LAKE AND DAM RESTORATION MASTER PLAN

LAKE OLATHE, CEDAR LAKE, FRISCO PARK, AND WATERWORKS PARK

JULY 25, 2018
EXECUTIVE SUMMARY

A comprehensive lake and dam restoration master planning document has been developed for six City lakes including – Lake Olathe, Cedar Lake, Frisco Park (North and South Lakes), and Waterworks Park (North and South Lakes). Recommendations from previously completed park improvements studies and dam safety inspections have been incorporated with recommended water quality improvements, suggested structural repairs, and cost estimates at each lake. Detailed findings are offered with specific recommendations for meeting funding and water quality goals at each lake.

The master planning recommendations are prioritized based on those most qualified for future Johnson County Stormwater Management Program (SMP) funding. SMP has established a sub-committee that is actively developing a future funding strategy that focuses on watershed approach, asset management, water quality, and flood risk reduction. Thus, recommended priorities defined by the study findings are based on said strategies which form the basis of the City’s targeted funding source. The recommended priorities do not consider the City wide capital improvements program schedule which may also factor in synergies with phased park improvements and addressing social needs, which are not factors of the targeted funding source. City staff indicates that adding these elements would likely result in the following priority: 1) Lake Olathe, 2) Cedar Lake, 3) South Frisco Lake, 4) Waterworks Park and lastly 5) North Frisco Lake. Based on the study findings and merits of the City’s targeted funding sources, the suggested prioritization of major lake improvements is as follows:

1) Waterworks Park. In general, improvements would create a new 17-acre stormwater treatment facility with a new dam, spillway, outlet works, sediment forebay, and wetland treatment train. A loop park trail would provide neighborhood connectivity and educational opportunities for properties that are currently isolated from Waterworks Park.

2) South Frisco Lake. In general, improvements focus on sediment dredging, extension of the outlet structure off railroad property, and water quality filtering at major inflow locations on the lake.

3) Cedar Lake. In general, improvements would include construction of a new dam, spillway and outlet works approximately 1,000 feet downstream of the current dam, localized sediment dredging, and water quality features.
4) **North Frisco Lake.** In general, improvements include sediment dredging, replacement of the outlet works, and constructing water quality features at two of the major tributaries entering the lake.

5) **Lake Olathe.** In general, improvements include enhancing water quality features in the two major arms of the lake, adding BMP’s to tributary and sheet flow drainages, and providing pedestrian connectivity along the south side of the lake.

Priorities and estimated costs are presented in three groups - 1) immediate needs, 2) short-term maintenance, and 3) major lake improvements. The immediate needs are estimated to be $151,000 and short-term dam safety and renewal repairs are estimated to cost $514,000. The major lake improvement costs related to reconstruction of aging dams, sediment dredging, water quality features and flood reduction enhancements are estimated to be $17,881,000. Some improvement concepts incorporate park trail, pedestrian safety and educational components that could be constructed concurrently with the dam and water quality improvements that are estimated to cost an additional $1,900,000. Total costs for all lake and dam master planning recommendations is approximately $21 million. All lake master planning recommendations and cost estimates are summarized in the table below.

<table>
<thead>
<tr>
<th>Lake</th>
<th>Immediate Needs</th>
<th>Short-Term Maintenance</th>
<th>Major Improvements Cost</th>
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<td></td>
<td>Lake Improvements</td>
<td>Park Improvements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar Lake</td>
<td>$77,000</td>
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<td>$9,900,000</td>
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<td>$13,000</td>
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<td>$2,039,000</td>
<td>$2,952,000</td>
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<tr>
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<td>$57,000</td>
<td>$1,327,000</td>
<td>$1,410,000</td>
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<tr>
<td>South Frisco Lake</td>
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<td>$57,000</td>
<td>$1,649,000</td>
<td>$2,254,000</td>
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<tr>
<td>Waterworks Park</td>
<td>$22,000</td>
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<td>$3,930,000</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$151,000</strong></td>
<td><strong>$514,000</strong></td>
<td><strong>$17,881,000</strong></td>
<td><strong>$20,446,000</strong></td>
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</table>

Four strategies to reduce the City's financial burden in consideration of the targeted funding source is offered. These items may include, but not limited to:

1. Lake dewatering services for all lakes, including providing the pumps, maintaining the pumps, and coordinating with the dredging contractor as required for dredging operations.
2. Bio swale and rain garden BMP’s at the southeast corner of South Frisco Lake.
3. Retrofitting of existing storm sewer systems to provide sediment trap BMP’s upstream of storm sewer outfalls at North Frisco, South Frisco, Lake Olathe, and Cedar Lake.

4. Burrowing animal control and embankment repairs noted on most of the structures.
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Appendix C - Water Quality Analysis of Proposed Improvements
Appendix D - Itemized Planning Level Cost Estimates
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1.0 PURPOSE AND APPROACH

GBA was retained by the City of Olathe to develop a comprehensive lake and dam master planning document for six lakes including – Lake Olathe, Cedar Lake, Frisco Park (North and South Lakes), and Waterworks Park (North and South Lakes), all of which are located within City of Olathe parks.

Figure 1-1 Map of lakes evaluated in master planning study.

As part of the lake and dam assessment, GBA reviewed available records provided by the City and on-line resources related to park planning and dam structures. Site visits were completed at each lake to supplement survey data needed to develop water quality improvement concepts, evaluate potential dredge spoils locations and review earthen embankment conditions. The City asked for structural inspections of the lake outlet works at select lakes, primarily those that did not have previously completed structural inspection reports.
Improvement priorities and estimated costs for the recommendations include maintenance, rehabilitation, modification, and/or enhancements. The master planning recommendations are prioritized based on those most qualified for future Johnson County Stormwater Management Program (SMP) funding. SMP has established a sub-committee that is actively developing a future funding strategy focused on watershed approach, asset management, water quality, and flood risk reduction.

This document will be used by City of Olathe to integrate lake and dam projects into the City wide capital improvements program schedule in consideration of anticipated park improvements, social impact, political expedience, implementation, and maintenance costs.

2.0 BACKGROUND RESEARCH

GBA performed background research of available information to gain a better understanding of the purpose and use of the lakes (historic and current). All documents provided by the City were reviewed which included as-built plans, previous lake studies performed by others, historical dam safety inspections, and park master plans. Detailed, site specific history was learned through staff interviews. GBA also reviewed future Johnson County SMP Strategic Planning implementation documents, Kansas Department of Health and Environment (KDHE) total maximum daily load (TMDL) reports and U.S. Geological Survey (USGS) water quality studies. Characteristics for each lake asset including watershed, topographic setting, water quality, and maintenance needs were cataloged and are reported in subsequent sections of this document. The bibliography of specific documents reviewed are provided in Appendix E.

All of the lakes in this study were historically used for water supply purposes and managed by the City Water Department. Today, all of the lake facilities are managed by City Parks for recreational purposes. In February 2018, GBA met with City Water Department staff to understand the history and connectivity of the lakes. South Frisco Lake was the site of the City’s original water supply in the early 1880’s. As the City grew, it became clear that South Frisco Lake was inadequate to serve the City’s needs. Plans for a new water supply system were developed as early as 1908 that included creation of Cedar Lake.

In the 1940’s growth and demand projections made it clear that Cedar Lake did not provide enough water to service City needs and Lake Olathe was planned for construction to add supply capacity.
All three lakes were once connected by a series of pipes and pumps, many of the primary systems have since been abandon or disconnected. Secondary systems connecting Lake Olathe and Waterworks South are still operational and may provide an economical way to drain Lake Olathe in the absence of any apparent drawdown pipes. GBA inquired about the possibility of utilizing the secondary water supply network. A 1963 map of the City’s water supply lines connecting Waterworks, Cedar and Lake Olathe and 1963 engineering report of the water supply, treatment and distribution system was provided. City staff advised that it would be possible to use the secondary pump and pipe network for drawdown but were unaware if the system had a ‘blow down’ pipe (pipe discharging downstream to Cedar Creek), that could be used. GBA agreed to investigate the possibility by gaining access to the pump house at Lake Olathe from Park Department staff. The findings of the pump house evaluation are offered in later sections of this report.

Many of the City’s lakes and ponds have been dredged in the past. City staff indicated that a hydraulic dredge was used to excavate unknown quantities of sediments in 2000 at Frisco and perhaps Waterworks lakes. Most of the dredge material was spread on City athletic fields. It is unknown if the dredge has been used on Cedar or Lake Olathe. For this study, conceptual areas for potential dredge disposal is to be located on-site in park areas and/or adjacent parcels owned by the City. Those areas considered are annotated with dredge spoils location and estimated quantities on an 11”x17” exhibit in Appendix A. Correspondence with Mr. Scott Satterthwaite, KDHE Bureau of Water, indicated that lake sediment sampling would not be required so long as dredged lake sediment is placed on-site or on other City-owned property. The location and suitability of off-site potential dredge disposal areas is not included in this scope of this study. As a result, costs may vary widely based on ultimate disposal site of excess dredge spoils that cannot be placed in the preferred on-site and adjacent areas. If necessary, alternate dredge disposal sites should be considered at the City’s composting landfill located at 1100 N Hedge Lane or application on over 15 City maintained athletic fields up to 12 inches thick. Parks staff suggested Lone Elm and Black Bob parks as the primary athletic field locations that could be considered.

In 2015, the City stopped using sand for winter road application and now exclusively uses salts and organic compounds depending on temperature. The City employs a street sweeping program to reduce sediment loads into area lakes and streams. Sweeping is performed during frost free periods, generally nine months or longer per year. The program strives to sweep main routes every two weeks and local routes three times per year. All roads are swept during the fall specifically to reduce leaves. Parking controls are utilized in the way of flyers or mailers for scheduled routes.
The City owns one vacuum sweeper and two broom sweepers. This best management practice (BMP) sweeping program should be continued. Research suggests that broom sweepers increase total suspended solids in stormwater. Thus, the City should consider focusing on vacuum sweepers to improve efficiency for water quality improvements.

All lake dams are within a seismic zone. Microquakes (earthquakes that are too small to feel) are frequent but larger earthquakes have occurred in 1881, 1903, 1931, 1961, 1975, 1999, 2005, and 2007 within 40 miles of the dams. The lithological structure, in combination with commercial extraction of geologic resources in the Kansas City area can cause unexpected results from each event. Seismic activity poses a risk to City-owned dam embankments and should be a design consideration concurrent with any recommendations involving replacement of the dam embankment.

2.1 Field Investigations
GBA coordinated with City staff from Public Works, Water, Parks and Stormwater to obtain access to many of the facilities needed to inspect structural conditions, understand connectivity, and measure specific features. Field reconnaissance was conducted to identify opportunities that may improve water quality, identify suitable areas for the placement of dredged lake sediment, define concentrated discharge points into and out of the lakes, and to provide visual inspection of earthen embankments. Due to planned construction alterations and previously completed studies, structural inspections were limited to only Olathe and Waterworks Lakes. Cedar and Frisco Lakes are summarized from previous reporting and/or studies completed by others. Geotechnical services were not included in the scope of this study.

Bathymetric surveys for each lake were limited to areas of interest to determine lake bottom elevations along a center line profile and 3 to 5 representative cross-sections. GBA utilized a Seafloor Hydrolite Transom Echosounder (depth sounder) connected to a GEOMAX RTK GPS unit to acquire the depths of ponds and lakes. Locations were determined every 10 feet in areas where the water was 2 feet or deeper. In areas with depths of 2 feet or less, conventional survey methods were utilized. This particular depth sounder doesn’t require calibration prior to utilizing. The manufacturer’s recommended method of checks was used to confirm the accuracy of the depths acquired which consisted of manually checking depths throughout the limits of the sounding and comparing to those acquired by the depth sounder. Bathymetric surveys were supplemented with topographic surveys of outlet pipes, spillways, sanitary sewer locations, and the natural channel of
Mill Creek. Volume and depth estimates compiled from bathymetric survey data is summarized in subsequent sections of the report.

2.2 Water Quality
KDHE has established TMDL's on all lakes. On the 303(d) impaired water list, Cedar and Olathe lakes are high priority, and Frisco and Waterworks lakes are low priority. All TMDL's cite eutrophication suggesting load limitations to reach a reduced eutrophic state which targets both total phosphorous (TP) and chlorophyll-a loading. Chlorophyll-a is the most common photosynthetic pigment found in all plants, algae, and cyanobacteria. It converts sunlight and carbon dioxide into organic compounds while generating oxygen as a byproduct. The direct causes of algal blooms are often associated with increased TP and/or total nitrogen (TN) levels in a waterbody. TP and TN are referred as the causal or contributing variables of nutrient enrichment. Chlorophyll-a is referred to as a response variable. For Kansas lakes, TP is most often the limiting factor for algal productions. Thus, excess TP inputs are more likely the main culprit of algal blooms for many lakes in Kansas.

For lakes, the intensity of algal response measured by chlorophyll-a is determined not only by the levels of TP and/or TN, but also by factors such as water turbidity, sunlight, water depth, temperature, seasons, etc. Chlorophyll-a is a measurement of response by the algal communities to all the chemical, physical, and biological conditions in a waterbody. It is regarded as a reliable indicator of the eutrophic conditions in lakes. Since TP is generally accepted as the limiting nutrient in Kansas lakes, reducing TP will also reduce chlorophyll-a. Numerical goals described in the TMDL's are provided in the following table, these TMDL’s prescribe total phosphorous load reduction goals. Note: the written TMDL’s for Frisco and Waterworks are ambiguous in the documents and do not distinguish nor identify the two sites as having two separate water bodies; therefore, it is assumed that all four water bodies are targeted.

<table>
<thead>
<tr>
<th>Lake</th>
<th>Year</th>
<th>Baseline TSI (CHL)</th>
<th>TP ppb</th>
<th>Chlorophyll-a ppb</th>
<th>TP Load lb/yr</th>
<th>Goal TSI (CHL)</th>
<th>TP ppb</th>
<th>Chlorophyll-a ppb</th>
<th>TP Load lb/yr</th>
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<tr>
<td>Cedar</td>
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<td>67</td>
<td>115</td>
<td>41</td>
<td>14700</td>
<td>55</td>
<td>12</td>
<td>5028</td>
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<tr>
<td>Olathe</td>
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<td>59.7</td>
<td>50</td>
<td>22.7</td>
<td>11050</td>
<td>53</td>
<td>36</td>
<td>10</td>
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<tr>
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<td>123</td>
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<td>55</td>
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<td>116</td>
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Table 2-1 TMDL baseline and goal for each lake.
Total suspended solids (TSS) removal is key to any stormwater treatment method. This is because many compounds like bacteria, microbes, hydrocarbons, metals, and phosphorous readily attach to sediments creating a transport mechanism to the lake. Nitrogen, phosphorous and metal compounds in stormwater are highly correlated with sediments in the stormwater. For this reason, many water quality BMP’s aim to remove sediments from stormwater prior to any treatment.

Water quality of the larger lakes are influenced by depth. Deep reservoirs typically have three basic layers that thermal dynamics strongly influence biochemical processes. The epilimnion, or the topmost thermal layer often has a constant temperature due to evaporation. The metalimnion is a thermocline where the temperature is changing rapidly with depth. The hypolimnion or deepest / coldest thermal layer is where the temperature stops changing with depth and typically has depths greater than 15 feet. Very shallow reservoirs many not have a hypolimnion. The hypolimnion plays an important role in conversion of nitrogen in very low oxygen conditions, thus to improve water quality in the reservoirs a deep pocket should be developed to release nitrogen. Precedence of the hypolimnion creates a risk of “turn over” when temperatures within the upper epilimnion are below that of the deep hypolimnion causing a density differential.

GBA observed water quality conditions in each lake in late February and early March 2018. During this period, North Frisco Lake and Lake Olathe had the largest amount of observed trash / rubbish debris. GBA also observed algae and odor at South Frisco Lake and excessive sedimentation at Cedar Lake. The observed water quality conditions are listed below in order of highest to lowest in quality:

1. South Waterworks Lake
2. North Waterworks Lake
3. Lake Olathe
4. North Frisco Lake
5. Cedar Lake
6. South Frisco Lake

GBA evaluated each lake to determine ideal locations for lake water quality BMP’s which can be found in subsequent sections of this document. Several BMP’s for water quality improvements proposed in this study consist of treatment trains on the upstream areas of the major lakes. These
BMP’s consist of three primary components - 1) forebay for sediment removal, 2) wetlands for sediment and phosphorus removal, and 3) a deep lake to encourage nitrogen removal.

In reviewing the preliminary Johnson County SMP scoring structure for water quality projects, half of the project score is related to water quality improvement / preservation. Scores can be derived by load reductions defined by the TMDL, habitat improvement and preservation of priority waters. For this reason, future project funding will be partially tied to water quality improvement. Water quality modeling for this project was completed to demonstrate load reduction of pollutants identified in the TMDL’s; therefore, demonstrating BMP efficiency in terms of the overall waterbody TMDL. Detailed descriptions of the water quality model selection, development, assumptions and results are provided in Appendix C.
3.0 LAKE OLATHE

3.1 Background
Lake Olathe dam is located 2.5 miles west of downtown Olathe on Santa Fe Street (135th) and was constructed in 1956 to supplement water supply to the growing City of Olathe. The lake is 154 acres and surrounded by 266 acres of City property. The east side of the lake is a former golf course with bedrock glades observed throughout in a savanna like setting. The west side of the lake is largely a wooded bluff. The lake has a drainage area of 16.5 square miles that is undergoing conversion from agriculture to urban use with baseflow through the lake is estimated to be 9.8 cubic feet per second.

