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May 24th, 2022

RE: Cross Lake Water Quality Improvements – Phase 3
Technical Summary Memo
Crosslake, MN

Project Summary

The City of Crosslake is undertaking a series of stormwater quality projects along County Road 66 from Manhattan Beach Lodge to the Pine River Reservoir. Phase 3 is located south of Swann Drive to the Pine River crossing on County Road 3. The City and Crow Wing County have partnered with Bolton & Menk to improve the quality of stormwater runoff that drains through the county road storm sewer infrastructure. Currently, that stormwater runoff discharges untreated into the Pine River Reservoir. Bolton & Menk has provided numerous locations for stormwater best management practices (BMPs) in the form of hydrodynamic separators (HDS structures) to remove stormwater pollutants including sediment, gross solids, hydrocarbons, and other floatable materials. Additional surface BMPs, that is bioretention facilities, were also preliminarily evaluated.

The US Army Corps of Engineers (USACOE) is a significant landowner within this project area and will require coordination as potential HDS structure locations are identified. Further, we understand that planning for the Loon Center, located in the current Cross Lake Recreational Area, is underway. Therefore, it may be prudent to consider the potential water quality impacts and regulatory requirements at the future Loon Center for possible project coordination/collaboration. The area is also known for an abundance of important archaeological artifacts. Also, the area has watermain and sanitary sewer utilities that must be protected. Coordination with the USACOE during design and construction will be paramount to avoid disturbance of these artifacts.

The HDS structures were evaluated using a program called Sizing Hydrodynamic Separators and Manholes (SHSAM) and surface BMPs were evaluated using the Minimal Impact Design Standards (MIDS) calculator to determine the total annual load, load removed and removal efficiency of total suspended solids and total phosphorus (TP). Several options were considered including a single large structure at the storm sewer outlet, several smaller structures spread throughout the drainage area, and potential sites for surface BMPs, like bioretention features, along the curb line.

Current Conditions

The project area and contributing subwatershed areas, delineated using aerial imagery and Light detection and ranging (LiDAR) topographic contours, was found to be approximately 17 acres, in which 9.2 acres are impervious (55%). Most of the impervious areas are concentrated on the east side of County Road 66 and County Road 3, where there are local and commercial businesses. The primary source of pervious area, that is vegetated surfaces with little to no soil compaction, is from the Cross Lake Recreational Area which provides minor stormwater runoff and pollution contribution. If these areas are removed from the project area, the direct impervious area contributing runoff to the storm sewer is closer to 85%. Stormwater from the impervious surfaces drains onto the roadway and is collected into the storm sewer system that runs along the corridor, which ultimately drains south into the Pine River Reservoir, which is located just downstream of the Cross Lake Dam outlet. The project location map and drainage areas can be seen in **Figure 1**.

Crosslake Water Quality Improvements Phase 3
Crosslake, MN

Figure 1 - Location Map
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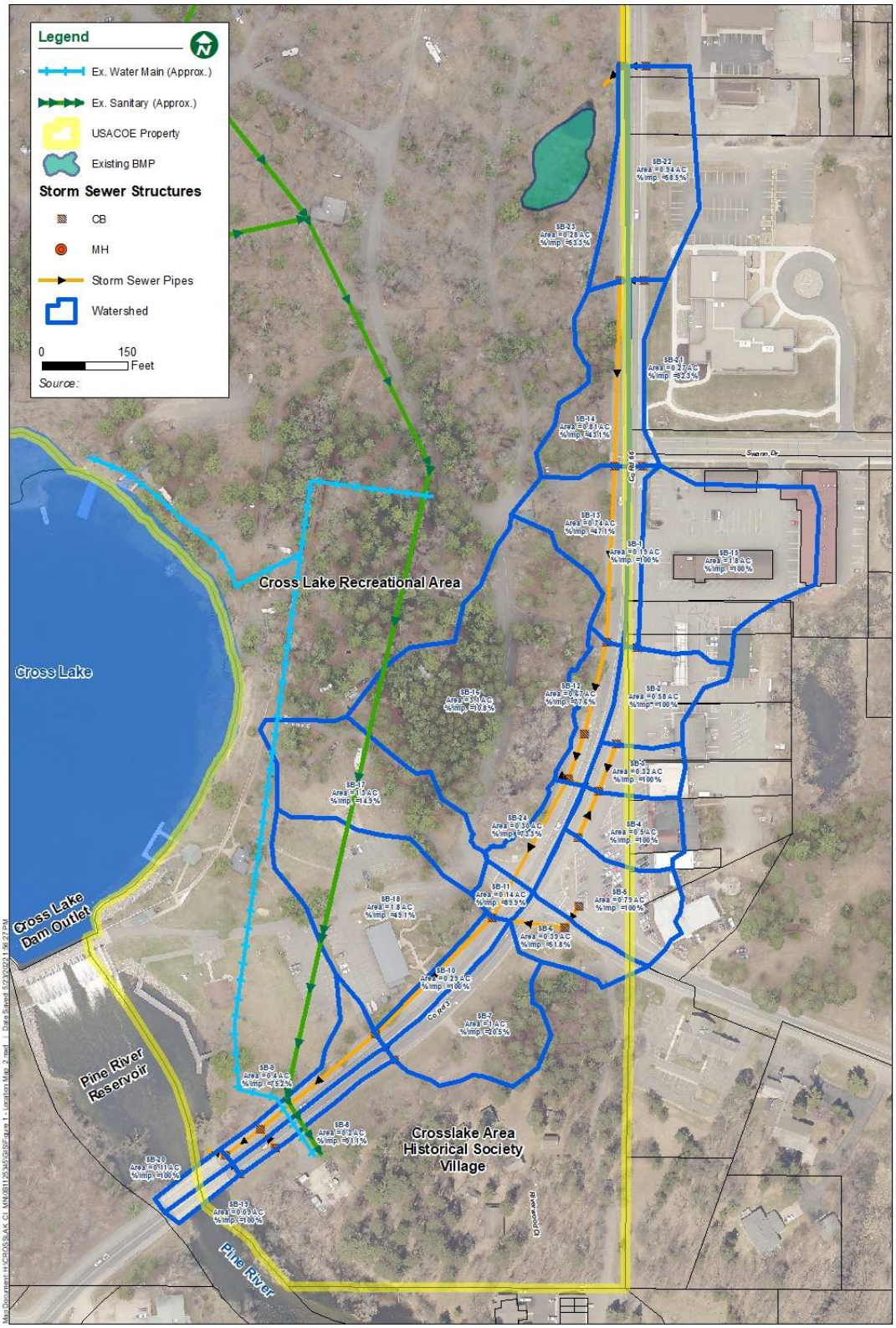

The primary soil type within Crosslake are sandy and alluvial soils which have relatively high infiltration rates, and therefore low runoff potential. This was taken into consideration for the BMP locations. For the HDS structures, it is most conducive to place these structures in areas of high runoff potential, which would be the heavily compacted impervious areas.

