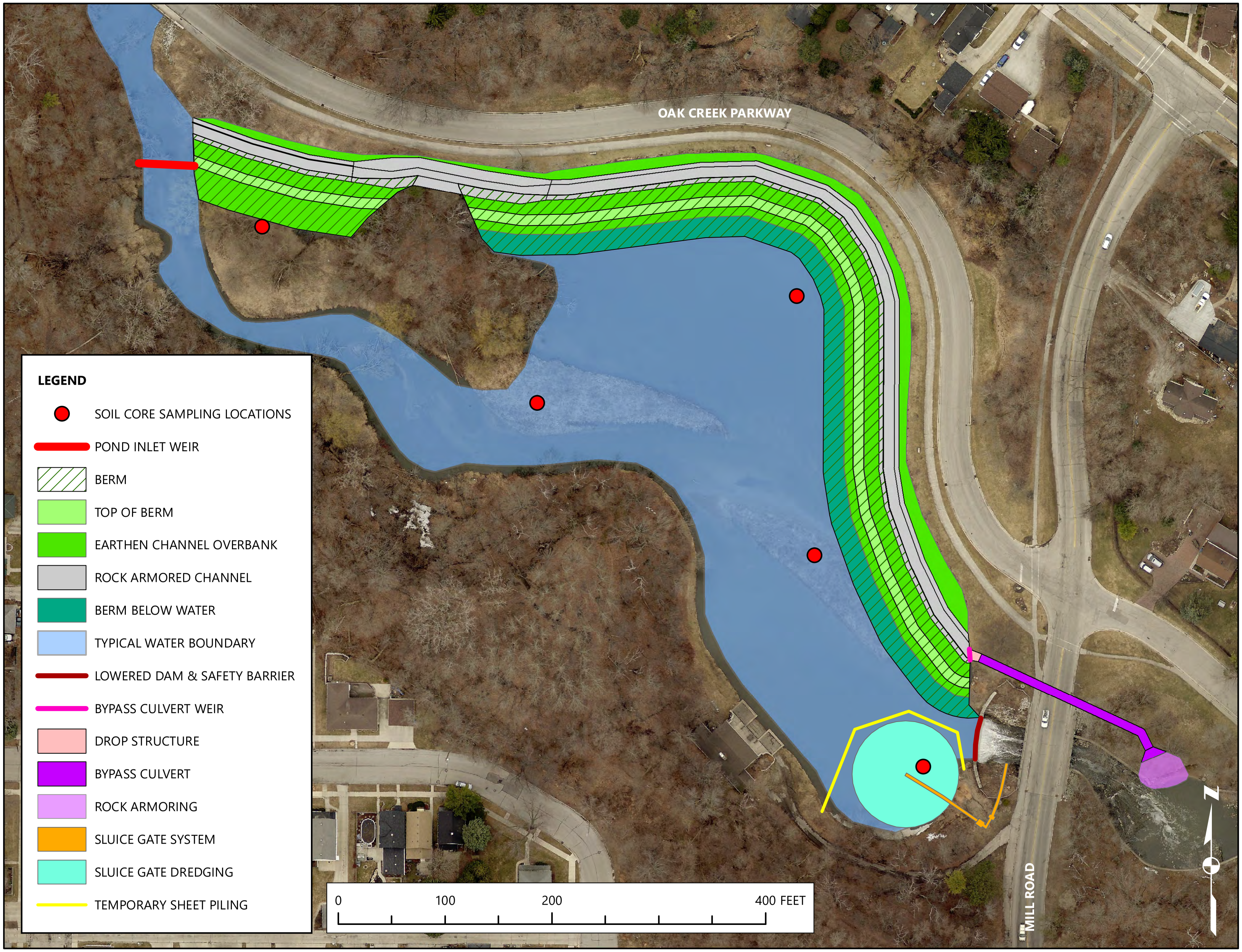


Figure 6.Mill-Alt4detail
Alternative 4 – Bypass Culvert Detail

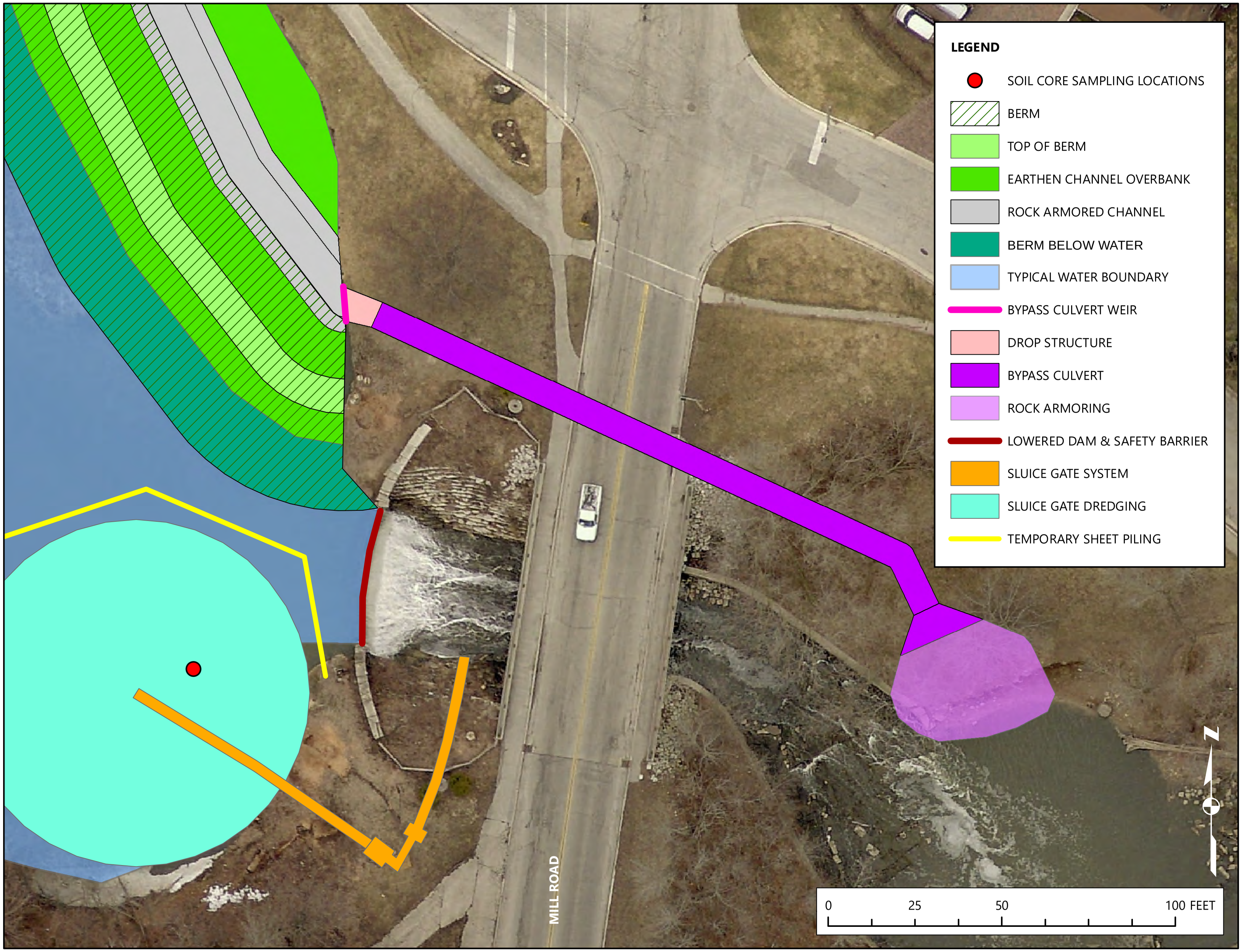
