# Feasibility Report

# Rice Marsh Lake Subwatershed RM_12a Water Quality Improvement Project

Prepared for
Riley Purgatory Bluff Creek Watershed District

May, 2020

Feasibility Report

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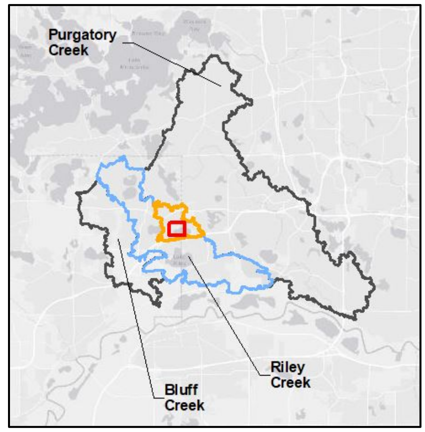
## Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

| | |
|---|---|
| | XXXXX |
| Scott Sobiech PE #: 41338 | Date |

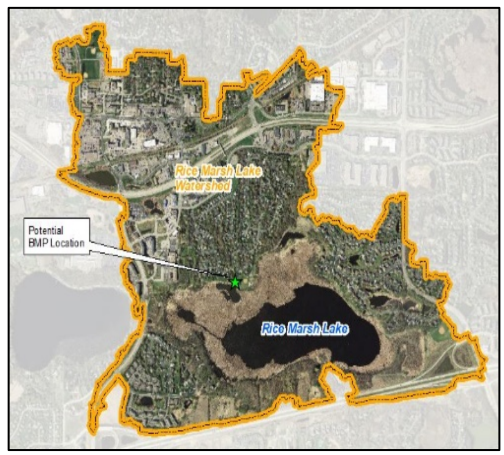
# Executive Summary

This study was completed to evaluate proposed actions within Rice Marsh Lake subwatershed RM_12a to improve the water quality in Rice Marsh Lake, located in the city of Chanhassen, Minnesota. The site was identified in the 2016 UAA as a location for a BMP to reduce the phosphorus loading to Rice Marsh Lake.




Site within Riley watershed

Seven best management practices (BMPs) were identified that would minimize site impacts, could be constructed on publically owned property, and have comparably low maintenance costs. The seven BMPs evaluated in various combinations include the following:




Location of proposed water quality BMP

### conventional BMPs

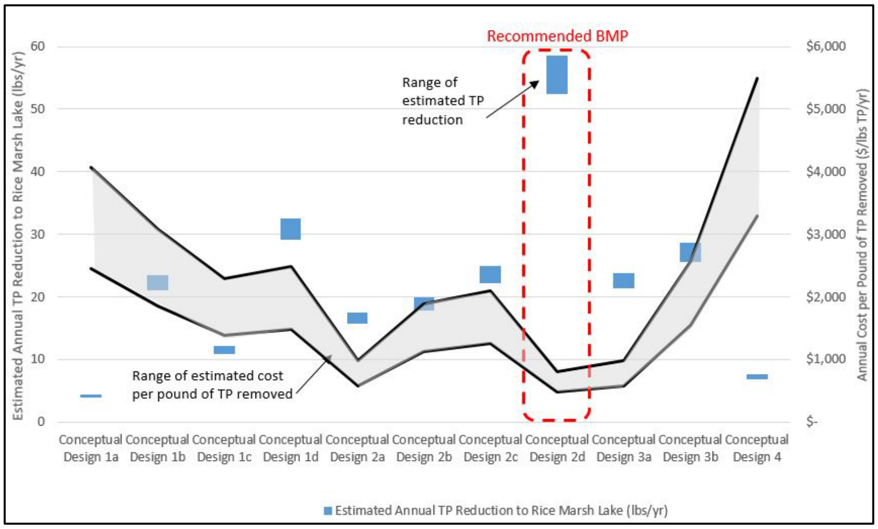
- Iron-enhanced sand filtration basin with underdrain
- Underground iron-enhanced sand filtration system with underdrain
- Subsurface gravel bed wetland
- Pond dredging

### proprietary BMPs

- Modular Wetland Systems (MWS) – Bio Clean (or similar)
- Kraken Filter – Bio Clean (or similar)
- Nutrient Removing Filtration System (NRFS) - SunTree (or similar)

An evaluation for each BMP was completed which considered water quality benefits, regulatory approvals, upland impacts, and cost to construct and maintain.

Based on the results of the evaluation, potential upland and tree impacts, as well as the cost per pound of phosphorous removed, a proprietary device, similar to the Bio Clean Kraken Filter, is the most feasible BMP for the site. The recommended BMP avoids damage to existing trees, has the lowest cost per pound of phosphorus removed and has the highest TP reduction to Rice Marsh Lake. Through a proprietary filtration media, the BMP has the potential to reduce phosphorus loading to Rice Marsh Lake by 52 to 59 pounds annually costing about $570 (ranging from $490 to $810) per pound of phosphorus removed when long-term maintenance is considered over a 30 year period. The engineer's opinion of probable cost for the design, permitting, and construction of the proprietary system is estimated at $569,000 with a potential range of $456,000 to $854,000 based on the feasibility level of design. Water quality BMPs require ongoing maintenance and operation to provide the intended water quality benefits. As additional site-specific information (e.g., soil borings) becomes available in the next stage of design, the proposed configuration, cost, performance of the BMP, and maintenance considerations will change. The District will also need to collaborate closely with the city of Chanhassen to ensure long-term maintenance.



Of the eleven BMPs evaluated, the stand-alone Kraken Filter (or similar) has the lowest annualized cost per pound of phosphorus removed and greatest TP load reduction to Rice Marsh Lake.

Other recommendations include the following:

- RPBCWD to monitor the Kraken for 2 to 4 years after construction,
- Collection of a sediment boring within the existing RM_12 pond,
- Incorporation of soil amendments (i.e., compost) and pollinator lawns into the disturbed area surrounding the BMP, with potential monitoring, and
- RPBCWD to conduct a study to enhance the understanding of soil health (structure) throughout the watershed.

# 1.0 Context and Goals for this Ecological Enhancement Plan

This report summarizes the proposed actions within subwatershed RM_12a to improve the water quality in Rice Marsh Lake, located in the city of Chanhassen, Minnesota. Figure 1-1 illustrates the Rice Marsh Lake watershed and drainage patterns of RM_12a and the contributing subwatersheds. This report is prepared under the direction of the Board of Managers of the Riley-Purgatory-Bluff Creek Watershed District.

The Riley-Purgatory-Bluff Creek Watershed District (RPBCWD or District) was established by the Minnesota Water Resources Board in 1969, acting under authority of the Watershed Law. As charged by the law and the order establishing the District, the general purpose of the District is to protect public health and welfare and to provide for the provident use of natural resources through planning, flood control, and conservation projects.

The District is located in the southwestern portion of the Twin Cities Metropolitan Area, encompassing an area of nearly 50 square miles. There are three major subwatersheds within the District—Riley Creek, with a watershed area of 10.0 square miles; Purgatory Creek (31.4 square miles), and Bluff Creek (5.9 square miles). All three creeks discharge to the Minnesota River. Stormwater management and development were guided by the District's 1973 Overall Plan, revised in May 1996, February 2011, and July 2018 in accordance with the Metropolitan Surface Water Management Act and Watershed Law (Minnesota Statutes Chapters 103B and 103D). The 2018 document is the current guiding document of the District (the Plan).

The Rice Marsh Lake and Lake Riley use attainability analysis (UAA) was prescribed by the 1996 Riley-Purgatory-Bluff Creek Watershed District Water Management Plan. The Rice Marsh Lake UAA was updated in January 2016 as part of *the Rice Marsh Lake and Lake Riley Use Attainability Analysis* and includes recommended remedial measures to improve the water quality (Barr Engineering, 2016).

The UAA provides the scientific foundation for lake-specific management plans that will preserve existing—or achieve potential—beneficial uses of the lakes. The UAA is a structured, scientific assessment of the factors affecting attainment of a beneficial use under both current and ultimate watershed development conditions. "Use Attainment" refers to achievement of water quality conditions that support lake-specific uses such as swimming, fishing, wildlife habitat, and aesthetic viewing.

The 2016 UAA Update was completed with the goal of: (1) assessing the water quality of major lakes in the Riley watershed based on more recent physical, chemical, and biological data, (2) improving the understanding of current water quality concerns in the lakes, and (3) identifying best management practices (BMPs) to improve and protect the lakes' water quality and increase the likelihood of them being removed from the Minnesota Pollution Control Agency's (MPCA) list of impaired waters list for excess nutrients. The overarching purpose of the UAA update was to identify and evaluate BMPs that can be implemented to improve and/or protect the lakes' water quality and achieve the long-term vision of sustainable uses, as outlined in the District's Plan.

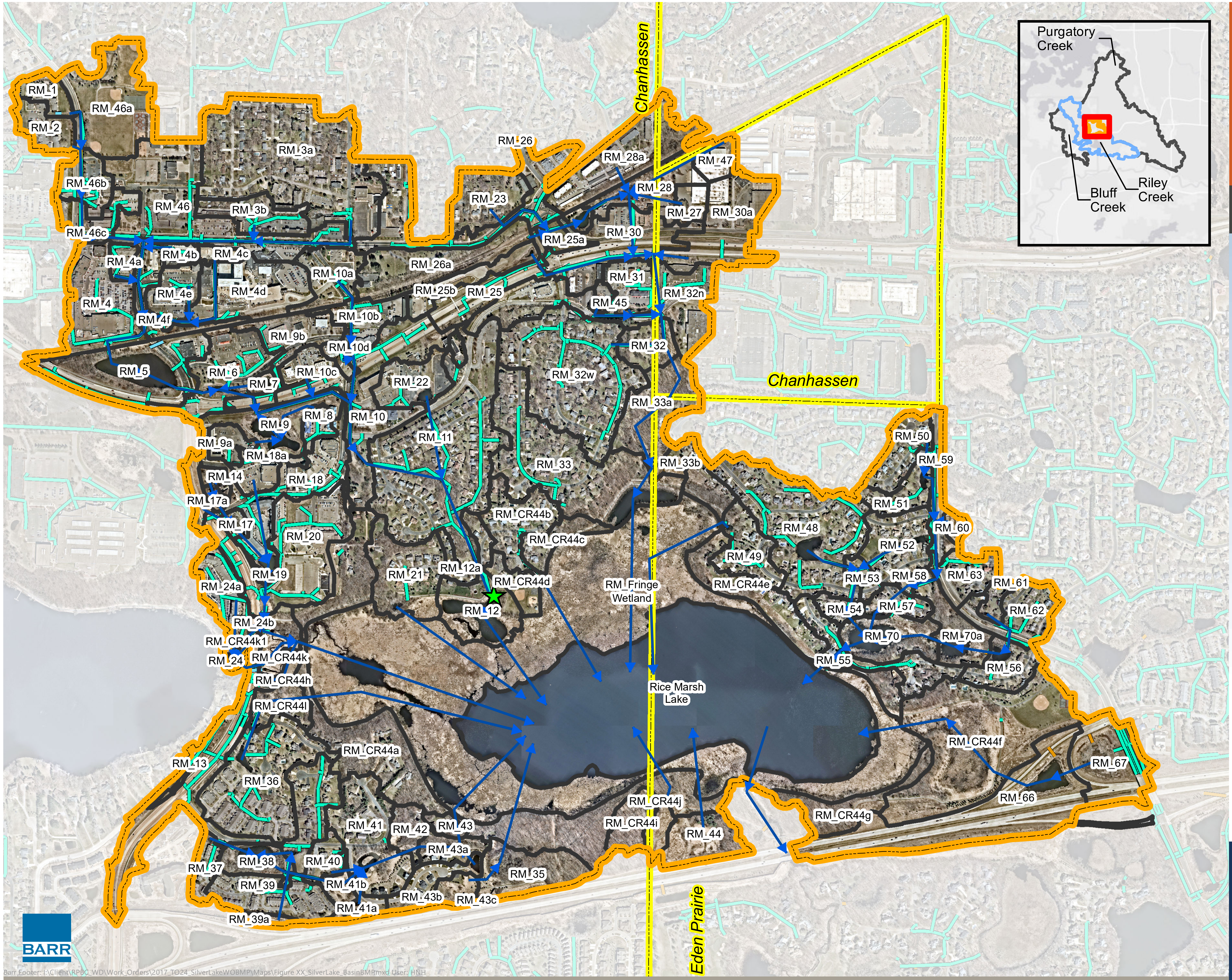
The District's 2018 Plan articulates the long-term vision of sustainable uses for each of its water bodies. Achieving this vision will result in:

- Waters dominated by diverse native fish and plant populations.
- Lakes with water clarity of 2 meters or more.
- Delisting of half of all impaired (303d) lakes or stream reaches.
- An engaged and educated public and scientific community that participates in adaptive management activities.
- Regulatory recommendations necessary for municipal, county, and state authorities to sustain the achieved conditions.

In February 2020, the MPCA released the Lower Minnesota River Watershed Total Maximum Daily Load (TMDL) Report which incorporates the 2016 UAA modeling and water quality data reported in the 2016 UAA. The TMDL utilizes the UAA to determine pollutant loading to the lake and estimate the required load reductions to meet the water quality goals (Agency, 2020).

# RICE MARSH LAKE WATERSHED AND FLOW PATTERNS

## FIGURE 1-1




Potential BMP Location
Flow Directions
Rice Marsh Lake Watershed
Municipal Boundaries
Rice Marsh Lake Subwatersheds

N

0 262.5 525 1,050 1,575 2,100 Feet

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

## 1.1 Vision, Approach and RM_12a Project Goals

The 2016 UAA update identified the Rice Marsh Lake subwatershed RM_12a as a targeted location within the Rice Marsh Lake watershed to reduce the phosphorus loading and improve the water quality of Rice Marsh Lake. The UAA indicates that runoff from approximately 232 acres drains through the location of the potential stormwater treatment system. The UAA suggests that an iron enhanced sand filtration system on the north side of Rice Marsh Lake just south of Dakota Lane and west of the baseball field in Rice Marsh Lake would be approximately 0.13 acres at the surface with the potential to reduce the annual total phosphorus (TP) loading to Rice Marsh Lake by 46 pounds. The UAA suggests a cost-benefit of about $265 per pound of TP removed, assuming the BMP functions for 30 years. Figure 1-2 shows the location of the proposed iron-enhanced sand BMP in the UAA report.

The 2018 Plan included this site a potential BMP location as part of the 10-year capital improvement program. The potential BMP was ranked using the District's prioritization metric which resulted in the score summarized in Table 1-1.

**Table 1-1 RM_12a Project Benefit Score(1)**

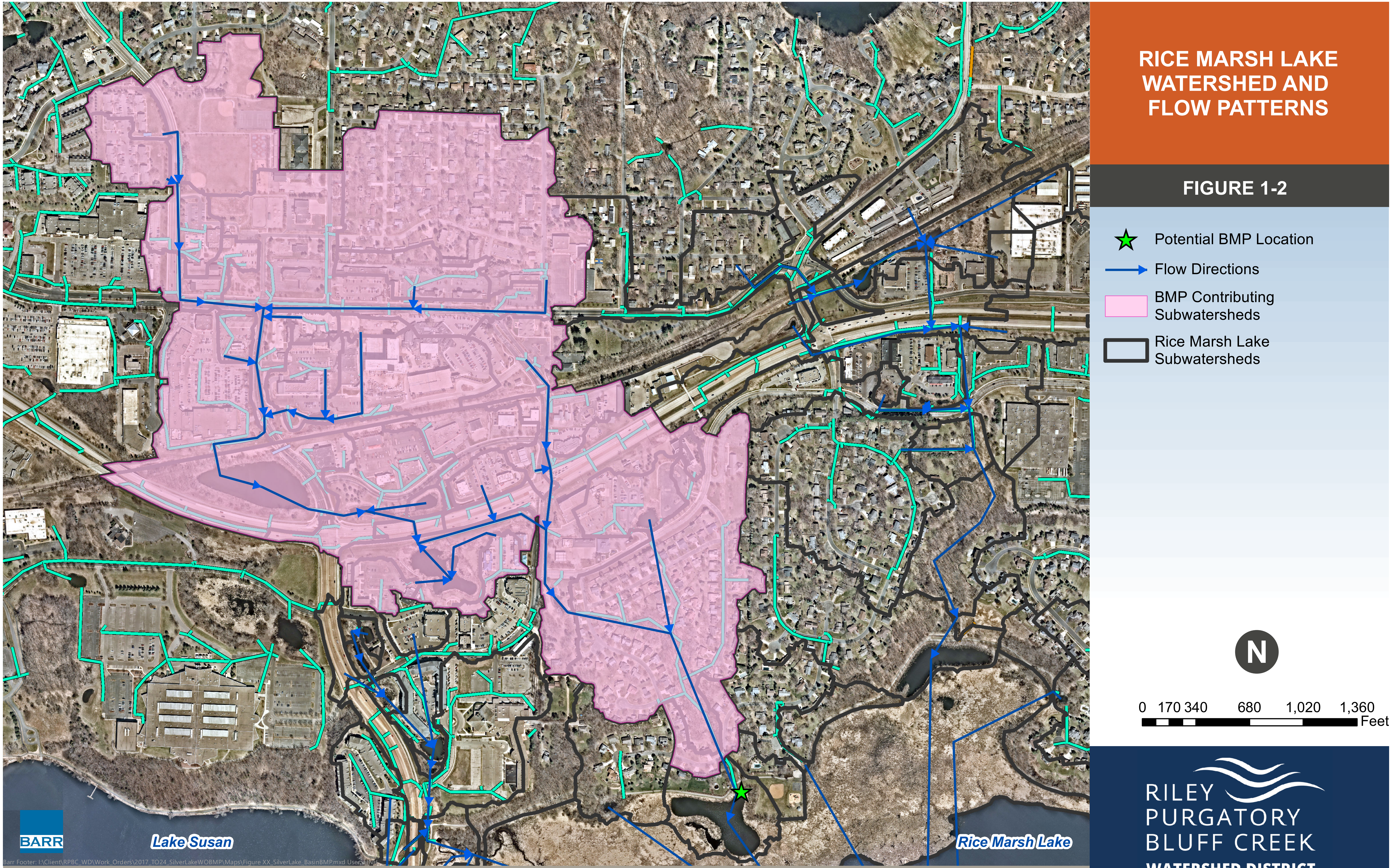
| Goal Index | Sustainability Index | Volume Management Index | Pollutant Management | Stabilization | Habitat Restoration | Partnership | Education | Watershed Benefit | Total Benefit Score |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 5 | 1 | 3 | 1 | 1 | 7 | 5 | 3 | 28 |

(1) See Section 4 of 10-Year Watershed Management Plan for additional details about the RPBCWD prioritization methodology and associated descriptions for the variables used to assess multiple project benefits.

The District ordered this feasibility study to evaluate the viability of constructing a BMP to treat runoff from the 232 acre watershed, and to identify if an iron enhanced sand filtration system would be the preferred BMP for the site. This study evaluates the feasibility of other stormwater BMPs, as well. Estimated total phosphorus removals and engineer's opinion of project costs were determined for ten feasible BMPs.

**RICE MARSH LAKE WATERSHED AND FLOW PATTERNS**

**FIGURE 1-2**




RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

## 1.2 Rice Marsh Lake Water Quality Goals and Current Lake Conditions

The MPCA lake eutrophication criteria establish water quality standards for lakes based on total phosphorus, chlorophyll *a*, and Secchi disc transparency ( Minnesota Pollution Control Agency, 2017). The standards are based on the geographic location of the water body (and associated ecoregion) and its depth (shallow vs. deep lakes). The growing season average Total Phosphorus (TP) concentration for the most recent 10 years (86 µg/L) for Rice Marsh Lake based on measurements collected by RPBCWD consistently failed to meet the MPCA water quality standards as shown in Figure 1-3. The growing-season average TP concentrations in years 2004, 2005, 2017, and 2019 were calculated as 56, 35, 60, and 33 µg/L, respectively, which are the only four years that meet the MPCA goal of ≤60 µg/L, and the four lowest growing season average concentrations on record since recording began in 1972. The next lowest growing season average was 76 µg/L in 2016. TP concentrations reached a maximum value of 709 µg/L in 1972 and has a generally decreasing trend since recording began.

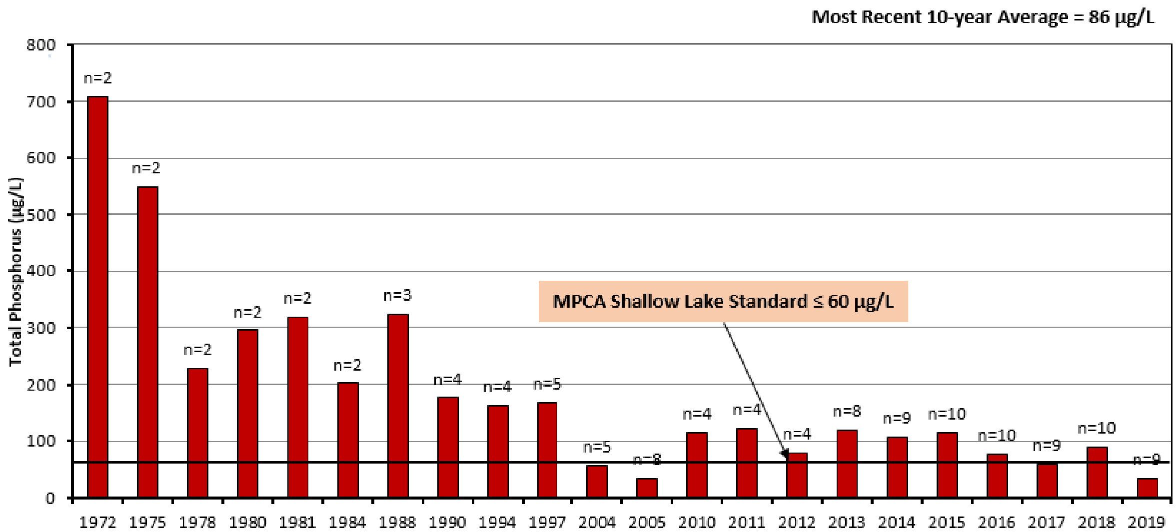



**Figure 1-3 Growing Season (June through September) Total Phosphorus Concentrations in Rice Marsh Lake from 1972 to 2019 (µg/L)**

Historically Chl-a concentrations in Rice Marsh Lake have exceeded the District goal of 14 µg/L for all but 6 years on record since 1972. The 2019 growing season average concentrations was 5 µg/L, which was the lowest value on record. The highest average value recorded was 189 µg/L in 1972.

Historical Secchi depths in Rice Marsh Lake have achieved the MPCA goal of ≥1.0 meter in the most recent 10 years. The highest (best) value in the past 10 years was 2.3 m in 2017 and 2019. The lowest (worst) value calculated was 0.9 meters in 2015.

An in-lake model was used to determine TP load reductions needed to meet the water quality goal for Rice Marsh Lake. Table 1-2 shows the measured and modeled growing season average (June – September) concentration, the TP load to the lake under existing conditions, the water quality goal, the TP loading capacity for meeting the water quality standard, and the required percent reduction needed to meet the TP goal (Barr Engineering, 2016). Under existing conditions, Rice Marsh Lake is not meeting the MPCA's water quality goal for a shallow lake of 60 µg/L. Modeled and measured growing season average concentrations in the lake surfaces waters for the 2015 water year was 110 µg/L and 107 µg/L respectively. The estimated TP load under existing conditions was 1,642 pounds for the 2014 water year. To achieve the TP goal the load to Rice Marsh Lake would need to be reduced by 681 pounds, resulting in a 41% TP load reduction.

**Table 1-2 Rice Marsh Lake estimated load reductions required to meet TP water quality goal for 2014 water year(1)**

| Measured growing season average TP concentration (µg/L) | Modeled growing season average TP concentration (µg/L) | Estimated 2014 TP loading rate (lbs/yr) | TP concentration goal (µg/L) | Estimated Loading Capacity to meet WQ goal (lbs/yr) | Percent reduction needed to achieve goal (%) |
|---|---|---|---|---|---|
| 107 | 110(2) | 1,642 | 60 | 961 | 41% |

(1) Values cited from the Lower Minnesota River Watershed Total Maximum Daily Load Part II (Agency, 2020)
(2) Volumetric average concentration for entire water column

# 2.0 Existing Conditions

## 2.1 Rice Marsh Lake Watershed and Lake Description

Rice Marsh Lake is located within the Riley Creek watershed. Riley Creek flows through Rice Marsh Lake, with the natural channel outlet located on the south side of the lake. Water levels in Rice Marsh Lake are controlled mainly by weather conditions (snowmelt, rainfall, and evaporation) and by the elevation of the streambed of Riley Creek, which is approximately 875 feet MSL. Rice Marsh Lake is split between the boundaries of the city of Chanhassen and the city of Eden Prairie. The overall watershed to Rice Marsh Lake is approximately 3,442 acres and includes the areas that drain through Lake Lucy, Lake Ann, and Lake Susan. The direct watershed to Rice Marsh Lake is approximately 966 acres, including the surface area of the lake, and comprises portions of Chanhassen and Eden Prairie. (Figure 1-1). Much of the Rice Marsh Lake watershed is developed with only a few areas expected to have changes in land use in the future, mostly in the western portion of the watershed. The existing land use within the Rice Marsh Lake watershed is primarily low- and medium-density residential, commercial, and open-space/park areas with some undeveloped, institutional, and high-density residential areas. The large park and undeveloped areas around Rice Marsh Lake are not expected to change significantly under future conditions.

Table 2-1 provides a summary of the physical characteristics for Rice Marsh Lake. Rice Marsh Lake has an open-water surface area of approximately 83 acres. The lake is shallow, with a maximum depth of approximately 11 feet and mean depth of approximately 5 feet. The lake area, depth, and volume depend on the water level of the lake, which has been observed to vary between a high measurement of 877.25 feet mean sea level (MSL) in 2012 to a low measurement of 872.0 feet MSL in 1976. Since 1970, water levels have typically been between 874 and 877 feet MSL. Given the shallow nature of Rice Marsh Lake, especially in comparison with its large surface area, the lake would be expected to be prone to frequent wind-driven mixing. While daily monitoring of the lake would be necessary to precisely characterize its mixing characteristics, review of temperature and dissolved oxygen profile data along the depth of the lake suggests that Rice Marsh Lake is polymictic, thermally stratifying and destratifying numerous times throughout the summer.