The USACOE owns most of the land within the project limits, specifically the west side of the corridor, as well as the majority of the parking lot on the east side. If stormwater BMPs are placed within the USACOE right-of-way, consistent coordination and partnership will be required for timely and cost-effective project implementation, especially considering cultural resources and water/sanitary utilities. The east side of the project limits consists of USACOE parking areas and additional properties owned by local and commercial businesses. This will also require careful communication and coordination for a successful project.

Preliminary Best Management Practice (BMP) Locations

Preliminary BMP locations have been identified along County Road 66 and County Road 3 corridors. It is assumed that the BMPs will be constructed to improve water quality by reducing the amount of sediment, hydrocarbons, gross solids, and other floatable materials coming from the roadway and adjacent impervious surfaces. Refer to **Figure 2** for a preliminary layout of HDS and surface BMP options. The preliminary location criteria were based on the following goals.

- Access to stormwater runoff – Ideal locations for HDS structures and surface BMPs have a high percentage of impervious surfaces that would develop the greatest amount of total suspended solids and other pollutants via overland flow. Furthermore, HDS structure retrofits with little additional storm sewer infrastructure additions will yield the most cost-effective projects.
- Public right-of-way – Public property is the most cost effective in terms of property acquisition and maintenance access. Although the USACOE owns most of the property within the project, targeting these locations in conjunction with maintenance agreements is best for USACOE, Crow Wing County and the City of Crosslake alike.
- Private property and partnerships – When public right-of-way is not available, open areas adjacent to the roadway corridor are considered. Business properties would require coordination and communication for successful project delivery. Potential project impacts to the following businesses/organizations will require coordination:
    - Pine Peaks Owner's Association
    - S & P Quisberg LLC
    - US Army Corps of Engineers
- Maintenance – Access to maintenance for the HDS structures is crucial. Additional maintenance considerations are discussed below.

Crow Wing County Soil and Water Conservation District (Crow Wing SWCD) collected water quality samples at Pine River Dam to understand E. coli, total phosphorus (TP), chloride, orthophosphate, biochemical oxygen demand (BOD), and residue-non filterable total suspended solids (TSS). This assessment analyzed TSS and TP. **Table 1** is a summary of the applicable results as compared to industry standard event mean concentrations (EMC) (based on MIDS, MPCA). The sampling results were variable, likely correlated to the flow conditions during the assessment. When averaged, the sampling results are generally lower than the MPCA recommended EMC. Also, all TP samples were below the MPCA EMC of 0.30 mg/L.

Table 1: Summary of Water Quality Sampling Results.

Pollutant	MIDS EMC (mg/L)	Sample 7/14/21 (mg/L)	Sample 7/14/21 (mg/L)	Sample 8/30/21 (mg/L)	Sample Average (mg/L)
TSS	54.5	17.2	90.8	25.8	44.6
TP	0.30	0.235	0.274	0.078	0.20

Using SHSAM, each subwatershed was assessed for total suspended solids loading. **Figure 3** displays the regional variation of anticipated sediment loading based on the models input. These inputs include:

- Drainage area.
- Percent impervious area.
- Flow path length (hydraulic length).
- Average percent slope.
- Pervious area curve number (61 for all analyses).

Since SHSAM relies on standard particle size distributions to determine TSS removals and not EMCs, the standard particle size distributions were not modified based on the sampling results. Furthermore, since the sample results were variable across the respective flow regimes during sampling, the averages do not provide enough statistical correlation to the MCPA's more conservative average to warrant modifying the EMCs.

It is understood that archeological artifacts may be present throughout the project site. Therefore, it will be critical to coordinate design information with USACOE and ensure that applicable staff are present on-site during construction. Whether the site is a surface stormwater BMP or a structural practice, excavation will be required. When alternatives are selected, the USACOE may assist in identifying locations where artifacts are known to be so that final design is focused in areas that may not contain artifacts. Costs for archaeological review and onsite inspections are not included in the engineers cost estimates herein. Furthermore, locations of water and sanitary sewer utilizes will be surveyed and considered during final design of any surface BMPs.

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Crosslake, MN

Figure 2 - HDS Options
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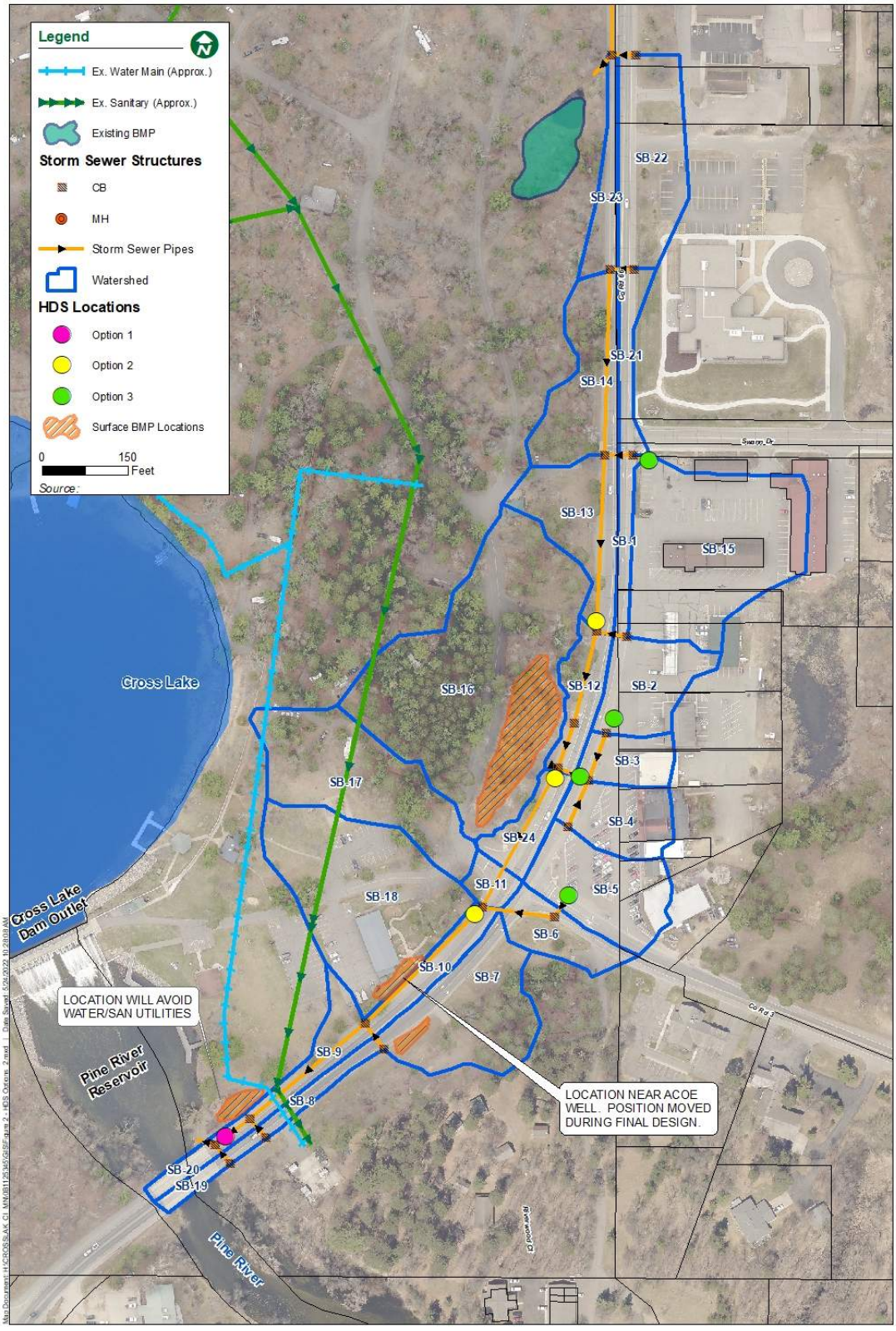