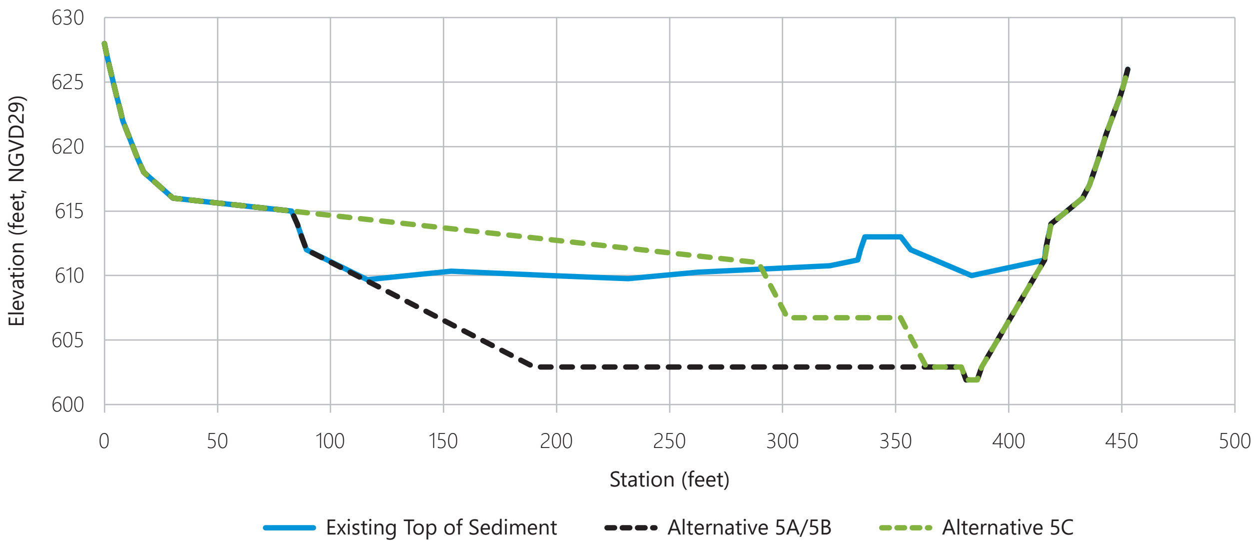


Figure 6.Mill-Alt5AB
Alternative 5A/5B - Dam Removal and Channel Restoration, Creating Large Floodplain Habitat