Stormwater runoff to the lake is provided by three major tributaries including Cedar Creek which enters from the southeast (9,538 acres), the south arm (727 acres) and east arm (301 acres). Because Cedar Lake is only 2.3 miles upstream of Lake Olathe, Cedar Lake traps much of the sediment that would otherwise enter Lake Olathe. As a result, much of Lake Olathe has maintained depths greater than 20 feet deep. The maximum depth is estimated to be 45 feet. Healthy wetland systems are concentrated on the Cedar Creek arm of the lake. The east arm has a large wetland system approximately 4,000 feet upstream of the lake that has a steep gradient entering the park property and the lake. Because of the large open areas in the park and proximity of bedrock at the surface, there are many areas that surround Lake Olathe that may be suitable for dredge spoils disposal. Park master plans indicate that much of the eastern flank will remain open space and water quality forebays are included on the Cedar Creek arm.

3.2 Assessment Findings
GBA met with City parks staff on March 9, 2018 to investigate Lake Olathe outlet works tower and pump house. The outlet works tower was opened and inspected utilizing a pole-mounted GoPro camera. The tower was filled with water so pipe connectivity, intake locations and valves were not

Figure 3-1 Area map of Lake Olathe.
Many fish were observed in the tower indicating that there is likely an active opening to the lake. Three valves are believed to exist within the tower including two operate sluice gate intakes from the lake and a third valve that controls flow to the pump house. According to City parks staff, valves within the outlet tower have not been operated for over 20 years and the positions / configuration of the valves, intakes and piping is unknown.

According to historical drawings, a 24 inch ductile iron pipe (DIP) connects the outlet works tower to the pump house on the west side of the dam. Discharge from the pump house is a 16 inch DIP which discharges along Santa Fe (135th Street) and Dennis Avenue (143rd Street) via a 12 inch DIP to the south Waterworks pond. The pump is normally operated in July and August to flush out ponds at Waterworks Park to reduce algae blooms. Between the pump house and Cedar Creek exists an air valve and blow off valve/discharge standpipe. According to City staff, the blow off valve can be turned to discharge lake water directly to Cedar Creek out of the discharge stand pipe. There is not any evidence of a dedicated drawdown pipe at Lake Olathe.

Embarkment, spillway and primary outfall chute observations were completed at Lake Olathe. The embankment of the dam on both the upstream and downstream faces is currently in fair condition. Undesirable trees were observed along the toe of the embankment segmental block wall, along the downstream face of the emergency spillway, and within Cedar Creek. Along the embankment retaining wall there are blocks and capstones that appear to have been removed and relocated, creating an uneven vertical alignment along the dam embankment. Rodent activity was observed on the downstream face of the embankment. There is a 200 square foot area that has evidence of potential water seepage on the downstream face that should be routinely monitored for saturation and heave.

The emergency spillway is approximately 180-feet long and has some minor concrete repairs needed. Additionally, the pressure drains on the downstream side of the spillway have vegetation.
and other obstructions that limits their potential effectiveness. Graffiti was noted on the emergency spillway. Garbage is abundant along the shoreline of the upstream face of the embankment. A neighborhood cleanup of the area is recommended to address the trash and graffiti.

At the primary outfall of the dam, there is undercutting present along the both chute sidewalls. The north end wall of the chute is in poor condition with reinforcement showing. Removal of trees within Cedar Creek may offer a reduction in erosion around the chute end walls. An exposed water line was observed in Cedar Creek downstream of the primary outfall that is believed to be an abandoned line. Riprap protection has been displaced within Cedar Creek downstream of the primary outfall that should be reset to reinforce the shoreline.

Along Dennis Avenue at the upstream end of the dam, there is limited roadway width. Widening Dennis Avenue right-of-way to include a pedestrian trail could offer safety benefits for drivers and pedestrians while improving connectivity to both sides of the lake. It is likely that adding this feature could encourage fishing adjacent to the roadway; therefore, the City should consider adding parking areas within the parcels between the lake and north side of Dennis Avenue. Although this concept feature is only 4,100 cubic yards of fill, expanded modifications to the shoreline could create additional fill areas and habitat expansion if desirable.

There is a gap in the fence on the south end of the embankment, which poses a safety risk to pedestrians. It is recommended that the fence be extended, or a gate installed to secure access to the embankment. It may also be beneficial to place a fence to close off access to the stilling basin and chute where fall hazards are apparent.

During the study, several potential dredge disposal areas were identified and vetted by City staff. Only the historical waste battery site at the eastern edge of the park was deemed acceptable.

### 3.2.2 Structural

Concrete deterioration was observed in several areas of the stilling basin, chute, emergency spillway and ogee weir. Recommendations, priorities and costs from the structural report are incorporated herein. Refer to Appendix B for detailed description of findings and photographs.
3.2.3 Surveying
Bathymetric surveys were conducted only on the two tributary arms of Lake Olathe. A total of eight (8) cross-sections and two (2) centerline profiles were completed within the eastern arm and main Cedar Creek arm. The survey included approximately 9,000 feet of the lake bottom and most of the survey detail was completed in the Cedar Creek arm with approximately 1,500 data points. A 2001 report utilizing crude DEM data was performed by Kansas Geologic Survey suggesting that Lake Olathe has filled only 10 percent of its sediment volume since construction.

3.2.4 Water Quality
Because the watershed upstream of Lake Olathe is undergoing urbanizing land use changes, mitigating measures to protect and improve water quality should be considered to meet lake TMDL requirements. The urbanizing land use changes will result in increased run-off which also results in decreased lake residence time and increased nutrient sources that may alter water quality loading. Cedar Creek filters through an extensive off channel wetland system upstream of Dennis Avenue. Secondary filtering is provided by another natural wetland in the tailwater of Lake Olathe downstream of Dennis Avenue. Dredge is proposed in this area to expand the current wetland system and separate its function from that of the lake. The east arm was found to be very deep and dredging is not recommended, however, development pressure in the east arm watershed is likely to increase stormwater pollutants to the lake. The steep tributary channel and presence of bedrock at the surface make in line BMP’s unfavorable. Sediment trap BMP’s at concentrated discharge points are recommended in ten (10) locations surrounding the lake. Native grass filter strip/swale/berms should be considered upgradient of the existing east access road and future east access road.

To treat all water inputs into Lake Olathe, excluding any site BMP’s in the upstream watershed, would require approximately 270 acres of wetland area. The improvements proposed herein will
provide approximately 21 acres of treatment zones in and surrounding the lake. With Cedar Lake added to the total then the value is 191 acres or approximately 71 percent of the treatment area needed to reach recommended TMDL goals for Lake Olathe.

The outlet tower has a profiling water quality monitoring station that is maintained by USGS. The City should consider developing a lake operation plan to improve nutrient removal efficiency and to promote an extended lifecycle for reservoir sediment storage volume. The operation plan should be simple, straightforward and passive (no pumping required). This would be based only on opening and closing the two sluice gate valves on the outlet tower to draft water out of the lake at variable elevations as needed for seasonal nutrient/sediment control which affect algae. The USGS station is ideal to measure and calibrate the lake operation plan.

3.3 Conceptual Modifications & Enhancements

Proposed improvements are identified in Figures 3-4 and 3-5. A detailed description of the recommendations is provided in the following list with the identifier corresponding to the location of each item on the figures. Many of the 2018 findings are consistent with those documented in the 2011 dam safety inspections completed by J2 Engineering.

A) With KDHE approval and modification of the Environmental Use Control (EUC) document, dredge spoils may be placed atop the historical battery waste disposal site along the eastern boundary of Olathe Lake Park that may accommodate up to 58,000 cubic yards of dredge material. Average depth of the potential fill is 4.7 feet. Because the dredging to create wetland enhancements in the lake requires 10,000 cubic yards of fill, this dredge disposal area would likely be utilized for overflow of dredged materials from other sites in this report. Historical documents reviewed indicate that the City wishes to construct a parking lot over the battery waste site. Said parking lot is not shown on current park master plans and would not be compatible with dredge fills in the same area due to settlement.

B) Transportation, pedestrian safety and park connectivity improvements along the north side of Dennis Avenue. These improvements include:

- 4,100 cubic yards of dredge / fill along the roadway to a minimum elevation of 942. This creates a 20-foot wide bench adjacent to the north edge of the roadway that is 3 feet above lake water surface.
- 2,300 linear feet of 10-foot wide concrete sidewalk to improve pedestrian access along Dennis Avenue.
• 1,500 cubic yards of riprap shoreline protection against lake fills to create the bench.
• Extend the existing 42-inch culvert 60 feet under the fill area.
• Add 8,000 square feet of paved parking area (including ADA parking) in lot north of Dennis Avenue between Wickford Road and Palmer Drive. (~2300 Dennis Avenue)
Figure 3-4 Proposed water quality improvements at Lake Olathe.
1) Construct Cedar Creek arm forebay. The anticipated volume is 10 acre-feet with a maximum depth of 9 feet and average depth of 4.5 feet. Dredging the forebay is not necessary. See item 3.

2) Construct wetland enhancements. The expanded wetland area is 12 acres, which requires 14,000 cubic yards of fill. Saturated dredge material in this area is estimated to be 8,000 cubic yards but dredge spoils volume is 4,100 cubic yards after dewatering. Thus, the expanded wetland requires a net fill of approximately 10,000 cubic yards excluding fills noted for item B.

3) Construct 1,900 cubic yards of heavy stone riprap weirs for Cedar Creek arm forebay / wetland treatment train. Stone for the forebay weir is 600 cubic yards, 550 cubic yards for the center weir dividing the two wetland cells and 750 cubic yards for the weir separating the main lake.

4) Install sediment trap BMP’s at four (4) locations. Construct standpipes to induce sedimentation and slow peak discharges from minor tributary areas.

5) Construct BMP enhancement at six (6) locations. This work includes expanding or enhancing 2.3 acres of fringe wetland or modify existing outlet structures at three (3) locations to improve sediment removal.

6) Construct 2,550 linear feet of native grass filter strip, wet swale and berm in four (4) locations. Berms are anticipated to be 2 feet high and 20 feet wide, filter strips/swales are estimated to be 40 feet wide. Near surface bedrock may make these features unfeasible.

7) Construct the proposed SMP MC-1 Berm / Floodplain protection improvements for two (2) homes as described by 2006 Cedar Creek Watershed study. The proposed berm is approximately 500 cubic yards with an average height of 5 feet. The improvements also include inlet, pipe and flap gate for internal drainage.

8) Remove trees and woody vegetation in four (4) locations.
   - Volunteer trees and shrubs along the base of the wall embankment retaining wall. Approximately 10 trees less than 4-inches in diameter and all trees a minimum of 5-feet away from the wall should be cut down.
   - Approximately 5 trees less than 4-inches in diameter growing on the downstream face of the spillway.
   - Approximately 5 trees greater than 4-inches in diameter in Cedar Creek downstream of primary spillway chute.
   - Trees within 20 feet of both primary spillway chute retaining walls.
9) Construct 135 feet of heavy riprap shoreline protection along the south bank of Cedar Creek immediately downstream of the spillway chute. This is estimated to be 500 cubic yards of stone.

10) Trap and relocate burrowing animal. Place compacted backfill in holes at 4 locations.

11) Install fencing to improve public safety at two (2) locations:
   - Gate at south end of the embankment to eliminate gap that currently allows for unwanted public access.
   - 135 linear feet of 6’ fence to limit public access to spillway chute.

12) Structural wall repairs include:
   - Embankment Retaining Wall - Reset or replace cap stone blocks on top of retaining wall. Replace missing blocks (removed by vandals, but still on-site).
   - Spillway Walls - Replace or reinforce the north wingwall on the downstream end of the spillway chute. Patch isolated areas of spalled and delaminated concrete on the north walls of the primary spillway, mostly along the control joints of the wall. Patch isolated areas of spalled and delaminated concrete atop of the south stilling basin wall. Clean and repair cracks in the south retaining wall and patch the adjacent top of wall at the bottom of the south side earth embankment wall.

13) Concrete slab repairs include:
   - Emergency spillway - Replace significant portions of the spillway slab at the base of the spillway (approx. 380 square feet total - varies between a 2-foot wide strip and a 10-foot by 10-foot panel). Replace isolated sections of the top spillway slab (approx. 135 square feet total). Patch an isolated area of spalled concrete at the top of the spillway side wall, also clean and repair 12 cracks in the wall. Remove vegetation and fill sawcut control joints in the spillway slab with sealant to help minimize freeze-thaw damage to the concrete.
   - Primary Spillway and Chute - Patch isolated areas of spalled and delaminated concrete in the base slab. These areas are primarily along the center joint. Replace sealant in wall joints. Investigate and possibly replace the previous patch area on the east ogee weir.

14) Remove vegetation from spillway pressure drains and backfill with gravel.

15) Exercise valves in outlet works tower. Repair concrete slab at the top of the tower, patch the isolated area of spalled and delaminated concrete around the valve stem after further assessment from the underside of the top slab. Clean and repair cracks in the slab. Patch
spalled and delaminated concrete at the perimeter guardrail post connections at the corners of the box.

Figure 3-5 Proposed outlet works improvements at Lake Olathe.

3.4 Recommended Priorities

Immediate considerations should be given to maintenance of the embankment and spillway. These high priority needs include tree removal, safety fencing and spillway maintenance noted in items 8, 10, 11 and 14. Water quality may be actively managed via development and implementation of a
reservoir management plan. This may be implemented immediately for low cost and may have extended benefits.

Many of the water quality improvements could be implemented prior to or concurrently with planned park improvements including items B, 1, 2, 3, 4, 5, 6, 7 and 9. These should be considered medium priority although many of the Lake Olathe park improvements are planned in 2018-2019 which could accelerate the priority of the recommended schedule.

Structural repairs do not require immediate attention but should be considered to extend the life of the concrete structures as the magnitude of the repairs will likely increase with time. These are low priority but should be completed within 2 to 5 years and include items 12, 13 and 15. The repairs to the primary spillway north wall, south wall, ogee weir and base slab spillway could possibly be delayed for 5 to 10 years unless major overtopping events occur that may require re-evaluation to the urgency of said repairs.

The proposed improvement at Lake Olathe result in a net fill of 10,000 cubic yards. The historical waste battery disposal site noted in item A can be used for dredge disposal overflow from other lakes in this document.

11”x17” exhibits summarizing the conceptual modifications and enhancements are provided in Appendix A.

3.5 Planning Level Cost Estimate

In consideration of the presented findings, observations and improvements planning level cost estimates have been developed in consideration of the presented findings, observations, and recommended improvements. Administration expenses included are contract administration, surveys, engineering, environmental permits and construction observation services. Many of the maintenance tasks may be performed by City staff including vegetation removal, nuisance animal control, repair of embankment voids, removal of miscellaneous encroachments, and safety fencing. Construction costs for water quality and structural improvements include contractor mobilization, clearing and grubbing, demolition of existing structures, proprietary BMP’s, concrete repairs, outlet works improvements, shoreline protection, mechanical dredging, mass grading, temporary erosion control, and native vegetation establishment in proposed wetland BMP’s.
All dredging costs assume that City staff will manage, monitor, and maintain pumping or outworks operations as necessary for dewatering of the proposed dredge areas by a contractor. Some concepts offer park safety or trail enhancements that are not included in the park master plans, those estimates include asphalt paving, pedestrian bridges and boardwalks for trails. Cost estimates exclude short-term and long-term maintenance costs associated with the lakes and proposed BMPs for vegetative management such as weeding, dethatching, harvesting, plant replacement, and aeration; monitoring of water quality, weirs and control structures; erosion repairs; and sediment removal. All costs are based on 2018 dollars with a 25% contingency added.

Costs for construction of the most easterly weir dividing the proposed wetland cell and the main lake are excluded from these costs per City request. A jetty is planned in said location to accommodate a new pedestrian bridge for the park. While detailed plans were not provided for the pedestrian bridge/jetty, it is unlikely that the jetty would function like a weir separating the main lake from the treatment train concept proposed herein. The costs have been broken into said sub categories of proposed work below.

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A detailed breakdown of the estimated costs is included in Appendix D.
4.0 CEDAR LAKE

4.1 Background

Cedar Lake is located 3 miles southwest of downtown Olathe near 159th Street and Lone Elm Road. The lake was constructed in 1938 for water supply to the City of Olathe and is one of the oldest manmade lakes in Kansas. Cedar Lake was abandoned for water supply use as sediment within it accumulated. Primary water supply shifted to Lake Olathe in the late 1950’s. Cedar Lake is 65 acres and is surrounded by 131 acres of open, mowed grassy areas with mature trees along a narrow strip of City property. The lake has a drainage area of 6.2 square miles that is undergoing land use changes, currently over 50 percent is urban.

Stormwater runoff to Cedar Lake is provided by two major tributaries entering from the south and east, both have similar sized drainage areas (1,800 +/- acres). Two minor tributaries draining agriculture land enter from the north and south. All tributary confluences with the lake contain natural wetland systems. Cedar Lake historically trapped much of the sediment from the two major watersheds. Currently, the average depth in the two arms is only 2.5 feet. The main lake has an average depth of 7 feet and maximum depth of 12 feet.

Several park master plan concepts were reviewed for Cedar Lake. Water quality features are recognized on the major tributary arms. Much of the City property surrounding the lake has planned park improvements which limits potential locations for on-site mass disposal of dredge materials. Limited fills are possible in the coves at three locations near the northwest corner of the lake and at one location near the south park access road. The cove filing is identified as shoreline restoration in park master plans. These features alone have insufficient dredge disposal volumes to provide any significant recovery of lake bathymetry needed for good stormwater treatment processes. Filling in the larger coves near the northeast corner of the lake, as proposed in park master plans, is not...
recommended as it is inconsistent with good stormwater management practice since the existing wetlands provide filtering and sediment removal.