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Crosslake, MN

Figure 3 - TSS Map
November 2021

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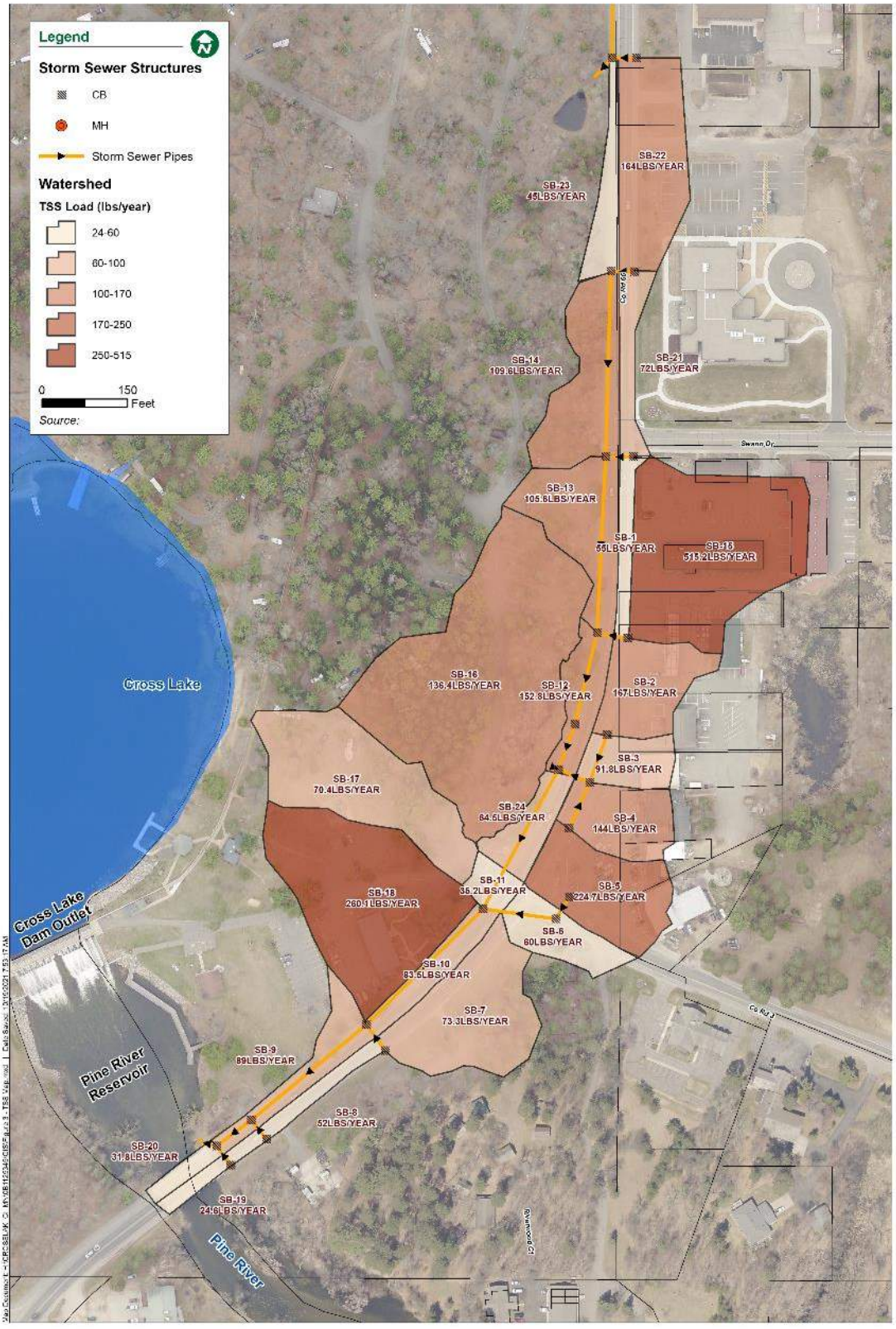

Summary of Preliminary BMPs

Four different options for the locations and sizing of HDS structures and surface BMPs were studied. Option 1 was to implement one single structure that would treat the entire area that drains onto County Road 66 and County Road 3. Option 2 involves three HDS structures that would be "on-line" or connected to the main storm sewer that runs along the project corridor. Option 3 includes four smaller off-line structures that would specifically target runoff coming from the businesses and parking lots on the west side of County Road 66 and County Road 3. Option 4 consists of the four HDS structures as part of Option 3, with the addition of four infiltration basins along the curb line.

All options were analyzed using both the MnDOT Road Sand and Nationwide Urban Runoff Program (NURP) particle distributions. The MnDOT particle distribution consists of larger diameter sand particles typically seen in curb lines, especially in the spring. The NURP distribution has a larger quantity of fine clay and sand particles, more typical of general soil erosion. It is important to understand that, while MnDOT particle size distribution may be more applicable to highly impervious areas with little exposed native soil and more representative of winter salt and sand applications, the resulting removal percentage will be much higher than the NURP distribution. HDS structures are much more efficient at capturing larger diameter particles, but will likely pass the smaller diameter particles, especially during high flows or intense storms.