Figure 6.Mill-Alt5example
Example of Creek Restoration Along Underwood Creek

Source: Milwaukee Metropolitan Sewerage District

Figure 6.Mill-XS
Conceptual Cross Section for Alternative 5 Options[a]



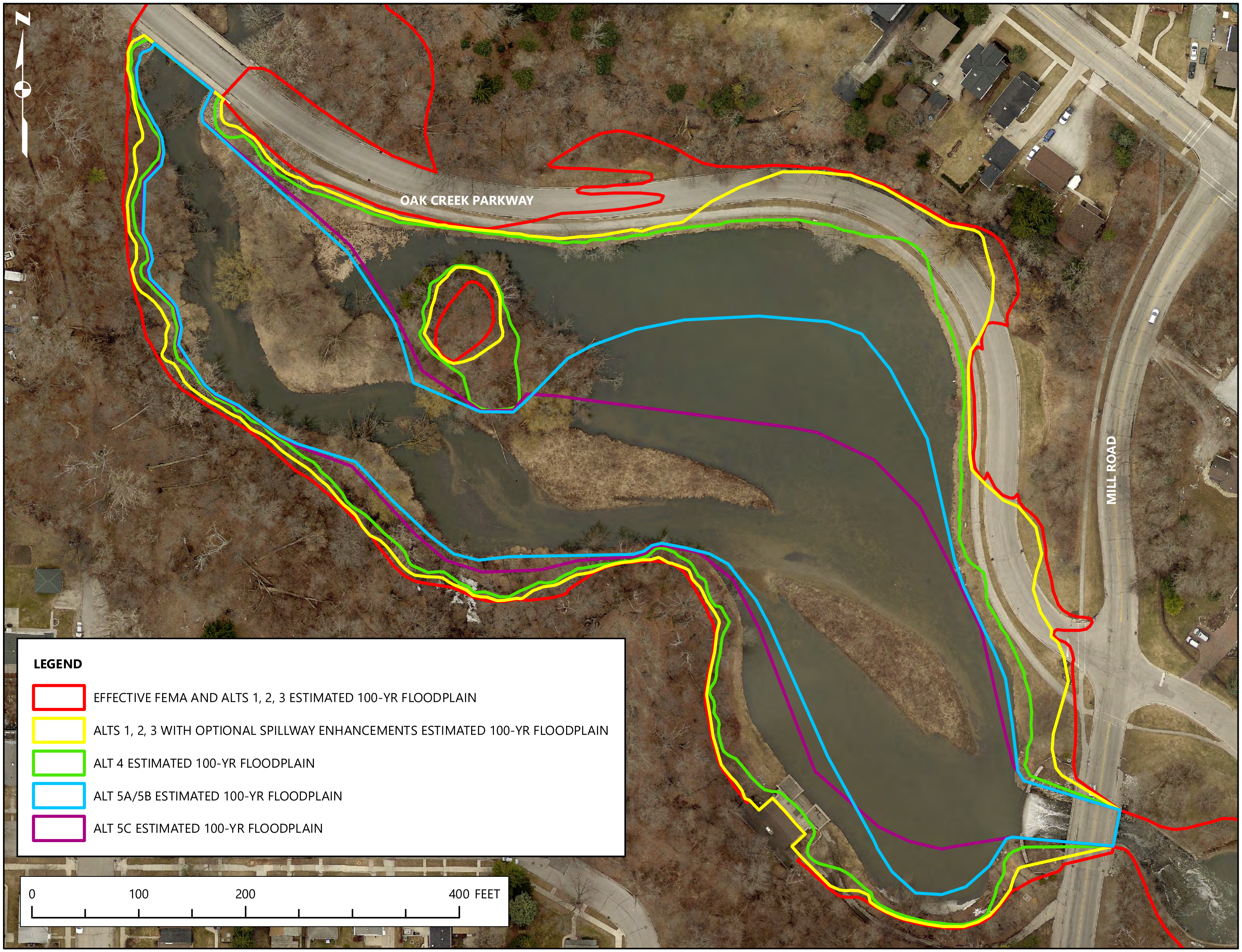
[a] *This figure represents the conceptual cross sections for Alternatives 5A/5B and 5C as compared to the existing top of sediment in the Mill Pond. The figure orientation is looking downstream, or to the southeast. The location of the example cross section is shown on Figure 6.Mill-Alt5AB and Figure 6.Mill-Alt5C.*

Source: SEWRPC

Figure 6.Mill-Alt5C
Alternative 5C – Dam Removal and Channel Restoration, Creating Small Floodplain Habitat