A 2009 lake restoration feasibility study was evaluated. The study completed a bathymetric survey and collected sediment cores from the lake. Calculations completed with the study suggest that 560,000 cubic yards of dredge is necessary to restore the original volume of the lake and the bottom sediments contain an average of 45% moisture. Six dredging options were evaluated utilizing both mechanical and hydraulic dredge techniques. The 2009 hydraulic dredging costs without disposal considerations were estimated to be $1.8 million dollars. Because of the volume of materials and land area needed to dispose of them, dredge disposal makes up most of the cost in the alternatives evaluated in the 2009 study, which ranged from $8 to $12 million, or up to 75% of the costs of a dredging project. This cost escalates significantly if on-site dredge disposal is not a viable option, which is why land acquisition of adjacent parcels specifically for disposal of dredge material is often recommended at Cedar Lake. Approximately 175 acres is currently for sale at the north side of Cedar Lake Park. Portions of this tract are identified in the 2009 study and park master plans for a dredge spoils disposal site.

In consideration of future park and sanitary sewer improvements, GBA identified mass dredge disposal sites only on the north side of the park. City staff reviewed the mass dredge spoils locations and determined that most sites do not mesh with park master planning uses / priorities. Concept dredging volumes were reduced such that all the dredge material may be placed within the coves, wetland features, and limited out of lake disposal locations found to be acceptable to the City.

The City has evaluated rehabilitation and replacement of Cedar Lake dam in a 2016 engineering report. The report offers four options, all of which replace the existing ogee weir and raise the embankment elevation 3.1 feet to meet State of Kansas freeboard requirements. None of the options considered would raise the normal pool elevation of the lake. The schedule for implementing the dam replacement project is dependent on adjacent quarry operators and is undefined.

4.2 Assessment Findings
Embarkment and historical outlet works observations were completed at Cedar Lake. The upstream face of the embankment is in fair condition and is protected with large riprap. The north end of the embankment appears to be lower than the dam crest which may elevate the risk of a breach during a dam overtopping event. Rodent holes and evidence of soil heave were observed on the
downstream face. Vegetation management is needed around the spillway walls. Graffiti was also observed along the spillway.

On March 1, 2018, GBA met with City parks staff to investigate the Cedar Lake outlet works. The historical water supply valve box was opened and inspected utilizing a pole-mounted GoPro camera. The box was filled with water approximately 25 feet deep. Pipe connectivity, intake locations, and valves were not able to be observed within the valve box. An 8 inch DIP drawdown pipe is located on the downstream side of the dam and is apparently operated from the outlet works valve box. According to City staff, the drawdown valve has not been used for over 20 years and it was difficult to close the valve at that time.

A secondary drawdown system is located on the east side of the spillway. The pipe discharges approximately 3.5 feet below lake level and would only be capable of partial drawdown. According to City staff, the valve was opened in 2016 for a spillway inspection. The City contracted CCTV of the secondary drawdown pipe and revealed that a log had become lodged in the valve. An inflatable ball was installed in attempt to stop flows with the valve stuck open. The 12 inch pipe was observed to flow approximately 1/3 full constantly.

During the 2016 inspection, City staff utilized a 12-inch pump for 10 days to lower Cedar Lake by 3 feet. The City has access to two (2) 12-inch pumps which may be beneficial for future dewatering needs and dredging.

4.2.2 Structural

Structural deficiencies on the concrete spillway are documented through previously completed dam safety inspections, engineering reports, and current GBA observations of the outlet works tower. The referenced 2016 Cedar Lake Dam Investigation recommendations and cost estimates have also been incorporated to the recommendations of this study. Detailed description of the structural inspection findings with photographs are included in Appendix B.
4.2.3 Surveying

Bathymetric surveys were conducted throughout Cedar Lake consisting of eight (8) cross-sections, 18,000 feet of the lake bottom, and approximately 1,500 data points. The current volume of the lake is 345 acre-feet at elevation 1001. The calculated volume is slightly larger than that from two previous studies at the same elevation. It is believed that the 2018 data is likely more accurate than those completed in 2000 and 2009 which utilized crude DEM modeling techniques resulting in storage volumes in the 330 acre-feet range. The original design volume is reported to have been 672 acre-feet, thus Cedar Lake has lost nearly 50% of its sediment storage capacity since original construction.

4.2.4 Water Quality

Because Cedar Lake is substantially filled with sediment, there is insufficient volume and depth to remove suspended sediments. As a result, most of the current sediment-laden stormwater runoff likely passes through untreated and will ultimately be transferred to Lake Olathe.

Proposed concepts that provide treatment for point sources at the main tributaries entering the lake primarily includes the development of sediment forebays. In anticipation of land use changes north and south of the lake, sediment trap BMP’s are suggested in three locations on small tributary systems. Bedrock near the surface, steep hillslope grades, and congested use of the land for future park plans likely limit any effective native grass filter strips/swales. Some very small areas may be suitable demonstration BMP’s for educational and/or landscaping features.

A limestone ledge, approximately 12 feet below the normal water surface is visible downstream of the spillway. This limestone ledge is believed to be the Captain Creek limestone formation and likely limits dredge excavation depths within large areas of the lake with the exception at the pre-dam thalweg where depths up to 30 feet below water surface may be possible without encountering the limestone. To reach a goal of 10 percent lake volume being greater than 15 feet deep, it is estimated that 330,000 cubic yards of dredging necessary. After water extraction, approximately 200,000 cubic yards of this dredged material will require disposal. Since there is limited space for disposal on-site, the dredging volume was reduced 46% by limiting dredge excavation to a 200-foot-wide main channel that roughly follows the historical flow path of Cedar Creek inundated by the lake surface. In consideration of the limited disposal space, this reduction allows for all proposed dredge and waste soils from the proposed relocation of the dam embankment to be disposed of on-site.
Ideally, Cedar Lake should be dredged to maintain depths over 15 feet or 25% of the lake volume to improve both sediment and nutrient removal efficiency.

Various local, state and national references recommend watershed management techniques to reduce non-point source sediment loads prior to reaching the lake. References suggest that treating all water running off into Cedar Lake, excluding any site BMP’s in the upstream watershed, would require approximately 120 acres of wetland area. The improvements proposed herein will provide approximately 15 acres of treatment zones in and surrounding the lake, or approximately 12% of the estimated treatment area needed to reach lake TMDL goals.

The historical water supply outlet tower should be replaced such that a lake operation plan can be implemented to improve nutrient removal efficiency and extend life of sediment storage volume of the reservoir. Pipework and valves would need to be installed to accomplish this goal. The operation plan should be simple, straightforward, and passive (no pumping required). This would be based only on opening and closing valves to draft water out of the lake at variable elevations as needed for seasonal nutrient/sediment control.

4.3 Conceptual Modifications & Enhancements
As previously stated, the City prefers to rehabilitate and replace the Cedar Lake spillway and embankment as outlined in the 2016 Cedar Lake Dam Investigation and Report. Favored options include raising the embankment elevation of the lake 3.1 feet to meet State of Kansas dam safety guidelines. The normal pool of the lake will remain unchanged for all replacement options, thus replacing the dam embankment will not affect the average depth of Cedar Lake. There is not sufficient volume and depth for water treatment of suspended solids, nutrient cycling or sustainable fish habitat. A plan to dredge Cedar Lake that restores storage capacity and enhance recreational activities should be completed prior to implementing sediment control BMP’s on the lake or watersheds entering the lake. As such, proposed concepts presented herein merge water quality recommendations from the findings of this study and that of the 2016 investigation report to reconstruct the dam and embankment.

Potential property acquisitions are represented from various park masterplans and previous lake assessment studies. Costs to purchase these properties are excluded from the master planning cost estimates. The total land area is 90.3 acres as detailed in the table below:
Proposed improvements are identified in Figure 4-3. A detailed description of the recommendations is provided in the following list with the identifier corresponding to the location of each item on the figures.

A) Dredge spoils may be placed in limited areas between the future park access road and north side of the lake. The annotated area may accommodate up to 44,500 cubic yards of dredge material with an average depth of the fill of 4.5 feet. The spoils berm could be contoured, then topped with landscaping.

B) Dredge spoils may be used to fill the three coves at the northwest corner of the lake. Filling the coves identified on the Cedar Lake parks master plan is estimated to accommodate 12,000 cubic yards of dredge with an average fill depth of 6.5 feet.

C) Dredge spoils may be used to fill the cove near the Monticello Road access on the south side of the lake. This area is identified on the Cedar Lake parks master plan and is estimated to accommodate 12,500 cubic yards of dredge with an average fill depth of 5 feet.

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Table 4-1 Potential property acquisitions near Cedar Lake.
Figure 4-3 Proposed improvements at Cedar Lake.
1) Construct replacement dam embankment and spillway (Alternative 3a) per 2016 Cedar Lake Dam Investigation and Report. Estimated earthwork necessary to construct the embankment is 72,000 cubic yards which may not be material dredged from the lake.

2) Construct 8’x8’x40’ low level water intake tower to manage water quality of future lake and provide a lake drain. Install three sluice gate valves and 120 linear feet of associated 12-inch DIP elbows, pipes, tees and anti-seep collars.

3) Remove existing dam embankment, spillway and outlet works tower. Excavation volume of the embankment is approximately 35,000 cubic yards if removed down to elevation 992 (Captain Creek Limestone). This material may be utilized to construct the new dam embankment described in item 1.

4) Dredge the main channel of the lake, target maximum water depth is 21 feet, average water depth through the excavated channel is 10 feet. Saturated dredge material is estimated to be 153,000 cubic yards, dredge spoils volume is 93,000 cubic yards after deducting water (40,000 cubic yards) and suspended sludge in the bottom (20,000 cubic yards).

5) Construct Cedar Creek forebay and wetland treatment train. Dredging in these areas involves 20,500 cubic yards of saturated dredge, which reduces to 7,500 cubic yards after deducting non-recoverable sludge and water. Fills to build the berms and marsh fringe is 9,300 cubic yards compacted, resulting in a net fill of 1,800 cubic yards.
   • Forebay - Maximum depth is 8 feet, average depth is 4.8 feet, anticipated permanent pool volume is 18.8 acre-feet.
   • Wetland - 7.1 acres, maximum depth is 5.5, average depth is 1.3 feet, anticipated permanent pool volume is 6.5 acre-feet.

6) Construct south tributary forebay and wetland treatment train. Dredging requires 13,000 cubic yards of saturated dredge, which reduces to 5,000 cubic yards after deducting non-recoverable sludge and water. Fill needed to build the berms and marsh fringe is 8,700 cubic yards compacted, resulting in a net fill of 3,700 cubic yards.
   • Forebay - Maximum depth is 8 feet, average depth is 4.4 feet, anticipated permanent pool volume is 11.9 acre-feet.
   • Wetland - 4.5 acres, maximum depth is 5.5, average depth is 1.2 feet, anticipated permanent pool volume is 3.6 acre-feet.

7) Construct 3.4 acres of wetland BMP enhancement on two drainages entering the northeast side of the lake. Net fill in the center cove is approximately 10,000 cubic yards.

8) Construct approximately 2,000 linear feet or 6,000 cubic yards of riprap revetments in six (6) locations to maintain wetland residence time and prevent short circuiting.
9) Construct approximately 1,800 linear feet or 2,000 cubic yards of heavy stone riprap weirs separating forebay, wetlands and the main lake (4 total).

10) Install BMP's for localized runoff:

- Retrofit existing inlet structure near the northeast corner of Lone Elm Road and east park access road with sediment trap BMP device.
- Construct a standpipe to induce sedimentation and slow peak discharges on the upstream side of the existing cross road pipe in two locations, prior to entering wetland BMP at the northeast corner of the lake along the east park access road and at the low point near the south park entrance off of Monticello Road.
- Construct 1,200 foot long, 40 foot wide native grass wet swale / infiltration basin. Note: due to near surface bedrock, this feature should only be installed if areas in item A are utilized for dredge spoils.

Until a defined schedule to replace the dam and spillway can be developed, maintenance recommendations to extend the life of the dam and improve dam safety are suggested based on current and historical findings. The recommended maintenance items are listed below and identified on Figure 4-4.

11) Remove trees and woody vegetation in three (3) locations

- Four (4) buttonbush shrubs are present on the upstream side of the embankment near the spillway that should be removed.
- Woody vegetation within the extents of the concrete walls of the primary spillway should be removed.
- Mow brushy vegetation along the downstream embankment to examine extent of heave and rodent burrows discussed in items 12 and 13.

12) Trap and relocate burrowing animal. Place compacted backfill in holes at least 5 locations.

13) Evidence of soil heave is present throughout the downstream face of the embankment for approximately 300 feet. It is recommended that brushy vegetation along the downstream embankment be cut low to provide a more detailed examination of potential damage and restoration needs from soil heave and rodent burrows. The area should be repaired and reseeded.

14) The north end of the embankment appears to be 1 to 3 feet lower than the dam crest elevation. It is recommended that the embankment be extended approximately 100 feet northeast to the fence line at an elevation of 1009.
15) Sheet flow from the south access road directly enters the lake which is a direct source of sediment and erosion. Consider a 150-linear foot berm and filter strip in this area.

16) Clean out and repair cracks in the top slab surface of the outlet works box. The secondary drawdown valve is lodged open. It is reported that a log is preventing the valve from closing. The log should be removed, and the valve be tested for operation.

17) Structural deficiencies have been reported throughout spillway. Repair cracks in the downstream weir apron and any cracks that are observed in the upstream apron after dewatering the lake. Clear vegetation from joints in the west sloped apron, repair any cracks identified thereafter. Many of these items are detailed in the 2016 Cedar Lake Dam Investigation and Report.

Figure 4-4 Interim maintenance needs at Cedar Lake outlet works and embankment.
4.4 Recommended Priorities

Immediate considerations should be given to maintenance of the embankment and repair to the secondary drawdown valve. These high priority needs also include vegetation removal, mitigating rodent damage and investigating soil heave noted in items 11, 12, 13 and 16.

Some repairs do not require immediate attention but should be considered to extend the life of the concrete structures and embankment as the magnitude of the repairs will likely increase with time. These are low priority and include items 14, 15 and 17. These items are not included in the cost estimates because City staff indicated the work is planned to be performed by in house maintenance staff.

The lake weir, weir apron, and spillway wingwalls are beyond their useful life and should be replaced. Many of the water quality improvements could be implemented concurrently with planned replacement of the dam including items A, B, C, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10. Water quality may be actively managed via development and implementation of a reservoir management plan and should be completed concurrently with construction of the new dam.

The current concept will only dredge a main channel to an average depth of 10 feet resulting in 105,500 cubic yards of dewatered solids. This was done to reduce the need for off-site dredge disposal and purchasing adjacent property. The final dredging plan could be modified to maximize on-site storage availability which is estimated to be 97,000 cubic yards within features A, B, C, 5, 6 and 7. Thus, 8,500 cubic yards of the dredge materials must be disposed of off-site under the proposed concepts presented herein.

Because Cedar Lake is substantially filled with sediment, there is insufficient volume and depth to remove suspended sediments in stormwater runoff. As a result, most of the current sediment-laden stormwater runoff likely passes through untreated and will ultimately be transferred to Lake Olathe. In addition, the shallow depth of Cedar Lake impairs recreation opportunities outlined in the parks master plan. Thus, it is highly recommended to dredge larger deep-water areas of Cedar Lake such that depths greater than 15 feet are present over 25% of the lake volume which would require disposal of approximately 240,000 cubic yards of dewatered sediments. This will extend the sediment storage lifecycle of both Cedar and Olathe Lakes, improve nutrient removal efficiencies in Cedar Lake and provide for more resilient fisheries, however, this dredging concept would likely
necessitate identification of alternative disposal areas off site from currently owned city property around the lake.

11”x17” exhibits summarizing the conceptual modifications and enhancements are provided in Appendix A.

4.5 Planning Level Cost Estimate

Re-construction of the existing ogee spillway in the same location as it currently lies and raising the embankment 3.1 feet is estimated to cost $1.78 million, which excludes proposed land acquisition cost. Moving the same proposed dam and spillway improvements approximately 1,000 feet downstream of the current dam location will increase the surface area of the lake 21 acres and add $2.26 million to the total rehabilitation costs, which also excludes land acquisitions costs. The cost estimates include clearing and grubbing, construction of the embankment and spillway, construction of the lake drawdown system, decommissioning of the existing dam and spillway, and required permitting.

Wetland mitigation may be required to fill the coves presented in item B and C. Adding the two treatment trains on the main tributaries will reduce the lake area from 65 to 47 acres. The wetland restoration on the treatment trains outlined in items 5 and 6 along with additional wetland enhancements outlined in item 7 may provide self-mitigation for the cove filling impacts.

Planning level cost estimates have been developed in consideration of the presented findings, observations, and recommended improvements. Administration expenses include bidding/contract administration, surveys, engineering, property negotiation, environmental permits and construction observation services for all work proposed on Cedar Lake. All costs are based on 2018 dollars with a 25% contingency added. The costs have been broken into said sub categories of proposed work below.