### Table 2-1 Rice Marsh Lake physical parameters

| Lake Characteristic | Rice Marsh Lake |
|---|---|
| Lake MDNR ID | 10000100 |
| MPCA Lake Classification | Shallow |
| Water Level Control Elevation (feet) (1) | 875.0 |
| Surface Area (acres) | 83 |
| Mean Depth (feet) | 5 |
| Maximum Depth (feet) | 11 |
| Littoral Area (acres) | 81 |
| Volume (below control elevation) (acre-feet) | 375 |
| Thermal Stratification Pattern | Dimictic |
| Estimated Residence Time (years) – 2014 Climatic Conditions | 0.13 |
| Estimated Residence Time (years) – 2010 Climatic Conditions | 0.22 |
| Watershed Area Tributary to Upstream Lake | 2,476 |
| Total Watershed Area | 3,442 |
| Subwatershed Area (acres) | 966(2,3) |
| Trophic Status Based on 2014 Growing Season Average Water Quality Data | Hypereutrophic |

(1) The water level control elevation from Rice Marsh Lake based on channel elevation determined from MDNR LiDAR data (2011) and Barr survey data (Data)
(2) Watershed area includes surface area of lakes.
(3) Does not include Lake Lucy, Lake Ann or Lake Susan Lake watersheds

## 2.2 Project Area Watershed

The drainage area to the proposed BMP in the RM_12a subwatershed to be approximately 232 acres.  The drainage area based on the proposed BMP location south of Dakota Lane is shown in Figure 1-2. The land use classification of the subwatershed is primarily low- and medium-density residential, commercial, and open-space/park areas with some undeveloped, institutional, and high-density residential areas.

## 2.3 Site Features

The project site consists of park space and managed vegetation. There is a baseball field south of the existing pedestrian trail (**A.** in Figure 2-1). The depressed area northwest of the baseball field and beneath the existing trail (**B.** in Figure 2-1) could support the placement of a BMP.

**A.** Project site looking east from park trail towards the baseball field

**B.** Project site looking south at RM_12 pond

**Figure 2-1 Site Features**

# 3.0 P8 Model Calibration

RPBCWD has collected several years of monitoring data at the proposed location of the RM_12a BMP. These data were used to calibrate/validate the existing water quality modeling of the RM_12a subwatershed. The updated water quality modeling formed the basis for the estimated phosphorus removal from the conceptual designs.

## 3.1 RM_12a Monitoring Data

The District gathered grab and composite samples in a manhole along the stormsewer south of Dakota Lane draining to the RM_12 pond. Grab and composite samples of total suspended soils (TSS), total phosphorus (TP), and total dissolved phosphorus (TDP) were collected during 2016, 2017, and 2018. Continuous flow data through the stormsewer was also collected from 2016 through 2018. District staff reported that the location of the monitoring gauge was not ideal for accurate readings. In many cases, the sensor did not capture the entire flow hydrograph, and field notes revealed that debris was often found on the sensor.

The composite water quality samples were often collected very quickly, capturing only portions of the rising limb of the flow hydrograph. As a result, phosphorus and total suspended solids concentrations are not representative of the entire event and are likely only reflective of pollutant concentrations from the direct residential subwatershed north of Dakota Lane.

Due to the shortcomings in the data, only a handful of events contained enough information to inform the model calibration. The calibration events meeting the following criteria were chosen:

1. velocity and depth readings were collected for the entire event hydrograph;
2. field notes indicated the measured and recorded depths were similar during dates leading up to the event;
3. the composite sample start and end times fell along a representative segment of the flow hydrograph; and

4. the total daily precipitation depth used in the model was similar to the daily depth reported in the National Weather Service (NWS) Chanhassen precipitation gauge closest to the monitoring site.

Variability in observed data leads to uncertainty in the model calibration. Total phosphorus loading to each BMP will be presented in a range in Section 6.0 and Section 7.0.

## 3.2 P8 Calibration

Before calibrating the water quality model, the hydrology parameters were updated to reflect more detailed land use conditions. The University of Minnesota published a high-resolution land-cover dataset in 2015. This dataset was used to estimate the total percent imperviousness for each subwatershed. The percent directly connected impervious was determined based on the classification from the 2016 Met Council Generalized Land Use dataset.

### 3.2.1 Volume Calibration

The water quality model was first calibrated to the recorded flow data from the selected events by comparing total volume between the model and the observed data. Precipitation data from the Flying Cloud Drive rain gauge, supplemented with precipitation data from the Minneapolis - St. Paul International Airport to fill data gaps, was used for calibration. In order to match the observed volumes for the selected events, the following adjustments were made to the P8 model:

1. the Antecedent Moisture Content (AMC) was set to remain at 2,
2. the pervious curve number was increased by 10%, and
3. the time of concentration from RM_11 was increased to simulate the flow restriction caused by the grate inlet on the north side of Dakota Lane.

Figure 3-1 shows the uncalibrated and calibrated total event volumes compared to the monitoring data. The uncalibrated model total volume was 18% higher than the observed data; whereas, the calibrated model total volume is within 1% of the observed total volume for the selected events.

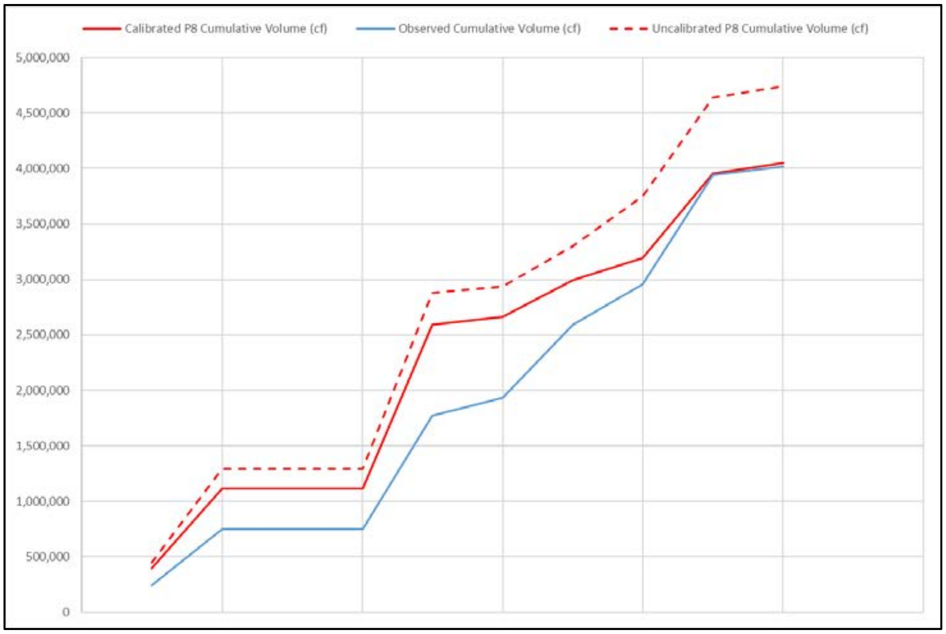



**Figure 3-1 Modeled vs. Observed Cumulative Event Volumes**

### 3.2.2 Pollutant Calibration

After the model was calibrated to flow data, modeled event mean concentrations of TSS and TP were compared to the selected composite samples. Events were removed from the analysis where flow data was incomplete or where composite sample start and end dates did not capture any portion of the flow hydrograph. The following adjustments were made to calibrate the model to monitoring data:

1. The TSS particle scale factor was increased from 1.0 to 1.4.
2. The TP particle fractions were revised to the following:

| Particle Fraction | Unadjusted TP (mg/kg) | Adjusted TP (mg/kg) |
|---|---|---|
| P0% | 99000 | 53000 |
| P10% | 3850 | 5500 |
| P30% | 3850 | 5500 |
| P50% | 3850 | 5500 |
| P80% | 0 | 0 |

Figure 3-2, Figure 3-3, and Figure 3-4 summarize the cumulative event load for TP, DP, and TSS, respectively, for the selected calibration events.

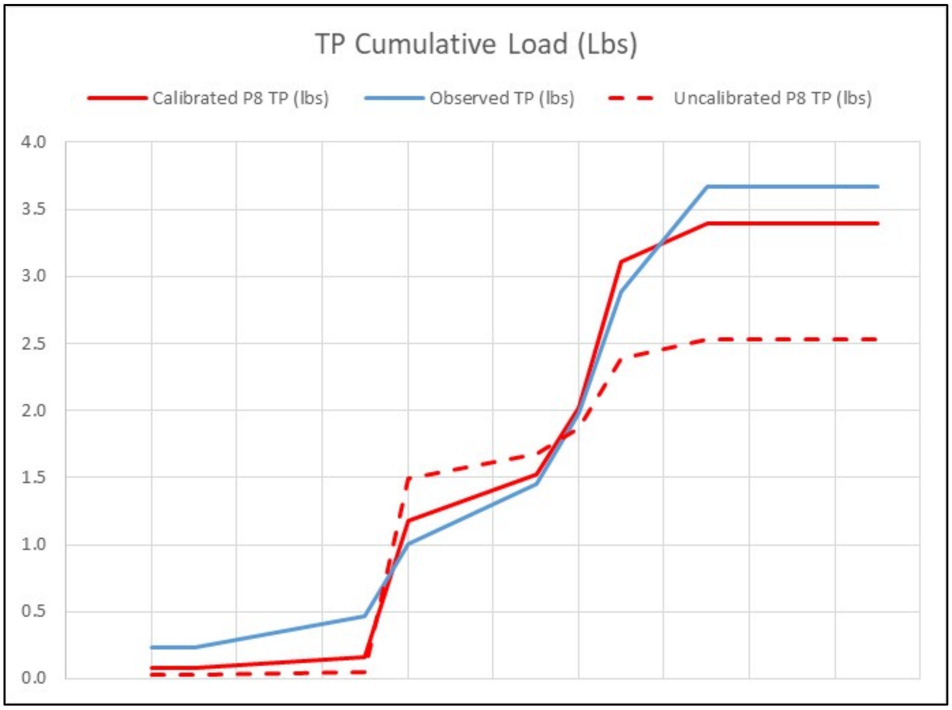



**Figure 3-2 Modeled vs. Observed Cumulative Event TP Load**

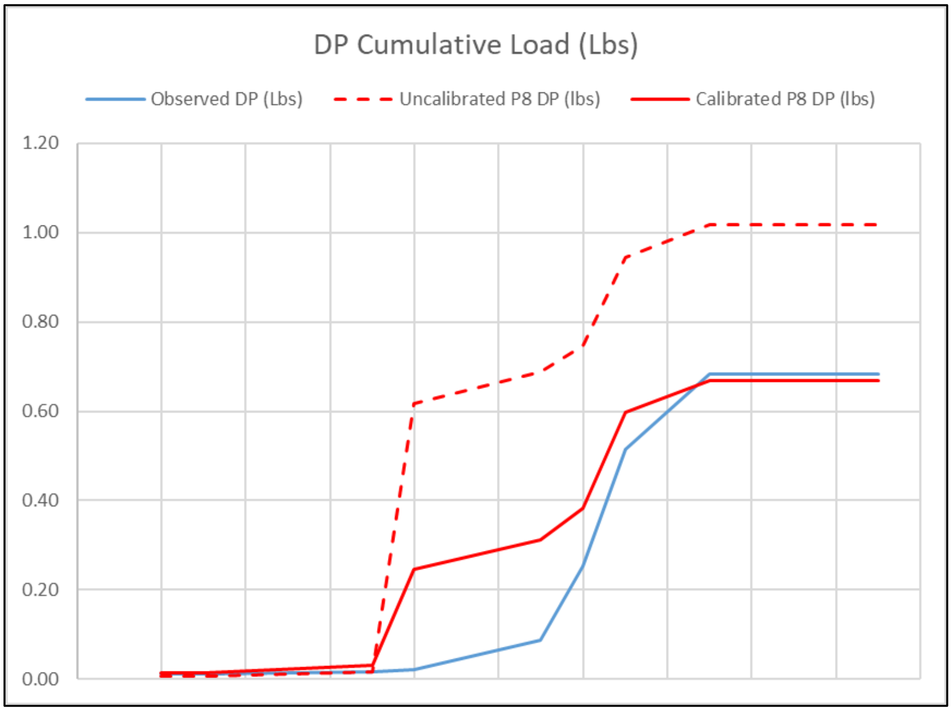



**Figure 3-3 Modeled vs. Observed Cumulative Event DP Load**

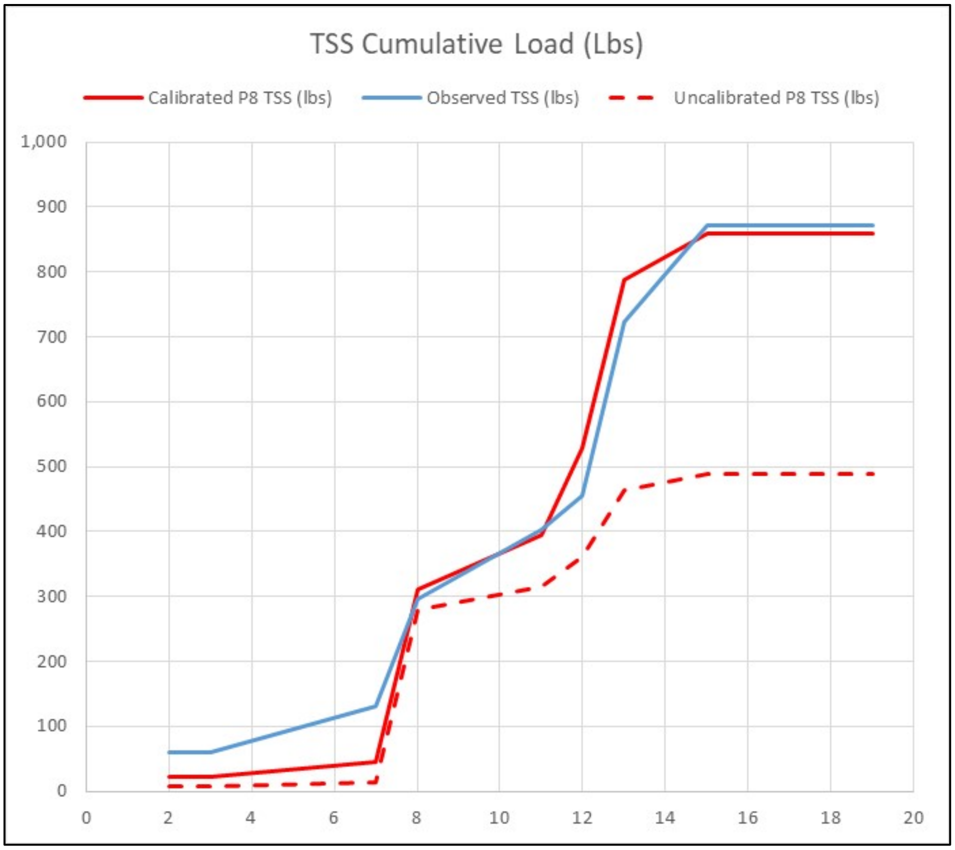



**Figure 3-4 Modeled vs. Observed Cumulative Event TSS Load**

# 4.0 Preliminary BMP Screening

Selection of feasible stormwater BMPs occurs by considering a holistic approach that accounts for unique site constraints, operation and maintenance, environmental concerns, effectiveness, and overall cost. Stormwater BMPs can provide stormwater treatment to reduce or limit downstream pollutant loading in several ways. Many stormwater manufactured treatment devices (MTDs) utilize a combination of the following practices:

- Pretreatment: upstream sedimentation, screening, and/or energy dissipation to protect and extend the long-term functionality of the downstream BMP.
- Infiltration: stormwater enters the soil at the source; sediment and pollutants remain onsite.
- Sedimentation: as part of stormwater detention, sediment and non-dissolved (particulate) pollutants settle to the bottom of the water column.
- Filtration: stormwater is routed through a filtering medium to trap sediment and pollutants but allow stormwater to pass through.
- Biofiltration: similar to filtration, but additional pollutant removal is provided by evapotranspiration from the vegetation.
- Chemical Treatment: chemicals are used to target and trap, settle, or breakdown specific pollutants.

## 4.1 BMP Background

Two types of BMPs were considered during the preparation of this report: conventional BMPs and manufactured treatment devices (MTDs).

### 4.1.1 Conventional Stormwater BMP Background

Conventional Stormwater BMPs temporarily store and treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities (Schueler, 1987). Conventional BMPs control TSS and TP loadings by slowing stormwater and allowing particles to settle or be filtered in areas before reaching receiving waters. More recently, these conventional BMPs have been modified and enhanced with materials such as iron filings or spent lime to improve removal of not only the pollutants associated with particulates but to also begin addressing the soluble fraction of pollutants (such as phosphorus) that cannot be filtered or settled out of runoff. The MPCA's Minnesota Stormwater Manual provides estimated median pollutant removal percentages for conventional stormwater BMPs as shown in Table 4-1.

**Table 4-1 Conventional stormwater BMPs and estimated median pollutant removal efficiencies**

| Practice | Treatment Type | Pollutant Removal Efficiencies (%) | | | |
|---|---|---|---|---|---|
| | | Total Suspended Solids (TSS) | Total Phosphorus (TP) | Particulate Phosphorus (PP) | Dissolved Phosphorus (DP) |
| Infiltration(1) | Infiltration | 100(2) | 100(2) | 100(2) | 100(2) |
| Biofiltration | Biofiltration | 80 | 44-71 | 80 | 0-60 |
| Sand filter | Filtration | 85 | 50 | 91 | 0 |
| Iron enhanced sand filter | Filtration and Chemical | 85 | 77 | 91 | 60 |
| Dry Swale | Pretreatment | 68 | 44-71 | 80 | 0-60 |
| Wet Swale | Pretreatment | 68 | 0 | 0 | 0 |
| Stormwater Pond(3) | Sedimentation | 84 | 50 | 91 | 0 |
| Stormwater Wetland | Sedimentation and Biofiltration | 73 | 38 | 69 | 0 |
| Permeable Pavement | Infiltration or Filtration | 74 | 45 | 82 | 0 |
| Green Roof | Pretreatment | 85 | 0 | 0 | 0 |

(1) BMPs designed to infiltrate stormwater runoff, such as infiltration basins/trenches, bioinfiltration, permeable pavement with no underdrain, tree trenches with no underdrain, and BMPs with raised underdrains.
(2) Pollutant removal is 100 percent for the volume infiltrated and 0 percent for the stormwater bypassing the BMP. For filtered stormwater, see values for the other BMPs in the table.
(3) Dry ponds do not receive credit for volume or pollutant removal.

### 4.1.2 Manufactured Treatment Device Background

There are many options on the market for stormwater MTDs. Two manufacturers that appear to be active in Minnesota are Bio Clean Environmental and Contech Engineered Solutions. While Table 4-2 lists a summary of numerous manufacturers that provide MTDs for filtration, biofiltration, or chemical treatment, it is not intended to be all-inclusive. MTDs designed primarily for pretreatment, infiltration, or sedimentation practices are not included in the table.

## Table 4-2 Manufacturers and stormwater MTDs

| Manufacturer | MTD | Treatment Type |
| --- | --- | --- |
| AquaShield | Aqua-Filter with Perlite Media | Filtration and Chemical |
| AquaShield | BioFilter | Biofiltration |
| BaySaver Technologies | BayFilter with Enhanced Media Cartridges | Filtration and Chemical |
| Bio Clean Environmental Services | Kraken Filter | Filtration |
| Bio Clean Environmental Services | Modular Wetland Systems | Biofiltration |
| Bio Clean Environmental Services | Water Polisher | Filtration |
| Contech Engineered Solutions | Filterra | Biofiltration |
| Contech Engineered Solutions | Jellyfish Filter | Filtration |
| Contech Engineered Solutions | StormFilter with PhosphoSorb Media | Filtration and Chemical |
| Cultec | StormFilter 330 | Filtration |
| Environmental 21 | ESK Koala | Filtration |
| Environmental 21 | PuriStorm | Filtration |
| Hydro International | Bioinfiltrator | Biofiltration |
| Hydro International | Up-Flo Filter with CPZ Media | Filtration and Chemical |
| Lane Enterprises | StormKleener | Filtration |
| Oldcastle Infrastructure | BioMod | Biofiltration |
| Oldcastle Infrastructure | BioPod | Biofiltration |
| Oldcastle Infrastructure | PerkFilter with ZPC Media | Filtration and Chemical |
| Rotondo Environmental Solutions | StormGarden | Biofiltration |
| StormTree | Tree Filter | Biofiltration |
| StormTree | DrainGarden | Biofiltration |
| StormwateRx | Aquip | Filtration |
| SunTree Technologies | Nutrient Removing Filtration System (NRFS) | Filtration and Chemical |
| SunTree Technologies | NutriMax Engineered Wetlands | Biofiltration |
| SunTree Technologies | SkimBoss UpFlow Filter | Filtration and Chemical |

Manufacturers of stormwater MTDs often subject their devices to third party testing to establish or verify treatment and pollutant removal efficiency. Third-party entities provide varying levels of verification or certification (Table 4-3) and pollutant removal efficiencies also vary between manufacturer claims, laboratory testing, and field testing (Table 4-4).

### Table 4-3 Third-party testing entities, programs, and approvals

| Entity | Program | Approval | Approval Qualifications | Approval Level |
|---|---|---|---|---|
| State of Washington Department of Ecology (WADOE) | Technology Assessment Protocol – Ecology (TAPE) | Pilot Use Level Designation (PULD) | Laboratory Testing Data | N/A |
| | | Conditional Use Level Designation (CULD) | Laboratory Testing Data and Field Testing Data | N/A |
| | | General Use Level Designation (GULD) | Laboratory Testing Data and Field Testing Data following TAPE protocol | Removal of 50% TP and 80% TSS |
| New Jersey Corporation for Advanced Technology (NJCAT) | Technology Verification Program | Verification | Laboratory Testing and Assessment of Data Quality (QA/QC) | N/A |
| State of New Jersey Department of Environmental Protection (NJDEP) | Process for Approval of Use for MTDs | Certification | NJCAT Verification | Removal of 80% TSS |
| Canadian Environmental Technology Verification (ETV) Program | General Verification Protocol (GVP) and General Test Protocol | Verification and Certification | Laboratory Testing Data and Field Testing Data | N/A |
| Environmental Protection Agency (EPA) | Environmental Technology Verification (ETV) Program [1] | Verification | Unknown | Unknown |

## Table 4-4 MTDs and claimed removal efficiencies

| Manufacturer and MTD | Removal Efficiency (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Manufacturer's Performance Claims | | Lab Testing | | WADOE TAPE Certification | | NJDEP Certification | |
| | TSS | TP | TSS | TP | TSS | TP | TSS | TP |
| AquaShield Aqua-Filter with Perlite Media | - | - | 92 | 69 | CIP | CIP | 80 | - |
| AquaShield BioFilter | - | - | - | - | - | - | - | - |
| BaySaver Technologies BayFilter with Enhanced Media Cartridges | 80 | 65 | 80 | 64 | 80 | 50 | 80 | - |
| **Bio Clean Environmental Services Kraken Filter** | **89** | **72** | **85** | **72** | **CIP** | **CIP** | **80** | **-** |
| Bio Clean Environmental Services Modular Wetland Systems | 85 | 64 | 85 | 65 | 80 | 50 | - | - |
| Bio Clean Environmental Services Water Polisher | 85 | 70 | - | - | - | - | - | - |
| Contech Engineered Solutions Filterra | 86 | 70 | 85 | 73 | 80 | 50 | 80 | - |
| **Contech Engineered Solutions Jellyfish Filter** | **89** | **59** | **89** | **59** | **CIP** | **CIP** | **-** | **-** |
| Contech Engineered Solutions StormFilter with PhosphoSorb Media | 89 | 82 | 85 | 75 | 80 | 50 | 80 | - |
| Cultec StormFilter 330 | 70 | - | - | - | - | - | - | - |
| Hydro International Bioinfiltrator | - | - | - | - | - | - | - | - |
| Hydro International Up-Flo Filter with CPZ Media | - | - | 83 | - | - | - | 80 | - |
| Lane Enterprises StormKleener | 80 | - | - | - | - | - | 80 | - |
| Oldcastle Infrastructure BioPod | - | - | 84 | 64 | 80 | 50 | 80 | - |
| Oldcastle Infrastructure PerkFilter with ZPC Media | 80 | 60 | 85 | 62 | 80 | 50 | 80 | - |
| Rotondo Environmental Solutions StormGarden | - | - | 85 | 54 | CIP | CIP | - | - |
| StormTree DrainGarden | - | - | - | - | - | - | - | - |
| StormTree Tree Filter | 85 | 63 | 94 | 38 | CIP | CIP | - | - |
| StormwateRx Aquip | - | - | 98 | 60 | CIP | CIP | - | - |
| SunTree Technologies Nutrient Removing Filtration System | 95 | 95 | 61 | - | - | - | 50 | - |
| SunTree Technologies NutriMax Engineered Wetlands | 83 | 57 | - | - | - | - | - | - |
| SunTree Technologies SkimBoss UpFlow Filter | 81 | 79 | - | - | - | - | - | - |

Manufacturers and MTDs in **bold** have been submitted to the RPBCWD for review
Manufacturers' performance claims obtained from brochures or websites
CIP = Certification in Progress
SCC removal efficiency, not TSS removal efficiency

## 4.2 BMP Evaluations

When evaluated individually, there may be several BMPs that meet the recommendations from the UAA. However, when multiple potential BMPs are compared, more feasible options may be identified. The first step to identify feasible BMPs for the RM_12a watershed was to complete a high-level qualitative screening. Both proprietary (aka MTDs) and conventional BMP options were considered. The screening compares several BMPs based on site specific requirements including minimizing site impacts, could be constructed primarily on publicly owned property, and have comparably low maintenance costs. In this analysis, seven conventional treatment devices (Table 4-5) and sixteen manufactured treatment devices (Table 4-6) were identified as part of the initial high-level screening. The tables list each BMP considered and summarize associated performance, estimated footprint, maintenance, design concerns, and schematic. Devices which were similar in design and approach were grouped together and are summarized in Table 4-5 and Table 4-6. The differences between treatment devices presented in the tables were used to identify five potentially feasible BMPs for the site, which are listed below and highlighted in green in Table 4-5 and Table 4-6. BMPs that were not identified for further evaluation are highlighted in red.