Figure 6.Mill-Alt5skate
Alternative 5 – Optional Skating Pond

Figure 6.Mill-FloodAlt
Floodplain Comparison by Alternative



DETAILED COST ESTIMATES FOR THE MILL POND AND DAM ALTERNATIVES

APPENDIX MILLPOND

ALTERNATIVE 1

Description: Minimum work required per WDNR order, which is to rebuild the sluice gate to be able to dewater the pond for dam maintenance.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water from Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal)	CY	1,212	$ 100	$ 121,203
11	Dewatering Dredged Material	CY	1,212	$ 5.17	$ 6,264
12	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
13	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
14	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
15	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
16	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
17	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
				Construction Sub-Total	**$ 243,700**
				35% Contingency	**$ 85,295**
				Construction Total	**$ 329,000**
CORE SAMPLING					
18	Sediment Core Sampling[1]	LS	1	$ 14,444	$ 14,444
ONGOING MAINTENANCE[2]					
19	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
20	Dredging Sluice Gate Cone Every 20 Years	LS	1	$ 138,833	$ 138,833
				Ongoing Maintenance Total	**$ 198,500**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 2A

Description: Southern lobe of pond restored to original 1930s design with all dredged material hauled offsite and no seeding of floodfringe area; repair sluice gate per Alternative 1.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
16	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	12,168	$ 100	$ 1,216,797
19	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
20	Pumping For Bypass Piping	Day	60	$ 1,394	$ 83,660
				Construction Sub-Total	**$ 1,631,000**
				35% Contingency	**$ 570,850**
				Construction Total	**$ 2,201,900**
CORE SAMPLING					
21	Sediment Core Sampling[1]	LS	1	$ 24,240	$ 24,240
ONGOING MAINTENANCE[2]					
22	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
23	Dredging Pond Every 20 Years	LS	1	$ 3,065,244	$ 3,065,244
				Ongoing Maintenance Total	**$ 3,124,900**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 2B

Description: Southern lobe of pond restored to original 1930s design with some of the dredging spoils used as fill in the floodfringe with vegetative seeding; repair sluice gate per Alternative 1

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
16	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	2,168	$ 100	$ 216,797
19	Dredging Material (Spread On Site in Floodfringe Area)	CY	10,000	$ 20.00	$ 200,000
20	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
21	Pumping For Bypass Piping	Day	60	$ 1,394	$ 83,660
22	Seeding - Floodfringe Fill Area	SY	6,415	$ 2.87	$ 18,416
				Construction Sub-Total	**$ 849,400**
				35% Contingency	**$ 297,290**
				Construction Total	**$ 1,146,700**
CORE SAMPLING					
23	Sediment Core Sampling[1]	LS	1	$ 24,240	$ 24,240
ONGOING MAINTENANCE[2]					
24	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
25	Dredging Pond Every 20 Years	LS	1	$ 3,065,244	$ 3,065,244
26	Vegetation Maintenance	LS	1	$ 18,815	$ 18,815
				Ongoing Maintenance Total	**$ 3,143,700**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 3

Description: Pond restored to original 1930s design; repair sluice gate per Alternative 1

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 110.65	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch)	SY	125	$ 5.60	$ 700
16	Replace Asphalt Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	45,968	$ 100	$ 4,596,797
19	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
20	Pumping For Bypass Piping	Day	130	$ 1,394	$ 181,263
				Construction Sub-Total	**$ 5,108,600**
				35% Contingency	**$ 1,788,010**
				Construction Total	**$ 6,896,700**
CORE SAMPLING					
21	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE[2]					
22	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
23	Dredging Pond Every 20 Years	LS	1	$ 5,404,268	$ 5,404,268
				Ongoing Maintenance Total	**$ 5,463,900**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 4

Description: Bypass channel for sediment and then a smaller restored pond with the dam lowered by 2-ft; repair existing sluice gate per Alt 1