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A detailed breakdown of the estimated costs is included in Appendix D.
5.0 FRISCO PARK LAKES

5.1 Background
Located one mile southeast of downtown Olathe, Frisco Park lakes were constructed in the late 1880’s and utilized as the City’s first water source and railroad water station for steam engines of the time. Both lakes are approximately 12 acres, surrounded by a total of 15 acres of City property. The City property around the north lake closely borders many residential properties and the south lake is the focal point of a popular City park. The embankment of both lakes is made up entirely from railroad ballast rock. Primary outflows from the lakes cross the railroad embankment via reinforced concrete box culverts. Secondary / emergency spillways do not exist resulting in potential for flooding. The lakes have watershed areas of 159 acres (north) and 260 acres (south).

North Frisco lake has seven (7) inflow points, three (3) are open channel, and four (4) are pipe outfalls. Two utility lines were observed to cross the lake. Although the south bank offers a small platform for fishing, much of the lake shoreline is very close to private properties and two fence lines restrict public access around the north side of the lake.
The drainage area to the lake is 100% developed but observed water quality is better in North Frisco than in South Frisco lake. Given its early history, it is highly probable that groundwater springs exist under North Frisco lake resulting in higher baseflow and improved circulation. Potential locations for on-site disposal of dredge spoils is very limiting.

South Frisco lake has six (6) inflow points of which two (2) are minor open channel drainages and four (4) are pipe outfalls. The upstream drainage area is 100% developed and the headwaters are south of I-35 consist of several large commercial areas. The park adjacent to South Frisco lake is heavily used by the public making it a highly visible place for water quality improvements. There are several perimeter locations that dredge spoils may be considered within the open spaces of the park. The embankment and outlet structure for South Frisco lake are on railroad property, which creates public safety and lake maintenance challenges for the City.

5.2 Assessment Findings

The dam embankments at both North Frisco and South Frisco lakes are in fair condition and ballast rock from the railroad provides adequate cover on the upstream and downstream faces. Several trees were observed that should be cut down. Although there is evidence of beaver activity along the embankment, no beaver or burrows were observed.

Along the north shoreline at North Frisco lake there are two fences encroaching into the lake and City property. Additionally, there are two utility crossings running North-South with cable exposed along the shoreline of the lake in both locations. Two private docks are present in the lake. The permanent pool had evidence of wave erosion in two locations. There is safety fence exhibiting damage around two outfalls along the east shoreline. Invasive honeysuckle bushes are present along the entire northwest corner of the lake. This area is also reported to attract squatter camps due to its remote location. The existing lake outlet is badly deteriorated and in need of replacement. Additionally, there is a log lodged in the outlet box that needs to be removed. There is a trash rack
present (livestock fence) around 50% of the outlet structure; however, it is insufficient and needs replacing. Access to the outlet is difficult due to the rail line being located on the embankment. The culvert connected to the outlet structure was in good, working condition. No spillway is present for North Frisco Lake. If either of the two lakes overtop, overland flow conveys water from one lake to the other. Over 15 homes are below the overtopping flood elevation of North Frisco Lake. Since discharge from the lake is controlled by the open area of the outlet structure, increasing its size to allow the culvert under the railroad to be limiting may reduce flooding around the lake by as much as 1.5 feet for a 1% chance event. There is a potential for ten (10) homes that could benefit from reduced flood elevations at North Frisco Lake.

At South Frisco lake, approximately 1,050 feet of shoreline has evidence of wave erosion with heights between 1-foot and 3-feet. The west and south banks show the most evidence of wave erosion, with the most severe being near the outfall at the southeast corner of the lake. Along the east side of the lake, where there is limestone block shore protection, there are occasional holes in the soil behind the blocks with some blocks falling into the lake. The outlet structure does not have a trash rack and has two sheets of corrugated metal hanging from the top of the structure that may impede the flow and cause debris to build up. One of six outfalls for the lake is in poor condition. There is a slope failure at a pipe outfall near the southwest corner of the lake. The end of a 24-inch pipe is collapsed and is in need of replacement. No spillway is present for South Frisco lake. If either of the two lakes overtops, overland flow conveys water from one lake to the other. There are four (4) homes below the overtopping elevation flood of South Frisco Lake.

5.2.2 Structural
Structural evaluations were not completed at either of the Frisco Lakes; however, a longitudinal crack along the pavement under the gazebo on the east side of South Frisco lake may pose as a tripping hazard and should be repaired. GBA reviewed engineering drawings provided by the City which proposes to retrofit the existing outlet spillway structure. Historical dam safety inspection reports were also reviewed, master plan recommendations noted herein incorporate findings / recommendations provided from these historical dam safety inspection reports.

5.2.3 Surveying
Bathymetric surveys were conducted on both Frisco lakes consisting of four (4) cross sections and a centerline profile. The survey included approximately 5,800 feet of lake bottom and approximately
800 data points. Average depth of North Frisco lake is 4.5 feet with a maximum depth of 7.5 feet. South Frisco lake has only an average depth of 2.2 feet and a maximum depth of 4.8 feet.

5.2.4 Water Quality

At South Frisco Lake there is some undesirable vegetative growth along the shoreline and within the lake, and cattail growth is prolific along the west bank line and in front of the outlet. Algae growth and obvious signs of eutrophication is present in permanent pool points, resulting in a strong odor. Trash was present throughout North Frisco lake (tires, traffic cones, debris, etc.).

Recommended water quality improvements include dredging, construction of sediment forebays at major storm sewer outfalls and construction of fringe wetlands. Some small areas may be suitable for demonstration BMP’s that may provide educational offerings in the form of rain gardens and bioswales. Note: these demonstration-type BMP’s were excluded from cost estimates at the request of City staff.

South Frisco lake is very shallow and substantially filled with sediment; therefore, much of the sediment-laden stormwater runoff today passes through untreated. To improve both sediment and nutrient removal efficiency, dredging should aim to maintain depths over 15 feet, ideally for 25% of the lake volume. Due to the lack of available space to place dredging materials, the scope of dredging was reduced to a 10-foot maximum depth target.

Outlet structures at both lakes should be replaced to provide more robust management tools for water quality management in the renovated lakes. The new outlet structures should include a low flow variable depth outlet, drawdown pipe, trash rack, and increased capacity to reduce flood risks.

Figure 5-4 Algae issues at South Frisco Lake.
5.3 Conceptual Modifications & Enhancements

Proposed improvements are identified on Figures 5-5 and 5-6. A detailed description of the recommendations is provided in the following list with the identifier corresponding to the location of each item on the figures. Many of the findings are consistent with those documented in previous dam safety inspections.

A) Dredge spoils may be placed in City right-of-way between the railroad and residential property along Mahaffie Street near the northwest corner of North Frisco lake. The annotated area may accommodate 1,700 cubic yards of dredge material. The spoils berm could be contoured and then topped with landscaping.

B) Dredge spoils may be placed in the open tract of park property at the southwest corner of North Frisco Lake. This area can accommodate 19,500 cubic yards of dredge with a maximum depth of 12 feet and maximum of 5:1 side slopes. The area could be landscaped and be used for a park vista overlooking the lake.

C) Dredge spoils may be used to fill the southwest corner of South Frisco Lake Park near Dennis Avenue and Keeler Street intersection. This area will accommodate 10,000 cubic yards of dredge with a maximum depth of 11 feet and maximum of 5:1 side slopes. A small storm sewer will need to be installed to drain water that would otherwise become trapped at the western edge of the feature. The area could be landscaped and be used for a park vista overlooking the lake.

D) Approximately 4,600 cubic yards of dredge may be disposed of in linear areas along the park trail on the east side of South Frisco lake. The maximum depth would be 5 feet and the berm could be contoured and landscaped into a buffer feature to provide screening to 10 adjacent residential properties.

E) Embankment safety and maintenance access enhancements include moving the park trail and lake outlet structure off railroad property at South Frisco lake. This concept would accommodate 5,000 cubic yards of dredge spoils. Also included with this enhancement are the following features:

- 600 feet of replacement asphalt park trail, 10 feet wide.
- 300 feet of boardwalk trail, 10 feet wide, crossing the fringe wetland system and new outlet structure.
- Two 50’x50’ boardwalk fishing / observation platforms over the wetland fringe areas.
- Four educational signage/kiosks.
1) Dredge the lakes.
   - North Frisco - The target maximum water depth is 12 feet. Saturated dredge material is estimated to be 63,000 cubic yards, dredge spoils volume is 30,200 cubic yards after deducting 16,500 cubic yards for water and deducting 8,300 cubic yards for suspended sludge in the lake bottom. These volumes include forebays, fringe wetland features described in items 2 and 3 which require approximately 8,300 cubic yards of fill to construct. To reach the recommended maximum depth, approximately 10,000 cubic yards of dredge will need to be disposed of off-site.
   - South Frisco - The target maximum water depth is 10 feet. Saturated dredge material is estimated to be 58,000 cubic yards, dredge spoils volume is 22,600 cubic yards after deducting 14,000 cubic yards for water and deducting 9,300 cubic yards for suspended sludge in the lake bottom. These volumes include embankment fills, forebays and fringe wetland features described in items 2, 3 and 2 which require approximately 12,100 cubic yards of fill to construct. A total of 8,200 cubic yards of dewatered dredge sediments must be disposed of off-site.

2) Construct sediment forebays at four (4) locations. Two forebays are proposed at the major outfalls for each lake. Forebays should be a maximum of 5 feet deep with average depths of 3 feet. Anticipated permanent pool volume of the two smaller forebays are 0.4 acre-feet, the large forebays should be a minimum of 0.7 acre-feet.

3) Construct 4.5 acres of fringe wetland BMPs in seven (7) locations.

4) Construct riprap shoreline protection as noted:
   - North Frisco - Approximately 350-feet along the south bank and 150-feet along the northeast corner of the lake.
   - South Frisco - Approximately 300 feet at the southeast corner of the lake, 100 feet east of 24-inch corrugated metal pipe along the south shore, and a 30-foot section near the 7-foot by 5-foot reinforced concrete box outfall at the southeast corner of the lake. Additional protection surrounding the outlet structure and new embankment fills along the west side of the lake. Limestone block shore protection should be repaired in approximately 15 areas along the east shoreline where some of the blocks have fallen into the lake. The voids behind the blocks should be filled with compacted soil.

5) Enhance BMP’s for localized runoff on two small tributaries at the southeast corner of South Frisco Park. This improvement would add 150 feet of bio-swale and three shallow infiltration/rain garden areas.
6) Maintenance needs to improve public safety where noted in two locations:
   - North Frisco - Repair safety fencing at two culvert outfalls along the east shoreline.
   - South Frisco - Repair longitudinal crack in pavement near gazebo on the east bank.

7) Deficiencies on the outlet structures of both lakes are noted and recommended improvements include:
   - North Frisco - Replace the primary outlet structure, construct 18’x4’x10’ outlet structure to manage water quality of the renovated lake, provide a lake drain, and reduce flooding risk to upstream buildings. Install a trash rack on the new outlet structure.
   - South Frisco - Extend the existing culvert 100 linear feet and replace the primary outlet structure to manage water quality of the renovated lake, provide a lake drain and reduce flooding risk to upstream buildings. Install a trash rack on the new outlet structure.
   - Repair collapsed 24-inch pipe and end section and install riprap at outfall along south shore of South Frisco Lake.

8) Remove trees, woody vegetation and debris:
   - North Frisco - 30 trees over 4-inches in diameter on the upstream face and 100 trees over 4-inches in diameter on the downstream face
   - South Frisco - 20 trees over 4-inches in diameter on the upstream face and 10 trees of greater than 4-inches in diameter on the downstream face.
   - Remove large trash items, debris and log stuck in outlet structure at North Frisco lake.

9) Remove fences encroaching into the lake on the north shoreline in two separate locations at North Frisco lake.

10) The two private docks on the lake should be removed at North Frisco lake.

11) On North Frisco lake, in two separate locations exposed utility crossings running north-south should be buried, relocate, or if possible removed by the utility owner.
Figure 5-5 Proposed improvements at North Frisco Lake.
Figure 5-6 Proposed improvements at South Frisco Lake.
5.4  Recommended Priorities

Immediate considerations should be given to vegetative maintenance of the embankment, private encroachments and utility line crossings. These high priority needs include items 8, 9, 10 and 11. Some repairs do not require immediate attention but should be considered to extend the life of the embankment such as shoreline protection. These are lower priority and include items 4 and 6.

The lake outlets do not meet current standards and should be replaced. Replacing the outlets may offer increased flood protection, park public safety, and water quality enhancements. Many of the water quality improvements could be implemented concurrently with proposed replacement of the outlet structures and trail upgrades including items A, B, C, D, E, 1, 2, 3, and 7.

Dredging from the two lakes will require approximately 20,000 cubic yards of dredge to be hauled off-site. Adequate storage for these materials is available at Lake Olathe. Water quality may be actively managed via development and implementation of a reservoir management plan, and should be completed concurrently with the proposed improvements. BMP’s proposed in item 5 should be considered after dredging of the two lakes.

11”x17” exhibits summarizing the conceptual modifications and enhancements are provided in Appendix A.

5.5  Planning Level Cost Estimate

Planning level cost estimates have been developed in consideration of the presented findings, observations, and recommended improvements. All costs are based on 2018 dollars with a 25% contingency added. The costs have been broken into said sub categories of proposed work below.

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A detailed breakdown of the estimated costs is included in Appendix D.
6.0 WATERWORKS PARK LAKES

6.1 Background

Waterworks park is located one mile southeast of downtown Olathe on East Sheridan Street. The two ponds in the park were constructed in the 1920’s and were historically utilized by the adjacent Water Treatment Plant No 1. The ponds are surrounded by 44 acres of City property. The 1.9-acre north pond was historically used for water storage and then in the 1980’s for backwash and sludge disposal. The 6-acre south pond was created exclusively for storage of water pumped from Lake Olathe. Approximately 2,800 linear feet of Mill Creek flows through Waterworks Park. It enters at the south side of the park, flows along the eastern boundary, and then exits the park at the northwest corner. The south pond discharges to the north pond through a low-level riser and 8-inch pipe. The north pond discharges to Mill Creek through an outlet structure and 12-inch pipe.

A pumping system that is capable of pumping water from Lake Olathe to the south pond is still operational. All connection between the pumping system and water treatment plant is reported to be disconnected. The pumping system serves only for potential recharge to the south pond. Since the City now receives water supply from the Kansas River aquifer, the ponds and area surrounding them is currently a City park.
Mill Creek parallels the dam embankment of both ponds but does not contribute flow to the ponds. The creek is relatively incised as evidence from several historical in-stream weirs that have been undermined within the channel adjacent to the ponds. The creek is founded on limestone with a bed/plane morphology with maximum pool depth 2.5 feet.

Currently the Waterworks ponds function only as a recreational facility. Floodplain mapping indicates that all flood events more frequent than a 0.2% chance event, or 500-year frequency, do not include the ponds. To be utilized for regional stormwater functions including potential flood mitigation both adjacent to and upstream of the facility, stormwater flows from Mill Creek should be routed through the ponds.

6.2 Assessment Findings

Embankment, spillway, and outlet works observations were completed on the ponds at Waterworks Park. The north pond embankment has evidence of internal wave erosion and external stream bank erosion from Mill Creek. Wave erosion at both ponds was observed approximately 1-foot above the water surface elevation for approximately 1200-feet of the shoreline concentrated in four locations. Another 20-foot long section had a significant slide.

Streambank erosion from Mill Creek threatens many areas of both pond embankments. The western streambank of Mill Creek is also the downstream embankment of the Waterworks ponds. Dense trees are located through this embankment/streambank corridor. Both ponds have inadequate scour protection with very steep slopes down to Mill Creek. Soil is exposed throughout the downstream toe of the embankment, making it susceptible to stream scour. Pond spillways do not have erosion protection; however, the limited drainage area to the ponds likely make the spillways nonfunctioning except when Mill Creek overtops and floods the ponds (backward flow).
Animal burrows were observed along the shoreline of the both ponds and muskrat was observed at the south pond. Evidence of beaver activity was observed in Mill Creek immediately south of the ponds. Settlement was observed along the dam embankment of both ponds with 1 to 2 feet of settlement observed along the downstream face of the embankment in three (3) locations. It was noted that the water surface elevation of the south pond is higher than the low opening elevation of homes along Curtis Street. A review of flood maps shows seven (7) structures in the floodplain. The discharge system for the south pond includes a 24-inch riser with a grate top, it was clear of debris and appeared to be in operating condition. Although there is not a trash rack present on the outlet structure, there is inadequate inflow to the pond to necessitate a trash rack. A 3-inch pipe was observed discharging into the creek west of the north pond. Evidence of iron and floatable debris were apparent and the City should investigate the source.

6.2.1 Structural
The valve box at the north pond and pump house intake structure at the south pond were observed for visible defects. Both were found to be in good working order, no work is recommended. Refer to Appendix B for a detailed description of structural inspection findings and photographs.

6.2.2 Surveying
Bathymetric surveys were conducted on the two ponds at Waterworks Park. Three (3) cross-sections and a centerline profile were completed on each of the two ponds. The survey also included a 700 linear foot profile of Mill Creek. A total of 700 data points was collected at the park. The north pond was found to have an average depth of 4.1 and a maximum depth of 10.5 feet. The south pond was found to have an average depth of 5.8 feet and maximum depth of 6.4 feet.