### 4.2.1 Conventional BMPs Evaluated

For this evaluation, a conventional BMP is defined as a BMP that a contractor could construct without purchasing a manufactured treatment system from a third party manufacturer. Examples of conventional BMPs are iron enhanced sand filtration, infiltration, woodchip bioreactors, and biofiltration. Four BMPs were identified based on nutrient reduction performance, device footprint and site constraints, and maintenance requirements. The most feasible conventional BMPs for the site are listed below.

- Iron-enhanced sand filtration system with underdrain
- Underground iron-enhanced sand filtration system with underdrain
- Subsurface gravel bed wetland with underdrain
- Dredging of existing RM_12 constructed pond

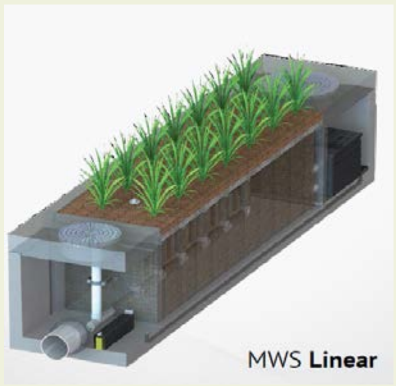
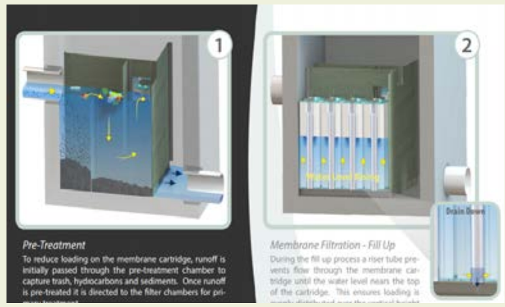
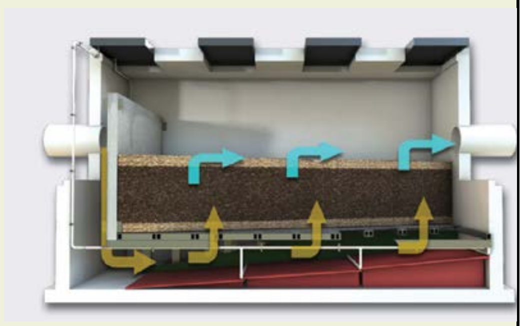
**Table 4-5 Conventional BMP Evaluation Matrix**

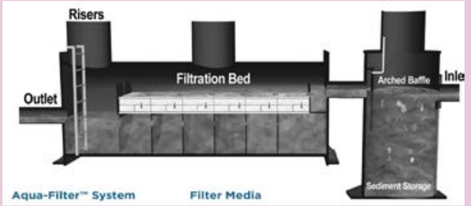
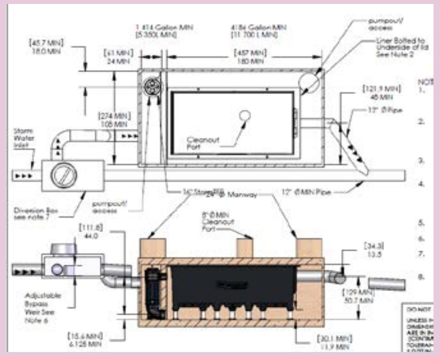
| Device Name | Description | Average Performance and Features | Approximate Device Footprint for RM_12a Watershed | Typical Maintenance | Site Specific Design Consideration | Schematic |
|---|---|---|---|---|---|---|
| Underground Iron-Enhanced Sand (IES) Filter with underdrain[3] | Underground sand filter in a storage vault, either on-line or off-line in the storm drain system. The first chamber is used for pre-treatment. The second is a sand filter chamber. Flows in excess of the filter's capacity are diverted through an overflow weir. | TP Removal: 50%<br>TN Removal: 35%<br>TSS Removal: 85% | Can size to match 0.13 acre footprint recommended by the UAA. | Periodic inspection of pre-treatment chamber, clean out of the underdrain system and pre-treatment chamber, and occasional addition of filtration media to maintain the design depth of media.<br><br>Approximately 35 year lifespan of media. | Would require sand filtration media, instead of iron-enhanced sand in order to prevent unit from becoming anoxic.<br><br>Larger footprint than manufactured treatment or IESF devices considered.<br><br>Device is not visible - limited educational or aesthetic component.<br><br>Would require deep excavation below ground level and tree removal. | <br>Upper Villa Infiltration and Reuse System, Roseville, MN. Designed by SRF Consulting Group, Inc. Courtesy of MPCA Stormwater Manual. |
| Iron-Enhanced Sand (IES) Filter with underdrain[3] | Iron-enhanced sand media with draintile. Pre-treatment sump can be used upstream of basin. | TP Removal: 77%<br>TN Removal: 35%<br>TSS Removal: 85% | Can size to match 0.13 acre footprint recommended by the UAA. | Periodic inspection of inlet and outlet structures, clean out of the underdrain system, and occasional addition of filtration media to maintain the design depth of media.<br><br>Approximately 35 year lifespan of media. | IES ditch checks must drawdown completely so as not to go anoxic.<br><br>Potential to go anoxic and must be accounted for in the design to prevent the release of phosphorus.<br><br>Larger footprint than manufactured treatment devices considered. | <br>Iron enhanced sand filter basin, Maplewood, MN. Designed by Barr Engineering. |
| Subsurface Gravel Bed Wetland (SGW)[6] | The SGW is designed as a series of horizontal flow-through treatment cells, preceded by a sedimentation forebay. The device is designed to retain and filter the entire Water Quality Volume (WQV) where the stormwater passes through a gravel substrate that is a microbe rich environment. | TP Removal: 55%<br>TN Removal: 80-95%<br>TSS Removal: 99%<br><br>Phosphorus removal is moderately effective. Research of removal performance is still on-going.<br><br>Outlet needs to be 4 inches above wetland ground surface to create 4 inches of standing water in BMP. | Gravel length to width ratio of 0.5 (L:W) or greater is needed for each treatment cell with a minimum flow path (L) within the gravel substrate of 15 feet (4.6 m).<br><br>8 in. (20 cm) minimum thickness of a wetland soil as the top layer.<br><br>Design flowrate through system of 1.0 cfs based on a study conducted by the University of New Hampshire Stormwater Center. | Routine inspection of inlet and outlet structures.<br><br>Clean out of the underdrain system as needed.<br><br>Thorough revegetation with grasses, forbs, and shrubs as necessary. | A study conducted by the University of New Hampshire Stormwater Center (UNHSC) shows they are among the most effective systems at protecting water quality.<br><br>Well suited for retrofits within stormwater pond systems - limited head required (4 inches), can be lined and doesn't require separation from groundwater.<br><br>Must be situated in low hydraulic conductivity soils or lined below the gravel layer.<br><br>Has the potential to go anoxic and release phosphorus since the gravel bed is in standing water. However, | <br>UNHSC Subsurface Gravel Bed Wetland constructed in 2004. |

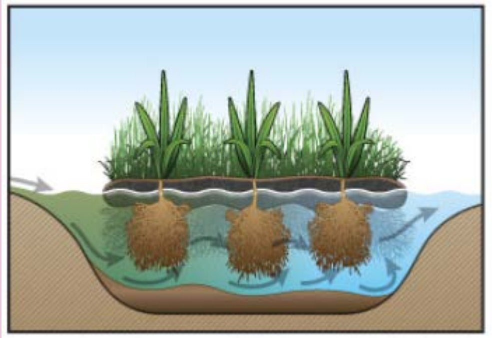
| Device Name | Description | Average Performance and Features | Approximate Device Footprint for RM_12a Watershed | Typical Maintenance | Site Specific Design Consideration | Schematic |
|---|---|---|---|---|---|---|
| | | | | | UNHSC study shows DO levels never below 4 mg/L. | |
| Woodchip Bioreactor[1] | A woodchip bioreactor routes drainage through a buried trench filled with woodchips. Woodchip bioreactors can be used in conjunction with a high flow bypass for large storm events. Woodchip bioreactors require 12 hours of contact time before leaving the system. | TP Removal: 53-79%<br>TN Removal: 15-60% (Nitrate)<br><br>Research of TP performance is still on-going. | Available footprint estimated by the UAA and verified by site visit would only treat approximately 0.3 cfs of the influent flow. | Periodic inspection of inlet and outlet structures and occasional addition of woodchip material to maintain the design depth of the bioreactor.<br><br>Approximately 10+ year lifespan of woodchip media. | Research for nutrient removal performance is still on-going.<br><br>Long contact time (+12 hr) results in very large footprint. | <br>Construction of trench for woodchip bioreactor. Photograph from presentation "Anaerobic Woodchip Bioreactors Under Minnesota Conditions," courtesy of Andy Ranaivoson, University of Minnesota |
| Woodchip Bioreactor in combination with upstream placed iron-enhanced phosphorus filter[2] | Adding an upstream phosphorus filter to a woodchip bioreactor in a separate chamber can increase TP reduction. | TP Removal: 88%<br>TN Removal:15-60%<br><br>Research of TP performance is still on-going. | Available footprint estimated by the UAA and verified by site visit would only treat approximately 0.3 cfs of the influent flow. | Periodic inspection of inlet and outlet structures and occasional addition of woodchip material to maintain the design depth of the bioreactor.<br><br>Approximately 10+ year lifespan of woodchip media. | Research for nutrient removal performance is still on-going.<br><br>Long contact time (+12 hr) results in very large footprint. | See photo above |
| Biofiltration/ Bioretention basin with underdrain[4] | Planting soil engineered media with sand trench and draintile. Pre-treatment sump can be used upstream of basin.<br><br>The optimally designed biofilter is at least 2% of its catchment area and possesses a sandy loam filter media, planted with C. appressa or M. ericifolia. | TP Removal: 44%<br>TN Removal: 50%<br>TSS Removal: 80%<br><br>Biofilter soil media with added organic matter has been known to reduce phosphorus treatment effectiveness. | Can size to match 0.13 acre footprint recommended by the UAA.<br><br>Maximum above ground storage depth of 1.0 ft. | Pruning and weeding as needed.<br>Stabilize and replace mulch as needed.<br>Remove sediment from pre-treatment systems annually.<br>Clean out of the underdrain system as needed. | Larger footprint than manufactured treatment devices considered.<br><br>Lower removal efficiencies for nutrients than other manufactured treatment devices, iron-enhanced filters, and spent lime filters.<br><br>May be difficult to establish desired vegetation, requiring more O&M relative to an IES basin.<br><br>Visible with opportunity for educational or aesthetic component near ballpark. | <br>Bioretention rain garden at American Legion, Roseville, MN. Designed by Barr Engineering. |

1 - Christianson, Laura E. and Helmers, Matthew J., "Woodchip Bioreactors for Nitrate in Agricultural Drainage" (2011). Agriculture and Environment Extension Publications. 85.
2 - Christianson, Laura E. and Lepine, C., "Denitrifying woodchip bioreactor and phosphorus filter pairing to minimize pollution swapping" (2017). Water Research.
3 - Erickson, A.J. and J.S Gulliver. 2010. Performance Assessment of an Iron-Enhanced Sand Filtration Trench for Capturing Dissolved Phosphorus. Project Report No. 549, St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, Prepared for the City of Prior Lake, Minnesota.
4 - Bratieres, K. (2008). Nutrient and sediment removal by stormwater biofilters: A large-scale design optimisation study.
5 - Antoine, R. (2016). Reducing Phosphorus Contamination in Stormwater Runoff.
6 - UNH Stormwater Center. (2009). Gravel Wetland Design and Maintenance.
7 - UNH Stormwater Center. (2010). Investigation of Nutrient Removal Mechanisms of a Constructed Gravel Wetland Used for Stormwater Control in a Northern Climat

**Table 4-6 Manufactured Treatment Device Evaluation Matrix**

| Device Name and *Manufacturer* | Description | Average Performance and Features | Approximate Device Footprint | Typical Maintenance | Site Specific Design Consideration | Schematic |
|---|---|---|---|---|---|---|
| Modular Wetland Systems (MWS) *Bio Clean*<br><br>Filterra<br>*Contech*<br><br>StormTree<br>*StormTree*<br><br>Nutrimax™<br>*Suntree Technologies, Inc.*<br><br>StormTreat Systems<br>*StormTreat* | These devices are stormwater treatment systems consisting of biofiltration via horizontal flow.<br><br>System has a pre-treatment cartridge and overflow pipe for large events. An open bottom for infiltration is possible. | TP Removal: 60-87%[1, 6, 7]<br>TSS Removal: 80-90%[1, 6, 7] | Concrete-lined vault may range from 4-8'W x 15-16'L x 2-5' D. Device can have open bottom for infiltration purposes.<br><br>Can treat maximum flow rates ranging from 0.175 - 0.462 cfs.<br><br>For StormTree: Device can treat 1.09 acres (0.34 cfs min.) with 9'x17' box using proprietary media with a 50 in/hr infiltration capacity. | Clean pre-treatment chamber by hand or with a standard vacuum truck.<br><br>Only periodic replacement of media in the pre-filter cartridges is required for long term operation.<br><br>No need to routinely replace or maintain biofiltration media.<br><br>Contech provides a first year of included maintenance consisting of a maximum of two scheduled visits. | Low maximum allowable flow rate through system could prevent treatment of high volume storms.<br><br>Requires additional underground storage unit upstream of filter.<br><br>Proprietary media is more expensive than locally sourced media.<br><br>Requires only 6" of head since it flows laterally. |  |
| Kraken Filter *Bio Clean*<br><br>StormFilter<br>*Contech*<br><br>Perk Filter™<br>*Kristar* | Underground vault with a pre-treatment chamber. Treatment occurs through membrane cartridges. This stormwater treatment device can treat high flows with the option of high flow bypass. Drain down eliminates standing water in the system. | TP Removal: 63%[2]<br>TSS Removal: 89%[2]<br><br>Metals Removal: > 50%[2]<br>TPH Removal: 90%[2]<br>Trash Removal: 99%[2] | Concrete-lined vault approximately<br>8'W x 16'L x 6'D<br><br>Contains many filter cartridges.<br><br>Can treat a maximum flow rate of 2.88 cfs. | No granular media to replace. Membrane filter cartridges can be removed and cleaned by hand with a hose.<br><br>Maintenance consists of removing debris from the pre-treatment sump with a standard sump vacuum or vactor truck.<br><br>Device requires many filter cartridges which must be replaced annually. | Device must be buried and requires at least 2-3 feet of head between the inlet and outlet pipes. This configuration would not be suitable downstream of a surface basin where available head is limited.<br><br>Device would be a stand-alone system or could be downstream of an underground vault. Device is not visible - limited educational or aesthetic component.<br><br>TAPE evaluation frequent replacement or cleaning of filter cartridges to achieve pollutant reduction claims. |  |
| Nutrient Removing Filtration System (NRFS)®<br>*Suntree Technologies, Inc.* | Underground vault without a prefilter chamber. Bold & Gold biosorption media accommodates high flow rates and resists clogging. | TP Removal: 80%[15]<br>TSS Removal: 95%[15] | Concrete-lined vault approximately<br>12'x24'<br><br>Can treat a maximum flow rate of 0.6 cfs. | Granular media replacement and filter inspection. | Requires only 6" of head since it flows laterally.<br><br>Higher construction and maintenance cost than non-prefabricated BMPs. Filter media must be replaced every few years.<br><br>Device is not visible - limited educational or aesthetic component. |  |

| Device Name and *Manufacturer* | Description | Average Performance and Features | Approximate Device Footprint | Typical Maintenance | Site Specific Design Consideration | Schematic |
|---|---|---|---|---|---|---|
| AquaFilter™ *AquaShield* | Flow-through water quality device custom designed to remove fine-grained sediment, heavy metals bound to particulate matter and residual oil by utilizing a treatment train approach. AquaFilter™ technology incorporates a hydrodynamic separation chamber (Aqua-Swirl™) for pretreatment and a separate chamber to provide filtration treatment. | TSS Removal: 90%[9]<br>No nutrient removal provided by device. | Sizing guidance not readily available from manufacturer webpage. | Inspection and maintenance activities are performed from the surface. A vacuum truck is typically used to perform maintenance on the swirl chamber while filter replacement requires personnel entry to the filtration chamber. | Replacing filters requires entry into filtration chamber. Confined space procedures must be followed. Installation of filter bags is more complicated than other proprietary systems.<br><br>No nutrient removal provided by manufacturer. |  |
| BioSTORM® *BioMicrobics* | Pre-engineered stormwater treatment system removes trash, sediment, oil and other pollutants from stormwater runoff. The BioSTORM®'s unique off-line design consists of a patented StormTEE® self-cleaning deflector screen and a modular separation/coalescing unit, all housed in readily-available precast concrete tanks. | TSS Removal: 90%[9]<br>No nutrient removal provided by device. | Sizing guidance not readily available from manufacturer webpage. | Annual vacuum pumping of the oil floating inside the BioSTORM® separation module. Annual pumping out of the solids from each tank or compartment. To clean the StormTEE® deflector screen, raise and lower the internal swab to dislodge any debris that may be stuck to the screen. | No nutrient removal provided by manufacturer.<br><br>Expensive and labor intensive maintenance.<br><br>Requires annual pumping out of the solids from each tank or compartment. |  |
| Aquip *stormwateRx* | Enhanced media filtration system for industrial stormwater application. Media housed in concrete vault. | TP Removal: 75%[10]<br>TSS Removal: 80%[10] | Device requires 3' 9" of drop between inlet and outlet.<br><br>Treats up to 1.7 cfs with a 13'W by 52'L device. | Device is a passive, underground system with no moving parts.<br><br>Maintenance requirements not provided on webpage. | Used for industrial applications.<br><br>Head differential is too large to use downstream of a surface basin. |  |

| Device Name and *Manufacturer* | Description | Average Performance and Features | Approximate Device Footprint | Typical Maintenance | Site Specific Design Consideration | Schematic |
|---|---|---|---|---|---|---|
| BioHaven® Floating Islands<br>*Floating Island International* | BioHaven® Floating Islands are patented biomimetic, self-sustaining floating treatment wetlands. The islands typically use a combination of microbial and plant growth to effectively take up, precipitate and/or filter nutrients and other pollutants from water. The islands can be anywhere up from 100 square feet and beyond by linking the islands together. | TP Removal: 42-91%[11]<br>TSS Removal: 54-93%[11]<br>TN Removal: 40-87%[11] | 250 square feet of BioHaven® floating island is equal to 1 acre of natural wetland surface area | Invasive species are expected to grow on the islands. Access to perform vegetative maintenance requires additional equipment. Mechanical removal of invasive species would be required.<br><br>As the floating treatment wetlands absorb suspended solids and develops a biofilm, the absorption rate declines. For the floating wetland to continue to function as a biofilter, the entire wetland would have to be removed from the water, allowed to drain, and the matrix beneath the island would have to be rinsed off into an approved area to not allow the suspended solids to reenter the water body. | Device requires extensive plant maintenance (see typical maintenance column).<br><br>Lifespan and pollutant reduction are unproven.<br><br>Device does little to reduce algal growth.<br><br>Device could be placed within the RM_12 pond. |  |
| Jellyfish Stormwater Treatment<br>*Contech* | The Jellyfish features high flow pretreatment and membrane filtration in a compact stand-alone system. Jellyfish removes floatables, trash, oil, debris, TSS, fine silt-sized particles, and a high percentage of particulate-bound pollutants; including phosphorus, nitrogen, metals and hydrocarbons. | TP Removal: 59%[13]<br>TSS Removal: 89%[13] | The Jellyfish filter requires a maximum design flux rate (surface loading rate) across the membrane filter cartridges of less than 0.21 $gpm/ft^2$.<br><br>Would require 48 cartridges to treat 7.8 cfs. The dimensions would be a surface area of 8 x 16 ft. Requires > 6.5 ft. between inlet pipe invert and bottom of system. | Contech has created a network of Certified Maintenance Providers to provide maintenance on stormwater BMPs.<br><br>Ongoing maintenance of the filter cartridges is performed by removing, rinsing and reusing the cartridge tentacles (once per year). Vacuum extraction of captured pollutants in the sump is recommended (once per year). Replacement of filter cartridges is anticipated every 2-5 years. | High surface area membrane filtration<br><br>Can treat a maximum of 7.8 cfs under largest design (48 filter cartridges)<br><br>Development located with the RPBCWD has Jellyfish experiencing very low removals and flowrates.<br><br>Requires low driving head (18 in or less).<br>High surface area membrane filtration. |  |


1 - Bio Clean Environmental. (2015). Modular Wetlands Advanced Stormwater Biofiltration: MWS Linear. Modular Wetland Systems, Inc.
2 - Bio Clean Environmental. (2015). The Kraken Filter.
3 - HydroInternational (2018). Up-Flo Filter.
4 - Contech Engineered Solutions. The Stormwater Management StormFilter® Solutions Guide.
5 - Contech Filterra Bioscape. http://www.conteches.com/products/stormwater-management/biofiltration-bioretention/filterra/filterra%20-%208830672-configurations
6 - StormTree. (2017). StormTree. Retrieved December 11, 2017, from http://www.storm-tree.com/
7 - AquaShield Water Treatment Solutions. Aqua-Filter. http://www.aquashieldinc.com/--aqua-filter.html.
8 - BioMicrobics. BioSTORM Stormwater Treatment Systems. http://www.biomicrobics.com/products/biostorm-stormwater-treatment-systems/
9 - stormwateRx. Aquip®. http://stormwaterx.com/stormwaterx_products/aquip/
10 - BioHaven® Floating Islands. http://www.floatingislandinternational.com/products/biohaven-technology/
11 - StormTreat Systems. https://stormtreat.com/
12 - Jellyfish Contech. https://www.conteches.com/stormwater-management/treatment/jellyfish-filter
13 - Nutrimax. Engineered Wetlands Biofilter. https://www.suntreetech.com/nutrimax.html
14 - Nutrient Removing Filtration System. https://www.suntreetech.com/nrfs.html

### 4.2.2 Manufactured Treatment Devices Evaluated

In addition to conventional devices, fourteen different MTDs were also considered. The differences between treatment devices, including typical maintenance required and implementation concerns, are presented in Table 4-6. MTDs that are similar in treatment type and configuration were grouped into a single row. The rows highlighted in green represent the devices which are considered feasible for application at the site. The rows highlighted in red are devices which were considered, but, for reasons indicated in the "Design Concerns" column, and further outlined in Table 4-7 below, would not be feasible at this site.

**Table 4-7 MTD Evaluation Summary**

| Device | Evaluation | Reasoning | WADOE – Use Level Designation (GULD) using TAPE |
|---|---|---|---|
| Modular Wetland System *Bio Clean* | Preferred | Requires only 6" of head since it flows laterally. Visual component for enhanced educational value. (64% TP, 85% TSS). | General |
| Filterra *Contech* | Feasible | Similar to MWS. Product is a pre-cast concrete box with engineered soil. More costly than the same conventional system. Requires tree planted in BMP. Smaller than needed for site. | General |
| StormTree *StormTree* | Feasible | Similar to MWS. Product is a pre-cast concrete box with engineered soil. More costly than the same conventional system. Comparable TP removal to the MWS (63% TP, 85% TSS). Requires tree planted in BMP. Smaller than needed for site. | Pilot |
| Nutrimax *Suntree Tech.* | Feasible | Similar to MWS. No nutrient removal claims. | No |
| StormTreat *StormTreat* | Feasible | Similar to MWS. Lower TP removal than MWS (44% TP, 89% TSS). Has many chambers and components which makes maintenance labor intensive. | No |
| Kraken Filter *Bio Clean* | Preferred | Device is being proposed by developers for stormwater permitting. Opportunity for District to monitor performance. Higher flowrate than many similar proprietary systems (up to 2.9 cfs). (63% TP, 89% TSS) | General |
| StormFilter *Contech* | Feasible | Similar to Kraken. Higher TP removal (82% TP, 89% TSS). Kraken was chosen as preferred device since developers are proposing to use the device for stormwater permitting. | General (using PhosphoSorb Media) |
| Perk Filter *Kristar* | Feasible | Similar to Kraken. Monitoring results indicate a lower flowrate and lower TP removal compared to Kraken. (62% TP, 85% TSS) | General |

| Device | Evaluation | Reasoning | WADOE – Use Level Designation (GULD) using TAPE |
|---|---|---|---|
| NRFS<br>*Suntree Tech* | Preferred | Requires only 6" of head since it flows laterally. Because of this, it can be placed on the downstream side of a surface basin.<br>Filter media can be replaced easily by vacuum.<br>Doesn't require filter cartridges. High treatment claims (73% TP, 83% TSS). | No |
| AquaFilter<br>*AquaShield* | Infeasible | Requires confined space entry for maintenance. Costly to replace media. No nutrient removal claims. | No |
| BioSTORM<br>*BioMicrobics* | Infeasible | No nutrient removal claims.<br>Expensive and labor intensive maintenance.<br>Requires annual pumping out of the solids from each tank or compartment. | No |
| Aquip *stormwaterRx* | Infeasible | Industrial above ground application from above ground systems (roof drainage). Not visually appealing for the site and requires a lot of head. | Conditional |
| BioHaven Floating Islands<br>*Floating Island Int.* | Infeasible | Requires extensive plant maintenance.<br>Lifespan and pollutant reduction are unproven.<br>Does little to reduce algal growth. | No |
| Jellyfish<br>*Contech* | Infeasible | Though appears feasible for site, a development located with the RPBCWD has a Jellyfish experiencing very low removals and flowrates. | General |

Of the fourteen manufactured treatment devices considered, the following three were identified as the most feasible (preferred) MTDs for the site.