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
Sluice Gate Repair Items Per Alternative 1					
1	Mobilization - Sluice Gate Repairs	LS	1	$ 5,603	$ 5,603
2	Remove Existing 36" CMP Storm Sewer	LF	10	$ 19.83	$ 198
3	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
4	Pumping Water Within Cofferdam - Sluice Gate Repairs	Day	1	$ 1,394	$ 1,394
5	Safety Fence	LF	150	$ 4.48	$ 672
6	Silt Fence	LF	100	$ 3.36	$ 336
7	Tracking Pad	EA	1	$ 1,681	$ 1,681
8	Common Excavation and Grading	LS	1	$ 5,603	$ 5,603
9	Stockpile Topsoil	LS	1	$ 1,681	$ 1,681
10	Dredging Material (Removal and Disposal) - Sluice Gate Repairs	CY	1,212	$ 100	$ 121,203
11	30" Diameter RCP Storm Sewer	LF	10	$ 111	$ 1,107
12	36" Diameter RCP Storm Sewer, Stub Out with Bulkhead	LF	3	$ 145	$ 434
13	Sluice Gate Manhole Structure, 4'x6' Precast (Including Metal Decking)	LS	1	$ 56,031	$ 56,031
14	Vertical Lift Gate	LS	1	$ 28,016	$ 28,016
15	Turf Restoration (Topsoil, Seed, and Mulch) - Sluice Gate Repairs	SY	125	$ 5.60	$ 700
16	Replace Asphalt - Pathway	SY	35	$ 44.82	$ 1,569
Additional Construction Items					
17	Cofferdam Construction, Maintenance, and Removal - Upstream of Pond	LS	1	$ 11,206	$ 11,206
18	Dredging Material (Removal and Disposal) - Pond	CY	43,248	$ 100	$ 4,324,797
19	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
20	Pumping For Bypass Piping	Day	130	$ 1,394	$ 181,263
21	Overflow Sharp-Crested Weir (Cast In Place Concrete)	CY	9.2	$ 414	$ 3,799
22	Inflow Notch Weir (Cast In Place Concrete)	CY	54	$ 414	$ 22,524
23	Drop Structure (Cast In Place Concrete)	CY	10	$ 414	$ 4,305
24	96" Diameter RCP Storm Sewer	LF	190	$ 673	$ 127,938
25	Mobilization - Crane to Place 96" Diameter RCP	LS	1	$ 2,000	$ 2,000
26	Rental - Crane to Place 96" Diameter RCP	Day	15	$ 2,003	$ 30,040
27	96" Apron End Wall	EA	1	$ 6,200	$ 6,200
28	Rock Rip-Rap at Culvert Outfall	CY	89	$ 80.00	$ 7,111
29	Rock Lining - Trapezoidal Channel	CY	1,674	$ 80.00	$ 133,888
30	Grate - Inlet Trash Guard	EA	1	$ 18,800	$ 18,800
31	Grate - Outlet	EA	1	$ 7,300	$ 7,300
32	Remove Asphalt - Mill Road	SY	68	$ 6.45	$ 439
33	Asphalt - Mill Road	SY	68	$ 22.64	$ 1,539
34	Aggregate Base Course - Mill Road	SY	68	$ 20.18	$ 1,372
35	Gravel Fill	CY	322	$ 38.04	$ 12,247
36	Excavation	CY	3,632	$ 100	$ 363,157
37	Lowering of Dam Weir	LS	1	$ 13,000	$ 13,000
38	Geotextile Filtration Fabric	SY	133	$ 3.11	$ 414
39	Clay Core - Berm	CY	1,633	$ 8.21	$ 13,417
40	Fill - Berm	CY	10,453	$ 2.58	$ 26,962
41	Topsoil (6") - Berm and Slopes	SY	6,043	$ 3.61	$ 21,820
42	Seeding - Berm and Slopes	SY	6,043	$ 2.87	$ 17,350
				Construction Sub-Total	**$ 5,672,200**
				35% Contingency	**$ 1,985,270**
				Construction Total	**$ 7,657,500**
CORE SAMPLING					
43	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE[2]					
44	Dam Inspection Every 10 Years	LS	1	$ 59,605	$ 59,605
45	Dredging Pond Every 20 Years	LS	1	$ 2,546,352	$ 2,546,352
46	Vegetation Maintenance	LS	1	$ 17,601	$ 17,601
				Ongoing Maintenance Total	**$ 2,623,600**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 5A

Description: Dam removed and channel restored through the pond area with riffle-pools; all dredged sediment hauled off site. Larger floodplain area.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization	LS	1	$ 5,603	$ 5,603
2	Remove Existing Dam	LS	1	$ 79,000	$ 79,000
3	Abandon Existing Sluice Gate	LS	1	$ 5,603	$ 5,603
4	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
5	Pumping For Bypass Piping	Day	240	$ 1,394	$ 334,640
6	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
7	Excavation - Riffle Pool Rocks	CY	4,726	$ 100	$ 472,593
8	Fill - Main Channel	CY	273	$ 2.58	$ 704
9	Dredging Material (Removal and Disposal)	CY	71,510	$ 100	$ 7,151,000
10	Clay Cap over Fill Placed Onsite	CY	1,111	$ 8.21	$ 9,127
11	Rock Rip-Rap along Riffles and Slopes	CY	2,954	$ 80.00	$ 236,356
12	Rounded Stone in Channel Riffles	CY	1,890	$ 115	$ 217,393
13	Rock Dam Between Riffles - 3' Rocks	CF	13,200	$ 5.00	$ 66,000
14	Topsoil for Restoration, 6" Deep	CY	3,646	$ 5.00	$ 18,232
15	Seeding - Bench Area	SY	10,253	$ 2.87	$ 29,435
16	Seeding - Higher/Drier Areas	SY	11,626	$ 2.87	$ 33,375
				Construction Sub-Total	**$ 8,752,200**
				35% Contingency	**$ 3,063,270**
				Construction Total	**$ 11,815,500**
CORE SAMPLING					
17	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE					
18	Vegetation Maintenance	LS	1	$ 60,694	$ 60,694
				Ongoing Maintenance Total	**$ 60,694**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 5B

Description: Dam removed and channel restored through the pond area with riffle-pools; some existing pond sediment allowed down stream in streamflow during dam removal, some sediment spoiled on site, and some sediment hauled off site. Larger floodplain area.