6.2.3 Water Quality
Because of the historical use of the Waterworks ponds, both are elevated above adjacent drainage features. This results in very little runoff to the ponds leading to only small amounts of sedimentation and nutrient loading currently. Besides sheet flow from the local park, there is one inflow pump from Lake Olathe at the south pond. The pump is used to improve circulation and maintain fisheries in Waterworks ponds. This has led to over pumping and a violation of the recreational water rights for Lake Olathe in the past. For the Waterworks ponds to function as part of a water quality and/or flood reduction regime they should be connected to area drainage ways to provide filtration and flood storage. Without headwater BMP’s on upper Mill Creek watershed or additional inflows from Frisco Lakes, connection to Mill Creek drainage may result in diminished water quality in the ponds.
compared to existing conditions, however lake pollutant trapping would increase water quality of Mill Creek downstream of the Waterworks ponds.

6.3 Conceptual Modifications & Enhancements

A concept plan integrating stormwater treatment, system renewal, flood reduction, increased dam safety, park enhancements and neighborhood connectivity is proposed at Waterworks park. The plan would raise the water elevation of the north pond 1.5 feet and modify the south pond into a sediment forebay and wetland treatment train.

To demonstrate the effectiveness of proposed water quality improvements at Waterworks Park, a water quality model was developed for Mill Creek. The results suggest that the regional treatment trains at Waterworks Park would reduce total suspended solids approximately 80% and total phosphorous 30% to 50% entering Mill Creek. A 58% reduction of total phosphorous was estimated when water quality data is normalized to KDHE’s TMDL which is efficient enough to exceed TMDL loading requirements, creating a potential to remove Waterworks ponds from the TDML list. Refer to Appendix C for details of the water quality evaluation.

Proposed improvements will create a 17-acre stormwater treatment facility and are identified on Figure 6-4. A detailed description of the recommendations is provided in the following list with the identifier corresponding to the location of each item on the figures.

A) Dredge spoils may be used to fill over the historic sludge disposal site off Keeler Street on the east side of the park. The annotated area may accommodate over 35,000 cubic yards of dredge with an average depth of 8 feet. It should be contoured, topped with landscaping, and incorporated into a park feature or potential vista.

B) Dredge spoils may be placed on the north side of the water treatment plant property between the access road and north property line. The annotated area may accommodate up to 3,400 cubic yards of dredge material with an average fill depth of 3 feet. The spoils berm could be contoured and topped with landscaping.

C) Dredge spoils should be used at the southwest corner of the park to prevent Mill Creek flood overflows from reaching Curtis Street. This fill area is estimated to accommodate 3,000 cubic yards of dredge with an average depth of 2 feet. A flood overflow swale should be constructed concurrently with this fill along the northwest corner of the park to provide for flood risk reduction to seven (7) buildings.
1) Remove existing dam embankment, spillway, and outlet works box. Creating the proposed pond involves 74,000 cubic yards of excavation. The overburden should be removed down to the Stanton Formation, which coincides with the bottom of Mill Creek. Saturated dredge material included in the total is estimated to be 4,000 cubic yards. Target maximum water depth is 12 feet in the new pond, average water depth is 6 feet, and pond surface area is 10.5 acres.

2) Construct replacement dam embankment and spillway to manage all stormwater runoff upstream of the site. The new embankment is 1,000 feet long with a top elevation of 1027 and the proposed spillway is 200 feet wide at elevation 1025.

3) Construct 8’x8’x15’ low level discharge outlet to manage water quality of future lake and provide a lake drain. Install two sluice gate valves and 150 linear feet of associated 36-inch pipe with anti-seep collars through the embankment.

4) Construct sediment forebay and wetland treatment train. Fill volumes in this area is approximately 30,000 cubic yards to build the berms and marsh fringe.
   - Forebay - Maximum depth is 6 feet, average depth is 5 feet, and anticipated permanent pool volume is 8.6 acre-feet.
   - Wetland - 3.5 acres, maximum depth is 4.5, average depth is 1.7 feet, and anticipated permanent pool volume is 4 acre-feet.

5) Retrofit existing low-level discharge structure to manage water level of wetlands.

6) Construct approximately 850 linear feet or 2,000 cubic yards of heavy stone riprap diversion of Mill Creek and weir separating forebay and wetlands.

7) Construct 600 cubic yards of heavy stone riprap for low level outlet energy dissipater.

8) Install sediment trap BMP’s, construct berm to elevation 1027, and install standpipe to induce sedimentation and slow peak discharges.

9) Raise sanitary sewer manhole top in five (5) locations to limit infiltration from new dam backwater.

10) Property acquisitions are recommended on four (4) tracts to accommodate grading for new pond, sediment trap BMP, and park trail improvements that will provide park connectivity for neighboring properties. Total land area is 0.64 acres.

11) Construct 5,800 linear foot, 6-foot-wide perimeter asphalt trail with two pedestrian bridges.

12) Construct 470 square foot boardwalk, 4,000 square feet of observation platforms, and educational kiosks within wetland cell.
Figure 6-4 Proposed improvements at Waterworks Park.
If replacement of the dam structures is not planned before 2023 then the City should consider the following maintenance recommendations to extend the life of the facilities, mitigate damage observed, and reduce the risk of deterioration to the existing dam embankments. Many of the 2018 findings are consistent with those documented in the previously completed dam safety inspections in 1979 and 1992. The historical inspections completed by Kansas Department of Agriculture suggested that the dams are hydrologically inadequate and high hazard.

13) Woody vegetation removal is needed along large portions of the dam embankments.
   - Approximately 20 trees of greater than 4-inches in diameter are recommended to be cut down and hauled off along the north pond embankment.
   - Approximately 40 trees of greater than 4-inches in diameter along the Mill Creek side of the south pond embankment are recommended to be cut down and hauled off.
   - Two trees and four stumps along the south pond shoreline should be removed.
14) Trap and relocate burrowing animal. Place compacted backfill in holes where noted:
   - Three (3) animal burrows were observed along the shoreline of the north pond near an overhanging tree.
   - Four (4) rodent holes were present on the downstream face of the south embankment.
15) Erosion protection is needed to protect the embankments from stream bank scour at the toe of Mill Creek in several locations.
   - North embankment - Approximately 480 linear feet of Mill Creek that is adjacent to the north pond embankment where 8 to 12-foot vertical slopes should be graded and stabilized with riprap.
   - South embankment - There is 400 linear feet of the south pond embankment with steep slopes and exposed soils that should be protected from stream bank erosion. Additionally, a 20-foot long slide was observed on the streambank of Mill Creek.
16) Shoreline protection is recommended to protect the embankments from wave action in several locations. Riprap protection should extend 2 feet above water surface.
   - North pond - Approximately 700 linear feet of riprap is recommended at north pond at two locations.
   - South pond - Approximately 500 linear feet of riprap is recommended at south pond embankment at three locations.
Figure 6-5 Interim maintenance needs at Waterworks pond embankment.
6.4 Recommended Priorities

If replacement of the dam structures is not planned before 2023 then the City should consider intermediate maintenance recommendations to extend the life of the facilities, mitigate damage, and reduce the risk of deterioration to the existing dam embankments. These needs include tree removal and rodent controls noted in items 13 and 14. If the proposed water quality improvements are planned and scheduled, then items 14 and 15 could be deferred. These items are consolidated into short-term embankment management costs.

Many of the water quality improvements could be implemented concurrently with the proposed park improvements noted in items 11 and 12. Because the pond embankments at Waterworks encroach into Mill Creek, a better solution would be reconstruction of the water features to provide water quality and flood mitigation which is the focus of the remaining items. The proposed concept would potentially reduce flooding at a minimum of seven (7) properties near Waterworks park. Due to storage of water in the proposed pond, additional flood reduction benefits may exist on Mill Creek downstream of the park. The extent of flood reduction and water quality benefits downstream of Waterworks park on Mill Creek are beyond the scope of this study; therefore, an analysis should be completed as part of a Preliminary Engineering Study that is typically required to qualify for SMP funding.

11”x17” exhibits summarizing the conceptual modifications and enhancements are provided in Appendix A.

6.5 Planning Level Cost Estimate

Planning level cost estimates have been developed in consideration of the presented findings, observations, and recommended improvements. All costs are based on 2018 dollars with a 25% contingency added. The costs have been broken into said sub categories of proposed work noted below.

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A detailed breakdown of the estimated costs is included in Appendix D.
7.0 OVERALL CONCLUSIONS

7.1 Recommended Improvement Priorities
The master planning recommendations are prioritized based on those most qualified for future Johnson County Stormwater Management Program (SMP) funding. Thus, recommended priorities defined by the study findings are based on lake and dam asset management, maintenance need, flooding risk, and water quality which form the basis of the City’s targeted funding source. The recommended priorities do not consider the City wide capital improvements program schedule which may also factor in synergies with phased park improvements and addressing social needs, which are not factors of the targeted funding source. City staff indicates that adding these elements would likely result in the following priority: 1) Lake Olathe, 2) Cedar Lake, 3) South Frisco Lake, 4) Waterworks Park and lastly 5) North Frisco Lake.

Recommended improvement priorities have been divided into three groups - 1) immediate needs, 2) short-term maintenance, and 3) major lake improvements. Immediate needs include vegetation removal, nuisance animal control and repair of embankment voids. Short-term maintenance includes shoreline protection, structural repairs, removal of encroachments and safety fencing repairs, these items may be considered system renewal. Major lake improvements are proposed for all the lakes and generally includes features for water quality enhancement, localized flood reduction, lake dredging, and systems management. Some major lake improvement concepts offer park safety or trail connectivity enhancements which may include new trails, pedestrian bridges, boardwalks, and educational kiosks. Based on the study findings and merits of the City’s targeted funding sources, the suggested prioritization of major lake improvements is offered below:

1) **Waterworks Park.** The proposed improvements would create a new 17-acre stormwater treatment facility. A new dam, spillway, and outlet works would be constructed. The design concept utilizes a watershed-based approach by routing Mill Creek through water quality features at the south end of the park. These stormwater treatment trains are estimated to reduce TMDL loading below KDHE goals. By acquiring 0.64-acre of land, a loop park trail would provide neighborhood connectivity and educational opportunities for properties that are currently isolated from Waterworks Park. Because areas around the park have recently been the focus of the City for infrastructure renewal, alternative funding sources may also apply.
2) **South Frisco Lake.** The proposed improvements focus on sediment dredging, extension of the outlet structure off railroad property, and water quality filtering at major inflow locations on the lake. The dam embankment is partially on railroad right-of-way creating ownership and maintenance challenges. Moving the outlet structure and trail so it is no longer located on railroad right-of-way will improve access and provide safety. Replacing the outlet structure could offer flood risk reduction to several properties near the lake. The replacement trail concept includes boardwalks, observation/fishing platforms, and educational kiosks. The recommended concept also includes enhancement of small-scale BMP’s on tributary channels within the park. South Frisco Park appears to be a frequently visited park so major improvements will be highly visible and appreciated by the public.

3) **Cedar Lake.** Built in 1938, this is the oldest lake studied in this master plan and is beyond its design life. Approximately 50% of the drainage area to Cedar Lake is not currently developed, so future development may negatively impact the volume of runoff and the water quality entering the lake. Cedar Lake improvements include construction of a new dam, spillway and outlet works approximately 1,000 feet downstream of the current dam. The recommended concept includes localized sediment dredging, and water quality features both on two major arms and small tributary drainages of the lake. Several properties around the lake have been proposed for acquisition which is consistent with the City Park Master Plan for Cedar Lake.

4) **North Frisco Lake.** The proposed improvements include sediment dredging, replacement of the outlet works, and constructing water quality features at two of the major tributaries entering the lake. Replacing the outlet works offers the opportunity to reduce flood risk to over 15 properties surrounding the lake. Water quality improvements for North Frisco Lake focus on retrofitting BMPs on local storm sewer networks prior to discharging into the lake.

5) **Lake Olathe.** The proposed improvements include enhancing water quality features in the two major arms of the lake, adding BMP’s to tributary and sheet flow drainages, and providing pedestrian connectivity along the south side of the lake. The contributing watershed surrounding Lake Olathe has not fully developed and regional BMP’s are being incorporated into new development areas. Existing water quality within the lake appears to be highly functional. To provide the most efficient use of public funding, Lake Olathe water quality improvements is recommended to be completed after improvements at Cedar Lake.
Reservoir operation plans should be developed for all lakes to manage lake outfalls for enhanced nutrient removal efficiencies and to maintain long-term sediment storage functions. The operation plan should be simple, straightforward, and passive (no pumping required).

### 7.2 Planning Level Cost Estimate

Costs associated with the recommended improvements are divided into the three groups previously presented. The immediate needs are estimated to be $151,000 and short-term dam safety and renewal repairs are estimated to cost $514,000. The major lake improvement costs related to reconstruction of aging dams, sediment dredging, water quality features, and flood reduction enhancements are estimated to be $17,881,000.

The major improvement concepts incorporate an additional $1,900,000 for park trial, pedestrian safety and educational components that could be constructed concurrently with the dam and water quality improvements. These features include trail replacement and boardwalk features at Waterworks Park, partial trail replacement and new boardwalk enhancements at South Frisco Lake, and Dennis Avenue connectivity and pedestrian safety features at Lake Olathe. All lake master planning recommendations and cost estimates are summarized in Table 7-1 below.

<table>
<thead>
<tr>
<th>Lake</th>
<th>Immediate Needs</th>
<th>Short-Term Maintenance</th>
<th>Major Improvements Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lake Improvements</td>
<td>Park Improvements</td>
</tr>
<tr>
<td>Cedar Lake</td>
<td>$77,000</td>
<td>$ N/A *</td>
<td>$9,823,000</td>
<td>$ --</td>
</tr>
<tr>
<td>Lake Olathe</td>
<td>$13,000</td>
<td>$400,000</td>
<td>$2,039,000</td>
<td>$500,000</td>
</tr>
<tr>
<td>North Frisco Lake</td>
<td>$26,000</td>
<td>$57,000</td>
<td>$1,327,000</td>
<td>$ --</td>
</tr>
<tr>
<td>South Frisco Lake</td>
<td>$13,000</td>
<td>$57,000</td>
<td>$1,649,000</td>
<td>$535,000</td>
</tr>
<tr>
<td>Waterworks Park</td>
<td>$22,000</td>
<td>$ N/A *</td>
<td>$3,043,000</td>
<td>$865,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$151,000</strong></td>
<td><strong>$514,000</strong></td>
<td><strong>$17,881,000</strong></td>
<td><strong>$1,900,000</strong></td>
</tr>
</tbody>
</table>

Table 7-1 Cost summary for all lake and dam master plan recommendations.

Many of the maintenance tasks may be performed by City staff including vegetation removal, nuisance animal control, repair of embankment voids, removal of miscellaneous encroachments, and safety fencing. Construction costs for short-term maintenance and major improvements include contractor mobilization, clearing and grubbing, demolition of existing structures, proprietary BMP’s,
concrete repairs, outlet works improvements, shoreline protection, mechanical dredging, mass grading, temporary erosion control, and native vegetation establishment in proposed wetland BMP’s.

Due to the saturated nature of materials dredged from the pond/lake bottoms, handling and storage of the dredge is an important cost consideration. All dredging computations assume in suspension sediments 1 to 2 feet deep over the entire underwater surface area of improvement below the surveyed elevation, which reduces the anticipated dredge volume. Dredge materials are likely to have very high moisture levels which will also reduce the ultimate volume of spoils storage needed to place dredge materials by 30 percent. Thus, volumes used for cost estimates are based on dredge spoils volume that is placed after deducting sludge and after deducting 30 percent for water. All dredging costs assume that City staff will manage, monitor, and maintain pumping or outworks operations as necessary for dewatering of the proposed dredge areas by a contractor.

Table 7-2 includes a breakdown of administration expense estimates for surveys, engineering, environmental permits and construction observation services that are typically used for City budgeting. All costs are based on 2018 dollars with a 25% contingency added.

<table>
<thead>
<tr>
<th>Lake</th>
<th>Design Phase Services</th>
<th>Construction Phase Services</th>
<th>Contingency (~25%)</th>
<th>Total Major Improvements Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar Lake</td>
<td>$450,000</td>
<td>$225,000</td>
<td>$1,118,000</td>
<td>$9,823,000</td>
</tr>
<tr>
<td>Lake Olathe</td>
<td>$145,000</td>
<td>$40,000</td>
<td>$590,000</td>
<td>$2,539,000</td>
</tr>
<tr>
<td>North Frisco Lake</td>
<td>$58,000</td>
<td>$15,000</td>
<td>$298,000</td>
<td>$1,327,000</td>
</tr>
<tr>
<td>South Frisco Lake</td>
<td>$82,000</td>
<td>$20,000</td>
<td>$499,000</td>
<td>$2,184,000</td>
</tr>
<tr>
<td>Waterworks Park</td>
<td>$300,000</td>
<td>$100,000</td>
<td>$783,000</td>
<td>$3,908,000</td>
</tr>
<tr>
<td>Total</td>
<td>$1,034,000</td>
<td>$400,000</td>
<td>$3,288,000</td>
<td>$19,781,000</td>
</tr>
</tbody>
</table>

* Short -term maintenance improvements are recommended on Cedar Lake and Waterworks Park, if major improvements are not planned prior to 2023. Cost of interim maintenance items are not included in the tables above per City request.

**Table 7-2 Breakdown of cost for major improvements in the lake and dam master plan.**
Maintenance considerations are needed for many of the water quality features to provide intended functions. Cost estimates exclude short-term and long-term maintenance costs associated with the lakes and proposed BMPs for vegetative management such as weeding, dethatching, harvesting, plant replacement, and aeration; monitoring of water quality, weirs and control structures; erosion repairs; and sediment removal. If not routinely completed, the water quality features will progressively lose effectiveness and ultimately encourage more pollutant loading within the water bodies. Table 7-3 gives a suggested maintenance schedule and description for BMP’s proposed in this master plan that is based upon the Mid-America Regional Council (MARC) BMP Manual. Cost estimates to perform the recommended maintenance items is not included in the cost estimates per request of City staff.