- Modular Wetland Systems (MWS) – Bio Clean (or similar)
- Kraken Filter – Bio Clean (or similar)
- Nutrient Removing Filtration System (NRFS) – SunTree (or similar)

### 4.2.3 Implementation of MTDs in RPBCWD

RPBCWD is seeing an increased interest in using proprietary stormwater manufactured treatment devices (MTDs) for development and redevelopment projects. As part of the permit review process for development and redevelopment projects in the RPBCWD, RPBCWD's engineer has reviewed stormwater MTDs for the following projects:

- Shoppes at Southwest Station – Eden Prairie (RPBCWD #2015-029)
  - Contech Engineered Solutions – Jellyfish Filter
- Chanhassen Retail (aka Total Wine) – Chanhassen (RPBCWD #2015-030)
  - Royal Environmental Systems Inc – EcoStorm Plus

- Preserve Boulevard Reconstruction – Eden Prairie (RPBCWD #2018-073)
    - Bio Clean Environmental Services – Kraken Filter
- Culvers – Eden Prairie (RPBCWD #2018-026)
    - Momentum Environmental – Preserve
    - Contech Engineered Solutions – Jellyfish Filter

However, there are not widely accepted levels of treatment or pollutant removal efficiencies associated with these devices. While most proprietary MTDs undergo testing, the conditions that they are tested under may not be independent or representative with the conditions in the Minnesota or RPBCWD. While RPBCWD's stormwater management rule includes a specific regulation allowing the District to impose monitoring, performance evaluation, additional compliance measures or other requirements for the purposes of demonstrating that performance standards are being met, efficiencies are gained by all parties to utilize existing data where applicable.

To address the shortcoming in Minnesota specific testing, RPBCWD cooperated with other watershed management organizations to send a letter to the Minnesota Pollution Control Agency (MPCA), formally requesting that the MPCA evaluate the performance of stormwater MTDs and include protocols for MTDs in the MN Stormwater Manual. In response to the joint letter the MPCA developed a small working group, including RPBCWD and Barr, to discuss MTDs, how these devices are being used, how MTDs are credited in regulatory programs (esp. phosphorus), incorporation of information into the MN Stormwater Manual, and an overview of existing testing programs. Some of the key takeaways to date include:

- Stormwater BMP testing and certification is costly and time intensive. Cost savings can be made through less sampling and/or lab sampling only (i.e. no field sampling).
- MTD verification testing can take several years
- MN workgroup focus is on phosphorus removal. There was some discussion of dissolved phosphorus, which is currently not required for TAPE and NJCAT.
- MN workgroup is leery of lab-tested approval – need field verification. There was some discussion of approved testing sites. For example, the University of New

Hampshire is approved as a testing site. Is this something we might want to pursue in Minnesota?

- Operation and maintenance are critical in the evaluation of MTDs
- Stormwater Testing and Evaluation for Products and Practices (STEPP) is not currently funded to take on regional verification of MTDs

While RPBCWD's stormwater management rule includes a specific regulation allowing the District to impose monitoring, performance evaluation, additional compliance measures or other requirements for the purposes of demonstrating that performance standards are being met, RPBCWD recognizes the efficiencies gain by all parties to utilize existing data where applicable. The following sequencing from RPBCWD rule guidance document was used to aid in identifying potential MTDs for this specific site.

1. Provide verification that the proposed stormwater MTDs have achieved General Use Level Designation (GULD) certification from the State of Washington's Technology Assessment Protocol – Ecology (TAPE) program. Applicant can then apply 50% TP and 80% TSS removals for the MTDs, as long as the MTDs are designed in accordance with the manufacturer's recommendations/guidelines or the GULD certification criteria, whichever is more restrictive.
2. Higher pollutant removal efficiencies require submitting third party testing data from the TAPE program for analysis by RPBCWD engineer. The MTDs need to be designed in accordance with the manufacturer's recommendations/guidelines or the GULD certification criteria, whichever is more restrictive, as well as maintained in a manner consistent with the testing data used to achieve the GULD certification.
3. If the MTD has not been evaluated as part of the TAPE program, independent third-party testing and monitoring data is needed for analysis by RPBCWD engineer. The MTDs need to be designed in accordance with the manufacturer's recommendations/guidelines as well as maintained in a manner consistent with the manufacturer's recommendation and/or as required by the district. If insufficient testing data representative of MN climate conditions, typical particle size distributions, and/or pollutant concentration for the land use proposed are

available for review, additional monitoring in accordance with Rule J, subsection 2.6 may be required.

Given the constraints of this site, there may be advantage to implementing an MTDs. In addition, implementation of an MTD would allow the monitoring of an MTD to aid RPBCWD and other water resources regulators in Minnesota with understanding how the MTD performs in Minnesota climatic conditions.

## 4.3 Preliminary BMP Screening Summary

Combining the aforementioned BMPs, the following ten combinations were identified for further evaluation. The BMPs selected include both manufactured treatment devices, as well as, non-propriety BMPs:

- Iron-enhanced sand filtration basin with underdrain
    - As a stand-alone system, or
    - Upstream of a NRFS – SunTree (or similar)
- Manufactured Treatment Device
    - Modular Wetland System: as a stand-alone system,
    - Modular Wetland System: downstream of an underground iron-enhanced sand filtration system,
    - Modular Wetland System: downstream of an underground storage system, or
    - Kraken Filter: as a stand-alone system
- Subsurface gravel bed wetland with underdrain
    - As a stand-alone system, or
    - Upstream of a NRFS – SunTree (or similar)
- Dredging of the existing RM_12 constructed pond

Each potential BMP identified was further evaluated to identify the anticipated nutrient removal, and identify a system that would fit within city-owned parcels, maximize TP reduction, minimize project cost, and minimize site impacts. Each conceptual design is discussed in Section 5.0.

# 5.0 Evaluated Best Management Practices

The following BMPs were evaluated:

- 1a – smaller iron-enhanced sand filtration basin with underdrain,
- 1b – larger iron-enhanced sand filtration basin with underdrain upstream of the SunTree NRFS,
- 1c – larger iron-enhanced sand filtration basin with underdrain,
- 1d – larger iron-enhanced sand filtration basin with underdrain upstream of the SunTree NRFS,
- 2a – Bio Clean Modular Wetland Systems (MWS),
- 2b – Bio Clean Modular Wetland Systems (MWS) downstream of an underground iron-enhanced sand filtration system,
- 2c – Bio Clean Modular Wetland Systems (MWS) downstream of an underground storage system,
- 2d – Bio Clean Kraken Filter,
- 3a – subsurface gravel bed wetland with underdrain,
- 3b – subsurface gravel bed wetland with underdrain upstream of the SunTree NRFS, and
- 4 – dredging the existing RM_12 constructed pond.

Each of the separate components of these BMPs are described in the following sections.

## 5.1 Iron-Enhanced Sand Filtration Basin

Iron-enhanced filtration consists of mixing iron filings or steel wool with a filtration media (i.e., sand). Filtration through the sand (or other filtration media) removes the particulate phosphorus, while the iron filings, which form iron oxide when rusted, increase the removal of dissolved phosphorus. When water containing dissolved phosphorus contacts the iron oxide, the dissolved phosphorus is removed from the stormwater through surface sorption. Figure 5-1 includes photographs of iron-enhanced sand filtration systems.

Construction of Lake Susan Park iron-enhanced sand filtration system (Riley Purgatory Bluff Creek Watershed District, 2018).

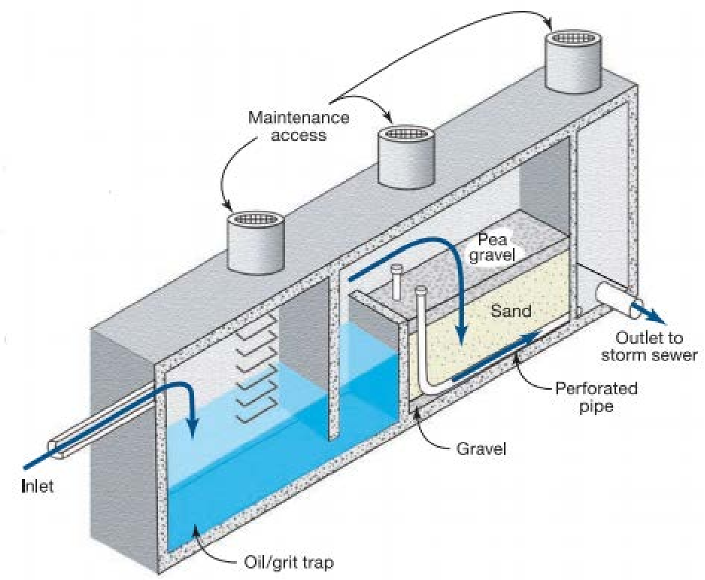
Iron-enhanced sand filtration system in Lake Susan Park following a rainfall event (Riley Purgatory Bluff Creek Watershed District, 2018).

**Figure 5-1 Photographs of iron-enhanced sand filtration system**

The use of iron-enhanced filtration in stormwater management is recognized by the MPCA and included as a BMP in the *Minnesota Stormwater Manual* (Minnesota Pollution Control Agency, 2015). Monitoring data reported in the *Minnesota Stormwater Manual* has shown promising results for the removal of both total and dissolved phosphorus. Total phosphorus removal through the system ranges from 70-77 percent (Minnesota Pollution Control Agency, 2015).

Use of iron-enhanced filtration was identified to target the removal of soluble phosphorus in the Rice Marsh Lake watershed. A relatively short contact time (20–30 minutes) is required for the surface sorption to bind phosphorus to the iron oxide on the iron filings. However, the filtration media must dry out between rainfall events to prevent anoxic conditions within the filter which can release phosphorus. Therefore, the filter must be drawn down within 48 hours of a rainfall event. This means the BMP footprint must be designed proportionally to the volume of water to be treated. Deposition of buildup of organic matter on the filter can adversely impact system performance. Periodic maintenance activities are required, including inspection of inlet and outlet structures, cleanout of the underdrain system, and occasional addition or replacement of filtration media to maintain the design depth (i.e., contact time) of the material.

Iron-enhanced sand can also be used in underground filtration systems. Similar to surface iron-enhanced sand basins, the filtration media must dry out between rainfall events to prevent anoxic conditions. Underground sand filtration is a common practice for stormwater treatment and rate control; using iron-enhanced media further increases total phosphorus removal. Figure 5-2 is a schematic of an example underground sand filtration system.




Example schematic of an underground sand filtration system (Protection, 2013).

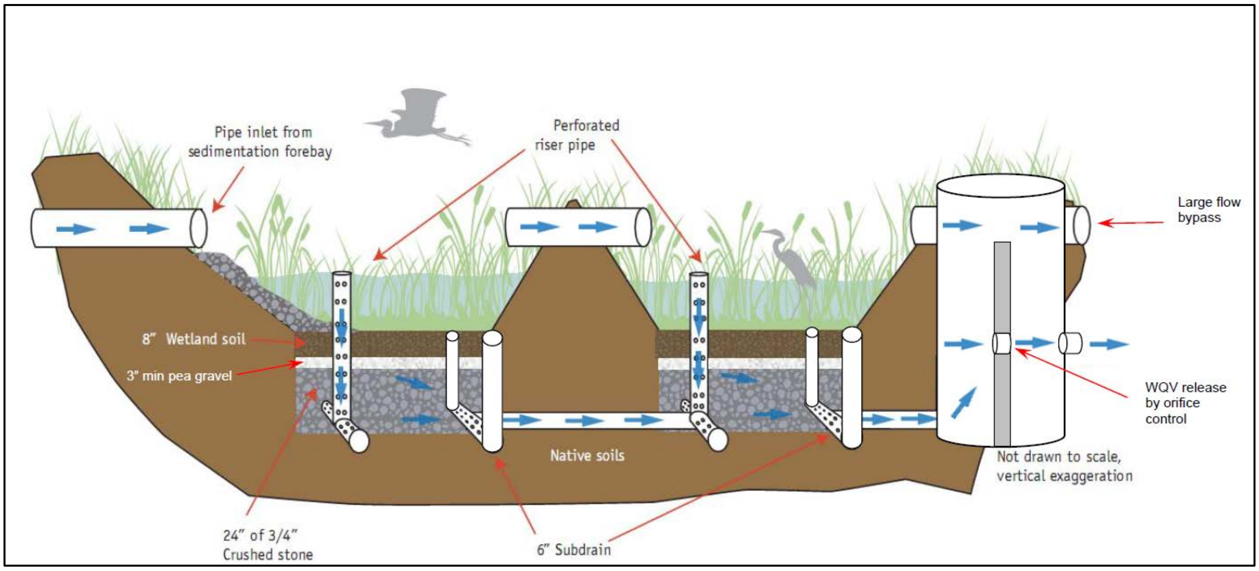
**Figure 5-2 Schematic of underground sand filtration system**

## 5.2 Subsurface Gravel Bed Wetland

Subsurface gravel bed wetlands are designed as a series of horizontal flow-through treatment cells, preceded by a sedimentation forebay. The device is designed to retain and filter the stored water quality volume by passing the stormwater through a microbe-rich gravel substrate. The system's outlet is situated below the normal water level to create approximately 4 inches of standing water in the gravel bed. The standing water creates an anoxic environment for denitrification of stormwater runoff. Although phosphorus release has been known to occur in anoxic sediment, the uptake from properly maintained wetland vegetation has been found to prevent the release of phosphorus in the effluent. Subsurface gravel bed wetlands are well-suited for retrofits within stormwater pond systems. They do not have a large head requirement (4 inches) and are most effective when situated in low hydraulic conductivity soils (University of New Hampshire Stormwater Center (UNHSC), 2009). These systems can be lined if needed, but do require separation from groundwater (University of New Hampshire Stormwater Center (UNHSC), 2009). When established, the surface of the wetland should be thoroughly vegetated with grasses, forbs, shrubs, and a dense, complete root mat. Figure 5-3 is a photo of the subsurface gravel bed wetland used in the University of New Hampshire study on the effectiveness of these BMPs. Standing water exists in the wetland during and after a rainstorm but draws down within 48 hours. A schematic of a typical subsurface gravel bed wetland is also shown in Figure 5-4.

Subsurface gravel bed wetland used in the UNHSC study on the BMP's treatment effectiveness. Image on left shows the basin during dry weather conditions. Image on the right shows the basin during a rain storm (University of New Hampshire Stormwater Center, 2010).

**Figure 5-3 Photo of a subsurface gravel bed wetland**



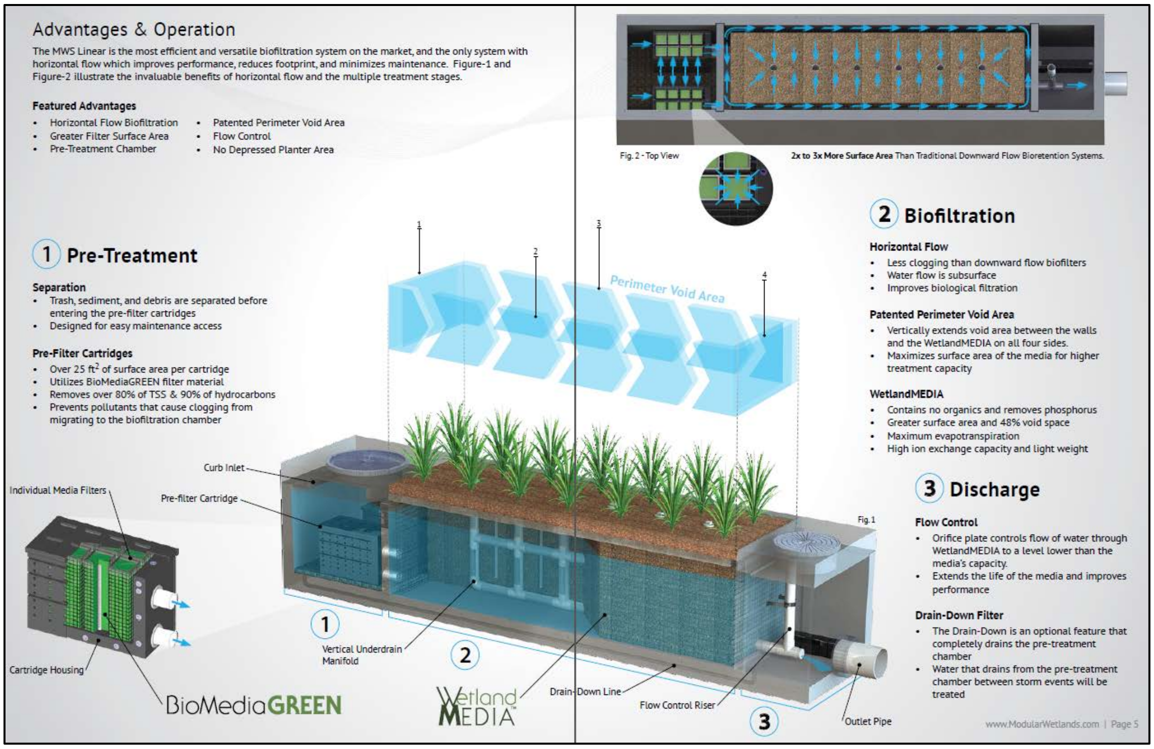

Schematic of a subsurface gravel bed wetland from the University of New Hampshire Stormwater Center Design Criteria (University of New Hampshire Stormwater Center (UNHSC), 2009).

### Figure 5-4 Schematic of a subsurface gravel bed wetland

The University of New Hampshire study showed that the BMP has the potential to remove approximately 55% TP and 99% TSS (University of New Hampshire Stormwater Center, 2010). The primary benefit of the BMP is retention of sediment and associated pollutants, however, the wetland may export phosphorus if not designed and maintained properly. Nutrients utilized by plants are removed from the water or sediments and stored in the plants. In the fall, the leaves and stems die back and accumulate on the surface of the wetland. If the plant debris are not cleared and removed from the wetland, the accumulated nutrients will be released back into the sediment as the plant matter decays. In addition, phosphorus removal is significantly higher during periods of vegetation establishment when plants have a high demand for nutrients and phosphorus. After the first few years, once vegetation is established, a cycle of growth-death-growth recycling of the nutrients and phosphorus occurs, reducing nutrient uptake and increasing the likelihood of nutrient release. In order to continue to remove certain pollutants, dead vegetation must be removed and existing plantings should be trimmed or mowed down to encourage new growth fed by nutrients from incoming stormwater.

## 5.3 Modular Wetland Systems (MWS) – Bio Clean

The Linear Modular Wetland System (MWS), by Bio Clean, increases filtration capacity for a given surface area by utilizing horizontal flow. This allows for a smaller footprint and higher treatment capacity than traditional vertical filtration BMPs (like a filtration basin). The MWS incorporates a pre-treatment chamber that includes separation and pre-filter cartridges allowing for a high particulate reduction capacity (Figure 5-5). According to manufacturer information, the pre-treatment chamber reduces maintenance costs and improves the filter performance. The vault-type configuration with an external diversion weir structure would receive upstream piped flow and allow for bypass during high-flow events. A detailed schematic of the curb-type is shown in Figure 5-6. This device has the capacity to treat 0.7 cfs through the filter, and the manufacturer indicates the filter will remove approximately 64% of TP and 85% of TSS from influent runoff (Bio Clean Environmental, 2015).




Modular Wetland System brochure from Bio Clean (Bio Clean Environmental, 2015).

**Figure 5-5 Schematic of the Modular Wetland System filtration chamber**

Schematic of Modular Wetland System – Linear with upstream underground storage vault (Bio Clean Environmental, 2015).

**Figure 5-6 Schematic of the Linear Modular Wetland System with curb inlet**

## 5.4 Kraken Filter (Bio Clean)

The Kraken Filter, by Bio Clean, is an engineered stormwater membrane filter that provides treatment for high flow rates (up to 2.9 cfs) using a number of filter cartridges. The membrane filter cartridges do not contain granular media and must be removed and cleaned by hand. The Kraken has a built-in pre-treatment chamber (A) which is designed to dry out between storm events. Runoff first passes through the pre-treatment chamber, moving to the membrane filter where it fills up the outer chamber (B). Once water reaches the top of the chamber, it flows down through the filter membrane (C), collecting in the underdrain, and flowing to the discharge chamber. High flows pass over the high-flow weir directly to the discharge chamber (D). Figure 5-8 depicts this process.

A B C D

Schematic of Kraken Filter treatment train from Bio Clean (Bio Clean Environmental, 2015).

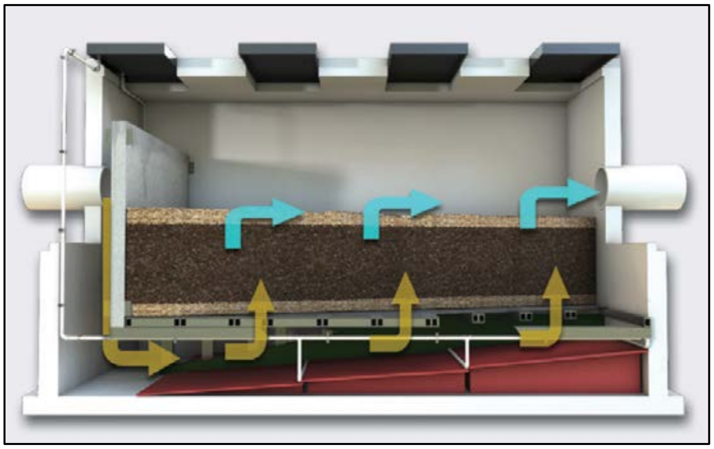
**Figure 5-7 Schematic of the Kraken Filter**

The largest model can treat 2.9 cfs and has an internal storage volume of 48 cubic-feet. The manufacturer and TAPE evaluation indicates that the device can remove 63% of TP and 85% of TSS from influent runoff (Bio Clean Environmental, 2015). The device would be buried and could discharge into the existing stormsewer via an outlet pipe.

The Kraken Filter is frequently being proposed as a stormwater treatment device for developers to meet the District's stormwater management requirements. If constructed, the District could monitor the efficacy of the device and determine if it is suitable for stormwater treatment.

## 5.5 Nutrient Removing Filtration System (NRFS)

The Nutrient Removing Filtration System®, by SunTree, is an engineered stormwater treatment vault that provides treatment for flow rates up to 0.6 cfs using a Bold & Gold® filter media. The Bold & Gold® filter media is a Biosorption Activated Media (BAM) designed to reduce nitrogen and phosphorus levels in stormwater by creating sorbent surface bonds to capture and consume nutrients. Replacement of the media in the filter requires the use of a vacuum truck and HydroSlide® system housed inside the unit. Figure 5-8 depicts the process in which water flows through the system.



Schematic of the Nutrient Removing Filtration System® by SunTree (SunTree Technologies Inc., 2020).

**Figure 5-8 Schematic of the Nutrient Removing Filtration System®**

The largest model can treat 0.6 cfs and has an approximate internal storage volume of 288 cubic-feet (assuming 1 foot of depth can be stored beneath the filter media). Field and lab testing data provided by the manufacturer suggests that the device can remove 73% of TP and 83% of TSS from influent runoff assuming the Bold & Gold® filter media is used (SunTree Technologies Inc., 2020). The device would be placed downstream of the filtration basin to receive untreated runoff from the basin. The device would be buried and could discharge into the existing RM_12 pond via an outlet pipe.

# 6.0 Conceptual Design Alternatives

The following conceptual designs for a stormwater BMP were considered:

- Conceptual Design 1 – Iron-enhanced sand filtration basin with underdrain
  - **Option 1a:** as a smaller stand-alone basin,
  - **Option 1b:** as a smaller basin upstream of an NRFS®– SunTree (or similar)
  - **Option 1c:** as a larger stand-alone basin,
  - **Option 1d:** as a larger basin upstream of an NRFS®– SunTree (or similar)
- Conceptual Design 2 – Manufactured Treatment Device
  - **Option 2a:** Modular Wetland System – Bio Clean (or similar) as a stand-alone system,
  - **Option 2b:** Modular Wetland System – Bio Clean (or similar) downstream of an underground iron-enhanced sand filtration system,
  - **Option 2c:** Modular Wetland System – Bio Clean (or similar) downstream of an underground storage system, or
  - **Option 2d:** Kraken Filter – Bio Clean (or similar) as a stand-alone system
- Conceptual Design 3 – Subsurface gravel bed wetland with underdrain
  - **Option 3a:** as a stand-alone system, or
  - **Option 3b:** upstream of a NRFS – SunTree (or similar)
- Conceptual Design 4 – Dredging of the existing RM_12 constructed pond

Each conceptual design is discussed in more detail below. The goal for each of the conceptual design was to identify a BMP that would fit within the existing city-owned parcels and minimize site impacts and project cost.

The performance of the various BMPs are dependent on the treatment flow rate and the nutrient reduction potential of each device. Figure 6-1 shows how the treated flow rate affects the TP load diverted to the BMP based on the water quality modeling. As shown, the inflection point in the graph to maximize the TP loading to the BMP for treatment occurs around 6 cfs. Each BMP listed above was optimized to increase the treatment flow rate through the BMP. The simulated TP reduction by the BMP is dependent on the nutrient reduction potential for each BMP.