Item #	Item Description	Unit	Quantity	Unit Price		Total	
CONSTRUCTION							
1	Mobilization	LS	1	$	5,603	$	5,603
2	Dewatering by Sequential Notch Removal of Dam Portion	Hrs	63	$	100	$	6,300
3	Remove Existing Dam	LS	1	$	23,000	$	23,000
4	Abandon Existing Sluice Gate	LS	1	$	5,603	$	5,603
5	36" Diameter HDPE Bypass Piping	LF	1,400	$	58.48	$	81,874
6	Pumping For Bypass Piping	Day	240	$	1,394	$	334,640
7	Cofferdam Construction, Maintenance, and Removal	LS	1	$	11,206	$	11,206
8	Excavation - Riffle Pool Rocks	CY	4,726	$	100	$	472,593
9	Dredging Material (Removal and Disposal)	CY	40,860	$	100	$	4,086,000
10	Dredging Material (Spread On Site in Floodfringe Area)	CY	7,090	$	20.00	$	141,800
11	Finishing Grading	SY	21,879	$	0.23	$	5,054
12	Rock Rip-Rap along Riffles and Slopes	CY	2,954	$	80.00	$	236,356
13	Rounded Stone in Channel Riffles	CY	1,890	$	115	$	217,393
14	Rock Dam Between Riffles - 3' Rocks	CF	13,200	$	5.00	$	66,000
15	Topsoil for Restoration, 6" Deep	CY	3,646	$	5.00	$	18,232
16	Seeding - Bench Area	SY	10,253	$	2.87	$	29,435
17	Seeding - Higher/Drier Areas	SY	11,626	$	2.87	$	33,375
					Construction Sub-Total	**$**	**5,774,500**
					35% Contingency	**$**	**2,021,075**
					Construction Total	**$**	**7,795,600**
CORE SAMPLING							
18	Sediment Core Sampling[1]	LS	1	$	48,980	$	48,980
ONGOING MAINTENANCE							
19	Vegetation Maintenance	LS	1	$	60,694	$	60,694
					Ongoing Maintenance Total	**$**	**60,694**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

ALTERNATIVE 5C

Description: Dam removed and channel restored through the pond area with riffle-pools; some pond sediment discharged down stream, some relocated within the pond area, and some hauled off site. Smaller floodplain area.

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION					
1	Mobilization	LS	1	$ 5,603	$ 5,603
2	Dewatering by Sequential Notch Removal of Dam Portion	Hrs	63	$ 100	$ 6,300
3	Remove Existing Dam	LS	1	$ 23,000	$ 23,000
4	Abandon Existing Sluice Gate	LS	1	$ 5,603	$ 5,603
5	36" Diameter HDPE Bypass Piping	LF	1,400	$ 58.48	$ 81,874
6	Pumping For Bypass Piping	Day	240	$ 1,394	$ 334,640
7	Cofferdam Construction, Maintenance, and Removal	LS	1	$ 11,206	$ 11,206
8	Excavation - Riffle Pool Rocks	CY	4,726	$ 100	$ 472,593
9	Fill - Main Channel	CY	273	$ 2.58	$ 704
10	Dredging Material (Removal and Disposal)	CY	11,865	$ 100.00	$ 1,186,504
11	Dredging Material (Spread On Site in Floodfringe Area)	CY	36,080	$ 20.00	$ 721,591
12	Finishing Grading	SY	20,932	$ 0.23	$ 4,835
13	Rock Rip-Rap along Riffles and Slopes	CY	2,954	$ 80.00	$ 236,356
14	Rounded Stone in Channel Riffles	CY	1,890	$ 115	$ 217,393
15	Rock Dam Between Riffles - 3' Rocks	CF	13,200	$ 5.00	$ 66,000
16	Topsoil for Restoration, 6" Deep	CY	3,646	$ 5.00	$ 18,232
17	Seeding - Bench Area and Shallow Slope Areas	SY	17,321	$ 2.87	$ 49,726
18	Seeding - 3:1 Slope Areas	SY	3,610	$ 2.87	$ 10,365
				Construction Sub-Total	**$ 3,452,600**
				35% Contingency	**$ 1,208,410**
				Construction Total	**$ 4,661,100**
CORE SAMPLING					
19	Sediment Core Sampling[1]	LS	1	$ 48,980	$ 48,980
ONGOING MAINTENANCE					
20	Vegetation Maintenance	LS	1	$ 60,694	$ 60,694
				Ongoing Maintenance Total	**$ 60,694**

[1] Core sampling to be done in winter with at least 11" to 16" of ice to safely support equipment.

[2] Costs as present worth - see Present Worth Worksheet

OPTIONAL SPILLWAY & DAM ABUTMENTS

Description: Optional emergency overflow spillway and optional dam abutments to expand overflow capacity