During recent projects on USACOE property, local USACOE representatives indicated that trained archeological staff must be present on site during all excavation. This is not necessarily reflected in cost estimates, but early and frequent coordination should be considered during preliminary design, through final design, and during construction.

Option 1 – Single HDS Structure

Option 1 consists of a single HDS structure that treats the entire roadway corridor within the project limits. **Figure 4** identifies the BMP location and corresponding treatment area for Option 1. SHSAM was used to calculate the annual total suspended solids (TSS) loading and reduction for each location. **Table 1** shows the potential water quality improvements for Option 1. **Table 2** is a preliminary cost estimate for this structure.

Having a single structure to treat the entire project roadway would be the most expensive solution, since the largest manufactured size, SC-12 (a structure with a 13-ft depth and 12-ft diameter), would be required. Construction of the structure would require substantial traffic control and roadway impacts. Furthermore, access for maintenance would likely require temporary lane closures. Although the amount of sediment removal is relatively significant, a structure this large would still only have a removal efficiency of 20% for the finer particles within the NURP particle distribution.

Table 2: Summary of Option 1 Water Quality Improvements

Pervious Area (Acres)	2.1
Impervious Area (Acres)	4.9
Total Area (Acres)	7.0
Total Suspended Solids Received (lbs)	2745.0
Total Suspended Solids Retained (lbs) – MnDOT Road Sand	2737.6
Total Suspended Solids Retained (lbs) - NURP	548.1
Percent Retained (%) – MnDOT Road Sand	100%
Percent Retained (%) - NURP	20%

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Crosslake, MN

Figure 4 - Option 1
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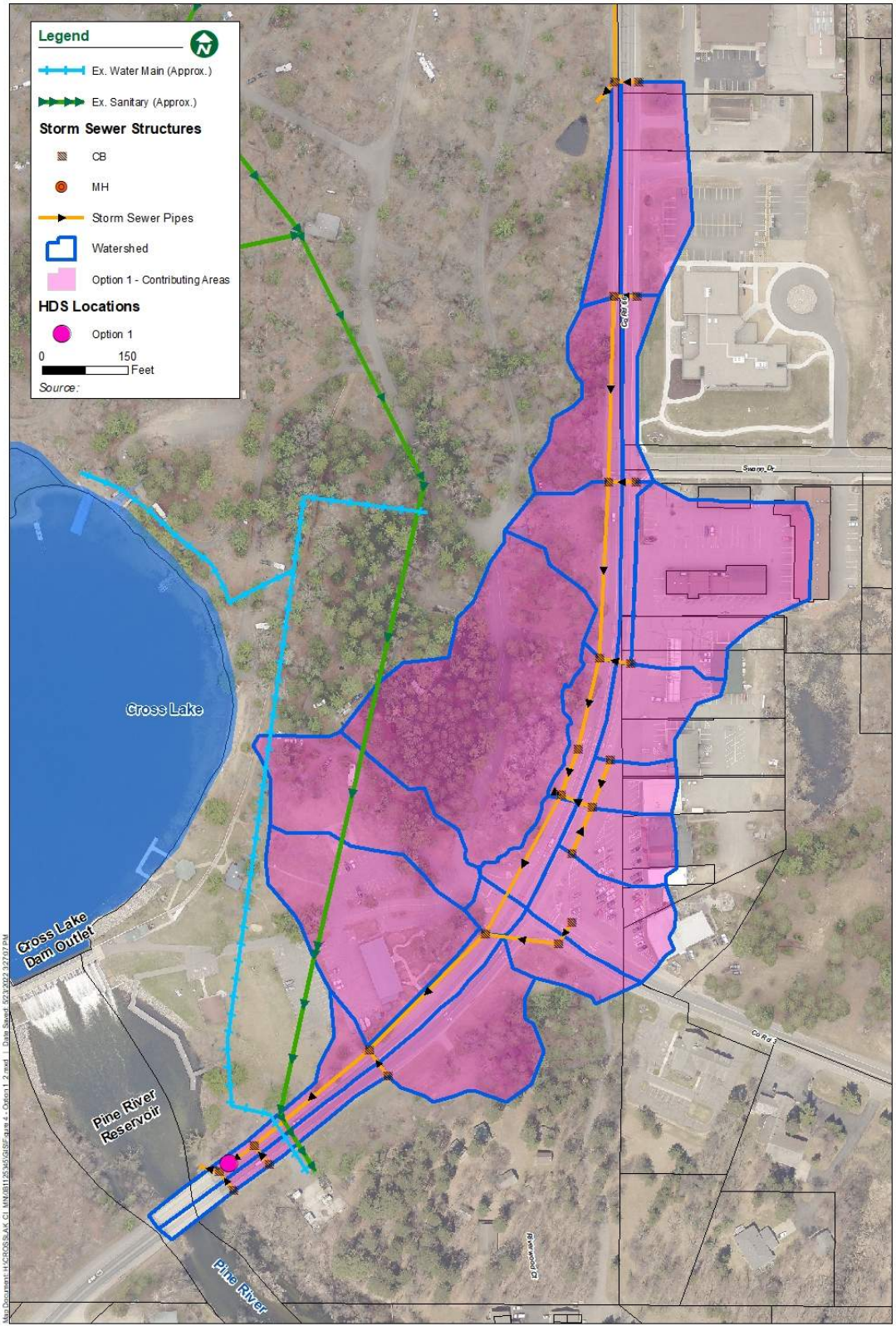

Table 3: Preliminary Cost Estimate for Option 1 Improvement

No.	Item	Units	Approx. Qty	Estimated Unit Price	Estimated Total Price
1	MOBILIZATION	LS	1	$ 8,500	$ 8,500
2	TRAFFIC CONTROL	LS	1	$ 6,000	$ 6,000
3	2-YEAR MAINTENANCE	LS	1	$ 8,000	$ 8,000
4	COMMON EXCAVATION (P)	CY	500	$ 15	$ 7,500
5	BITUMINOUS PAVEMENT RESTORATION	SY	25	$ 50	$ 1,250
6	CURB REPLACEMENT	LF	30	$ 100	$ 3,000
7	CONNECT TO EXISTING STORM SEWER	EA	1	$ 900	$ 900
8	HDS STRUCTURE DELIVERED AND INSTALLED	LS	1	$ 130,000	$ 130,000
9	EROSION AND SEDIMENT CONTROL	LS	1	$ 3,000	$ 3,000
				TOTAL ESTIMATED CONSTRUCTION COSTS	**$168,200.00**
				PROJECT CONTINGENCY (20%)	**$33,600.00**
				SURVEY/ENGINEERING/CONST ADMIN (20%)	**$33,640.00**
				TOTAL ESTIMATED PROJECT COSTS	**$235,440.00**
				POTENTIAL BWSR CWF GRANT REQUEST	***$176,580.00***
				POTENTIAL LOCAL MATCH REQUIREMENT	***$58,860.00***

Option 2 – Multiple HDS Structures On Mainline

Figure 5 shows the locations and treatment areas for the three on-line structures of Option 2. Option 2 would require three smaller, more practical structures ranging from 5 to 6 ft deep with 4 to 5 ft diameters, respectively. This option is the least expensive in terms of structure costs. However, from a construction and maintenance perspective, having structures that are connected to the main storm sewer system would be challenging. A summary of the potential water quality improvements for Option 2 is shown in **Table 3**. **Table 4** shows the corresponding preliminary cost estimate for each of the HDS structures.