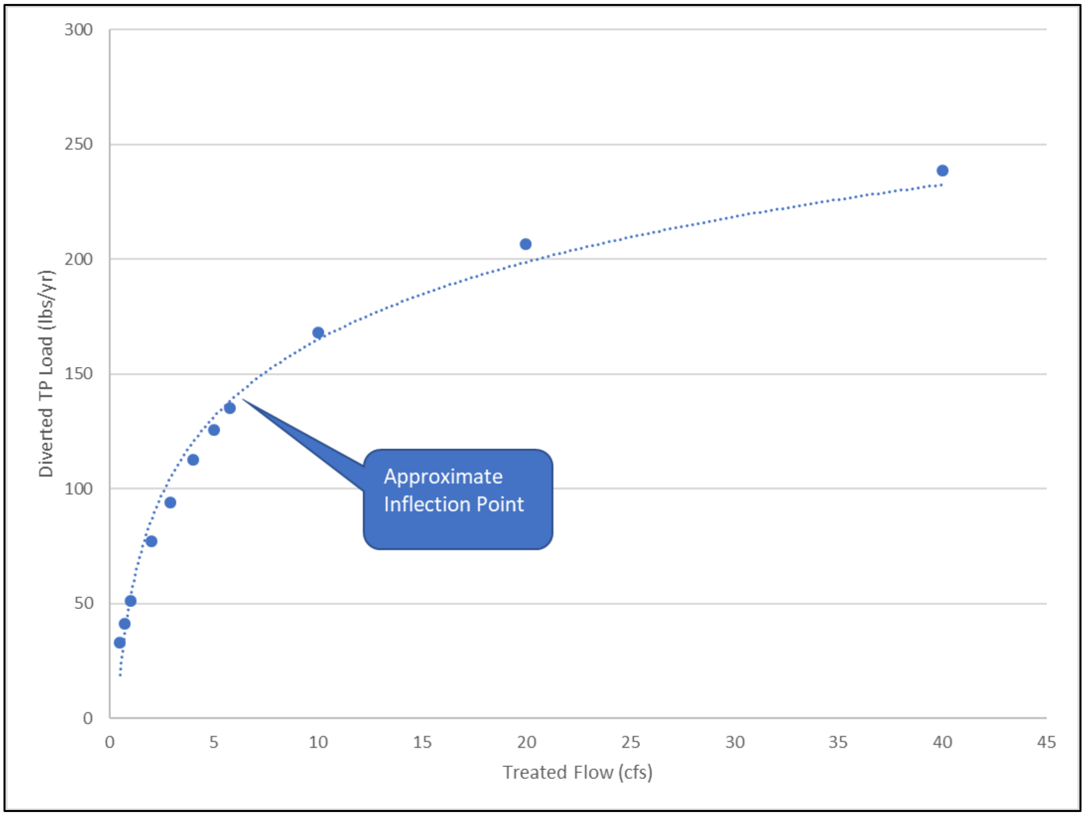



**Figure 6-1 Estimated TP load to the potential BMP as a function of flow rate diverted to the BMP**

## 6.1 Conceptual Design 1 – Iron-Enhanced Sand Filtration Basin with Underdrain

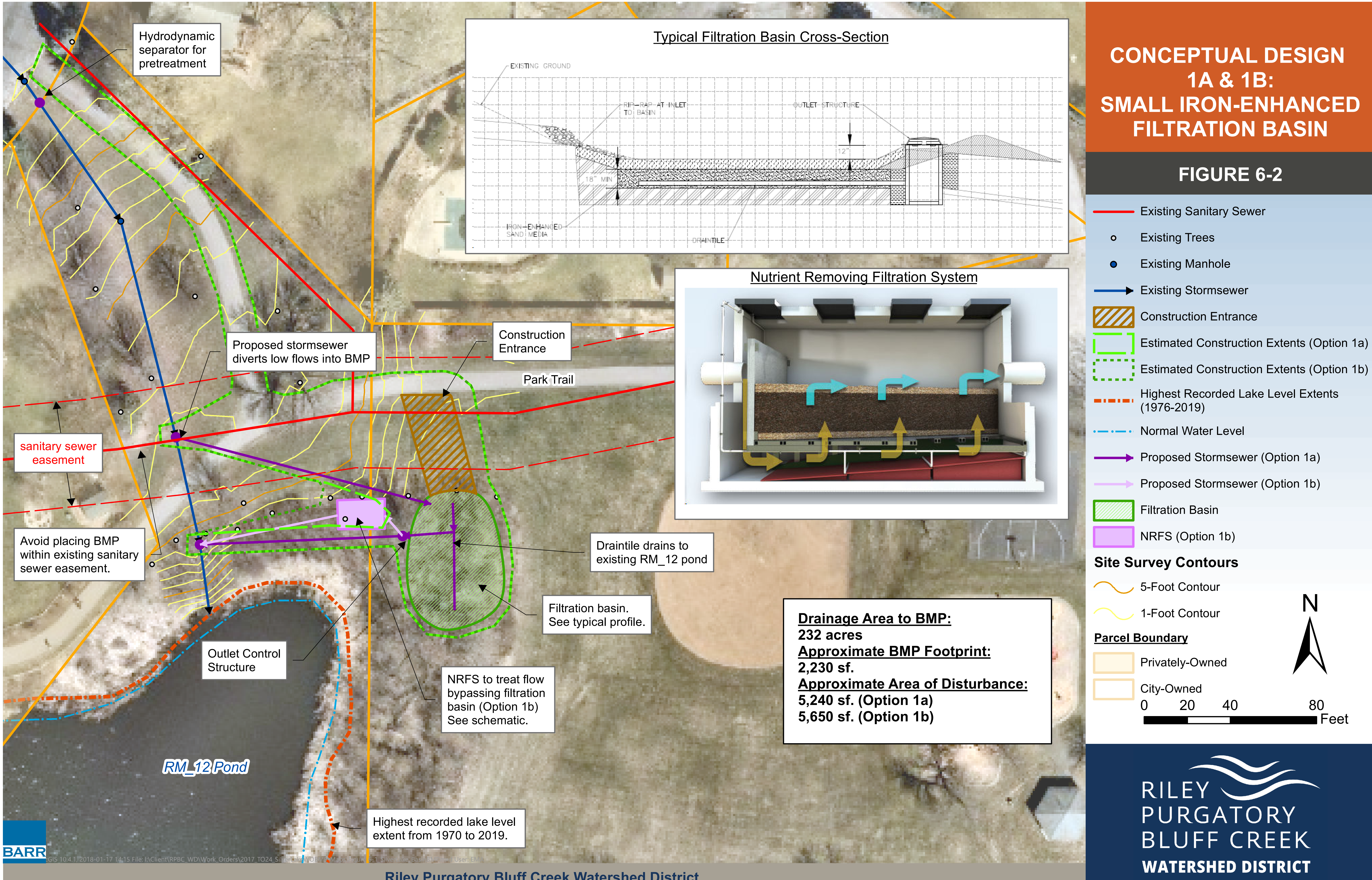
The four configurations of Conceptual Design 1 are shown in Figure 6-2 and Figure 6-3. Conceptual Design 1 was analyzed using the following combinations:

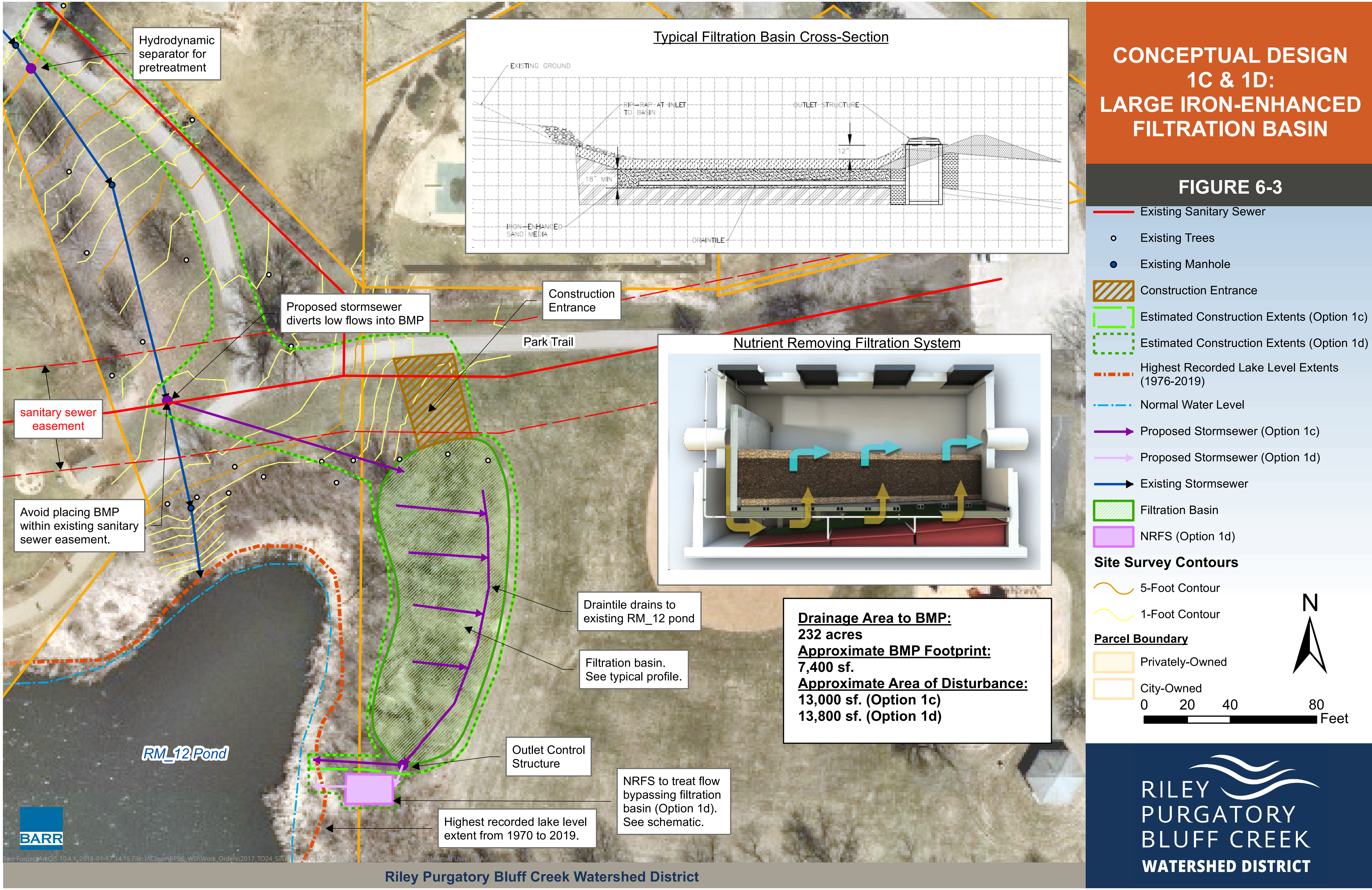
**1a –** smaller footprint iron-enhanced sand filtration basin,

**1b –** smaller footprint iron-enhanced sand filtration basin upstream of a Nutrient Removing Filtration System (NRFS),

**1c –** larger footprint iron-enhanced sand filtration basin, and

**1d –** larger footprint iron-enhanced sand filtration basin upstream of a Nutrient Removing Filtration System (NRFS).


CONCEPTUAL DESIGN 1A & 1B: SMALL IRON-ENHANCED FILTRATION BASIN
FIGURE 6-2
Existing Sanitary Sewer
Existing Trees
Existing Manhole
Existing Stormsewer
Construction Entrance
Estimated Construction Extents (Option 1a)
Estimated Construction Extents (Option 1b)
Highest Recorded Lake Level Extents (1976-2019)
Normal Water Level
Proposed Stormsewer (Option 1a)
Proposed Stormsewer (Option 1b)
Filtration Basin
NRFS (Option 1b)
Site Survey Contours
5-Foot Contour
1-Foot Contour
Parcel Boundary
Privately-Owned
City-Owned
0 20 40 80 Feet
N
Typical Filtration Basin Cross-Section
EXISTING GROUND
RIP-RAP AT INLET TO BASIN
OUTLET STRUCTURE
12"
18" MIN
IRON-ENHANCED SAND MEDIA
DRAINTILE
Nutrient Removing Filtration System
Hydrodynamic separator for pretreatment
Proposed stormsewer diverts low flows into BMP
Construction Entrance
Park Trail
sanitary sewer easement
Avoid placing BMP within existing sanitary sewer easement.
Draintile drains to existing RM_12 pond
Filtration basin. See typical profile.
Outlet Control Structure
NRFS to treat flow bypassing filtration basin (Option 1b) See schematic.
RM_12 Pond
Highest recorded lake level extent from 1970 to 2019.
Drainage Area to BMP:
232 acres
Approximate BMP Footprint:
2,230 sf.
Approximate Area of Disturbance:
5,240 sf. (Option 1a)
5,650 sf. (Option 1b)
BARR
Riley Purgatory Bluff Creek Watershed District
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT


CONCEPTUAL DESIGN 1C & 1D: LARGE IRON-ENHANCED FILTRATION BASIN
FIGURE 6-3
Typical Filtration Basin Cross-Section
EXISTING GROUND
RIP-RAP AT INLET TO BASIN
OUTLET STRUCTURE
12"
18" MIN
IRON-ENHANCED SAND MEDIA
DRAINTILE
Nutrient Removing Filtration System
Hydrodynamic separator for pretreatment
Proposed stormsewer diverts low flows into BMP
Construction Entrance
Park Trail
sanitary sewer easement
Avoid placing BMP within existing sanitary sewer easement.
Draintile drains to existing RM_12 pond
Filtration basin. See typical profile.
Outlet Control Structure
NRFS to treat flow bypassing filtration basin (Option 1d). See schematic.
Highest recorded lake level extent from 1970 to 2019.
RM_12 Pond
Drainage Area to BMP:
232 acres
Approximate BMP Footprint:
7,400 sf.
Approximate Area of Disturbance:
13,000 sf. (Option 1c)
13,800 sf. (Option 1d)
Existing Sanitary Sewer
Existing Trees
Existing Manhole
Construction Entrance
Estimated Construction Extents (Option 1c)
Estimated Construction Extents (Option 1d)
Highest Recorded Lake Level Extents (1976-2019)
Normal Water Level
Proposed Stormsewer (Option 1c)
Proposed Stormsewer (Option 1d)
Existing Stormsewer
Filtration Basin
NRFS (Option 1d)
Site Survey Contours
5-Foot Contour
1-Foot Contour
Parcel Boundary
Privately-Owned
City-Owned
N
0 20 40 80
Feet
BARR
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
Riley Purgatory Bluff Creek Watershed District

*Option 1a*

The proposed location of the stand-alone smaller footprint iron-enhanced sand filtration basin is south of the Rice Marsh Lake Park trail, north of the RM_12 constructed pond, and west of the ballfield. Due to the presence of an existing 66-inch sanitary sewer forcemain, the BMP must be placed within the extents of the small trees surrounding the RM_12 pond to prevent encroaching on the outfield of the ballfield. The basin will be lined to prevent interference and contamination of groundwater. Removal of approximately 0.05 acres of brush and small trees surrounding the pond will be required for the construction of the basin and outlet pipe. This area would be restored with native tamarack trees or swamp white oaks. This design requires minor reconstruction of the existing trail and the construction of a manhole structure and diversion weir to divert low flows into the basin.

Given the significant amount of sedimentation within the RM_12 pond over the last fifteen years, the proposed BMP would need to include a pretreatment structure to prevent frequent plugging. A hydrodynamic separator, or similar device, constructed near the catch basin along the south side of Dakota Lane would be easily accessible for regular maintenance and cleanout. A manhole to tie back into the existing stormsewer and an outlet control structure to manage flow through the basin would also be needed. From the existing stormsewer, low flows will be directed to the filtration basin where a series of draintile will convey filtered runoff back into the existing stormsewer to the RM_12 pond.

Soil borings were not completed as part of this feasibility evaluation. When additional information is available, an impermeable geomembrane may be required below the underdrain to prevent groundwater from seeping into the filtration system. High flows would exit the basin via an outlet structure. The outlet structure pipe would drain back into the existing stormsewer to the RM_12 pond. Option 1a is shown in Figure 6-2.

The filtration basin is designed with a minimum of 2.0 feet of sand media. This results in a design discharge rate of less than 0.1 cfs (assuming an infiltration rate of 1.6 in/hr through the sand media). The design discharge rate allows the filter to draw down within 48 hours of a rainfall event to prevent the filtration media from becoming anoxic, and potentially releasing phosphorus. This design would treat approximately 5 percent of the flow. The filtration media would be comprised of a mixture of sand and iron filings. It is anticipated that the iron filings would be 5 percent by weight of the filtration media.

*Option 1b*

Option 1b includes the smaller footprint filtration basin described in option 1a in conjunction with a Nutrient Removing Filtration System (NRFS). The NRFS will treat 0.6 cfs of the flow to the filtration basin that bypasses iron-enhanced sand treatment. Any large particulates that discharge from the hydrodynamic separator will have a chance to settle on the basin surface before flowing into the Nutrient Removing Filtration System, thus reducing maintenance within the proprietary device. The outlet structure pipe from the filtration basin would drain to the NRFS and back into the existing stormsewer to the RM_12 pond. Option 1b is shown in Figure 6-2.

*Option 1c*

Option 1c is a stand-alone, larger footprint iron-enhanced sand filtration basin located in the same area as option 1a. This option requires the removal of approximately 0.17 acres of brush and small trees surrounding the RM_12 pond to prevent encroaching on the outfield of the adjacent ballfield. This area would be restored with native tamarack trees or swamp white oaks. Although this option requires the removal of more trees around the RM_12 pond than in option 1a and 1b, it has been included in order to show the increased treatment provided by the larger basin configuration. Option 1c is shown in Figure 6-3.

The filtration basin is designed with a minimum of 2.0 feet of sand media. This results in a design discharge rate of 0.2 cfs (assuming an infiltration rate of 1.6 in/hr through the sand media). The design discharge rate allows the filter to draw down within 48 hours of a rainfall event to prevent the filtration media from becoming anoxic, and potentially releasing phosphorus. This design would treat approximately 12 percent of the flow. The filtration media would be comprised of a mixture of sand and iron filings. It is anticipated that the iron filings would be 5 percent by weight of the filtration media. An underdrain would be located below the filtration media to convey filtered stormwater to the proposed outlet structure.

*Option 1d*

Option 1d includes the larger footprint filtration basin described in option 1c in conjunction with a Nutrient Removing Filtration System (NRFS). The NRFS will treat 0.6 cfs of the flow to the filtration basin that bypasses iron-enhanced sand treatment. Any large particulates that discharge from the hydrodynamic separator will have a chance to settle on the basin surface before flowing into the Nutrient Removing Filtration System, thus reducing maintenance within the proprietary device. Option 1d is shown in Figure 6-3.

While option 1d is roughly ten times more costly to construction and maintain, it provides the added benefit of removing about ten times more phosphorus than option 1a. Thus the annual cost per pound of TP removed is only slightly less than that of option 1a.

### 6.1.1 Anticipated Water Quality Improvements

The calibrated Rice Marsh Lake P8 model described in Section 3.0 was used to define the phosphorus loading from the Rice Marsh Lake watershed. With the calibrated model, the performance of Conceptual Design 1 was evaluated, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals.

The performance of the conceptual design was evaluated for the same 2014 water year used in the 2016 UAA. The estimated average annual total phosphorus removal for the four Conceptual Design 1 configurations are shown in Table 6-1. Due to uncertainty in the observed data used for model calibration, the TP loading and removal are presented in a range provided from the uncalibrated and calibrated model results.

**Table 6-1 Total phosphorus removal by Conceptual Design 1**

| Conceptual Design 1 Configuration | TP Loading from Drainage Area (lbs/yr) | TP Bypassing BMP (lbs/yr) | TP Removed by BMP (lbs/yr) | Percent Removed By BMP (%) | TP Reduction to Rice Marsh Lake (lbs/yr) | Percent Removed To Rice Marsh Lake (%) |
|---|---|---|---|---|---|---|
| Conceptual Design 1a Iron-Enhanced Filtration Basin (small) | 256 - 286 | 239 - 267 | 17 - 19 | 7% | 4 - 5 | 2% |
| Conceptual Design 1b Iron-Enhanced Filtration Basin (small) with NRFS | 256 - 286 | 222 - 248 | 34 - 38 | 13% | 21 - 24 | 8% |
| Conceptual Design 1c Iron-Enhanced Filtration Basin (large) | 256 - 286 | 220 - 246 | 36 - 40 | 14% | 11 - 12 | 4% |
| Conceptual Design 1d Iron-Enhanced Filtration Basin (large) with NRFS | 256 - 286 | 209 - 234 | 47 - 52 | 18% | 29 - 33 | 11% |

### 6.1.2 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost (OPC) is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the estimated cost range for construction, planning engineering and design, permitting, construction management, and contingency for the four Conceptual Design 1 configurations are shown in Table 6-2. Maintenance requirements for Conceptual Design 1 include yearly site inspections, maintenance of vegetation surrounding the BMP, and maintenance of the native tree plantings to replace the removal of existing trees surrounding the RM_12 pond. Replacement of the sand media is required every 15 years. With the addition of the NRFS, an annual inspection of the filter and clean out of the pre-treatment chamber is required. The replacement of Bold & Gold media is required every 3-4 years. This level of maintenance equates to the annual costs shown in Table 6-2. The annual cost per pound of phosphorus removed is also provided in the table.

### Table 6-2 Engineer's OPC for Conceptual Design 1

| Conceptual Design 1 Configuration | Total Estimated Cost | Annual Maintenance Cost | Annual Cost per LB of TP removed(1) |
|---|---|---|---|
| Conceptual Design 1a<br>Iron-Enhanced Filtration Basin (small) | $303,000<br>($243,000 - $455,000) | $2,100<br>($1,800 - $3,200) | $2,850<br>($2,450 - $4,070) |
| Conceptual Design 1b<br>Iron-Enhanced Filtration Basin (small) with NRFS | $1,210,000<br>($968,000 - $1,815,000) | $8,000<br>($6,600 - $11,900) | $2,170<br>($1,850 - $3,080) |
| Conceptual Design 1c<br>Iron-Enhanced Filtration Basin (large) | $428,000<br>($343,000 - $642,000) | $4,500<br>($3,800 - $6,800) | $1,620<br>($1,390 - $2,300) |
| Conceptual Design 1d<br>Iron-Enhanced Filtration Basin (large) with NRFS | $1,310,000<br>($1,048,000 - $1,965,000) | $10,400<br>($8,600 - $15,500) | $1,750<br>($1,490 - $2,480) |

(1) Annual cost calculated over a 30-year lifespan.

Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 1.

### 6.1.3 Upland Impacts

The total area of disturbance for the proposed BMP is approximately 0.13 acres for the smaller footprint, and 0.30 acres for the larger footprint. This area includes the footprint of the filtration basin, the optional NRFS additional, and the construction of the diversion pipes. Based on the site survey conducted on November 12, 2019, 0.05 and 0.17 acres of small trees and underbrush near the RM_12 pond exist within the proposed BMP extents of the smaller basin and larger basin, respectively. These trees would need to be removed for the placement of the BMP. Tree impacts outside of the basin footprint would be restored with native tamarack or swamp white oak trees. The number of trees impacted by the proposed BMP may change in the next phase of design as grading extents are optimized.

### 6.1.4 Regulatory Approval

A grading permit for Conceptual Design 1 will be required by the city of Chanhassen.

The MPCA regulates the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. A NPDES permit is required for construction projects on less than 1 acre of soil that the MPCA determines pose a risk to water resources. Considering the location of the proposed BMP upstream of Rice Marsh Lake, it is likely that a NPDES permit will be required. The MPCA will also require a stormwater pollution prevention plan.

RPBCWD regulates the control of floodwater to ensure the preservation of floodplains and flood storage areas, improve water quality, preserve vegetation, alleviate identified erosion problems, ensure the preservation of wetland and creek buffers, and prevent erosion of shorelines and stream banks. A RPBCWD permit will be required, although the applicable rules will depend on the final site design and configuration. It is anticipated that a permit for Rule C – Erosion and Sediment Control, Rule D – Wetland and Creek Buffers, and Rule J – Stormwater Management would be required.

Pollutant loading reduction credits relative to Waste Load Allocations would be determined during the development of a cooperative agreement with the City.

### 6.1.5 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the city of Chanhassen. An access and cooperative agreement with the City will be needed.

## 6.2 Conceptual Design 2 – Manufactured Treatment Device

The four configurations of Conceptual Design 2 are shown in Figure 6-4 (options 2a, 2b, and 2c) and Figure 6-5 (option 2d). Conceptual Design 2 was analyzed using the following combinations:

**2a –** stand-alone Modular Wetland System (MWS),
**2b –** Modular Wetland System downstream of an underground storage vault,
**2c –** Modular Wetland System downstream of an underground iron-enhanced sand filtration system, and
**2d –** stand-alone Kraken Filter.

The Modular Wetland System (MWS) and Kraken Filter are two proprietary BMPs developed by Bio Clean. Both devices are suitable for placement beneath and west of the Rice Marsh Lake Park trail as it runs perpendicular to Dakota Lane north of the RM_12 pond. The Kraken has a higher treatment flow rate (2.9 cfs) compared to the MWS (0.7 cfs). To optimize the Modular Wetland System, the BMP was analyzed with upstream underground storage vaults to increase the treated volume through the device. Because the Kraken has a large treatment flow rate, this BMP was analyzed as a stand-alone system.

*Option 2a*

As previously mentioned, the BMP would be placed beneath and west of the Rice Marsh Lake Park trail as it runs perpendicular to Dakota Lane north of the RM_12 pond. The BMP minimizes removal of large trees within the park and does not require removal of any brush and small trees surrounding the pond. This design requires minor roadwork on Dakota Lane. Construction of a manhole structure and diversion weir to divert low flows into the BMP, and an outlet manhole to tie back into the existing stormsewer, would also be needed. From the existing stormsewer, low flows will be directed to the BMP. High flows which exceed the capacity of the BMP will re-enter the existing stormsewer to the pond.

Given the significant amount of sedimentation within the RM_12 pond over the last fifteen years, the flow to the proposed BMP will need to undergo pretreatment. However because the MWS has a built-in pretreatment chamber, an additional pretreatment device is not required.

The Modular Wetland System (MWS) will treat 0.7 cfs of the flow to the BMP. This option would not require road work on Dakota Lane, and would not encroach on the ballfield to the southeast. However, to avoid damage to the 12-inch basswood tree to the west of the trail, the park trail may need to be re-constructed further east.

With the exception of the plantings in the MWS, this BMP is entirely underground, limiting its visibility to the public.

*Option 2b*

Option 2b includes the Modular Wetland System described in option 2a with the addition of an underground storage vault upstream of the MWS. Construction of a manhole structure and diversion weir to divert low flows into the underground storage vault, an outlet manhole to tie back into the existing stormsewer from the MWS, and an additional structure to connect the underground vault to the Modular Wetland System would be needed.

From the existing stormsewer, low flows would be directed to the underground storage vault where stored runoff can be treated by the MWS. High flows which exceed the capacity of the underground storage vault would re-enter the existing stormsewer to the pond. This option requires reconstruction of a section of the park trail.

The Modular Wetland System (MWS) will treat 0.7 cfs of the flow to the BMP. Large particulates will have a chance to settle in the upstream underground vault before receiving treatment in the proprietary media, thus reducing maintenance within the proprietary device.

Option 2b will tie into the existing catch basin on the south side of Dakota Lane, requiring the replacement of a small section of curb and gutter, as well as, approximately 115 square yards of road/asphalt replacement for the trail and street.