Item #	Item Description	Unit	Quantity	Unit Price	Total
CONSTRUCTION - OPTIONAL EMERGENCY SPILLWAY ITEMS					
1	Sharp-Crested Weir (Cast In Place Concrete)	CY	28	$ 414	$ 11,512
2	Drop Structure (Cast In Place Concrete)	CY	29	$ 414	$ 11,972
3	Mobilization - Crane to Place 8'x12' Box Culvert	LS	1	$ 2,000	$ 2,000
4	Concrete Box Culvert (8'x12')	LF	200	$ 1,293	$ 258,549
5	Wing Walls - 8'x12' Box Culvert Outlet	EA	1	$ 5,000	$ 5,000
6	Straight Apron End Wall - 8'x12' Box Culvert Outlet	EA	1	$ 14,000	$ 14,000
7	Rock Rip-Rap at Culvert Outfall	CY	70	$ 80.00	$ 5,570
8	Grate - Inlet Trash Guard	EA	1	$ 10,500	$ 10,500
9	Grate - Outlet	EA	1	$ 14,000	$ 14,000
10	Remove Asphalt	SY	83	$ 6.45	$ 536
11	Gravel Fill	CY	445	$ 38.04	$ 16,914
12	Excavation	CY	1,890	$ 100	$ 189,000
13	Asphalt	SY	83	$ 22.64	$ 1,881
14	Aggregate Base Course	SY	83	$ 20.18	$ 1,677
15	Geotextile Filtration Fabric	SY	35	$ 3.11	$ 108
				Construction Subtotal (Optional Spillway)	**$ 543,300**
				35% Contingency (Optional Spillway)	**$ 190,155**
				Construction Total (Optional Spillway)	**$ 733,500**
CONSTRUCTION - OPTIONAL EXTENSION OF ABUTMENTS					
16	Cast in Place Concrete (Extension of Abutments)	LS	1.0	$ 1,850	$ 1,850
				Construction Subtotal (Optional Abutment Extension)	**$ 1,850**
				35% Contingency (Optional Abutment Extension)	**$ 648**
				Construction Total (Optional Abutment Extension)	**$ 2,500**
				Total Optional Emergency Spillway and Extension of Abutments	**$ 736,000**

Present Worth Worksheet

Engineering Economics Formulas

(P/F, *i* %, n) = $(1+i)^{-n}$

DAM INSPECTION EVERY 10 YEARS

PW Cost of Dam Inspections Every 10[1] Years for Next 50 Years = $59,605

Recurring cost =	$10,000	[2] 2019 Dollars
CCI 10-Yr Factor =	1.476	
i =	3.375%	

PW for Inspection at Year:		10
Inspection cost at yr 10 =	$14,761	
PW factor =	0.7175	
PW cost =	$10,592	

PW for Inspection at Year:		20
Inspection cost at yr 20 =	$21,789	
PW factor =	0.5149	
PW cost =	$11,218	

PW for Inspection at Year:		30
Inspection cost at yr 30 =	$32,162	
PW factor =	0.3694	
PW cost =	$11,882	

PW for Inspection at Year:		40
Inspection cost at yr 40 =	$47,475	
PW factor =	0.2651	
PW cost =	$12,585	

PW for Inspection at Year:		50
Inspection cost at yr 50 =	$70,078	
PW factor =	0.1902	
PW cost =	$13,329	

[1] Per WDNR, low hazard dams must be inspected every 10 years https://dnr.wisconsin.gov/topic/dams/inspections.html. Per AECOM report in Ch. 4 appendix, the dam is a low hazard dam.

[2] DNR FAQ document listed inspection costs can range from $2,000 to $10,000 every 10 years (for low hazard dams)

ONGOING MAINTENANCE COSTS

[ALTERNATIVE 1]

DREDGING MAINTENANCE

PW Cost of Dredging 1/2 Sluice Gate Cone Volume Every 20 Years for Next 50 Years = $138,833

Recurring cost =	$60,602	2019 Dollars
Dredging volume =	606	CY
CCI 20-Yr Factor =	2.125	
i =	3.375%	

	Dredging
PW for Year:	20
Dredging cost at yr 20 =	$128,772
PW factor =	0.5149
PW cost =	$66,300

PW for Year:	40
Dredging cost at yr 40 =	$273,627
PW factor =	0.2651
PW cost =	$72,534

Note: Exercising the sluice gate every year is assumed to flush sediment from the sluice gate cone, so it was assumed dredging would be done every 20 years and only half the original volume (and cost) would be dredged at those future times.

ONGOING MAINTENANCE COSTS

[ALTERNATIVE 2A & 2B]

DREDGING MAINTENANCE (Both 2A and 2B)

2A PW Cost of Dredging Southern Lobe and Sluice Cone =				**$3,065,244**
2B PW Cost of Dredging Southern Lobe and Sluice Cone =				**$3,065,244**
2A Recurring cost =	$1,338,000	2019 Dollars		
2B Recurring cost =	$1,338,000	2019 Dollars		
Dredging volume =	13,380	CY		
CCI 20-Yr Factor =	2.125			
i =	3.375%			

VEGETATIVE MAINTENANCE (Only 2B)

PW Cost of Vegetation Maintenance =				**$18,815**
Initial Seeding Cost =	$6,200	2019 Dollars		
Half of Initial Seeding Cost =	$3,100	2019 Dollars		
CCI 1-Yr Factor =	1.038			
i =	3.375%			