Table 4: Summary of Option 2 Water Quality Improvements

Pervious Area (Acres)	1.21
Impervious Area (Acres)	3.93
Total Area (Acres)	5.14
Total Suspended Solids Received (lbs)	1147
Total Suspended Solids Retained (lbs) – MnDOT Road Sand	1122.42
Total Suspended Solids Retained (lbs) - NURP	165.5
Percent Retained (%) – MnDOT Road Sand	98
Percent Retained (%) - NURP	14

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Crosslake, MN

Figure 5 - Option 2
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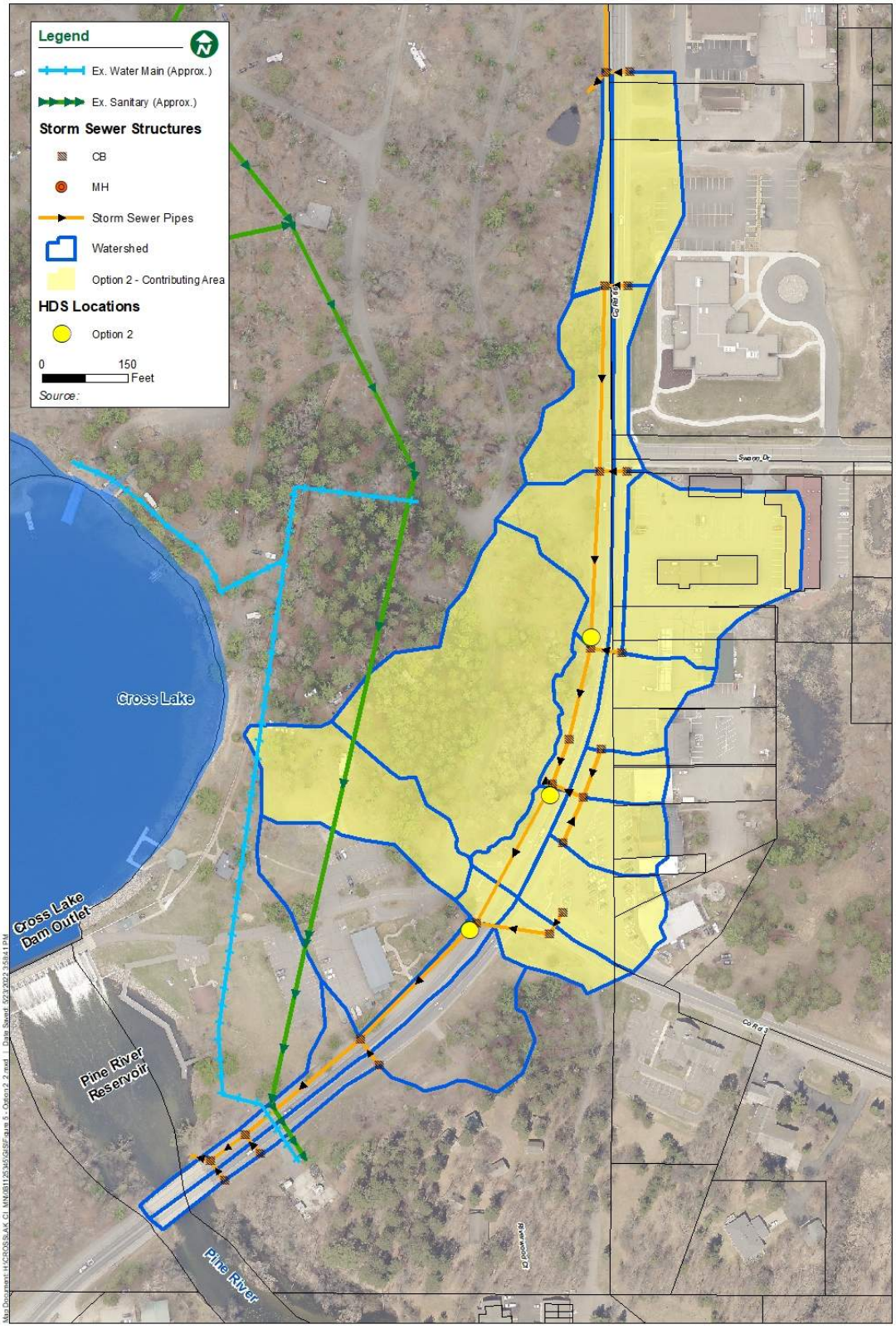

Table 5: Preliminary Cost Estimate for Option 2

No.	Item	Units	Approx. Qty	Estimated Unit Price	Estimated Total Price
1	MOBILIZATION	LS	1	$ 7,500	$ 7,500
2	TRAFFIC CONTROL	LS	1	$ 6,000	$ 6,000
3	2-YEAR MAINTENANCE	LS	1	$ 8,000	$ 8,000
4	COMMON EXCAVATION (P)	CY	270	$ 15	$ 4,050
5	BITUMINOUS PAVEMENT RESTORATION	SY	1067	$ 50	$ 53,333
6	CURB REPLACEMENT	LF	60	$ 100	$ 6,000
7	CONNECT TO EXISTING STORM SEWER	EA	3	$ 900	$ 2,700
8	HDS STRUCTURE DELIVERED AND INSTALLED	LS	3	$ 18,000	$ 54,000
9	EROSION AND SEDIMENT CONTROL	LS	1	$ 3,000	$ 3,000
				TOTAL ESTIMATED CONSTRUCTION COSTS	**$144,600.00**
				PROJECT CONTINGENCY (20%)	**$28,900.00**
				SURVEY/ENGINEERING/CONST ADMIN (20%)	**$28,920.00**
				TOTAL ESTIMATED PROJECT COSTS	**$202,420.00**
				POTENTIAL BWSR CWF GRANT REQUEST	***$151,815.00***
				POTENTIAL LOCAL MATCH REQUIREMENT	***$50,605.00***

Option 3 – Multiple HDS Structures Off Mainline

Option 3 consists of four stand-alone structures on the east side of the roadway corridor, as shown in Figure 6, which will target the runoff coming from the local and commercial businesses. This is the highest concentration of impervious area. This option requires four 5-ft deep, 4-ft diameter structures that would treat nearly four acres of impervious area. Although slightly more expensive than Option 2 in terms of structure costs, Option 3 provides the best access for maintenance and lowest potential impact to traffic during both construction and maintenance. At the same time, Option 3 achieves similar percentages of retained sediment. Table 5 shows the water quality improvements for Option 3 and Table 6 shows the preliminary cost estimate.