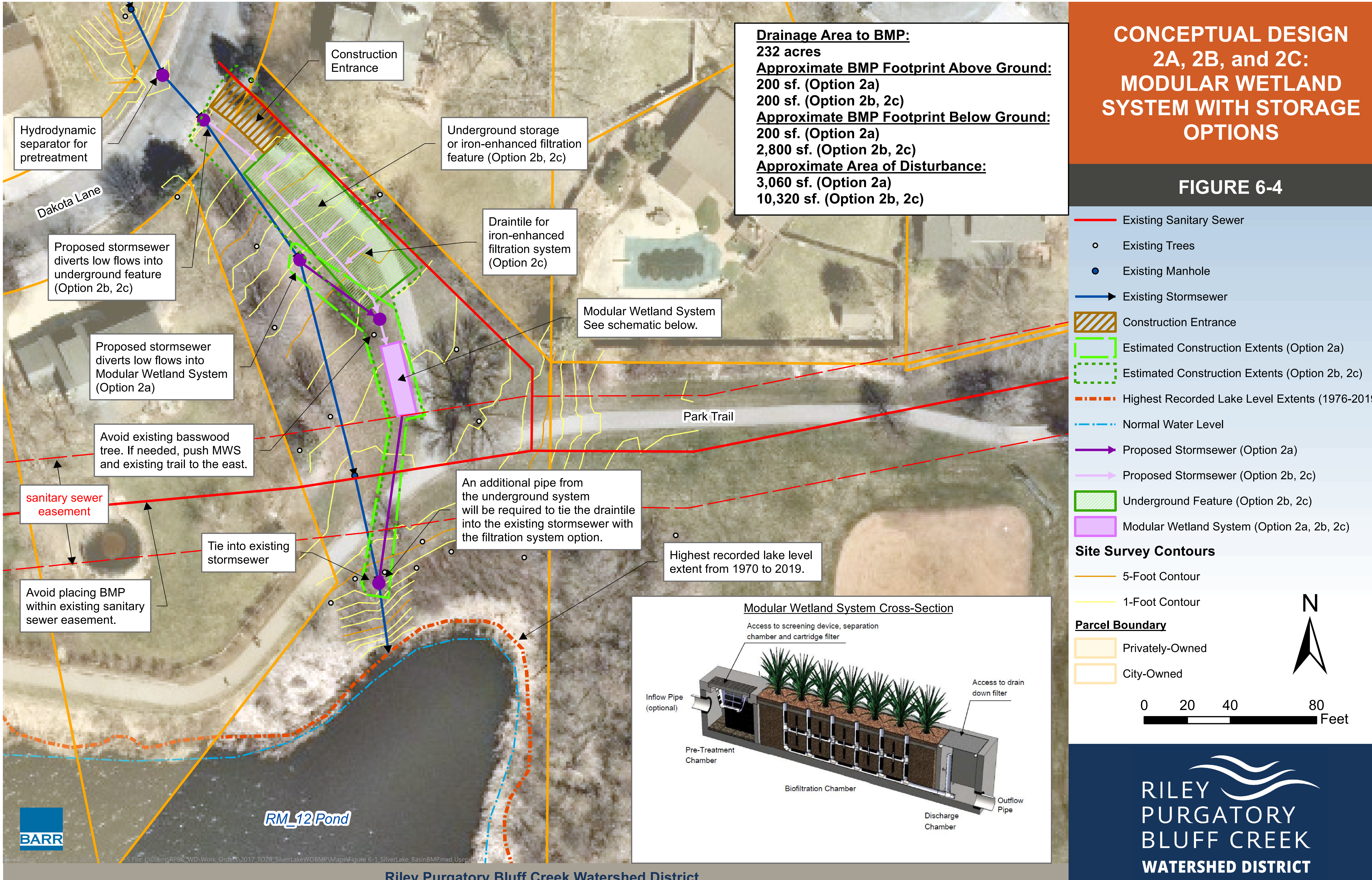
*Option 2c*

Option 2c includes the Modular Wetland System described in option 2a with the addition of an underground iron-enhanced sand filtration system upstream of the MWS. Construction of a manhole structure and diversion weir to divert low flows into the underground filtration system, an outlet manhole to tie back into the existing stormsewer from the MWS, draintile to convey filtered runoff from the filtration system back to the existing stormsewer, and an additional structure to connect the filtration system to the Modular Wetland System would be needed.

Because the underground iron-enhanced vault does not have a pretreatment chamber as part of the design, a hydrodynamic separator must be placed upstream of the vault to collect sediment before low flows are directed to the underground system. Stored runoff would be treated by the iron-enhanced sand media. Portions of high flows which exceed the capacity of the underground filtration system would enter the MWS for treatment. The Modular Wetland System (MWS) will treat 0.7 cfs of the flow to the BMP. Large particulates will have a chance to settle in the iron-enhanced sand filtration system before receiving treatment in the proprietary media, thus reducing maintenance within the proprietary device. Treated flow would re-enter the stormsewer to the pond.

Option 2c would tie into the existing catch basin on the south side of Dakota Lane, requiring the replacement of a small section of curb and gutter, as well as, approximately 115 square yards of road/asphalt replacement for the trail and street. This option also requires reconstruction of a section of the park trail.

The underground filtration system is designed with a minimum of 2.0 feet of sand media. This results in a design discharge rate of 0.1 cfs through the media (assuming an infiltration rate of 1.6 in/hr through the sand media). The design discharge rate allows the filter to draw down within 48 hours of a rainfall event to prevent the filtration media from becoming anoxic, and potentially releasing phosphorus. Filtration media would be comprised of a mixture of sand and iron filings. It is anticipated that the iron filings would be 5 percent by weight of the filtration media. An underdrain would be located below the filtration media to convey filtered stormwater back into the existing stormsewer.


CONCEPTUAL DESIGN 2A, 2B, and 2C: MODULAR WETLAND SYSTEM WITH STORAGE OPTIONS
FIGURE 6-4
Drainage Area to BMP:
232 acres
Approximate BMP Footprint Above Ground:
200 sf. (Option 2a)
200 sf. (Option 2b, 2c)
Approximate BMP Footprint Below Ground:
200 sf. (Option 2a)
2,800 sf. (Option 2b, 2c)
Approximate Area of Disturbance:
3,060 sf. (Option 2a)
10,320 sf. (Option 2b, 2c)
Construction Entrance
Hydrodynamic separator for pretreatment
Underground storage or iron-enhanced filtration feature (Option 2b, 2c)
Dakota Lane
Draintile for iron-enhanced filtration system (Option 2c)
Proposed stormsewer diverts low flows into underground feature (Option 2b, 2c)
Modular Wetland System See schematic below.
Proposed stormsewer diverts low flows into Modular Wetland System (Option 2a)
Park Trail
Avoid existing basswood tree. If needed, push MWS and existing trail to the east.
An additional pipe from the underground system will be required to tie the draintile into the existing stormsewer with the filtration system option.
sanitary sewer easement
Tie into existing stormsewer
Highest recorded lake level extent from 1970 to 2019.
Avoid placing BMP within existing sanitary sewer easement.
RM_12 Pond
BARR
Modular Wetland System Cross-Section
Access to screening device, separation chamber and cartridge filter
Inflow Pipe (optional)
Access to drain down filter
Pre-Treatment Chamber
Biofiltration Chamber
Discharge Chamber
Outflow Pipe
Existing Sanitary Sewer
Existing Trees
Existing Manhole
Existing Stormsewer
Construction Entrance
Estimated Construction Extents (Option 2a)
Estimated Construction Extents (Option 2b, 2c)
Highest Recorded Lake Level Extents (1976-2019)
Normal Water Level
Proposed Stormsewer (Option 2a)
Proposed Stormsewer (Option 2b, 2c)
Underground Feature (Option 2b, 2c)
Modular Wetland System (Option 2a, 2b, 2c)
Site Survey Contours
5-Foot Contour
1-Foot Contour
Parcel Boundary
Privately-Owned
City-Owned
N
0 20 40 80
Feet
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
Riley Purgatory Bluff Creek Watershed District

*Option 2d*

Option 2d is a stand-alone, double unit, KF-10-16 Kraken Filter (or similar) placed at the same location as option 2a. The BMP minimizes removal of large trees within the park and does not require removal of any brush and small trees surrounding the pond. This design requires minor roadwork on Dakota Lane. Construction of a manhole structure and diversion weir to divert low flows into the BMP, and an outlet manhole to tie back into the existing stormsewer, would also be needed. From the existing stormsewer, low flows will be directed to the BMP. High flows which exceed the capacity of the BMP will bypass the BMP and continue to discharge into the existing pond.

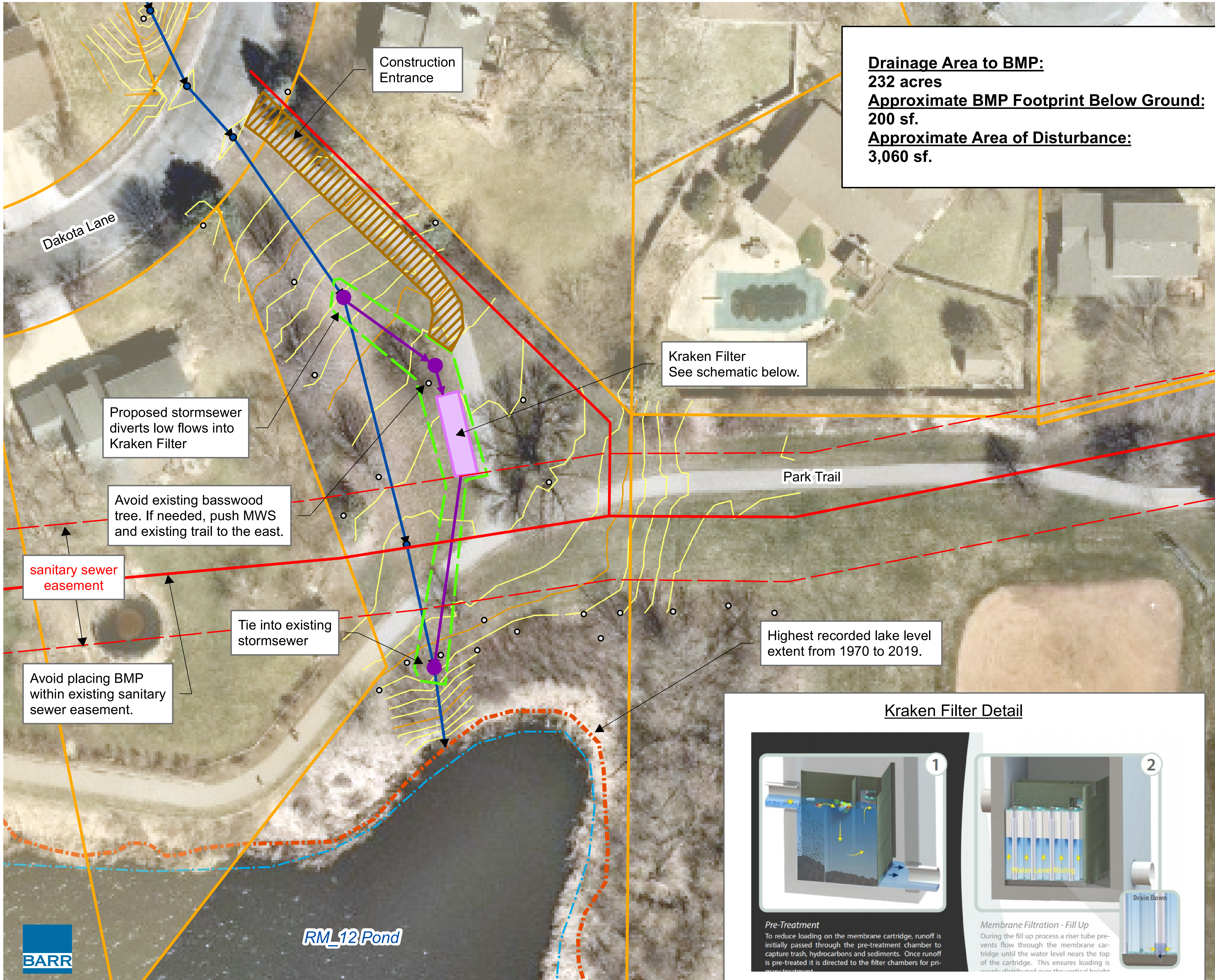
The Kraken Filter has a built-in pretreatment chamber at the upstream end of the device; therefore, this device would not require the construction of an additional pretreatment device.

The largest Kraken Filter unit (model number KF-10-16) can treat 2.9 cfs of the flow to the BMP. In order to optimize the treatment potential to achieve a treatment flow near 6 cfs, a Kraken Filter, or similar MTD, sized to the equivalent of two of the largest units is recommended. The double unit will treat 57% of the flow passing through the existing stormsewer to Rice Marsh Lake. However, to avoid damage to the 12-inch basswood tree to the west of the trail, the park trail may need to be re-constructed further east.

This BMP is entirely underground, limiting its visibility to the public.

# CONCEPTUAL DESIGN 2D: KRAKEN FILTER

## FIGURE 6-5




- Existing Sanitary Sewer
- Existing Trees
- Existing Manhole
- Existing Stormsewer
- Construction Entrance
- Estimated Construction Extents
- Highest Recorded Lake Level Extents (1976-2019)
- Normal Water Level
- Proposed Stormsewer
- Kraken Filter

**Site Survey Contours**

- 5-Foot Contour
- 1-Foot Contour

**Parcel Boundary**

- Privately-Owned
- City-Owned

N

0 20 40 80 Feet

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

The percentage of flow treated by Conceptual Design 2 is provided in Table 6-3.

**Table 6-3 Flow Treated by Conceptual Design 2**

| Conceptual Design 2 Configuration | Model Estimated Percentage of Flow Treated |
|---|---|
| Conceptual Design 2a<br>Modular Wetland System | 16 |
| Conceptual Design 2b<br>Modular Wetland System<br>with Underground IESF | 18 |
| Conceptual Design 2c<br>Modular Wetland System<br>with Underground Storage | 20 |
| Conceptual Design 2d<br>Kraken Filter | 57 |

### 6.2.1 Anticipated Water Quality Improvements

The calibrated Rice Marsh Lake P8 model described in Section 3.0 was used to define the phosphorus loading from the Rice Marsh Lake watershed. With the calibrated model, the performance of Conceptual Design 2 was evaluated, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals.

The performance of the conceptual design was evaluated for the same 2014 water year used in the 2016 UAA. The estimated average annual total phosphorus removal for the three Conceptual Design 2 configurations are shown in Table 6-4.

### Table 6-4 Total phosphorus removal by Conceptual Design 2

| Conceptual Design 2 Configuration | TP Loading from Drainage Area (lbs/yr) | TP Bypassing BMP (lbs/yr) | TP Removed by BMP (lbs/yr) | Percent Removed By BMP (%) | TP Reduction to Rice Marsh Lake (lbs/yr) | Percent Removed To Rice Marsh Lake (%) |
|---|---|---|---|---|---|---|
| Conceptual Design 2a Modular Wetland System | 256 - 286 | 231 - 258 | 25 - 28 | 10% | 16 - 18 | 6% |
| Conceptual Design 2b Modular Wetland System with Underground Storage | 256 - 286 | 227 - 254 | 29 - 32 | 11% | 18 - 20 | 7% |
| Conceptual Design 2c Modular Wetland System with Underground IESF | 256 - 286 | 222 - 248 | 34 - 38 | 13% | 22 - 25 | 9% |
| Conceptual Design 2d Kraken Filter | 256 - 286 | 172 - 192 | 84 - 94 | 33% | 52 - 59 | 20% |

### 6.2.2 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost (OPC) is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the estimated cost range for construction, planning engineering and design, permitting, construction management, and contingency for the three Conceptual Design 2 configurations are shown in Table 6-5. Maintenance requirements for Conceptual Design 2 include yearly filter inspection, maintenance of pre-treatment chamber, and replacement of pre-treatment filter cartridges. Iron-enhanced media replacement is required every 15 years for option 2c. This level of maintenance equates to the annual costs shown in Table 6-5. The annual cost per pound of phosphorus removed is also provided in the table.

**Table 6-5 Engineer's OPC for Conceptual Design 2**

| Conceptual Design 2 Configuration | Total Estimated Cost | Annual Maintenance Cost | Annual Cost per LB of TP removed(1) |
|---|---|---|---|
| Conceptual Design 2a<br>Modular Wetland System | $273,000<br>($219,000 - $410,000) | $2,400<br>($2,000 - $3,600) | $690<br>($590 - $980) |
| Conceptual Design 2b<br>Modular Wetland System with Underground Storage | $682,000<br>($546,000 - $1,023,000) | $2,400<br>($2,000 - $3,600) | $1,330<br>($1,130 - $1,890) |
| Conceptual Design 2c<br>Modular Wetland System with Underground IESF | $927,000<br>($742,000 - $1,391,000) | $4,000<br>($3,400 - $6,000) | $1,480<br>($1,260 - $2,100) |
| Conceptual Design 2d<br>Kraken Filter | $569,000<br>($456,000 - $854,000) | $12,800<br>($10,600 - $19,100) | $570<br>($490 - $810) |

(1) Annual cost calculated over a 30-year lifespan.

Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 2.

### 6.2.3 Upland Impacts

The total area of disturbance for the proposed BMP is approximately 0.1 acres for the stand-alone systems (option 2a and 2d), and 0.24 acres for the MWS with the upstream underground vault (option 2b and 2c). This area includes the footprint of the Modular Wetland System, the optional upstream underground vault, and the construction of the diversion pipes. Based on the site survey conducted on November 12, 2019, one 12-inch tree is near the BMP footprint. This tree would be protected by moving the existing park trail further east, if needed. This BMP would not compromise any of the recreational opportunities provided by park.

### 6.2.4 Regulatory Approval

A grading permit for Conceptual Design 2 will be required by the city of Chanhassen.

The MPCA regulates the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. A NPDES permit is required for construction projects on less than 1 acre of soil that the MPCA determines pose a risk to water resources.

Considering the location of the proposed BMP upstream of Rice Marsh Lake, it is likely that a NPDES permit will be required. The MPCA will also require a stormwater pollution prevention plan.

RPBCWD regulates the control of floodwater to ensure the preservation of floodplains and flood storage areas, improve water quality, preserve vegetation, alleviate identified erosion problems, ensure the preservation of wetland and creek buffers, and prevent erosion of shorelines and stream banks. A RPBCWD permit will be required, although the applicable rules will depend on the final site design and configuration. It is anticipated that a permit for Rule C – Erosion and Sediment Control, Rule D – Wetland and Creek Buffers, and Rule J – Stormwater Management may be required.

### 6.2.5 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the city of Chanhassen. An access and cooperative agreement with the City will be needed.

## 6.3 Conceptual Design 3 – Subsurface Gravel Bed Wetland

The two configurations of Conceptual Design 3 are shown in Figure 6-6. Conceptual Design 3 was analyzed using the following combinations:

> **3a –** stand-alone gravel bed wetland and
> **3b –** gravel bed wetland upstream of a Nutrient Removing Filtration System (NRFS).

*Option 3a*

The proposed location of the gravel bed wetland is south of the Rice Marsh Lake Park trail, north of the RM_12 constructed pond, and west of the ballfield. Due to the presence of an existing 66-inch sanitary sewer forcemain, the BMP must be placed within the extents of the small trees surrounding the RM_12 pond to prevent encroaching on the outfield of the ballfield. Removal of approximately 0.17 acres of brush and small trees surrounding the pond will be required for the construction of the wetland and outlet pipe. The affected area surrounding the basin would be restored with native tamarack trees or swamp white oaks.

Option 3a requires minor reconstruction of the trail and the construction of a manhole structure and diversion weir to divert low flows into the wetland. A manhole to tie back into the existing stormsewer and an outlet control structure to manage flow through the wetland would also be needed. From the existing stormsewer, low flows would be directed to the wetland where a series of draintile would convey filtered runoff back into the existing stormsewer to the RM_12 pond.

Given the significant amount of sedimentation within the RM_12 pond over the last fifteen years, the proposed BMP would need to include a pretreatment structure to prevent frequent plugging of the gravel bed. A hydrodynamic separator, or similar device, constructed near the catch basin along the south side of Dakota Lane would be easily accessible for regular maintenance and cleanout.

The wetland is designed with 8 inches of wetland soil and 2 feet of crushed stone for water storage. The wetland is designed to have approximately 4 inches of standing water in the crushed rock and works well in low hydraulic conductivity soils. The optimal discharge rate through the gravel bed is approximately 1.0 cfs which can be metered by the plug valve at the inlet pipe to the wetland. Research conducted by the University of New Hampshire has shown that although standing water exists in the crushed rock, dissolved oxygen levels never fell below 4.0 mg/L. Due to the close proximity to groundwater, the gravel bed wetland would be lined, and a backflow preventer would be installed on the subsurface drain outlet.

Option 3a would treat approximately 23 percent of the flow passing through this location. High flows would exit the wetland via an outlet structure. The outlet structure pipe would drain back into the existing stormsewer to the RM_12 pond.

*Option 3b*

Option 3b includes the subsurface gravel bed wetland described in option 3a, with the addition of a Nutrient Removing Filtration System (NRFS) downstream of the gravel bed forebay. The NRFS will treat 0.6 cfs of the flow to the wetland that bypasses treatment through the gravel bed forebay. Any large particulates that discharge from the hydrodynamic separator will have a chance to settle in the wetland forebay before flowing into the Nutrient Removing Filtration System. When the flowrate exceeds the capacity of the NRFS, the remaining volume will continue through the main bed of the gravel wetland.

Option 3b would treat approximately 26 percent of the flow passing through this location. High flows that exceed the capacity of the NRFS and gravel bed wetland would exit via an outlet structure at the downstream end of the gravel bed wetland. The outlet structure pipe would drain to the RM_12 pond.

### 6.3.1 Anticipated Water Quality Improvements

The calibrated Rice Marsh Lake P8 model described in Section 3.0 was used to define the phosphorus loading from the Rice Marsh Lake watershed. With the calibrated model, the performance of Conceptual Design 3 was evaluated, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals.

The performance of the conceptual design was evaluated for the same 2014 water year used in the 2016 UAA. The estimated average annual total phosphorus removal for the two Conceptual Design 3 configurations are shown in Table 6-6.

**Table 6-6 Total phosphorus removal by Conceptual Design 3**

| Conceptual Design 3 Configuration | TP Loading from Drainage Area (lbs/yr) | TP Bypassing BMP (lbs/yr) | TP Removed by BMP (lbs/yr) | Percent Removed By BMP (%) | TP Reduction to Rice Marsh Lake (lbs/yr) | Percent Removed To Rice Marsh Lake (%) |
|---|---|---|---|---|---|---|
| Conceptual Design 3a Subsurface Gravel Wetland | 256 - 286 | 222 - 248 | 34 - 38 | 13% | 21 - 24 | 8% |
| Conceptual Design 3b Subsurface Gravel Wetland with NRFS | 256 - 286 | 215 - 240 | 41 - 46 | 16% | 26 - 29 | 10% |

### 6.3.2 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the estimated cost range for construction, planning engineering and design, permitting, construction management, and contingency for the two Conceptual Design 3 configurations are shown in Table 6-7. Maintenance requirements for Conceptual Design 3 include yearly site inspections and maintenance of vegetation surrounding the BMP. With the addition of the NRFS, an annual inspection of the filter and clean out of the pre-treatment chamber is required. The replacement of Bold & Gold media is required every 3-4 years. This level of maintenance equates to the annual costs shown in Table 6-7. The annual cost per pound of phosphorus removed over the expected 30-year lifespan is also provided in the table.

### Table 6-7 Engineer's OPC for Conceptual Design 3

| Conceptual Design 3 Configuration | Total Estimated Cost | Annual Maintenance Cost | Annual Cost per LB of TP removed(1) |
|---|---|---|---|
| Conceptual Design 3a<br>Subsurface Gravel Wetland | $335,000<br>($268,000 - $503,000) | $4,400<br>($3,700 - $6,600) | $690<br>($590 - $980) |
| Conceptual Design 3b<br>Subsurface Gravel Wetland with NRFS | $1,106,000<br>($885,000 - $1,659,000) | $12,200<br>($10,100 - $18,200) | $1,810<br>($1,550 - $2,570) |

(1) Annual cost calculated over a 30-year lifespan.

Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 3.

### 6.3.3 Upland Impacts

The total area of disturbance for the proposed BMP is approximately 0.2 acres. This area includes the footprint of the gravel bed wetland, the NRFS, and the construction of the diversion pipes. Based on the tree survey conducted on November 12, 2019, 0.14 acres of clearing within the underbrush and small trees near the RM_12 pond will be required for the construction of the wetland and pipes tying into the existing stormsewer and directly to the pond. Tree impacts outside of the gravel bed wetland footprint would be restored with native tamarack or swamp white oak trees. The number of trees impacted by the proposed BMP may change in the next phase of design as grading extents are optimized.

### 6.3.4 Regulatory Approval

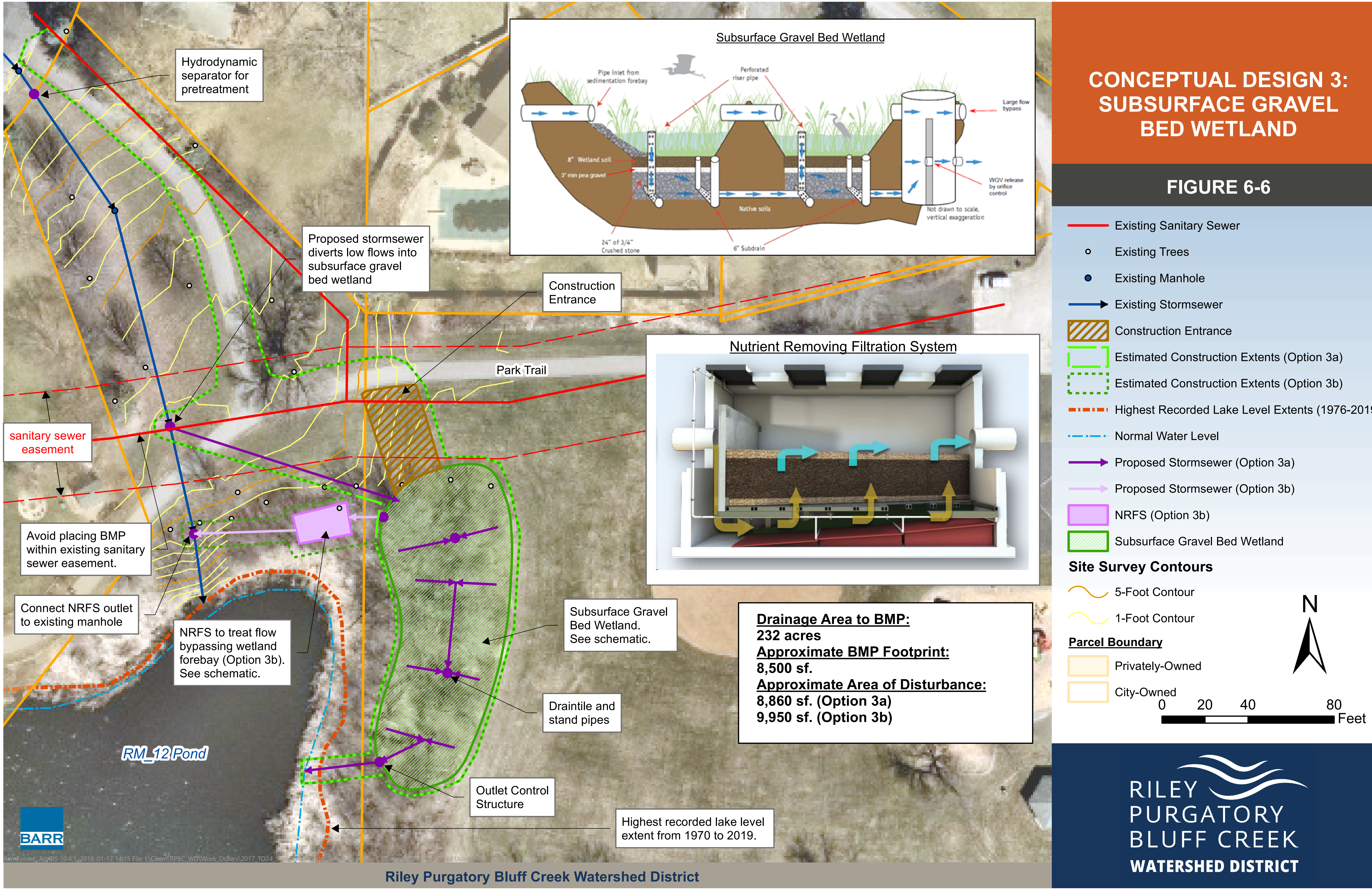
A grading permit for Conceptual Design 3 will be required by the city of Chanhassen.