<table>
<thead>
<tr>
<th>Maintenance Item</th>
<th>Schedule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term - Treatment Train Establishment</td>
<td>Every 6 months for 5 years</td>
<td>Weeding, plant replacement, debris removal, monitoring</td>
</tr>
<tr>
<td>Short term - Treatment Train Maintenance</td>
<td>Annually</td>
<td>Weir monitoring, invasive species management / plant composition corrections, erosion repairs, harvesting</td>
</tr>
<tr>
<td>Long term - Treatment Train Maintenance</td>
<td>Every 5 Years</td>
<td>Plant composition correction, sediment / debris removal. weir maintenance, animal damage, depth surveys</td>
</tr>
<tr>
<td>Short term - Tributary sediment BMP</td>
<td>Every 3 Months</td>
<td>Clean out sediments, monitor outfall, erosion repairs</td>
</tr>
<tr>
<td>Long Term - Tributary sediment BMP</td>
<td>Every 3 Years</td>
<td>Outfall monitoring / maintenance, aeration, mowing / dethatching</td>
</tr>
<tr>
<td>Short term - Lake Structures</td>
<td>Annually</td>
<td>Embankment monitoring and maintenance repairs</td>
</tr>
<tr>
<td>Long term - Lake Structures</td>
<td>Every 5 Year</td>
<td>Reservoir management operations / monitoring / documentation/ reporting / structural repairs due to weathering, depth surveys</td>
</tr>
</tbody>
</table>

Table 7-3 Maintenance recommendations for BMP’s in the lake and dam master plan.

7.3 Funding Sources

GBA reviewed the City’s published capital improvement plan (CIP) for 2018-2022. The Lake and Dam Restoration project (#2-C-002-XX) is scheduled to start in 2020 and has a total budget of $3,500,000. As published, the projects are expected to be funded 75% by the Johnson County SMP fund and 25% by City bonds/stormwater funds. Construction of a lake/dam project is scheduled every 2 years. Since the recommendations of this master planning document far exceed the current budget allocation, it is likely that many of the improvements will need to be scheduled beyond 2022.
unless additional funding sources are sought. CIP project phasing will be adjusted as needed based upon Watershed Plan priorities and funding availability, both defined by Johnson County SMP.

The targeted funding source for the lake and dam improvement projects is Johnson County SMP funding. SMP funding has historically been cost-share and merit-based with a focus primarily on public safety as related to flooding. The SMP is being revised to include other stormwater elements in the merit-based funding criteria. Projects most likely to be funded by the program should touch on subjects that are key to the future program funding, including:

1. Watershed-based Approach - All previously completed watershed master plans for both Cedar Creek and Mill Creek recognize the need for the improvements proposed in this document as part of a watershed-based improvement approach.
2. Flood Damage Reduction - Some of the improvement recommendations in Mill Creek watershed have the potential for reducing flood risk of adjacent properties.
3. System Management - Some of the dam structure, embankment, and water quality recommendations could be considered system renewal.
4. Water Quality - These include reduced Non-Point Source pollution strategies, reducing in-stream loading of sediment through use of forebays, wetland and reservoir sinks, support of the National Pollutant Discharge Elimination System (NPDES) permit requirements by attempting to comply with lake TMDL, and improved habitat by creation of diverse wetland topography. Some reference studies have found wetland to provide $10,000 per acre in ecosystem services to a community. These values are based on floodplain retention, nutrient filtering, sediment sequestration, public enjoyment, and habitat preservation.
5. Other - Preliminary prioritization matrixes provided by SMP also include points for public education, alternative funding sources, public acceptance and permitting complexity.

Eligible in-kind City contributions should be leveraged for SMP applications. These services could provide a way for the City to offset financing costs of the projects. To provide the maximum leverage, the in-kind contributions should be accounted for using the full cost as if these items were bid out to a contractor. These items may include, but not limited to:

1. Lake dewatering services for all lakes, including providing the pumps, maintaining the pumps, and coordinating with the dredging contractor as required for dredging operations.
2. Bio swale and rain garden BMP’s at the southeast corner of South Frisco Lake.
3. Retrofitting of existing storm sewer systems to provide sediment trap BMP’s upstream of storm sewer outfalls at North Frisco, South Frisco, Lake Olathe, and Cedar Lake.
4. Burrowing animal control and embankment repairs noted on most of the structures.
APPENDIX A

11"x17" Conceptual Modification and Enhancement Exhibits

11"x17" Dredge Spoils and Quantities
Recommended Improvement Categories

- Immediate Needs
- Short-Term Maintenance
- Major Lake & Park Improvements

A) With KDHE approval and modification of the Environmental Use Control (EUC) document, dredge spoils may be placed atop the historical battery waste disposal site, which will accommodate up to 58,000 cubic yards with an average of 4.7 feet deep.

B) Potential transportation, pedestrian safety and park connectivity improvements. Creation of a 20-foot wide bench, adjacent to the roadway and 3 feet above lake water surface requiring 4,100 cubic yards fill, 60-foot culvert extension, 1,500 cubic yards of riprap shoreline protection, 21,000 square feet concrete sidewalk along Dennis Avenue and 8,000 square feet of paved parking between Wickford Road and Palmer Drive.

1) 10 acre-feet forebay. Maximum depth is 9 feet and average depth is 4.5 feet. Dredging the forebay is not necessary, see item 3.

2) 12 acres wetland enhancements. Dredge 8,000 cubic yards (saturated volume) to create aquatic features, place an additional 10,000 cubic yards of fill for reshaping wetland features.

3) 1,900 cubic yards of heavy stone riprap for forebay / wetland treatment train weirs.

4) Sediment trap BMP. Install standpipes to induce sedimentation and slow peak discharges from minor tributary areas.

5) BMP enhancement. Retrofit existing outlet structures to improve sediment removal, enhance 2.3 acres of fringe wetland.

6) 2,550 linear foot native grass filter strip, wet swale and berm. Berms are 2 feet high and 20 feet wide, filter strips/swales are 45 feet wide.

7) 500 cubic yard berm for flood protection of two homes. Berm is 5 feet high, includes inlet, pipe and flap gate.
8) Remove trees and woody vegetation.
   * 10 trees less than 4-inches in diameter and all trees a minimum of 5-feet away from the wall along the base embankment retaining wall.
   * 5 trees less than 4-inches in diameter on the downstream face of the spillway.
   * 5 trees greater than 4-inches in diameter downstream of primary spillway chute.
   * Trees within 20 feet of both primary spillway chute retaining walls.

9) 500 cubic yards of heavy riprap immediately downstream of the spillway chute.

10) Trap and relocate burrowing animal. Place compacted backfill in holes at 4 locations.

11) Install fencing to improve public safety at two (2) locations:
   * Gate at south end of the embankment.
   * 135 linear feet of 6’ fence to limit public access to spillway chute.

12) Structural wall repairs include:
   * Embankment Retaining Wall - Reset or replace cap stone blocks on top of retaining wall.
   * Spillway Walls - Replace or reinforce the north wingwall on the downstream end of the spillway chute.
   * Patch isolated areas of spalled and delaminated concrete on the north walls of the primary spillway, mostly along the control joints of the wall. Patch isolated areas of spalled and delaminated concrete atop of the south stilling basin wall. Clean and repair cracks in the south retaining wall and patch the adjacent top of wall at the bottom of the south side earth embankment wall.

13) Concrete slab repairs include:
   * Emergency spillway - Replace 380 square feet of the spillway slab at the base of the spillway. Replace 135 square feet of the top spillway slab. Patch an isolated area of spalled concrete at the top of the spillway side wall, also clean and repair 12 cracks in the wall. Remove vegetation and fill sawcut control joints in the spillway slab with sealant to help minimize freeze-thaw damage to the concrete.
   * Primary Spillway and Chute - Patch isolated areas of spalled and delaminated concrete in the base slab. These areas are primarily along the center joint. Replace sealant in wall joints. Investigate and possibly replace the previous patch area on the east ogee weir.

14) Remove vegetation from spillway pressure drains and backfill with gravel.

15) Exercise valves in outlet works tower. Repair concrete slab at the top of the tower, patch the isolated area of spalled and delaminated concrete around the valve stem after further assessment from the underside of the top slab. Clean and repair cracks in the slab. Patch spalled and delaminated concrete at the perimeter guardrail post connections at the corners of the box.

M) Monitor area for saturation and heave.
### Recommended Improvement Categories

- **Immediate Needs**
- **Short-Term Maintenance**
- **Major Lake & Park Improvements**

**Potential property acquisitions are represented from various park masterplans and previous lake assessment studies. The total land area is 90.3 acres.**

1. New dam embankment and spillway 72,000 cubic yards fill.
2. Construct 8’x8’x40’ low level water intake tower to manage water quality of future lake and provide a lake drain. Install three sluice gate valves and 120 linear feet of associated 12-inch DIP elbows, pipes, tees and anti-seep collars.
3. Remove existing dam embankment, spillway and outlet works tower. Excavation volume of the embankment is approximately 35,000 cubic yards.
4. Dredge the main channel of the lake, target maximum water depth is 21 feet, average water depth through the excavated channel is 10 feet. Saturated dredged material is estimated to be 153,000 cubic yards.
5. Cedar Creek forebay and wetland treatment train. Dredge 20,500 cubic yards (saturated). Fill for the berms and marsh fringe is 9,300 cubic yards compacted.
   - 18.5 Acre-Feet Forebay - Maximum depth is 8 feet, average depth is 4.8 feet.
   - 6.9 Acre-Feet Wetland - Maximum depth is 5.5, average depth is 1.3 feet.
6. South tributary forebay and wetland treatment train. Dredge 13,000 cubic yards (saturated). Fill for the berms and marsh fringe is 6,700 cubic yards compacted.
   - 11.9 Acre-Feet Forebay - Maximum depth is 8 feet, average depth is 4.4 feet.
   - 3.6 Acre-Feet Wetland - Maximum depth is 5.5, average depth is 1.2 feet.
7. 3.4 acres wetland enhancement. Net fill in the center cove is 10,000 cubic yards.
8. 6,000 cubic yards of riprap revetments to maintain wetland residence time and prevent short circuiting.
9. 2,000 cubic yards of heavy stone riprap weirs separating forebay, wetlands and the main lake.
10. BMP’s for localized runoff.
   - Retrofit existing inlet structure with sediment trap BMP device.
   - Construct a standpipe to induce sedimentation and slow peak discharges on the upstream side of the existing cross road pipe in two locations.
   - Native grass wet swale / infiltration basin. 1,200 feet long, 40 feet wide.
Recommended Improvement Categories

- **Immediate Needs**
- **Short-Term Maintenance**
- **Major Lake & Park Improvements**

1) Remove trees and woody vegetation.  
2) Raise north end of the embankment 1 to 3 feet lower to match dam crest elevation for 100 feet.  
3) Evidence of soil heave is present throughout the downstream face of the embankment for approximately 300 feet. It is recommended that brushy vegetation along the downstream embankment be cut low to provide a more detailed examination of potential damage and restoration needs from soil heave and rodent burrows. The area should be repaired and reseeded.  
4) Trap and relocate burrowing animal. Place compacted backfill in holes at least 5 locations.  
5) 150-linear foot berm and filter strip BMP.  
6) Clean out and repair cracks in the top slab surface of the outlet works box. The secondary drawdown valve is lodged open. It is reported that a log is preventing the valve from closing. The log should be removed, and the valve be tested for operation.  
7) Structural deficiencies have been reported throughout spillway. Repair cracks in the downstream weir apron and any cracks that are observed in the upstream apron after dewatering the lake. Clear vegetation from joints in the west sloped apron, repair any cracks identified thereafter.
A) Dredge spoils may accommodate 1,700 cubic yards of dredge material.

B) Dredge spoils may accommodate 19,500 cubic yards with a maximum depth of 12 feet and maximum of 5:1 side slopes.

1) Dredge the lake - 63,000 cubic yards of dredge (saturated), maximum water depth is 12 feet. Volume include forebays, fringe wetland features described in items 2 and 3 which require approximately 8,300 cubic yards of fill to construct.

2) Sediment forebays. Forebays should be a maximum of 5 feet deep with average depths of 3 feet. Permanent pool volumes should be a minimum of 0.7 acre-feet.

3) Fringe wetland.

4) Riprap shoreline protection - 350-feet along the south bank and 150-feet along the northeast corner of the lake.

6) Maintenance needs to improve public safety - Repair safety fencing at two culvert outfalls.

7) Outlet structure improvements - Construct 18'x4'x10' outlet structure to manage water quality of the renovated lake, provide a lake drain, and reduce flooding risk to upstream buildings. Install a trash rack on the new outlet structure.

8) Remove trees, woody vegetation and debris - 30 trees over 4-inches in diameter on the upstream face and 100 trees over 4-inches in diameter on the downstream face.

9) Remove fences encroaching into the lake on the north shoreline in two separate locations.

10) The two private docks on the lake should be removed.

11) On North Frisco lake, in two separate locations exposed utility crossings running north-south should be buried, relocated, or if possible removed by the utility owner.
C) Dredge spoils may accommodate 10,000 cubic yards with a maximum depth of 11 feet and maximum of 5:1 side slopes.

D) Dredge spoils may accommodate 4,600 cubic yards in linear areas along the park trail, maximum depth would be 5 feet.

E) Embankment safety and maintenance access enhancements may accommodate 5,000 cubic yards of dredge spoils. Also included with this enhancement are the following features:
   * 600 feet of replacement asphalt park trail, 10 feet wide.
   * 300 feet of boardwalk trail, 10 feet wide.
   * Two 50’x50’ boardwalk fishing/observation platforms.
   * Four educational signage/kiosks.

1) Dredge the lake – 58,000 cubic yards of dredge (saturated), maximum water depth is 10 feet. Volume include embankment fills, forebays and fringe wetland features described in items E, 2 and 3 which require approximately 12,100 cubic yards of fill to construct.

2) Sediment forebays. Forebays should be a maximum of 5 feet deep with average depths of 3 feet. Permanent pool volume is 0.4 acre-feet.

3) Fringe wetland.

4) Riprap shoreline protection - 300 feet at the southeast corner of the lake, 100 feet east of 24-inch corrugated metal pipe along the south shore, and a 30-foot section near the 7-foot by 5-foot reinforced concrete box outfall at the southeast corner of the lake.
   * Limestone block shore protection should be repaired in approximately 15 areas along the east shoreline where some of the blocks have fallen into the lake. The voids behind the blocks should be filled with compacted soil.

5) Enhance BMP’s for localized runoff on two small tributaries at the southeast corner of South Frisco Park. This improvement would add 150 feet of bio-swale and three shallow infiltration/rain garden areas.

6) Maintenance needs to improve public safety - Repair longitudinal crack in pavement near gazebo.

7) Outlet structure improvements - Extend the existing culvert 100 linear feet and replace the primary outlet structure to manage water quality of the renovated lake, provide a lake drain and reduce flooding risk to upstream buildings. Install a trash rack on the new outlet structure.
   * Repair collapsed 24-inch pipe and end section and install riprap at outfall.

8) Remove trees, woody vegetation and debris - 20 trees over 4-inches in diameter on the upstream face and 10 trees of greater than 4-inches in diameter on the downstream face.
A) Dredge spoils to fill over the historic sludge disposal site may accommodate over 35,000 cubic yards with an average depth of 8 feet.

B) Dredge spoils may accommodate up to 3,400 cubic yards with an average fill depth of 3 feet.

C) Dredge spoils to prevent Mill Creek flood overflows from reaching Curtis Street is estimated to accommodate 3,000 cubic yards with an average depth of 2 feet. A flood overflow swale should be constructed concurrently with this fill along the northwest corner of the park to provide for flood risk reduction to seven (7) buildings.

1) Remove existing dam embankment, spillway, and outlet works box. 74,000 cubic yards of excavation, maximum water depth is 12 feet, average water depth is 6 feet, 10.5 acres.

2) Replacement dam embankment and spillway. New embankment is 1,000 feet long with a top elevation of 1027 and the proposed spillway is 200 feet wide at elevation 1025.

3) Construct 8’x8’x15’ low level discharge outlet and lake drain. Install two sluice gate valves and 150 linear feet of associated 36-inch pipe with anti-seep collars.

4) Construct stormwater treatment train. Fill volume is 30,000 cubic yards.
   * 8.6 Acre-Feet Forebay - Maximum depth is 6 feet, average depth is 5 feet.
   * 4.0 Acre-Feet Wetland - Maximum depth is 4.5, average depth is 1.7 feet.

5) Retrofit existing low-level discharge structure to manage water level of wetlands.

6) 2,000 cubic yards of heavy stone riprap for Mill Creek diversion and weir separating forebay and wetlands.

7) 600 cubic yards of heavy stone riprap for low level outlet energy dissipater.

8) Sediment trap BMP’s. Berm elevation 1027, install standpipe to induce sedimentation.

9) Raise sanitary sewer manhole top in five (5) locations.

10) Property acquisitions. Four (4) tracts. total land area is 0.64 acres.

11) 5,800 linear foot, 6-foot-wide perimeter asphalt trail with two pedestrian bridges.