Table 6: Summary of Option 3 Water Quality Improvements

Pervious Area (Acres)	0.05
Impervious Area (Acres)	3.98
Total Area (Acres)	4.03
Total Suspended Solids Received (lbs)	1142.5
Total Suspended Solids Retained (lbs) – MnDOT Road Sand	1011.5
Total Suspended Solids Retained (lbs) - NURP	141.25
Percent Retained (%) – MnDOT Road Sand	96
Percent Retained (%) - NURP	12

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Crosslake, MN

Figure 6 - Option 3
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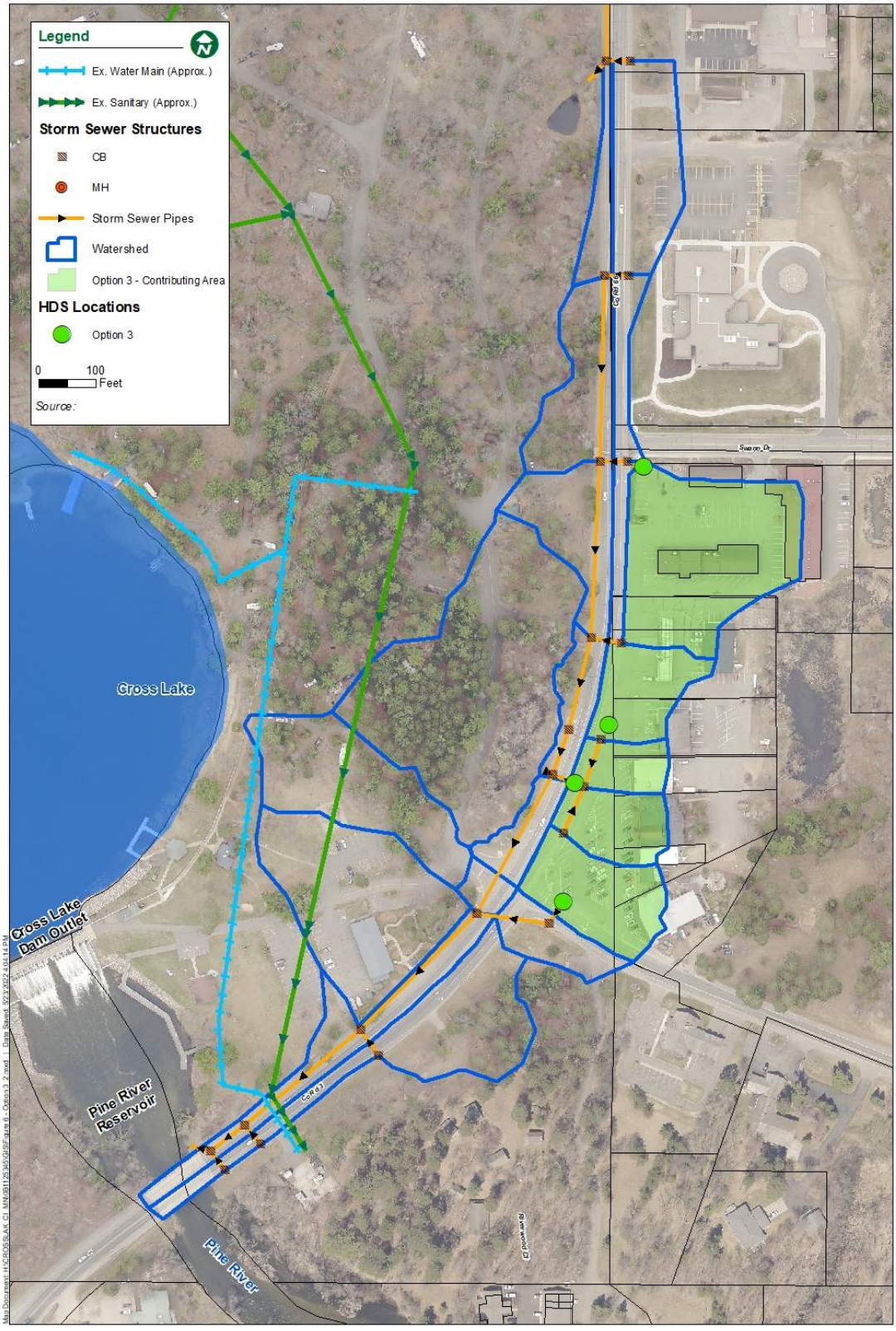

Table 7: Preliminary Cost Estimate for Option 3

No.	Item	Units	Approx. Qty	Estimated Unit Price	Estimated Total Price
1	MOBILIZATION	LS	1	$ 10,000	$ 10,000
2	TRAFFIC CONTROL	LS	1	$ 3,000	$ 3,000
3	2-YEAR MAINTENANCE	LS	1	$ 8,000	$ 8,000
4	COMMON EXCAVATION (P)	CY	360	$ 15	$ 5,400
5	BITUMINOUS PAVEMENT RESTORATION	SY	1422	$ 50	$ 71,111
6	CURB REPLACEMENT	LF	80	$ 100	$ 8,000
7	CONNECT TO EXISTING STORM SEWER	EA	4	$ 900	$ 3,600
8	HDS STRUCTURE DELIVERED AND INSTALLED	LS	4	$ 18,000	$ 72,000
9	EROSION AND SEDIMENT CONTROL	LS	1	$ 3,000	$ 3,000
				TOTAL ESTIMATED CONSTRUCTION COSTS	**$184,100.00**
				PROJECT CONTINGENCY (20%)	**$36,800.00**
				SURVEY/ENGINEERING/CONST ADMIN (20%)	**$36,820.00**
				TOTAL ESTIMATED PROJECT COSTS	**$257,720.00**
				POTENTIAL BWSR CWF GRANT REQUEST	***$193,290.00***
				POTENTIAL LOCAL MATCH REQUIREMENT	***$64,430.00***

Option 4 - Multiple HDS Structures Off Mainline & Bioretention Features

Option 4 consists of the hydrodynamic separators from Option 3, as well as identifying as many as four surface treatment BMPs in the form of infiltration basins. Figure 5 shows potential bioretention locations based on surface topography and access to storm sewer. These features would include installation of a curb cut upstream of the adjacent catch basin. As stormwater fills the bioretention volume, excess runoff will back flow onto the street or bypass the curb cut and discharge into the catch basin. Soil types indicate that infiltration may be possible. However, during final design, soil types and infiltration rates should be confirmed. With access to adjacent storm sewer structures, these bioretention BMPs could be converted to biofiltration features with drain tile.