The MPCA regulates the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. A NPDES permit is required for construction projects on less than 1 acre of soil that the MPCA determines pose a risk to water resources. Considering the location of the proposed BMP upstream of Rice Marsh Lake, it is likely that a NPDES permit will be required. The MPCA will also require a stormwater pollution prevention plan.

RPBCWD regulates the control of floodwater to ensure the preservation of floodplains and flood storage areas, improve water quality, preserve vegetation, alleviate identified erosion problems, ensure the preservation of wetland and creek buffers, and prevent erosion of shorelines and stream banks. A RPBCWD permit will be required, although the applicable rules will depend on the final site design and configuration. It is anticipated that a permit for Rule C – Erosion and Sediment Control, Rule D – Wetland and Creek Buffers, and Rule J – Stormwater Management may be required.

### 6.3.5 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the city of Chanhassen. An access and cooperative agreement with the City will be needed.



CONCEPTUAL DESIGN 3: SUBSURFACE GRAVEL BED WETLAND
FIGURE 6-6
Existing Sanitary Sewer
Existing Trees
Existing Manhole
Existing Stormsewer
Construction Entrance
Estimated Construction Extents (Option 3a)
Estimated Construction Extents (Option 3b)
Highest Recorded Lake Level Extents (1976-2019)
Normal Water Level
Proposed Stormsewer (Option 3a)
Proposed Stormsewer (Option 3b)
NRFS (Option 3b)
Subsurface Gravel Bed Wetland
Site Survey Contours
5-Foot Contour
1-Foot Contour
Parcel Boundary
Privately-Owned
City-Owned
N
0 20 40 80 Feet
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
Subsurface Gravel Bed Wetland
Pipe inlet from sedimentation forebay
Perforated riser pipe
Large flow bypass
8" Wetland soil
3" min pea gravel
WQV release by orifice control
Native soils
Not drawn to scale, vertical exaggeration
24" of 3/4" Crushed stone
6" Subdrain
Nutrient Removing Filtration System
Hydrodynamic separator for pretreatment
Proposed stormsewer diverts low flows into subsurface gravel bed wetland
Construction Entrance
Park Trail
sanitary sewer easement
Avoid placing BMP within existing sanitary sewer easement.
Connect NRFS outlet to existing manhole
NRFS to treat flow bypassing wetland forebay (Option 3b). See schematic.
Subsurface Gravel Bed Wetland. See schematic.
Draintile and stand pipes
Outlet Control Structure
Highest recorded lake level extent from 1970 to 2019.
RM_12 Pond
Drainage Area to BMP:
232 acres
Approximate BMP Footprint:
8,500 sf.
Approximate Area of Disturbance:
8,860 sf. (Option 3a)
9,950 sf. (Option 3b)
BARR
Riley Purgatory Bluff Creek Watershed District

## 6.4 Conceptual Design 4 – Dredging of RM_12 Pond

Conceptual Design 4 involves the dredging of the existing RM_12 pond to NURP standards. The BMP will not require removal of large trees and minimizes the removal of the smaller trees and underbrush surrounding the pond. The pond was originally constructed to NURP standards in 2005 (see Appendix B for design). However, bathymetry data collected by the City of Chanhassen indicates that the pond has filled in significantly in the last 15 years. According to the bathymetry survey, the pond has experienced a loss of approximately 3.4 ac-ft of storage below the normal water level due to sediment inflow. In some locations, the pond is less than 2.0 feet deep (see Figure 6-7). Conceptual Design 4 recommends dredging the pond back to the original design and repairing the 30-foot-wide overflow outlet to Rice Marsh Lake (Figure 6-6).

Conceptual Design 4 would treat all of the flow passing through this location.

Because the City is responsible for maintaining the pond, an opportunity for the City to help fund, supply equipment, and/or provide maintenance staff may exist. For additional treatment, the pond dredging option could also be included with Conceptual Designs 1, 2, or 3.


# EXISTING RM_12 POND BATHYMETRY

## FIGURE 6-7

- 0.5-Foot Approx. Depth Contour
- 2-Foot Approx. Depth Contour
- Existing Manhole
- Existing Stormsewer

N

0 37.5 75 150 Feet

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

### 6.4.1 Anticipated Water Quality Improvements

The existing pond bathymetry and restored pond bathymetry were modeled in the calibrated Rice Marsh Lake P8 model described in Section 3.0 to determine the reduction in phosphorus loading to Rice Marsh Lake. With the calibrated model, the performance of Conceptual Design 4 was evaluated, estimating the average annual volume of runoff treated by the proposed BMP and the associated phosphorus removals.

The performance of the conceptual design was evaluated for the same 2014 water year used in the 2016 UAA. The estimated average annual total phosphorus removal for Conceptual Design 4 is shown in Table 6-8.

**Table 6-8 Total phosphorus removal by Conceptual Design 4**

| Conceptual Design 4 Configuration | Existing Conditions TP Loading to Rice Marsh Lake (lbs/yr) | Dredged Conditions TP Loading to Rice Marsh Lake (lbs/yr) | TP Removed by BMP (lbs/yr) | Percent Removed By BMP (%) |
|---|---|---|---|---|
| Conceptual Design 4 Dredging of RM_12 Pond | 170 - 190 | 163 - 182 | 7 - 8 | 4% |

### 6.4.2 Engineer's Opinion of Probable Cost

The Engineer's opinion of probable cost is reported as a range of probable costs. The range reflects the level of uncertainty, unknowns, and risk associated with the level of design completed. Based on the current level of design, the estimated cost range for construction, planning engineering and design, permitting, construction management, and contingency for Conceptual Design 4 is shown in Table 6-9. Conceptual Design 4 requires clean out and inspection of the dredged pond every 15 years. The annual cost per pound of phosphorus removed is also provided in Table 6-9.

**Table 6-9 Engineer's OPC for Conceptual Design 4**

| Conceptual Design 4 Configuration | Total Estimated Cost | Annual Maintenance Cost | Annual Cost per LB of TP removed(1) |
|---|---|---|---|
| Conceptual Design 4<br>Dredging of RM_12 Pond | $680,000<br>($544,000 - $1,020,000) | $5,600<br>($4,600 - $8,300) | $3,870<br>($3,300 - $5,490) |

(1) Annual cost calculated over a 30-year lifespan.

Appendix A includes a detailed discussion including assumptions used to determine the Engineer's opinion of probable cost for Conceptual Design 4.

### 6.4.3 Upland Impacts

The total area of disturbance for the proposed BMP is approximately 0.02 acres for site access. As previously mentioned, only a minimal amount of clearing of the underbrush near the RM_12 pond will be required for maneuvering through the pond.

### 6.4.4 Regulatory Approval

A grading permit for Conceptual Design 4 will be required by the city of Chanhassen.

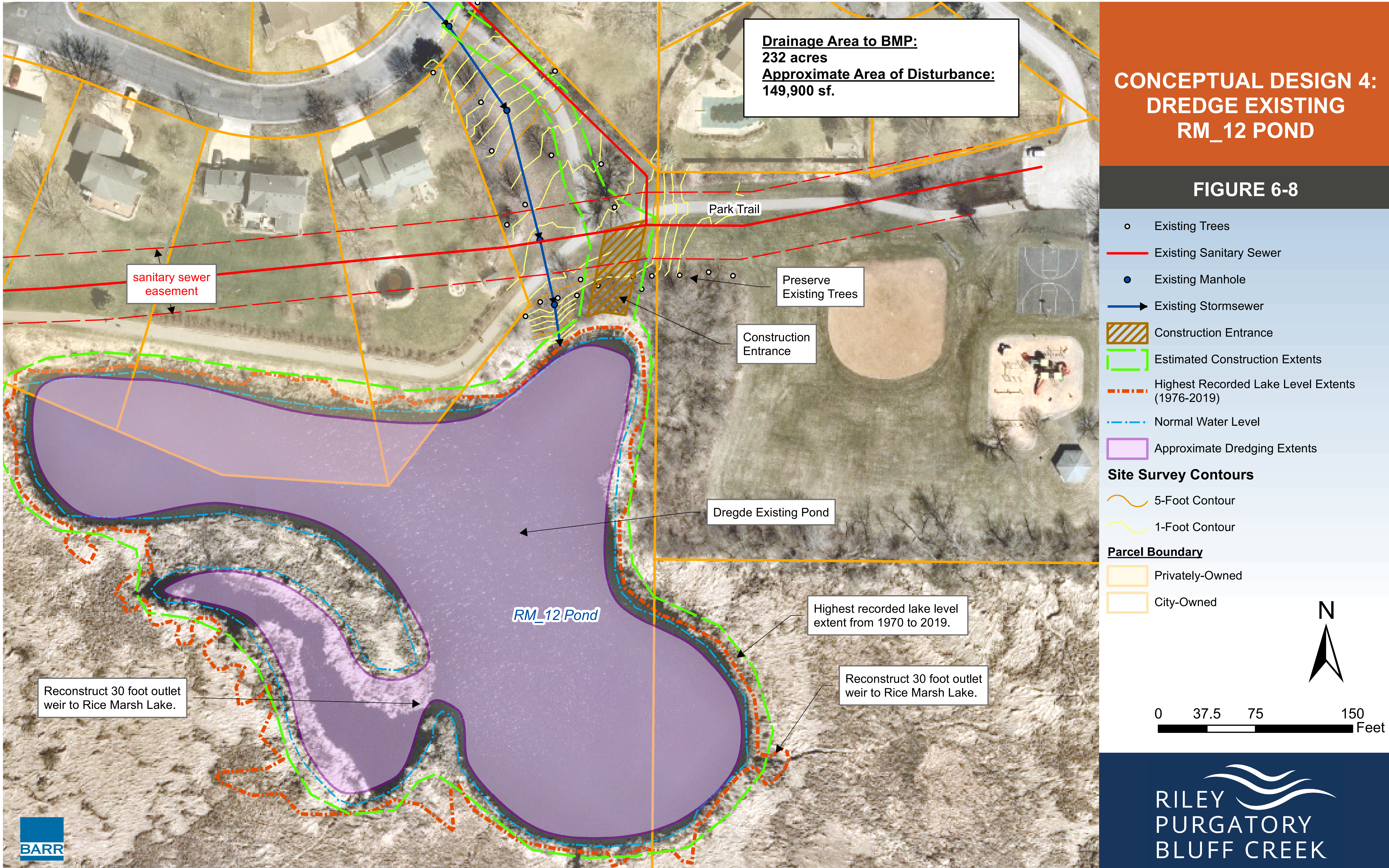
Because there would be work below the Ordinary High Water Level of Rice Marsh Lake, permitting for DNR approval would be required.

The MPCA regulates the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. A NPDES permit is required for construction projects on less than 1 acre of soil that the MPCA determines pose a risk to water resources. Considering the location of the proposed BMP upstream of Rice Marsh Lake, it is likely that a NPDES permit will be required. The MPCA will also require a stormwater pollution prevention plan.

RPBCWD regulates the control of floodwater to ensure the preservation of floodplains and flood storage areas, improve water quality, preserve vegetation, alleviate identified erosion problems, ensure the preservation of wetland and creek buffers, and prevent erosion of shorelines and stream banks. A RPBCWD permit will be required, although the applicable rules will depend on the final site design and configuration. It is anticipated that a permit for Rule C – Erosion and Sediment Control, Rule D – Wetland and Creek Buffers, and Rule J – Stormwater Management may be required.

### 6.4.5 Affected Property Owners

The proposed stormwater treatment BMP would be constructed completely within parcels owned by the city of Chanhassen. An access and cooperative agreement with the City will be needed.


CONCEPTUAL DESIGN 4: DREDGE EXISTING RM_12 POND
FIGURE 6-8
Drainage Area to BMP:
232 acres
Approximate Area of Disturbance:
149,900 sf.
Park Trail
sanitary sewer easement
Preserve Existing Trees
Construction Entrance
Dregde Existing Pond
RM_12 Pond
Highest recorded lake level extent from 1970 to 2019.
Reconstruct 30 foot outlet weir to Rice Marsh Lake.
Reconstruct 30 foot outlet weir to Rice Marsh Lake.
Existing Trees
Existing Sanitary Sewer
Existing Manhole
Existing Stormsewer
Construction Entrance
Estimated Construction Extents
Highest Recorded Lake Level Extents (1976-2019)
Normal Water Level
Approximate Dredging Extents
Site Survey Contours
5-Foot Contour
1-Foot Contour
Parcel Boundary
Privately-Owned
City-Owned
N
0
37.5
75
150
Feet
BARR
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

## 6.5 Soil Health

The Natural Resources Conservation Service (NRCS) defines "soil health, also referred to as soil quality, as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. This definition speaks to the importance of managing soils so they are sustainable for future generations." Because the water resources are directly impacted by what happens on the land within the resource's watershed, understanding and promoting soil health is an important avenue to achieving the many RPBWCD's goals identified the 10-year plan, Planning for the Next Ten Years 2018-2027. Table 6-10 summarizes various RPBCWD goals and strategies that have some connection to healthy soils.

**Table 6-10 Soil Health Connection to RPBCWD Goals and Strategies**

| Goal | Description | Applicable Strategies |
|---|---|---|
| EO 1 | Design, maintain, and implement Education and Outreach programs to educate the community and engage them in the work of protecting, managing, and restoring water resources. | EO S4,<br>EO S7<br>EO S9 |
| Plan 2 | Include sustainability and the impacts of climate change in District projects, programs, and planning. | Plan S2<br>Plan S3<br>Plan S7 |
| WQual 1 | Protect, manage, and restore water quality of District lakes and creeks to maintain designated uses. | WQual S1<br>WQual S3<br>WQual S6<br>WQual S8<br>WQual S11<br>WQual S13<br>WQual S14<br>WQual S18 |
| WQual 2 | Preserve and enhance the quantity, as well as the functions and values of District wetlands. | |
| WQual 3 | Preserve and enhance habitat important to fish, waterfowl, and other wildlife. | |
| Ground 1 | Promote the sustainable management of groundwater resources. | Ground S1<br>Ground S2 |
| WQuan 1 | Protect and enhance the ecological function of District floodplains to minimize adverse impacts. | WQuan S1<br>WQuan S2<br>WQuan S3<br>WQuan S6<br>WQuan S7<br>WQuan S8<br>WQuan S9<br>WQuan S10 |
| WQuan 2 | Limit the impact of stormwater runoff on receiving waterbodies. | |

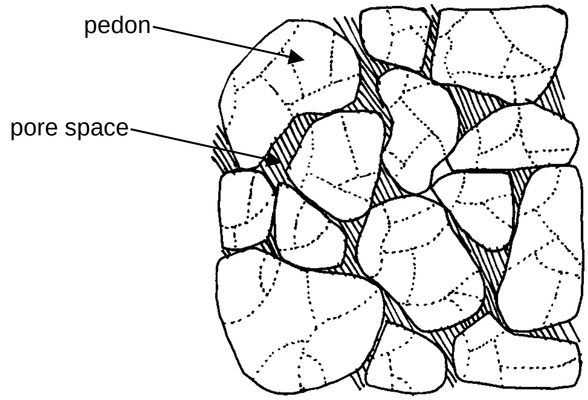
Therefore, in addition to any of the aforementioned BMPs, tilling to loosen soils and amending with compost within the construction extents of the BMP is recommended and would result in additional runoff retention and reduce TP loading to Rice Marsh Lake. Typically, a soil with good structure (defined below) has 25% of the pore space available to retain water. That means that eight inches of healthy amended/tilled soil can retain two inches of water during a storm event. This assumes that the soil is vegetated so that the water flow is slowed to allow for infiltration rather than run across the surface.

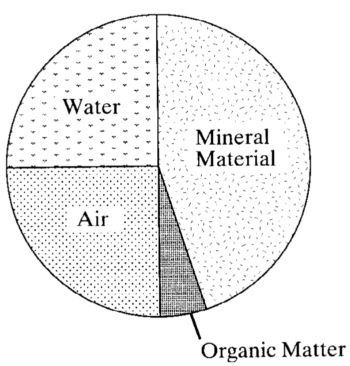
### 6.5.1 Soil Structure

Soil structure refers to how the sand, silt, and clay in soils are grouped together into aggregates called pedons. With the formation of pedons, pore space is provided in soils – the combination of pedons and pore spaces promotes the development of good soil structure.

Soil pedons are formed by:

- humus (highly decomposed compost and organic matter),
- organic glues created by fungi and bacteria in the decomposing organic matter, and
- polymers and sugars excreted from plant roots.




Soils with ideal soil structure contain 50% mineral material and 50% pore space. Water readily infiltrates into the soil and is held in this pore space. Plants grown on soils with good soil structure are healthy and resilient to stresses of flood, drought, insects, and disease.

*Soil scooped from a badger mound in a prairie that has never been tilled, compacted, or otherwise disturbed. All soil processes are functioning. Pedons are visible that make up soil structure.*

Much of the Rice Marsh Lake watershed has low infiltrating, clayey soil, and so infiltration of runoff on landscaped areas is a challenge. Clay soils have a very dense (poor) soil structure because this soil is characterized by very small clay particles that tightly bond together to form a very dense soil. In addition, while the clay soil has a lot of tiny pore spaces, the water is held very tightly within these pore spaces. These properties make it difficult for plant roots to grow deep into the soil, for water to infiltrate, and for plants to use the water stored in the soil. Plant growth should be encouraged by tilling organic matter amendments into the soil to provide additional larger pore space and to facilitate structure enhancement by the soil food web (described below) to increase aeration and infiltration.

*Soil being tilled to incorporate organic matter in a compacted urban landscape. This method helps to provide nutrients and promote development of soil structure for plants to thrive.*

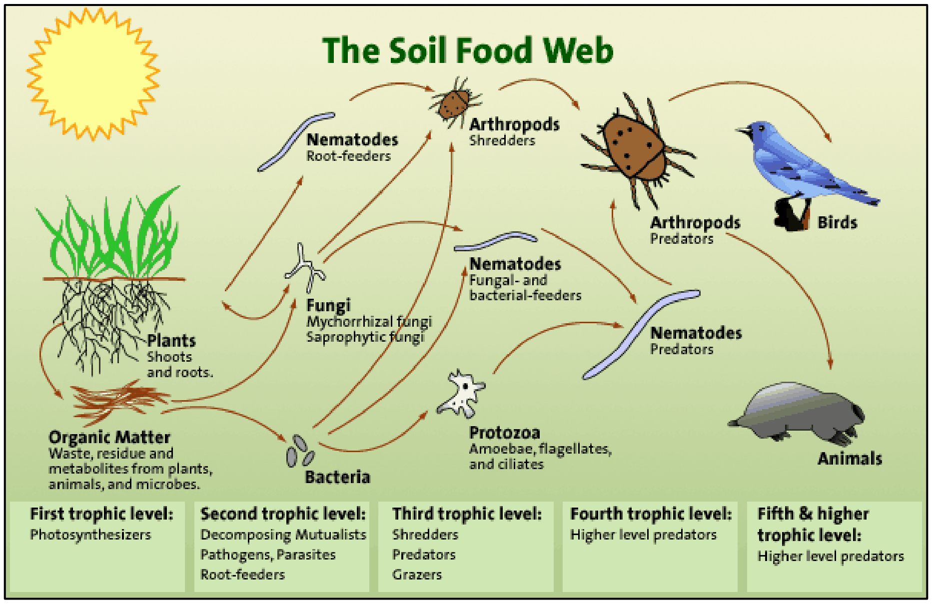
Soil compaction through mass grading, soil stripping and construction (including lawns) destroys soil structure and significantly reduces the ability of water to soak into ground. Amending lawns and landscapes with organic matter increases infiltration and facilitates pollutant removal by binding contaminants to soil particles or breakdown by microbes. In most cases, amending any soil type with organic matter is beneficial; amending sandy soil improves nutrient and water holding capacity, while amending clay soil improves drainage and aeration. Organic matter is any decomposed plant or animal material (compost, mulch, rotted manure, etc.) which improves soil structure and porosity.

*Compost produced from yard waste by metro cities.*

There are many advantages to building soil structure by amending soils with organic matter. Good soil structure means that the porous soil will:

- Readily accept stormwater, allowing for quick infiltration of large volumes of water.
- Hold large volumes of water in the soil for future availability to plants. This makes for healthier, more resilient plantings.
- Reduce the amount of phosphorus reaching water bodies because first, large volumes of water are intercepted by soils, and second because soils readily and strongly adhere phosphorous to soil particles. Phosphorus is an essential plant nutrient. Its best held in the soil where landscape and native plants can use it rather than letting it run to lakes where it feeds algae.
- Hold oxygen in the soil. This is essential for root respiration and diversity of microbes in the soil.
- Provide nutrients to plants as compost further breaks down soil microbes.

- Provide food and habitat for microbes living in the soil which break down organic matter and supply nutrients to plants. In exchange, they consume sugars and proteins release from plant roots, therefore feeding the soil food web. Larger organisms, like nematodes and arthropods, burrow through the soil, mixing it, providing the mechanism for soil aeration, increased infiltration, and physically developing soil pedons.




Organic matter is naturally found in the upper soil layers (topsoil). The color of the topsoil can provide some clues as to how much organic matter is in the soil. Typically, darker color soil has more organic matter caused by the carbon in the organic matter. Conversely, a lighter color soil would have less organic matter (because there is less carbon).

*Soil under a dry lawn that is devoid of organic matter. Organic matter (black topsoil) was added as an amendment to promote plant growth and water infiltration.*

Organic matter acts like glue to bind soil particles into pedons, which improves the soil structure and water holding capacity. Organic matter can also reduce soil erosion by promoting infiltration (rather than runoff) and improving the stabilization of soil pedons (so pedons stay in place).

Soil structure is destroyed by:

- Compaction – through construction activities, driving vehicles, or excessive foot traffic. Compaction reduces pore space, limits oxygen circulation and plant growth, and decreases water infiltration.
- Stripping of topsoil and mass grading – which eliminates or mixes topsoil deep into the soil profile and out of reach for plants.
- Pesticides and other contaminants – which kill soil organisms that are the backbone of developing and maintaining soil structure.
- Fertilizers – which throw off the nutrient balance for microbes, and impact the soil food web by altering the function of bacteria.
- Excessive tilling – which destroys soil structure and vital fungal systems. This is mainly a problem in agricultural settings. Initial tilling of compost into a depleted or compacted soil is an essential first step in restoring soil.

While most native soils are 2 to 10 percent organic matter, urban soils typically contain a minimal amount of organic matter due to the action of mass grading and mixing soil deep in the ground. Therefore, the addition of organic matter to feed the soil food web is a key component for soil restoration. Tilling 6 to 8 inches of compost into the top 8 inches of soil will help restore the soil food web by providing pathways for oxygen and sources of nutrition to sustain microbes, which maintain the looseness of the soil. Tilling can initially promote a flush of beneficial microbial activity in the soil, increasing the rate of decomposition. As the food webs of microbes and invertebrates (fed by the nutrients released from the decomposing organic material) in the amended soil develop and become more active, they help to improve porosity and infiltration capacity of the soil.

### 6.5.2 Soil Amendments

Amendments such as compost, manure, biochar, or any other form of decomposed organic material can be used to amend the soil. Biochar is a charcoal-like material that is made by burning biomass (wood, grasses, etc.) in the absence of oxygen, and stores carbon, the key component of organic matter. Biochar is a stable solid that remains intact in soils for a long time. It is used as a soil amendment because it increases the water holding capacity of the soil. If soil pH is an issue, amendments to balance it include lime (raises pH and lowers acidity) and gypsum (modifies calcium) which, if used correctly, will change pH and modify the soil structure allowing better infiltration. A soil test should be conducted before adding these amendments. As landscapes and lawns are established, incorporating soil amendments helps turf, trees, and shrubs survive drought periods (because the water-holding capacity of the soil is increase) and prevents sogginess during wet periods (because water infiltrates deeper into the soil profile).

### 6.5.3 Recommendations

For this project, it is recommended that eight inches of compost be incorporated into the top eight inches of existing soil within the construction extents of the chosen BMP. Areas where soil amendment is recommended are shown on Figure 6-9. For the surface BMP options (i.e., Conceptual Designs 1 and 3), the amended soil would serve as an infiltration bench surrounding the basin, providing additional abstraction of runoff from basin overflow during large storm events.

If implemented, performance monitoring of rehabilitated soil is recommended in order to document effectiveness of the BMP. This effort could be a potential site within a larger study for the District to document and compare the ecological health of amended soil areas versus adjacent areas with more typical restoration techniques. Sample collection could be conducted using a tube-type or edger-type lawn sampler as shown in the figures below.