12) 470 square foot boardwalk, 4,000 square foot observation platforms, and educational kiosks within wetland cell.
Recommended Improvement Categories

- **Immediate Needs**
- **Short-Term Maintenance**
- **Major Lake & Park Improvements**

13) Remove woody vegetation along large portions of the dam embankments.
   - 20 trees of greater than 4-inches in diameter along the north pond embankment.
   - 40 trees of greater than 4-inches in diameter along the Mill Creek.
   - 2 trees and 4 stumps along the south pond shoreline.

14) Trap and relocate burrowing animal. Place compacted backfill in holes in 7 locations.

15) Erosion / scour protection with riprap along Mill Creek.
   - North embankment – 480 linear feet.
   - South embankment - 400 linear feet.

16) Shoreline protection should extend 2 feet above water surface.
   - North pond - 700 linear feet of riprap.
   - South pond - 500 linear feet of riprap.

Legend
- Existing Stream
- Building Below Lake Overflow
- City Property

13905.00
7/25/2018
APPENDIX
Conceptual Modifications and Enhancements

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* South pond - 500 linear feet of riprap.

Without further legibility or coherent text content, the map appears to depict various improvement areas and features around a body of water, likely a park or lake, with numbered points indicating specific areas for action.
Dredge Spoil Locations & Quantities

**Lake Olathe**
- Dredge Spoils = 58,000 CY
- Avg. Depth = 4.7 FT
- Dredge Spoils = 4,100 CY
- Avg. Depth = 3.0 FT

**Waterworks Park**
- Dredge Spoils = 3,000 CY
- Avg. Depth = 2 FT
- Dredge Spoils = 3,400 CY
- Avg. Depth = 3 FT
- Dredge Spoils = 35,000 CY
- Avg. Depth = 8 FT

**Frisco Lakes**
- Dredge Spoils = 10,000 CY
- Max. Depth = 11 FT
- Avg. Depth = 3.5 FT
- Dredge Spoils = 4,600 CY
- Max. Depth = 5 FT
- Avg. Depth = 2.6 FT

**Cedar Lake**
- Dredge Spoils = 12,000 CY
- Avg. Depth = 6.5 FT
- Dredge Spoils = 12,500 CY
- Avg. Depth = 6.0 FT

**Dredge Spoils = 44,500 CY**
- Avg. Depth = 4.5 FT

**Dredge Spoils = 1,700 CY**
- Avg. Depth = 2.5 FT
- Dredge Spoils = 19,500 CY
- Max. Depth = 12 FT
- Avg. Depth = 7.5 FT
- Dredge Spoils = 2,000 CY
- Avg. Depth = 2 FT

**Dredge Spoils = 12,000 CY**
- Max. Depth = 12 FT
- Avg. Depth = 7.5 FT
- Dredge Spoils = 10,000 CY
- Max. Depth = 11 FT
- Avg. Depth = 3.5 FT
APPENDIX B

Detailed Structural Assessment Findings
Appendix B - Detailed Structural Assessment Findings

LAKE OLATHE

A visual assessment was conducted on March 8, 2018 and March 9, 2018. The following structures were reviewed:

1. PRIMARY SPILLWAY

**Existing Structure Description:** The existing spillway walls are constructed of cast-in-place concrete. The base of the upper stilling basin consists of cast-in-place concrete adjacent to the ogee weir and native limestone adjacent to the earth bank, up to the cast-in-place concrete vertical chute. Native limestone serves as the base of the spillway at the downstream end of the chute.

**Method of Observation:** Some areas of the spillway structure are not accessible by foot. Visual observation was conducted on foot where possible and was supplemented with up-close photographs acquired through use of a UAS mounted video camera.
Limitations: Portions of the concrete spillway structure were concealed from view due to the water level in the spillway. Only the exposed concrete surfaces of the spillway structure were reviewed as a part of the assessment.

Observations:

- The north wingwall on the downstream end of the spillway has begun to fail. The concrete wall has rotated, pulling the corner apart. Concrete at the corner has spalled off and exposed the wall reinforcing that could continue to rust and deteriorate.

- The south ogee weir appears to be in relatively good condition for the age of the structure. The bottom half of the east ogee weir appears to have been patched previously. The patch exhibits some surface cracking. The patch area should be evaluated more closely for deterioration or possible delamination.

- There are isolated areas of spalled and delaminated concrete in the base slab of the stilling basin, primarily located along the control joints in the slab. There is similar deterioration in the base slab of the spillway chute. Vegetation was observed in some of the slab joints.
• The side walls of the stilling basin appear to be in relatively good condition for the age of the structure. A significant amount of mineral leaching has occurred but no rust stains were observed, which would be a sign of rebar corrosion. Deteriorated sealant was observed in some wall joints, and vegetation was observed in others.
• There are isolated areas of spalled and delaminated concrete in the walls of the stilling basin, primarily located along the control joints in the wall, along with mineral leaching.

• On the south side of the spillway the construction type varies from the ogee weir at the east end, to what is likely a large buttress wall along the high earth bank, and then to a traditional retaining wall at the top of the chute on downward to the west end of the spillway. Cracks were observed in the retaining wall at the interface of the tall earth embankment wall and the lower retaining wall just upstream of the chute. Spalling at the top of the earth embankment wall has also occurred at this location. Cracking and delamination has occurred on the lower shelf of this wall within the spillway. Mineral leaching was observed in hairline cracks of the buttress wall.
Stilling Basin - Retaining Wall Cracks

Earth Embankment Wall – Top of Wall Spalling

Earth Embankment Wall – Lower Shelf Spalling, Delamination & Cracking

- Along the vertical chute, there is a construction joint in the south side retaining wall. At the joint, the lower wall has rotated in toward the spillway. There is a tree located directly behind this wall. The tree’s roots may have disturbed the soil behind the wall and may have played a role in the wall rotation. Further downstream, there are additional, much larger trees positioned directly
behind the wall that could cause similar damage in the future. The trees should be removed to prevent any further impact on the wall.

- Along the north wall at the base of the vertical chute, there is a tree located directly behind this wall and a significant amount of vegetative growth has covered the wall.
Recommended Repair Priorities:

These repairs could be deferred. They do not require immediate attention, but the magnitude of the required repairs will likely increase with time.

- Replace or reinforce the north downstream wingwall
- Investigate and possibly replace the previous patch area on the east ogee weir
- Joints in the walls and the base slab of the spillway should be cleared of all vegetation and old sealant, and any spalling concrete along the joint edges should be removed down to sound concrete in preparation for patching.
- Patch isolated areas of spalled and delaminated concrete in the base slab of the stilling basin
- Patch isolated areas of spalled and delaminated concrete in the base of the vertical chute
- Patch isolated areas of spalled and delaminated concrete in the north walls of the spillway (primarily at the stilling basin walls)
- Patch isolated areas of spalled and delaminated concrete at the top of the lower shelf along the south earth embankment wall
- Route out and repair cracks in the south retaining wall and patch the adjacent top of wall at the bottom of the south side earth embankment wall.
- Remove vegetation adjacent to the chute at the downstream end of the spillway (on both the north and south sides of the spillway). Clean vegetative growth off the north wall.
- Replace sealant in wall joints along the north wall of the stilling basin

2. EMERGENCY SPILLWAY

Existing Structure Description: Original construction plans for the emergency spillway were prepared by Martell & Associates, P.A., dated March 2, 1993. The existing spillway consists of a cast-in-place concrete slab poured over top of an earth embankment. A short weir wall was constructed at the top of the spillway between the approach slab and the channel chute. A toe weir was constructed at the base of the chute by creating a sloped slab anchored to grouted shot rock. The spillway chute contains a series of drainage holes along the slope and PVC drain lines at the base of the shoot that extend through the toe weir.
Method of Observation: Visual observation was conducted on foot. Additionally, a UAS mounted video camera was utilized.

Observations:
- Several areas of spalled and delaminated concrete were observed in the slab on grade at the base of the spillway chute near the weir, primarily located along the control joints in the slab. A number of these areas were “sounded” by striking the concrete slab surface with the handle of a shovel looking for a hollow sound, a sign of delaminated concrete. Concrete was chipped away at one of the worst areas of delamination and sound concrete was encountered a few inches deep. The concrete deterioration appears to be limited to the top surface. This damage is likely the result of freeze/thaw effects that might occur when water sits at the base of this spillway, up to the depth of the base weir height.
- The concrete slab for the remainder of the concrete chute is in relatively good condition with only isolated areas of spalled concrete observed along control joints.
- Three areas of spalled and delaminated concrete were observed in the slab on grade at the top spillway approach slab, also primarily located along control joints and mostly in the center of the approach slab. The concrete deterioration appears to be limited to the top surface. This damage
is likely the result of freeze/thaw effects at the control joint locations. A crack was also observed in the approach slab but was hairline in nature and is not a structural concern.

Spalled & Delaminated Concrete at Base of Spillway Chute

Cracked & Delaminated Concrete at Base of Spillway Chute

Spalled Concrete in Spillway Chute

Cracked Concrete in Spillway Chute
12 cracks were observed in the short weir wall at the top of the spillway located between the approach slab and the channel chute. This weir wall is 2 feet wide and 1.5 feet tall and was constructed with no control joints or construction joints. These cracks run across the width of the top of wall and down the exposed side of the wall adjacent to the approach slab.

Along the length of the weir wall near the center of the wall, there is an isolated location where spalling has occurred at the top of the wall.
Recommended Repair Priorities:

These repairs are recommended within the next 2 to 5 years. They do not require immediate attention, but the magnitude of the required repairs will likely increase with time.

- Replace significant portions of the spillway slab at the base of the spillway (varies between a 2’ wide strip and a 10’x10’ panel) – approximately 380 square feet total
- Replace an isolated 10’x10’ section in the top spillway approach slab and patch two other areas (1’x5’ and 3’x10’)
- Patch one isolated area of spalled concrete at the top wall of the spillway
- Route out and repair 12 cracks in the top weir wall to help prevent water infiltration below the spillway chute slab
- Remove vegetation and fill sawcut control joints in the spillway approach slab and the chute slab with sealant to help minimize freeze/thaw damage to the concrete

3. WEST SIDE DAM SEGMENTAL BLOCK RETAINING WALL

Existing Structure Description: Original construction plans for the dam embankment retaining wall were prepared by Martell & Associates, P.A., dated March 2, 1993. The existing retaining wall consists a modular block system buried approx.16 inches below grade with a maximum retainage of roughly 6’-8” above grade. The wall has three layers of geogrid that extend back into the embankment, a 12’ long layer at the base of the wall and two upper layers that extend 5’-6” into the embankment.

Method of Observation: Visual observation was conducted on foot. Additionally, a UAS mounted video camera was utilized.

Observations:
- There were no obvious signs of soil erosion observed at the top or base of the wall
- There were no obvious signs of wall movement or distress
- Many cap blocks along the top of the wall and a few wall blocks were missing, presumably removed by vandals
- Volunteer trees and shrubs were observed at several locations along the base of the wall
- Chips and spalling were observed in some of the blocks but are not a structural concern.
Recommended Repair Priorities:

These repairs could be deferred. They do not require immediate attention, but a delay could result in future damage to the wall.

- Remove volunteer trees and shrubs along the base of the wall to prevent their roots from undermining the AB-3 base and soil support for the retaining wall
- Replace missing cap stones and blocks (removed by vandals, but many still on site) – approximately 170 total cap blocks and missing blocks

4. OUTLET WORKS BOX

Existing Structure Description: The existing outlet works box is constructed of cast-in-place concrete. The box structure is approximately 8'-0" x 8'-0" in overall footprint, with an unknown depth greater than 32'-0'. The walls and top slab are 1'-0" thick.
Method of Observation: The Outlet Works Box is located within the lake and was accessed by boat. The top of the box extends approximately fifteen feet above the lake elevation, with a wall mounted ladder. The top of the box structure has a hatch to access the inside of the box structure. Visual observation of the exterior portion of the concrete box structure was conducted by boat, on foot by ladder access to the top of the box, and through use of a UAS mounted video camera. Visual observation of the interior portion of the concrete box structure was conducted through use of a pole mounted video camera that was lowered into the box through the access hatch.

Limitations: Portions of the concrete box structure were concealed from view due to the water level in the lake and the water level inside the box (same as the lake level). Only the exposed concrete surfaces of the box structure were reviewed as a part of the assessment.

Observations:

- The guardrails posts are cast into the top slab of the outlet box, extremely close to the corners of the box. As a result, the concrete on the corners of the box have cracked and spalled off on all four corners. Radial cracks were observed at some of the post sleeve connections.
- Radial cracks were observed at other pipe penetrations in the top slab.
A large area of spalled and delaminated concrete was observed in the top slab of the outlet box at a valve stem location. The underside of this slab area could not be observed on interior video.

**Recommended Priorities:**

These repairs are recommended within the next 2 to 5 years. They do not require immediate attention, but the magnitude of the required repairs will likely increase with time.

- After the box has been drained, investigate more closely the underside of the top slab at the valve stem location where delamination was observed in the top slab surface. Repair any damaged reinforcing and patch the concrete. Patch the isolated area of spalled and delaminated concrete in the top slab surface around the valve stem, along with any damage observed on the underside of the slab.
- Route out and repair cracks in the top slab
- Patch isolated areas of spalled and delaminated concrete at the perimeter guardrail post connections located at the corners of the box
CEDAR LAKE

1. SPILLWAY

A field investigation and recommendation report for the Spillway was previously prepared by Olsson Associates, dated June 2016. The field investigation included the existing spillway Ogee weir, spillway aprons, access ramps and associated concrete retaining walls. The report included an Opinion of Probable Cost (OPC) for spillway repairs and partial replacement of some spillway components. GBA was asked to utilize both the recommendations and the OPC from the previous report in lieu of performing a new assessment and preparing a new rough order of magnitude cost.

The following items were recommended for repair or replacement at the time of the report:

Repair Items
- Repair existing cracks in the downstream weir apron
- Repair any cracks that are observed in the upstream apron after dewatering the lake
- Clear vegetation from joints in the west sloped apron and refill, and any cracks identified can be repaired

Replacement Items
- Replace the weir wall (208 foot long, 4-foot tall by 6-foot wide trapezoid concrete slab poured over top of native shale bedrock – weathered and unweathered with underlying limestone)
- Replace the upstream key/sloped weir apron
- Replace the east and west wingwalls, along with associated footings. This includes removing/replacing the first panel of the apron, near the weir, and the east/west aprons at the toe of the wall.

2. OUTLET WORKS BOX

A visual assessment was conducted on March 1, 2018.

Existing Structure Description: The existing outlet works box is constructed of cast-in-place concrete. The box structure is approximately 12'-0" x 9'-6" in overall footprint, with an unknown depth greater than 27'-0'. Wall thicknesses vary: 1'-0" thick on the short walls and 1'-9" thick on the longer walls.
**Method of Observation:** The Outlet Works Box is located within the lake and was accessed by boat. The top of the box structure is located just above the lake elevation. The top of the box structure has a manhole to access the inside of the box structure. Visual observation of the exterior portion of the concrete box structure was conducted by boat and on foot by access to the top of the box. Visual observation of the interior portion of the concrete box structure was conducted through use of a pole mounted video camera that was lowered into the box through the access manhole.

**Limitations:** Portions of the concrete box structure were concealed from view due to the water level in the lake and the water level inside the box (one foot lower than the lake level). Only the exposed concrete surfaces of the box structure were reviewed as a part of the assessment.

**Observations:**
- The internal steel steps that are cast into the west concrete wall at the manhole location are severely corroded.
• The underside of the top slab has three areas where chucks of concrete have broken out and have presumably fallen to the bottom of the box. Rebar could not be observed due to limited video access.

Top Slab – missing concrete at underside of slab

Top Slab – missing concrete at underside of slab

• Minor cracks were observed in the top surface of the top slab.
• The top slab also exhibits abrasion with approximately 1/8” to 1/4” of the cement paste on the surface of the exposed concrete being worn off. No reinforcing steel is exposed. The claw end of a carpenter’s hammer was used to strike the face of the concrete, and the remaining concrete appears to be sound at this time.

Top Slab – crack and eroded cement paste

Top Slab – crack and eroded cement paste

**Recommended Repair Priorities:**

**These repairs are recommended if the box will be reused. They do not require immediate attention, but the magnitude of the required repairs may increase with time.**

• Replace the steel stairs down to the base of the manhole
• After the box has been drained, investigate more closely where the concrete chunks are missing in the top slab for any rusted or damaged slab reinforcing. Repair any damaged reinforcing and patch the concrete.
• Rout out and repair the cracks in the top slab surface
1. CONCRETE VALVE BOX

A structural field investigation was conducted on March 8, 2018.

Existing Structure Description: The existing concrete valve box is constructed of cast-in-place concrete. The box structure is approximately 6'-0" x 4'-0" in overall footprint, with an open grate top. The depth to the bottom of the sloped grouted base was measured at 5'-7" on the east side (concrete box depth is maybe 6' deep), and 4'-0" at the west end. The walls are 8" thick.

Method of Observation: The Valve Box is located on the edge of the lake and was visually observed from the bank only. The top grate was temporarily removed for access inside the box, which was dry at the time of the assessment.

Limitations: Portions of the concrete box structure were concealed from view due to the water level in the lake. Only the exposed concrete surfaces of the box structure were reviewed as a part of the assessment.

Observations:
- The concrete box structure is in relatively good condition with no obvious signs of deterioration.

Recommended Repair Priorities:
- None
WATERWORKS PARK (SOUTH LAKE)

1. PUMP HOUSE INTAKE STRUCTURE

A structural field investigation was conducted on March 1, 2018.

Existing Structure Description: It appears that a wood deck was constructed over top of what was likely the original concrete outlet structure to create a recreational fishing pier. We understand the outlet structure has been abandoned and there are no plans for use of this structure in the future, other than to serve as a fishing pier for the public.