Since the HDS structures in Option 3 only target the impervious area on the east side of the corridor, this option provides treatment for runoff on the west side of the project where HDS treatment along the mainline of the pipe is less feasible. Although there is not significant impervious area on the west side, it will be beneficial to treat the runoff coming from the roadway. Furthermore, HDS structures target TSS only. The bioretention BMPs proposed would target TSS and total phosphorus (TP), which has been identified as a pollutant of concern during previous phases of the Crosslake Water Quality Improvement project. A summary of the water quality improvements for the infiltration basins is shown in **Table 7**. **Table 8** outlines the preliminary cost estimate for these features.

One BMP location is situated near the existing ACOE well. It is understood that a stormwater BMP in this location is not conducive and would need to be relocated during final design. There appears to be space to modify the location and an impermeable liner could be considered with out substantially impacting cost to protect the well.

Crosslake Water Quality Improvements Phase 3 — Figure 7 - Option 4
Crosslake, MN — May 2022
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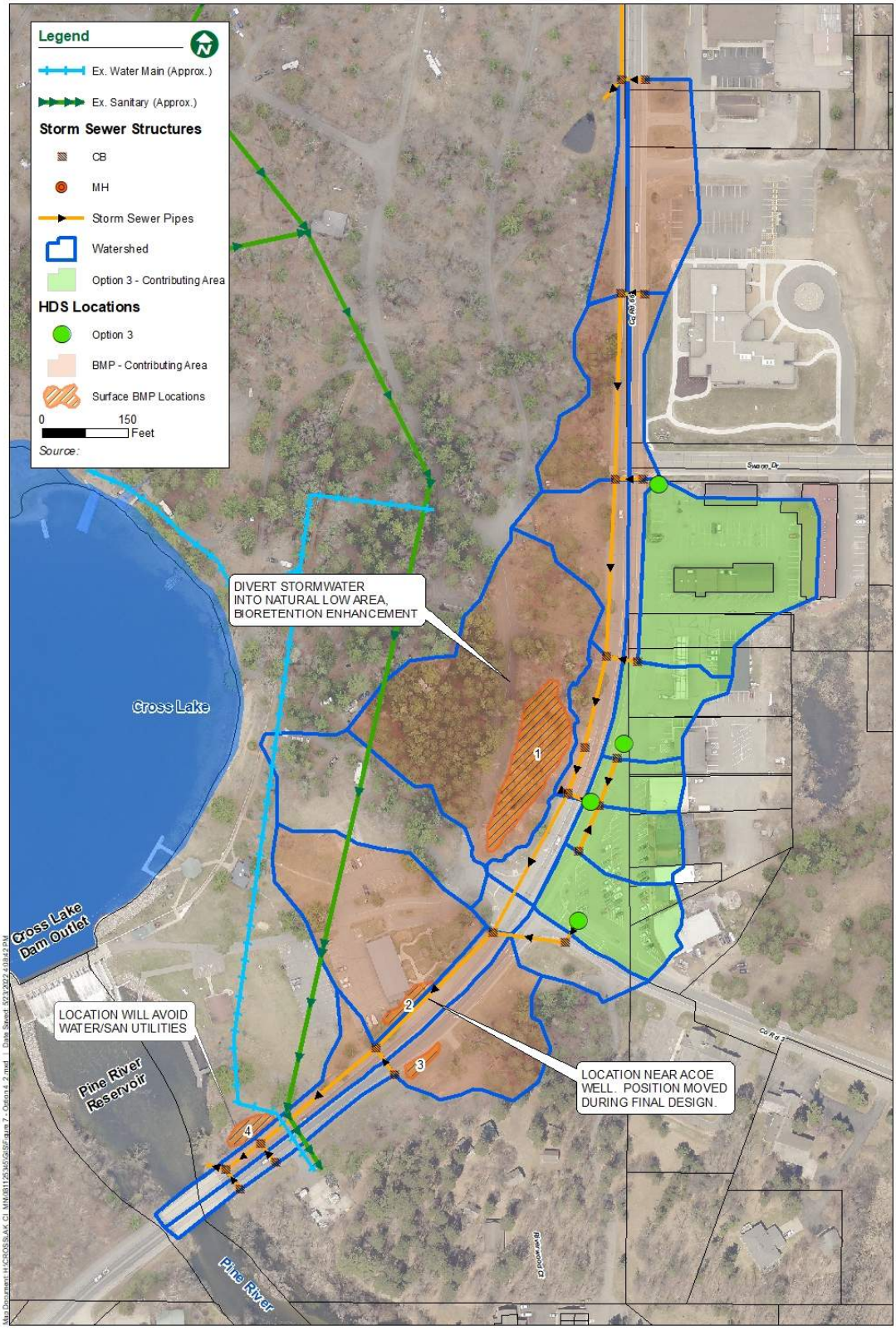

Table 8: Summary of Option 4 Water Quality Improvements

Infiltration Basin Water Quality	Basin 1	Basin 2	Basin 3	Basin 4
Pervious Area (Acres)	3.8	0.89	0.81	0.1
Impervious Area (Acres)	2.0	1.16	0.21	0.3
Total Area (Acres)	5.8	2.1	1.0	0.4
BMP Volume (CF)	2294	2630	1663	2671
BMP Annual Volume Received (Acre-ft)	5.1	2.6	0.68	0.64
BMP Annual Volume Retained (Acre-ft)	3.1	2.2	0.66	0.63
Percent Retained (%)	61	83	97	98
Phosphorus Load Received (lbs)	4.20	2.13	0.56	0.52
Phosphorus Load Retained (lbs)	2.56	1.75	0.54	0.51
Percent Retained (%)	61	82	96	98
Total Suspended Solids Received (lbs)	762.2	388.7	101.0	94.4
Total Suspended Solids Retained (lbs)	465.5	318.5	98.0	93.8
Percent Retained(%)	61	82	97	99