	Dredging - 2A	**Dredging - 2B**	**Vegetation**
PW for Year:	10	10	1
Cost at Yr 10 / Yr 1 =	NA	NA	$6,437
PW factor =	0.7175	0.7175	0.9674
PW cost =	$0.00	$0.00	$6,227
PW for Year:	20	20	2
Cost at Yr 20 / Yr 2 =	$2,843,110	$2,843,110	$3,341
PW factor =	0.5149	0.5149	0.9358
PW cost =	$1,463,805	$1,463,805	$3,127
PW for Year:	30	30	3
Cost at Yr 30 / Yr 3 =	NA	NA	$3,469
PW factor =	0.3694	0.3694	0.9052
PW cost =	$0.00	$0.00	$3,140
PW for Year:	40	40	4
Cost at Yr 40 / Yr 4 =	$6,041,312	$6,041,312	$3,602
PW factor =	0.2651	0.2651	0.8757
PW cost =	$1,601,439	$1,601,439	$3,154
PW for Year:	50	50	5
Cost at Yr 50 / Yr 5	NA	NA	$3,739
PW factor =	0.1902	0.1902	0.8471
PW cost =	$0.00	$0.00	$3,167

Note: It was assumed dredging would be done every 20 years for the entire original south lobe pond volume (and cost) at those future times. For vegetative maintenance, it was assumed approximately 1/3 of the initial seeding (and cost) would need to be replaced in the first year and half the cost of year 1 costs would occur for each year for years 2-5.

[ALTERNATIVE 3]

DREDGING MAINTENANCE

PW Cost of Dredging 1/2 Pond and Sluice Cone Volume Every			**$5,404,268**
Recurring cost =	$ 2,359,000	2019 Dollars	
Dredging volume =	23,590	CY	
CCI 20-Yr Factor =	2.125		
i =	3.375%		

	Dredging
PW for Year:	20
Dredging cost at yr 20 =	$ 5,012,628
PW factor =	0.5149
PW cost =	$ 2,580,804
PW for Year:	40
Dredging cost at yr 40 =	$ 10,651,311
PW factor =	0.2651
PW cost =	$ 2,823,463

Note: It was assumed dredging would be done every 20 years and only half the original volume (and cost) would be dredged at those future times.

ONGOING MAINTENANCE COSTS

[ALTERNATIVE 4]

DREDGING MAINTENANCE

PW Cost of Dredging 1/4 Pond and Sluice Cone Volume Every			**$2,546,352**
Recurring cost =	$ 1,111,500	2019 Dollars	
Dredging volume =	11,115	CY	
CCI 20-Yr Factor =	2.125		
i =	3.375%		

VEGETATIVE MAINENANCE

PW Cost of Vegetation Maintenance =			**$17,601**
Initial Seeding Cost =	$5,800	2019 Dollars	
Half of Initial Seeding Cost =	$2,900	2019 Dollars	
CCI 1-Yr Factor =	1.038		
i =	3.375%		

	Dredging	**Vegetation**
PW for Year:	10	1
Cost at Yr 10 / Yr 1 =	NA	$6,022
PW factor =	0.7175	0.9674
PW cost =	$0.00	$5,825
PW for Year:	20	2
Cost at Yr 20 / Yr 2 =	$2,361,821	$3,126
PW factor =	0.5149	0.9358
PW cost =	$1,216,008	$2,925
PW for Year:	30	3
Cost at Yr 30 / Yr 3 =	NA	$3,245
PW factor =	0.3694	0.9052
PW cost =	$0.00	$2,938
PW for Year:	40	4
Cost at Yr 40 / Yr 4 =	$5,018,623	$3,369
PW factor =	0.2651	0.8757
PW cost =	$1,330,343	$2,950
PW for Year:	50	5
Cost at Yr 50 / Yr 5	NA	$3,498
PW factor =	0.1902	0.8471
PW cost =	$0.00	$2,963

Note: The bypass channel is designed to pass the majority of sediment around the pond, thus it was assumed dredging would be done every 20 years and only one quarter the original volume (and cost) would be dredged at those future times. For vegetative maintenance, it was assumed approximately 1/3 of the initial seeding (and cost) would need to be replaced in the first year and half the cost of year 1 costs would occur for each year for years 2-5.

[ALTERNATIVE 5]

VEGETATIVE MAINTENANCE

PW Cost of Vegetation Maintenance =			**$60,694**
Initial Seeding Cost =	$20,000	2019 Dollars	
Half of Initial Seeding Cost =	$10,000	2019 Dollars	
CCI 1-Yr Factor =	1.038		
i =	3.375%		

PW for Year:	1
Vegetation Costs at Yr 1 =	$20,764
PW factor =	0.9674
PW cost =	$20,086
PW for Year:	2
Vegetation Costs at Yr 2 =	$10,779
PW factor =	0.9358
PW cost =	$10,087
PW for Year:	3
Vegetation Costs at Yr 3 =	$11,191
PW factor =	0.9052
PW cost =	$10,130
PW for Year:	4
Vegetation Costs at Yr 4 =	$11,618
PW factor =	0.8757
PW cost =	$10,174
PW for Year:	5
Vegetation Costs at Yr 5 =	$12,062
PW factor =	0.8471
PW cost =	$10,218

Note: Assumed approximately 1/3 of the initial seeding (and costs) would need to be replaced in the first year, then we assumed a cost of $10,000 (2019 dollars) for each year for years 2-5.