Method of Observation: The Pump House Outlet Structure is located on the edge of the lake and was visually observed from the bank only.

Limitations: Significant portions of the concrete box structure were concealed from view due to the water level in the lake, the deck construction over top of the structure, and lack of access to the inside of the structure. Only the exposed concrete surfaces of the box structure were reviewed as a part of the assessment.

Observations:

• Although cracking was observed on the exterior of the concrete box structure, there are no obvious signs of structural distress in the underlying concrete outlet structure that would indicate an immediate safety concern for continued support of the wood framed pier deck.

Recommended Repair Priorities:

• None

Recommendations for Future Monitoring:

• Given the age of the concrete outlet structure, continue to periodically monitor the condition of the outlet structure for any obvious signs of settlement or continued deterioration of the concrete.
APPENDIX C

Water Quality Analysis of Proposed Improvements
Appendix C - Water Quality Analysis of Proposed Improvements

Water Quality Model Development

To demonstrate the effectiveness of proposed water quality improvements, a water quality model was developed for Mill Creek using available watershed study data and data cataloged from reviewed water sampling / historical reports. GBA evaluated over 20 water quality models for use in estimating pollutant load reductions by the proposed lake improvements recommended herein. The screening process was completed to define a model specific to the project need without requiring vast data sets and complex calibration to local conditions. The selected model needed to provide scenario modeling for eutrophication reduction (Total Phosphorous, Chlorophyll-a) created by proposed best management practices (BMP’s), increased storage/residence time created by proposed dredging, and estimation of total sediment load reduction from BMP’s proposed.

Ultimately, GBA selected the P8 Urban Catchment Model for water quality simulation of existing lakes and proposed BMP’s. P8 can be used for predicting the generation and transport of stormwater runoff pollutants in urban watersheds. P8 simulations are driven by continuous hourly rainfall and daily air temperature time series. Continuous water-balance and mass-balance calculations are performed by entering data within four elements: Watersheds, Devices (BMP’s), Particle Classes, and Water Quality Components.

Watershed data was obtained from Cedar Creek and Mill Creek watershed studies completed for Johnson County Stormwater in the early 2000’s. Many sub-basins were consolidated to provide a simplified model for water quality evaluations for
Waterworks lake. Because of the sub-basin consolidation and need to have a water quality model based on lower flowrates, runoff curve number, and basin lag times were recalculated. Curve numbers were reduced to that under Antecedent Moisture Type 2 conditions. Basin lag time was recalculated with reconfigured basins using the Natural Resources Conservation Service (NRCS) watershed lag method. Data for these re-calculations was provided by Johnson County Automated Information Mapping System (AIMS).

Select devices or BMP's are included in the P8 model to evaluate load reductions for proposed or modified BMP's. Simulated BMP types include ponds (wet, dry, extended), infiltration basins, swales, and buffer strips. The model is used to examine the water quality implications of alternative treatment options. The lakes themselves are BMP's included in the simulations.

Reference water quality data and BMP efficiency is unavailable for the Kansas City region. As such, particle classes are derived and calibrated to predict runoff quality typical of that measured under the U.S. Environmental Protection Agency (EPA) Nationwide Urban Runoff Program (Athayede et al., 1983) for Minnesota rainfall patterns which was completed in P8 by others. Predicted water quality components include suspended solids of five size fractions (TSS), total phosphorus (TP), and total Kjeldahl nitrogen (TKN).

**BMP Design Criteria**

Several BMP's for water quality improvements proposed in this study consist of treatment trains on the upstream areas of the lakes. These BMP's consist of three primary components, forebay for sediment removal, wetlands for sediment and phosphorus removal, and a deep lake to encourage nitrogen removal. Local criteria provided by the Mid-America Regional Council (MARC) BMP Manual of Best Management Practices for Stormwater Quality manual is specific to site development and site-based goals. Because the BMP's proposed by the lake projects provide more regional service, the BMP manual criteria is only partially applicable. Additional referenced sources were utilized for sizing and efficiency estimates of the water quality improvement concepts.

Forebay volume should be a minimum of 10% of normal pool of wetland volume and strive for 24-40 hour detention volume for the water quality event or approximately 90% of mean annual runoff. This is to allow sufficient residence time to remove sediments. Forebay should be 2:1 length to width minimum. Forebays require occasional maintenance to remove accumulated sediments.
To provide the most efficient water quality improvements, wetlands should be approximately 3% of watershed drainage area and strive for volumes allowing 24-hr residence time for 1-year storm. Approximately 75% of the wetland area should be less than 12 inches deep and 25% of the wetland area should be 3 to 4 feet deep. Properly sized wetlands offer nutrient / metals removal through infiltration, settling and plant uptake. Reference data suggest that lake dredging should strive to have a minimum depth of 15 feet for 25% of the reservoir volume. This is to both maintain fisheries and provide an anoxic zone for nitrogen cycling. Recommended water quality targets for healthy ecosystems would include pH between 5 and 9, dissolved oxygen greater than 5,000 ppb, fecal coliform less than 200 colonies per 100 mL, total ammonia less than 9,000 ppb and orthophosphate less than 10 bpb.

GBA compared volume requirements utilizing the American Public Works Association (APWA) / BMP methodology to concept design volumes of each feature of the extended wetland proposed at Waterworks Park. The drainage area entering the proposed treatment train is 461 acres that is primarily industrial, impervious area was determined to be 60%. Water quality volume is 0.81 inches resulting in a recommended design wetland volume of approximately 31.1 acre-feet. The APWA recommended feature size of the extended wetland was used to compare the volumes of each individual feature within the wetland as demonstrated in the table.

<table>
<thead>
<tr>
<th>Extended Wetlands Feature</th>
<th>APWA Feature Size as Percent of Total Volume (%)</th>
<th>BMP Volume per APWA Method (Acre-feet)</th>
<th>Concept Design Volume Achievable (Acre-feet)</th>
<th>Concept Volume / APWA Volume (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forebay</td>
<td>20</td>
<td>6.2</td>
<td>8.6</td>
<td>139</td>
</tr>
<tr>
<td>Micro-pool</td>
<td>20</td>
<td>6.2</td>
<td>1.3</td>
<td>21</td>
</tr>
<tr>
<td>Low Marsh</td>
<td>40</td>
<td>12.4</td>
<td>3.9</td>
<td>31</td>
</tr>
<tr>
<td>High Marsh</td>
<td>20</td>
<td>6.2</td>
<td>4.7</td>
<td>76</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>31.1</td>
<td>18.5</td>
<td>60</td>
</tr>
</tbody>
</table>

**P8 Model Calibration**

APWA/BMP methodology will only estimate total suspended solids removal efficiency. As such the P8 model was calibrated to reflect the same water quality runoff volume as that produced utilizing APWA/BMP method. This results in a comparison of expected removal efficiencies of targeted pollutants with a calibrated P8 water quality model to APWA volume as demonstrated in the following table.
Note that the efficiencies are larger using the calibrated model which highlights the limitation of the APWA/BMP method. The regional BMPs at the lakes applied to low flow conditions like APWA/BMP method will have little relative impact to the eutrophication condition of the lakes. Kansas Department of Health and Environment (KDHE) data suggests that bioavailable phosphorus occurs during higher flow events because of the large surge entering the lake during higher volume events. Thus, practices to reduce the limiting total maximum daily load (TMDL) nutrient phosphorous to the lakes will be most efficient for those BMP’s that are effective for greater than mean flow, KDHE suggests 25% exceedance probability. For this reason, GBA utilized three (3) other precipitation events to capture performance of the BMP’s through the entire treatment train at variable discharges.

1) The SCS synthetic, 1-year, 24-hour, 2.92” precipitation event suggested by reference data.
2) All precipitation data from 2010, which represents and average volume precipitation year for Johnson County that yields approximately 36” of precipitation.
3) Select storm data from June 8, 2010 representing an actual 1 year, 24-hour storm of 2.86” precipitation.

Another limitation of the APWA/BMP methodology is that it is only valid for one BMP. BMP’s in series, as proposed in treatment trains cannot be accurately evaluated with APWA to determine total system efficiency. Thus, to estimate treatment train efficiency, the P8 model was expanded to include the entire treatment train, then calibrated to the APWA/BMP water quality volume considering all drainage area to the treatment train. This results in a water quality volume of 0.49 inch (38-acre feet) over the entire 919-acre watershed. The reduced volume is attributed to disconnected impervious areas and increased residence time from both Frisco Lakes that enter the treatment train downstream of the proposed wetland and forebay. Utilizing this volume quality volume requires 80 acre-feet of permanent pool volume using APWA/BMP manual criteria, the
The proposed concept design has a permanent pool volume of approximately 84 acre-feet for all treatment train components.

<table>
<thead>
<tr>
<th>Waterworks Treatment Train BMP Efficiency (919 Acres Inflow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P8 Simulation</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Calibrated to APWA / BMP Method</td>
</tr>
<tr>
<td>1 Year - 24 Hour SCS Storm</td>
</tr>
<tr>
<td>Average Water Year - 2010 Annual Rainfall</td>
</tr>
<tr>
<td>Similar 2010 Storm (June 8, 2010)</td>
</tr>
</tbody>
</table>

The 2010 data allows performance comparison to KDHE TMDL’s for the lake which targets allowable phosphorous loading in pound per year to meet the TMDL requirement. As previously mentioned, since there is a lack of locally calibrated water quality pollutant data, to compare the phosphorus loading estimated by the runoff calibrated P8 model, the phosphorus loading results must be normalized to KDHE TMDL baseline.

<table>
<thead>
<tr>
<th>Waterworks TMDL Performance</th>
<th>Baseline</th>
<th>Goal</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TSI (CHL)</td>
<td>TP</td>
<td>Clorophyll-a</td>
</tr>
<tr>
<td></td>
<td>ppb</td>
<td>ppb</td>
<td>ppb</td>
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<tr>
<td>Existing Condition - KDHE</td>
<td>60</td>
<td>38</td>
<td>34</td>
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<tr>
<td>Proposed Treatment Train - P8 - 2010</td>
<td>N/A</td>
<td>364</td>
<td>N/A</td>
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<tr>
<td>Proposed Treatment Train - Normalized to KDHE Goal</td>
<td>44</td>
<td>16</td>
<td>4</td>
</tr>
</tbody>
</table>

The normalized comparison suggests that the proposed treatment trains at Waterworks park are efficient enough to exceed the TMDL requirement and thus be removed from the TDML list. There are likely other water quality benefits from the Waterworks treatment train affecting the TMDL associated with Mill Creek but evaluation of Mill Creek TMDL downstream of the proposed treatment train is beyond the scope of this study.

Detailed modeling data demonstrating pollutant loading and removal efficiency of TSS and TP from two of the optimized P8 simulations for Waterworks treatment train improvements are provided hereafter in this appendix.
APPENDIX D

Itemized Planning Level Cost Estimates
## Planning Level Opinion of Cost

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT PRICE</th>
<th>TOTAL</th>
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<td>Contract Administration</td>
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<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Nuisance Animal Control</td>
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<td>$0</td>
<td>$0</td>
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<td>Topographic &amp; Utility Survey</td>
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<td>Engineering Design</td>
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<td>Property Description/Negotiation</td>
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<td>Property Acquisition</td>
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<td>Easement Acquisition</td>
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<td>Permit Applications</td>
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<td>Construction Services</td>
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<td>Mobilization</td>
<td>L.S.</td>
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<td>$125,000</td>
<td>$125,000</td>
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<tr>
<td>Clearing and Grubbing</td>
<td>AC</td>
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<td>$2,500</td>
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<tr>
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<td>Ea.</td>
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</tr>
<tr>
<td>Remove/Dispose Shoreline Encroachments</td>
<td>Ea.</td>
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</tr>
<tr>
<td>Repair Embankment Voids</td>
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<tr>
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<tr>
<td>Medium Enclosed System BMP - 6'</td>
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<tr>
<td>Large Enclosed System BMP - 8'</td>
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<td>Jumbo Enclosed System BMP -10'</td>
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<td>L.F.</td>
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</tr>
<tr>
<td>Raise / Replace Sanitary MH Cone</td>
<td>Ea.</td>
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<td>$1,800</td>
<td>$0</td>
</tr>
<tr>
<td>Outfall Repair / Protection</td>
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<tr>
<td>Primary Outlet Works Structure Repairs</td>
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<td>Days</td>
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<td>$0</td>
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<td>Dredging and Excavation</td>
<td>C.Y.</td>
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<td>$5</td>
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<td>$4</td>
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<tr>
<td>Soil Filled Turf Reinforced Matrix</td>
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<td>$0</td>
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<td>Native Seeding</td>
<td>S.Y.</td>
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<td>$0</td>
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<td>S.Y.</td>
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<td>$6.00</td>
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<td>$15,000</td>
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| Subtotal | | | | $2,361,475 |
| 25% Contingency | | | | $590,369 |
| Total Opinion of Probable Cost | | | | $2,951,844 |
### Appendix D - Itemized Planning Level Cost Estimates

#### Planning Level Opinion of Cost

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT PRICE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Administration</td>
<td>%</td>
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<td>$0</td>
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<td>Property Acquisition</td>
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<td>$0</td>
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<tr>
<td>Easement Acquisition</td>
<td>Ac.</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
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<td>Permit Applications</td>
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<td>$225,000</td>
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<td>$300,000</td>
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<td>$2,500</td>
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<td>Selective Tree Removal &gt; 8&quot;</td>
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<td>$500</td>
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<td>Remove/Dispose Shoreline Encroachments</td>
<td>Ea.</td>
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<td>$1,500</td>
<td>$0</td>
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<tr>
<td>Repair Embankment Voids</td>
<td>Ea.</td>
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<td>$1,000</td>
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<td>Large Filter Basket BMP - Retrofit 8'</td>
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<td>Ea.</td>
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<td>$16,000</td>
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<tr>
<td>Medium Enclosed System BMP - 6'</td>
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<td>$0</td>
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<td>Large Enclosed System BMP - 8'</td>
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<tr>
<td>Jumbo Enclosed System BMP -10'</td>
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<td>Underdrain System</td>
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<td>$1,800</td>
<td>$0</td>
</tr>
<tr>
<td>Outfall Repair / Protection</td>
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<td>$0</td>
<td>$0</td>
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<td>$225,000</td>
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<td>$7,000</td>
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<tr>
<td>Dewatering</td>
<td>Days</td>
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<td>Soil Filled Turf Reinforced Matrix</td>
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<td>$6.00</td>
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</tr>
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<td>Site Restoration</td>
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Lake and Dam Restoration Master Planning
(PN 2-C-002-17)

Cedar
7/6/2018
## Appendix D - Itemized Planning Level Cost Estimates

### Planning Level Opinion of Cost

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT PRICE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Administration</td>
<td>%</td>
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<td>Nuisance Animal Control</td>
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<td>$0</td>
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<td>Topographic &amp; Utility Survey</td>
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<td>Selective Tree Removal &gt; 8&quot;</td>
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<td>Small Filter Basket BMP - Retrofit 5'</td>
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<td>$3,500</td>
<td>$0</td>
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<td>Large Filter Basket BMP - Retrofit 8'</td>
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<td>$5,000</td>
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<td>Small Enclosed System BMP - 4'</td>
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<td>Medium Enclosed System BMP - 6'</td>
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</tr>
<tr>
<td>Large Enclosed System BMP - 8'</td>
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<tr>
<td>Jumbo Enclosed System BMP -10'</td>
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<td>$67,000</td>
<td>$0</td>
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<td>$200</td>
<td>$0</td>
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<td>Underdrain System</td>
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<td>Raise / Replace Sanitary MH Cone</td>
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<td>Outfall Repair / Protection</td>
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<td>Days</td>
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<td>$0</td>
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<td>Native Seeding</td>
<td>S.Y.</td>
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<tr>
<td>Native Seeding with Bare Root Plantings</td>
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<tr>
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Subtotal $1,126,500

25% Contingency $281,625

Total Opinion of Probable Cost $1,408,125
## Appendix D - Itemized Planning Level Cost Estimates

### Planning Level Opinion of Cost

<table>
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<tr>
<th>ITEM DESCRIPTION</th>
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<th>UNIT PRICE</th>
<th>TOTAL</th>
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<td>Days</td>
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<td>Ac.</td>
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<td>$10,000</td>
<td>$20,000</td>
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| Subtotal                              |      |          | $1,802,600 |         |
| 25% Contingency                       |      |          | $450,650   |         |

| Total Opinion of Probable Cost        |      |          | $2,253,250 |         |
## Appendix D - Itemized Planning Level Cost Estimates

### Planning Level Opinion of Cost

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT PRICE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Administration</td>
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<td>$0</td>
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<td>Remove/Dispose Shoreline Encroachments</td>
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<td>Repair Embankment Voids</td>
<td>Ea.</td>
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<td>$200</td>
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<td>Small Filter Basket BMP - Retrofit 5'</td>
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<td>Large Filter Basket BMP - Retrofit 8'</td>
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<td>$25,000</td>
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<td>Large Enclosed System BMP - 8'</td>
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<td>Jumbo Enclosed System BMP -10'</td>
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<tr>
<td>Underdrain System</td>
<td>L.F.</td>
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<td>$0</td>
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<td>Raise / Replace Sanitary MH Cone</td>
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<td>$1,800</td>
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<td>$15,000</td>
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</table>
APPENDIX E

Bibliography of Reviewed and Referenced Source Data
Appendix E - Bibliography of Reviewed and Referenced Source Data

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