Table 9: Preliminary Cost Estimate for Option 4

No.	Item	Units	Approx. Qty	Estimated Unit Price	Estimated Total Price
1	MOBILIZATION	LS	1	$ 17,000	$ 17,000
2	TRAFFIC CONTROL	LS	1	$ 3,000	$ 3,000
3	2-YEAR MAINTENANCE	LS	1	$ 6,400	$ 6,400
4	COMMON EXCAVATION (P)	CY	5357	$ 15	$ 80,362
5	FINE FILTER AGGREGATE	CY	581	$ 70	$ 40,644
6	COMPOST GRADE 2	CY	145	$ 50	$ 7,290
7	MNDOT SEED MIX 35-241	LB	11	$ 15	$ 170
8	6" PVC PIPE DRAIN CLEAN OUT	EA	8	$ 450	$ 3,600
9	6" PERF TP PIPE DRAIN	LF	500	$ 16	$ 8,200
10	6" GATE VALVE AND BOX	EA	4	$ 1,700	$ 6,800
11	BITUMINOUS PAVEMENT RESTORATION	SY	1422	$ 50	$ 71,111
12	CURB REPLACEMENT	LF	80	$ 100	$ 8,000
13	HDS STRUCTURE DELIVERED AND INSTALLED	LS	4	$ 18,000	$ 72,000
14	CONNECT TO EXISTING STORM SEWER	EA	8	$ 900	$ 7,200
15	EROSION AND SEDIMENT CONTROL	LS	2	$ 3,000	$ 6,000
				TOTAL ESTIMATED CONSTRUCTION COSTS	**$337,800.00**
				PROJECT CONTINGENCY (20%)	**$67,600.00**
				SURVEY/ENGINEERING/CONST ADMIN (20%)	**$67,560.00**
				TOTAL ESTIMATED PROJECT COSTS	**$472,960.00**
				POTENTIAL BWSR CWF GRANT REQUEST	***$354,720.00***
				POTENTIAL LOCAL MATCH REQUIREMENT	***$118,240.00***

Recommendations

A summary of the overall project's measurable water quality outcomes, an estimated cost for the improvements, and the anticipated cost per pound of sediment removed are summarized in **Table 9**. The following is a summary of recommendations.

- While Option 1 is the most cost effective, it presents multiple challenges from a constructability and maintenance perspective, further exacerbated by its location on USACOE property. Construction alone will require massive traffic control, which is also likely during construction. Given the quantity of cars using the corridor, access for maintenance and construction become more sensitive. Furthermore, since the structure is located directly online with the mainline storm sewer, the single HDS structure has a higher likelihood of seeing excessive stormwater runoff well beyond the water quality event. Therefore, stormwater flows have a higher potential to "flush" captured sediment and debris during storms larger than 1" in 24 hours.
- Similar to Option 1, Option 2 presents structure locations that are online with the mainline storm sewer. Therefore, stormwater flows have a higher potential to "flush" captured sediment and debris during storms larger than 1" in 24 hours. However, the contributing treatment areas are smaller than in Option1. Option 2 also presents some challenges in terms of construction and maintenance as the locations are located in high traffic and pedestrian use areas along County Road 66.
- The recommended option for Phase 3 of the project is Option 4, with four hydrodynamic separators and up to four bioretention basins along the curb line. Although this option has the highest total estimated cost, overall, this option will provide greater treatment in the long-term, making it the most sustainable option. Besides Option 1, this is the only alternative that effectively treats runoff from the west side of corridor, with the additional benefit of potential infiltration and removal of TP. Natural topographic depressions within the project area would be suitable for these surface treatment basins. Although Option 4 does not remove as much sediment as Option 1, it will be much more feasible in terms of construction, maintenance, and traffic control with the smaller HDS structures. Even if the City decides to implement only one or a few of the surface treatment features in Option 4, it will provide great benefits in terms of sediment and pollutant removal.
- Option 3 would be the second most effective solution; however, we would be missing out on the treatment of runoff from the roadway. The cost per pound removed for Option 3 and Option 4 are essentially the same.

Table 10: Summary of Overall Measurable Outcomes and cost efficiency.

	Total Annual Load Removed (lbs) [1]	Total Estimated Cost	Cost/Lb Removed
Option 1	2738	**$235,440**	$86
Option 2	1122	**$202,420**	$180
Option 3	1012	**$257,720**	$255
Option 4[2]	1987	**$472,960**	$238

[1] Estimated TSS removed based on MnDOT Road Sand Distribution

[2] Estimated TSS removed equals MnDOT Road Sand from HDS structures plus TSS removed at bioretention areas based on MIDS results

Maintenance

HDS structures have variable maintenance schedules depending on data collected during the first few years of operation. It is important for the organization responsible for maintenance to collect information on how much sediment and other solids accumulate during the year, taking into consideration seasonal variations. In other words, spring is likely to have higher accumulation of heavy sand particles, while fall is likely to have higher accumulation of leaf litter. The following is an anticipated maintenance schedule for HDS structures.

- First two years of operation - It is recommended that the HDS structures be monitored regularly and cleaned as many as 4 times per the manufacturer's recommendations.
- After the first two years - maintenance schedules may be adjusted based on watershed conditions.
- Removal of sediment should occur after approximately 12 to 18 inches of sediment accumulation and removal of trash and other floatables have accumulated and impacted overflow weir performance. Maintenance should be performed with a vacuum truck.

Surface BMPs such as bioretention features also require routine inspection and maintenance. The following is a general maintenance schedule for bioretention features.

- 2 to 3 times per week, first 4 months – Visual inspection for sediment accumulation. Pull weeds and other non-native plant species. Remove sediment accumulation at curb cut/pretreatment device.
- Weekly, first 4 months to first year – Visual inspection for sediment accumulation. Pull weeds and other non-native plant species. Remove sediment accumulation at curb cut/pretreatment device. Remove excess debris after significant rainfall. Ensure drain tile discharges during rainfall.
- After significant rainfall – Remove excessive accumulation of sediment and debris.
- Annually – Excavate all accumulated sediment. Reseed native vegetation as necessary. Scarify top 6" of filter/infiltration media to restore infiltration. Flush drain tile, as necessary, to ensure drain tile discharges as designed.
- First 3 to 5 years – mow native vegetation twice per year. Consider controlled burn biannually (once every two years) to control non-native and invasive species. Continue regular mowing as needed to control non-native and invasive species.

It is assumed that these features have a 30-year life cycle. Therefore, a good estimate of annual maintenance is to assume that the initial cost of the BMP will essentially be reinvested in the BMP over the course of its life cycle. In other words, the initial construction cost divided by 30 approximates annual maintenance costs.

Sincerely,

Bolton & Menk, Inc.

Timothy J. Olson, PE, CFM
Principal Water Resources Engineer