Tube-type lawn sampler

Edger-type lawn sampler

It is also recommended that RPBCWD undertake a study to better understand the health (structure) of soils throughout the watershed. The study would document the potential for healthy, well-structured soils to improve water quality, to reduced flood potential, and to enhance community resiliency. This study could include:

- **Assessment of sentinel sites**. Collecting soil samples at various land use locations throughout the District to document the background health of soils. These sentinel soil sites could include both undisturbed and disturbed soils including: the "Big Woods", bluff area, wetlands west of Lake Ann, sample residential properties, parks, and commercial/industrial areas. Soil samples would be collected and analyzed for compaction, percent organic matter and microbial function.
- **Literature review**. Extensive research exists on soil health and its effects on improved water quality. A literature review could be conducted to compile research findings and to identify best practices for soil improvement and soil guidance/policies for water quality improvement in the District.
- **Develop recommendations**. From the soils analysis of sentinel sites and the literature review, summarize findings to include:
    - the comparison of soils in sentinel sites.
    - a summary of literature findings of soil health to water quality.
    - a summary of potential guidance and policies for soil improvement.
- **How to guide**. Develop a primer on soil health and protocols for soil improvement could be developed for citizens of the District and contractors developing projects within the District.

Outcomes of this study would:

- provide data and logic behind the funding (cost-share efforts) of soil amendment projects,
- provide permit applicants a mechanism to better understand the benefits of incorporating soil amendments as a BMP for meeting volume abstraction requirements, and
- support RPBCWD groundwater and wetland function by providing means to improve surficial groundwater recharge and baseflows.

If the Board elects to move forward with this initiative, a detailed study outline will be developed. The majority this work could be undertaken by District service learners (i.e., interns) once a study outline has been developed.

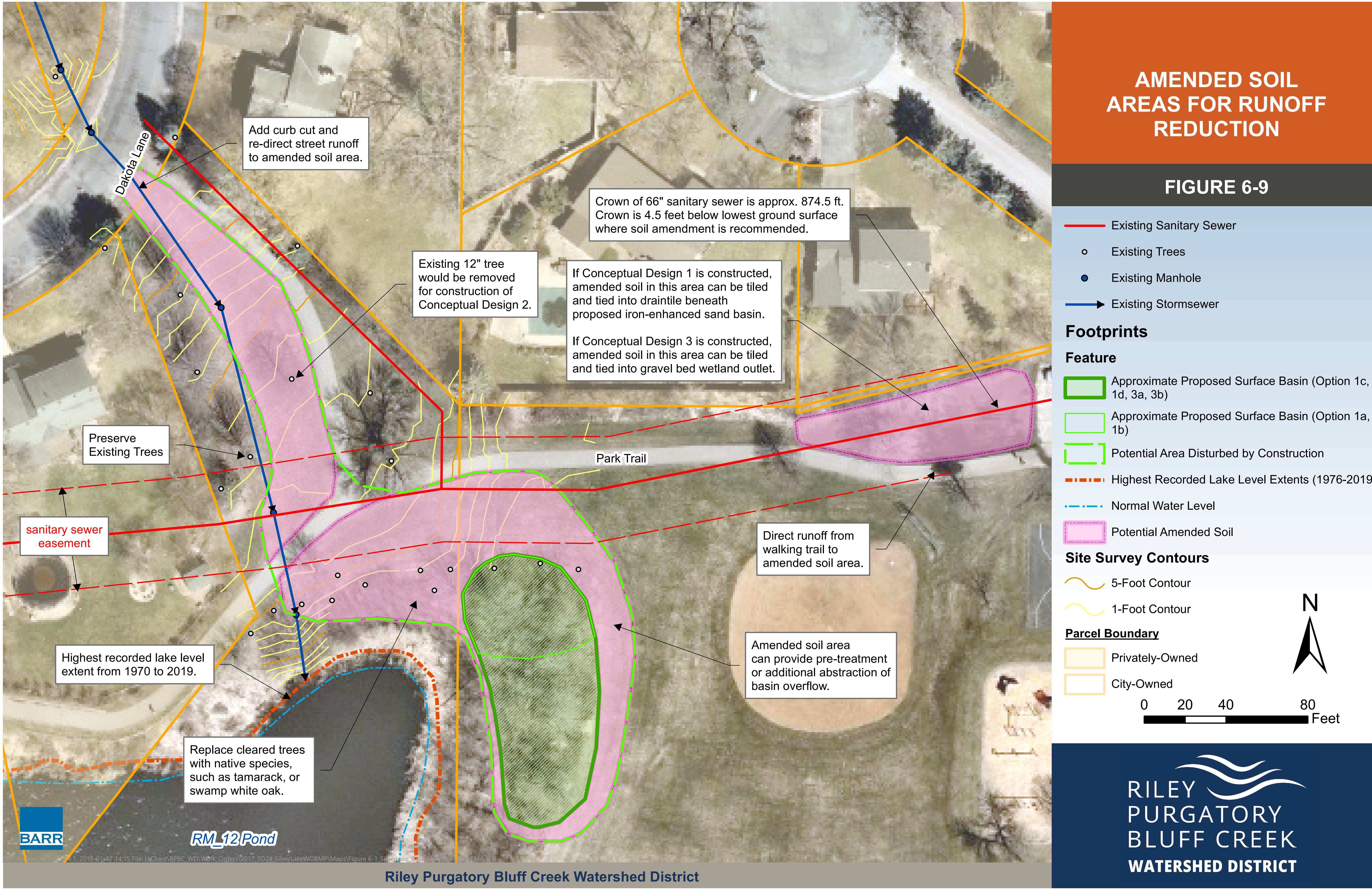
### 6.5.4 Engineer's Opinion of Probable Cost

Soil amendment was not included in the Engineer's opinion of probable cost for each conceptual design option. Table 6-11 summarizes the estimated cost for each BMP if soil amendment was applied within the construction extents, assuming $21 - $25 per square yard of amended soil.

**Table 6-11 Engineer's OPC for Soil Amendment**

| Conceptual Design | Soil Amendment Area (acres) | Total Estimated Cost ($) |
|---|---|---|
| Conceptual Design 1a<br>Iron-Enhanced Filtration Basin (small) | 0.31 | $34,000<br>($30,800 - $37,200) |
| Conceptual Design 1b<br>Iron-Enhanced Filtration Basin (small) with NRFS | 0.31 | $34,000<br>($30,800 - $37,200) |
| Conceptual Design 1c<br>Iron-Enhanced Filtration Basin (large) | 0.31 | $34,000<br>($30,800 - $37,200) |
| Conceptual Design 1d<br>Iron-Enhanced Filtration Basin (large) with NRFS | 0.31 | $34,000<br>($30,800 - $37,200) |
| Conceptual Design 2a<br>Modular Wetland System | 0.14 | $15,200<br>($13,800 - $16,700) |
| Conceptual Design 2b<br>Modular Wetland System with Underground Storage | 0.14 | $15,200<br>($13,800 - $16,700) |
| Conceptual Design 2c<br>Modular Wetland System with Underground IESF | 0.14 | $15,200<br>($13,800 - $16,700) |
| Conceptual Design 2d<br>Kraken Filter | 0.14 | $15,200<br>($13,800 - $16,700) |
| Conceptual Design 3a<br>Subsurface Gravel Wetland | 0.31 | $34,000<br>($30,800 - $37,200) |
| Conceptual Design 3b<br>Subsurface Gravel Wetland with NRFS | 0.31 | $34,000<br>($30,800 - $37,200) |
| Conceptual Design 4<br>Dredging of RM_12 Pond | 0.00 | $0 |

(1) $23 per square yard includes the cost of importing and placing MNDOT Grade 2 compost ($70-80/C.Y.) and soil loosening ($5-7/S.Y.). A depth of 8" of added compost was assumed.


AMENDED SOIL AREAS FOR RUNOFF REDUCTION
FIGURE 6-9
Existing Sanitary Sewer
Existing Trees
Existing Manhole
Existing Stormsewer
Footprints
Feature
Approximate Proposed Surface Basin (Option 1c, 1d, 3a, 3b)
Approximate Proposed Surface Basin (Option 1a, 1b)
Potential Area Disturbed by Construction
Highest Recorded Lake Level Extents (1976-2019)
Normal Water Level
Potential Amended Soil
Site Survey Contours
5-Foot Contour
1-Foot Contour
Parcel Boundary
Privately-Owned
City-Owned
N
0 20 40 80
Feet
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
Dakota Lane
Add curb cut and re-direct street runoff to amended soil area.
Crown of 66" sanitary sewer is approx. 874.5 ft. Crown is 4.5 feet below lowest ground surface where soil amendment is recommended.
Existing 12" tree would be removed for construction of Conceptual Design 2.
If Conceptual Design 1 is constructed, amended soil in this area can be tiled and tied into draintile beneath proposed iron-enhanced sand basin.
If Conceptual Design 3 is constructed, amended soil in this area can be tiled and tied into gravel bed wetland outlet.
Preserve Existing Trees
Park Trail
sanitary sewer easement
Direct runoff from walking trail to amended soil area.
Amended soil area can provide pre-treatment or additional abstraction of basin overflow.
Highest recorded lake level extent from 1970 to 2019.
Replace cleared trees with native species, such as tamarack, or swamp white oak.
BARR
RM_12 Pond
Riley Purgatory Bluff Creek Watershed District

# 7.0 Conceptual Design Summary

Table 7-1 summarizes the estimated annual total phosphorus removal, site impacts, and Engineer's opinion of probable cost for each conceptual design considered.

Of the conceptual designs evaluated, the stand-alone Kraken Filter (i.e., Conceptual Design 2d) has the lowest estimated cost per pound of phosphorus removed and higher TP reduction to Rice Marsh Lake. The smaller iron-enhanced sand basin (i.e., Conceptual Design 1a) has the lowest capital cost. The Modular Wetland System and Kraken Filter (i.e., Conceptual Designs 2a and 2d) have the smallest upland and tree impacts.

In order to summarize and supplement the quantitative parameters in Table 7-1, a second evaluation matrix with some additional considerations has been provided. Table 7-2 ranks each conceptual design based on the following criteria:

- **Annual Pounds of TP Removed** – *quantitative* – 0 for the lowest reduction in annual TP and 1.0 for highest reduction in annual TP.
- **Cost per Pound of TP Removed** – *quantitative* – 0 for the highest cost per pound of TP removed and 1.0 for lowest cost for the lowest cost per pound of TP removed.
- **Opinion of Probable Cost** – *quantitative* – 0 for the highest capital cost and 1.0 for the lowest capital cost.
- **Habitat Creation** – *quantitative* – 0 for the lowest amount of restored area and 1.0 for the largest amount of restored area.
- **Number of Trees Impacted** – *quantitative* – 0 for the largest number of impacted trees and 1.0 for the smallest number of impacted trees.
- **Operation and Maintenance Effort** – *quantitative* – 0 for the highest estimated man-hours and 1.0 for the lowest estimated man-hours required for maintenance per year.
- **Educational Opportunity** – *qualitative* – assigned a value of 0 if the BMP cannot be seen by the general public and 1.0 if the BMP is visible or signage can be used for educational demonstrations.

The individual scores for each parameter were summed into a total score, with the largest score being the recommended option. Based on the results, the conceptual design with the largest score of 5.4 is Conceptual Design 2d, the stand-alone Kraken Filter.

Proprietary stormwater treatment systems are often proposed by developers for meeting stormwater regulations. Because manufacturer claims for pollutant reductions have not been widely studied, the District is often wary of allowing these proprietary systems as a means to meet stormwater treatment requirements. If Conceptual Design 2d is implemented, the Kraken Filter can be monitored by the District and provide first-hand efficacy results.

## Table 7-1 Quantitative Summary of Rice Marsh Lake, RM_12a, Conceptual Design Options

| Conceptual Design | Estimated Annual TP Reduction (lbs/yr)(1) | Upland Impacts (acre) (2) | Tree Impacts (acre) (2) | Engineer's Opinion of Probable Cost ($) | Anticipated Maintenance Cost over 30-year lifecycle ($)(3) | Annual Cost per Pound TP Removed ($/lbs TP/yr)(4) |
|---|---|---|---|---|---|---|
| | A | | | B | C | E = (B+C) / A / 30 |
| Conceptual Design 1a<br>Iron-Enhanced Filtration Basin (small) | 4 - 5 | 0.12 | 0.05 | $303,000<br>($243,000 - $455,000) | $64,300<br>($51,500 - $96,500) | $2,850<br>($2,450 - $4,070) |
| Conceptual Design 1b<br>Iron-Enhanced Filtration Basin (small) with NRFS | 21 - 24 | 0.16 | 0.07 | $1,210,000<br>($968,000 - $1,815,000) | $238,700<br>($191,000 - $358,100) | $2,170<br>($1,850 - $3,080) |
| Conceptual Design 1c<br>Iron-Enhanced Filtration (large) | 11 - 12 | 0.30 | 0.16 | $428,000<br>($343,000 - $642,000) | $136,100<br>($108,900 - $204,200) | $1,620<br>($1,390 - $2,300) |
| Conceptual Design 1d<br>Iron-Enhanced Filtration Basin (large) with NRFS | 29 - 33 | 0.35 | 0.20 | $1,311,000<br>($1,049,000 - $1,967,000) | $310,500<br>($248,400 - $465,800) | $1,750<br>($1,490 - $2,490) |
| Conceptual Design 2a<br>Modular Wetland System | 16 - 18 | 0.06 | 0.00 | $273,000<br>($219,000 - $410,000) | $71,800<br>($57,500 - $107,700) | $690<br>($590 - $980) |
| Conceptual Design 2b<br>Modular Wetland System w/ Underground Storage | 18 - 20 | 0.16 | 0.00 | $682,000<br>($546,000 - $1,023,000) | $71,800<br>($57,500 - $107,700) | $1,330<br>($1,130 - $1,890) |
| Conceptual Design 2c<br>Modular Wetland System w/ Underground IESF | 22 - 25 | 0.16 | 0.00 | $927,000<br>($742,000 - $1,391,000) | $120,800<br>($96,700 - $181,200) | $1,480<br>($1,260 - $2,100) |
| Conceptual Design 2d<br>Kraken Filter | 52 - 59 | 0.12 | 0.00 | $569,000<br>($456,000 - $854,000) | $382,500<br>($306,000 - $573,800) | $570<br>($490 - $810) |
| Conceptual Design 3a<br>Subsurface Gravel Wetland | 21 - 24 | 0.20 | 0.14 | $335,000<br>($268,000 - $503,000) | $132,400<br>($106,000 - $198,600) | $690<br>($590 - $980) |
| Conceptual Design 3b<br>Subsurface Gravel Wetland with NRFS | 26 - 29 | 0.23 | 0.17 | $1,106,000<br>($885,000 - $1,659,000) | $353,300<br>($282,700 - $530,000) | $1,810<br>($1,550 - $2,570) |
| Conceptual Design 4<br>Dredging of RM12 Pond | 7 - 8 | 0.06 | 0.00 | $680,000<br>($544,000 - $1,020,000) | $166,600<br>($133,300 - $249,900) | $3,870<br>($3,300 - $5,490) |

(1) Estimated annual total phosphorus (TP) reduction is the removal with the BMP. The BMP performance was evaluated using the 2014 water year.
(2) Impacts to upland areas are approximate and will be optimized during the next phase of design
(3) Anticipated annual maintenance cost includes filter inspections, replacement and maintenance of filter media, replacement and maintenance of filter components, and BMP vegetation.
(4) Based on the 2014 water year. Includes estimated costs for permitting, engineering, and construction; and estimated annual operation and maintenance costs.

### Table 7-2 Evaluation Matrix Summary of Rice Marsh Lake, RM_12a, Conceptual Design Options

| Evaluation Metric | Conceptual Design 1a | Conceptual Design 1b | Conceptual Design 1c | Conceptual Design 1d | Conceptual Design 2a | Conceptual Design 2b | Conceptual Design 2c | Conceptual Design 2d | Conceptual Design 3a | Conceptual Design 3b | Conceptual Design 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual Lb. TP Removed | 0.1 | 0.4 | 0.2 | 0.6 | 0.3 | 0.3 | 0.4 | 1.0 | 0.4 | 0.5 | 0.1 |
| Cost per Lb. TP Removed | 0.2 | 0.3 | 0.4 | 0.3 | 0.8 | 0.4 | 0.4 | 1.0 | 0.8 | 0.3 | 0.1 |
| Opinion of Probable Cost | 0.9 | 0.2 | 0.6 | 0.2 | 1.0 | 0.4 | 0.3 | 0.5 | 0.8 | 0.2 | 0.4 |
| Habitat Creation | 0.3 | 0.4 | 0.8 | 1.0 | 0.2 | 0.5 | 0.5 | 0.3 | 0.6 | 0.7 | 0.2 |
| Number of Trees Impacted | 0.8 | 0.7 | 0.2 | 0.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.3 | 0.2 | 1.0 |
| Operation and Maintenance Effort | 0.5 | 0.4 | 0.3 | 0.2 | 0.8 | 0.8 | 0.9 | 0.6 | 0.4 | 0.4 | 1.0 |
| Educational Opportunity | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Total Score** | **3.8** | **3.4** | **3.5** | **3.3** | **5.1** | **4.5** | **4.4** | **5.4** | **4.4** | **3.2** | **3.9** |

# 8.0 Schedule of Activities

Figure 8-1 summarizes an estimated schedule of anticipated tasks if the RPBCWD Board of Managers authorize final design of a water quality improvement project.

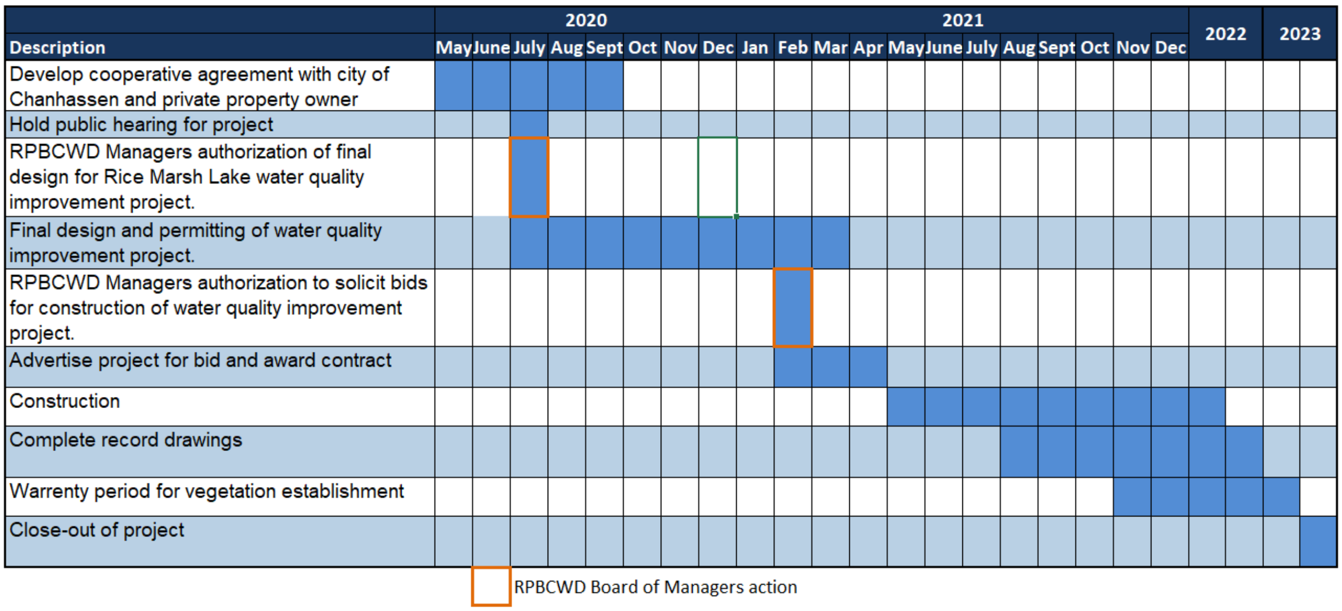



**Figure 8-1 Potential Schedule of Activities**

# 9.0 Agreements

Table 9-1 summarizes anticipated agreements required prior to construction of a water quality BMP.

**Table 9-1 Summary of Anticipated Agreements**

| Description | Notes | Period | Lead Organization |
|---|---|---|---|
| Cooperative agreement between RPBCWD and city of Chanhassen | Cooperative agreement between RPBCWD and city of Chanhassen for activities related to construction and operation and maintenance of the BMP. The agreement would establish procedures for performing specific tasks, and define responsibilities of each organization. | 2020 | RPBCWD and city of Chanhassen |

# 10.0 Financing & Work Plan

RPBCWD would finance design, permitting, construction, and monitoring of the proposed water quality BMP for 2 to 4 years following construction. The city of Chanhassen and RPBCWD need to determine responsibilities for financing ongoing operation and maintenance activities following construction, including implementation of system modifications based on monitoring data collected by RPBCWD.

RPBCWD would lead the design, permitting, construction, and monitoring of a proposed water quality BMP. During final design RPBCWD would regularly coordinate with the City regarding design of project features that affect ongoing operation and maintenance of the BMP, access to city-owned property, and modifications to Dakota Lane.

Responsibility for annual operation and maintenance of the BMP needs to be established through a cooperative agreement. Potential roles and responsibilities could include the following:

- RPBCWD will take the lead in developing a cooperative agreement with the city of Chanhassen to allow RPBCWD staff and contractors to access the site to construct a water quality BMP.
- Following construction, ongoing maintenance of the BMP including vegetation removal within filtration BMPs, cleaning of pretreatment facilities, adding additional or replacing filtration material, and all other tasks necessary such that the BMP provides the intended nutrient removal will be needed.
- RPBCWD typically monitor system performance for 2-4 years following construction. Monitoring results would be shared with the city of Chanhassen on an annual basis.
- Recommendations for system modifications to improve system performance will be developed based on monitoring data.
- The anticipated primary points of contact are summarized in Table 10-1.

### Table 10-1 Anticipated Primary Points of Contact

| Organization | Name | Phone |
|---|---|---|
| RPBCWD | Claire Bleser | 952.607.6512 |
| City of Chanhassen | Charles Howley | 952.227.1169 |

# 11.0 Recommendations

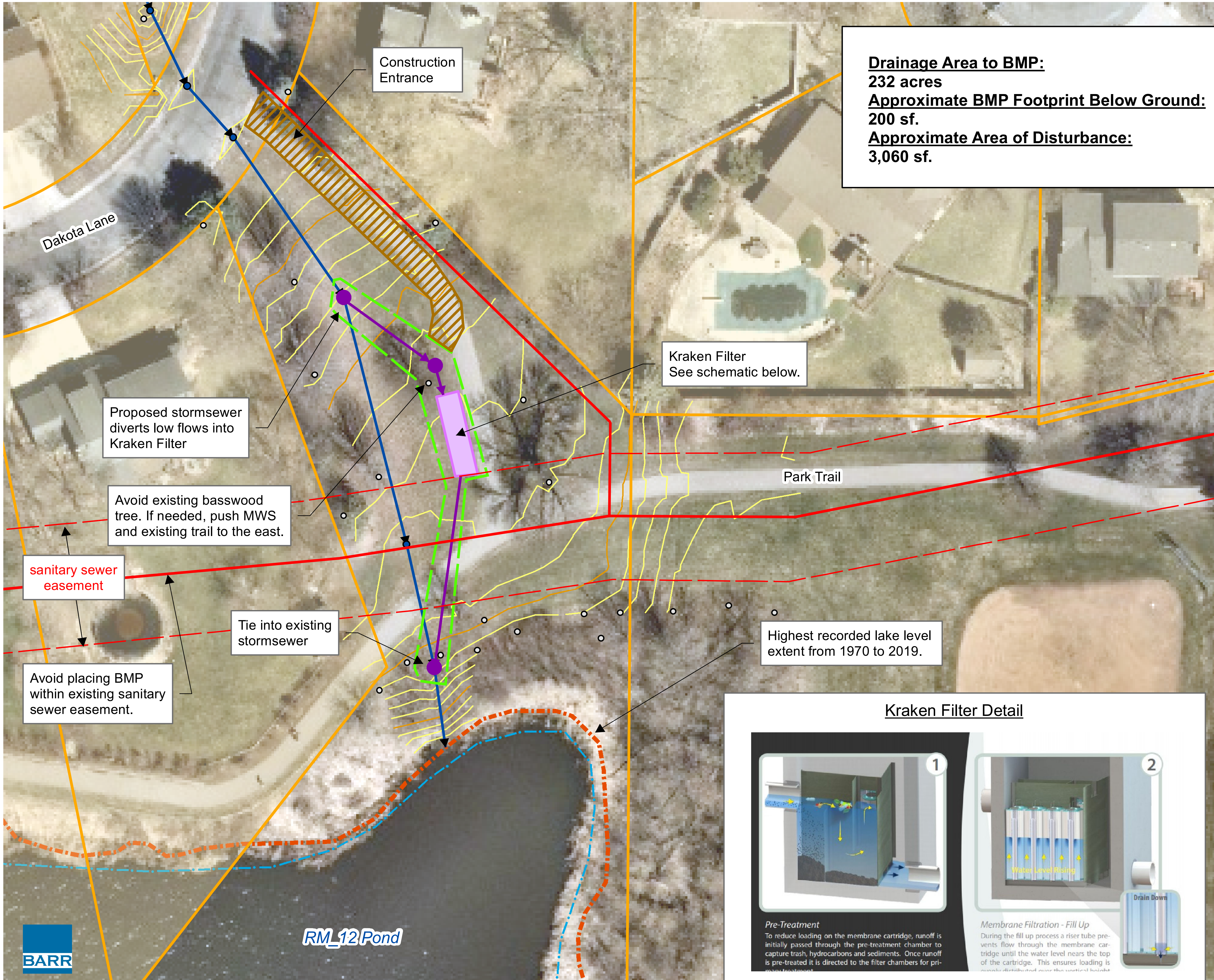
The recommendation for improving the quality of the runoff entering Rice Marsh Lake from subwatershed 12a to help meet the water quality and load goals for the lake are listed below.

1. Based on the results of the evaluation matrix, Conceptual Design 2d — a stand-alone Kraken Filter, or similar MTD, to treat low flows through the existing stormsewer upstream of the RM_12 pond, is recommended as the most feasible BMP. A schematic of the Conceptual Design is shown in Figure 11-1.
    a. Conceptual Design 2d presents the lowest annual cost per pound of TP removed, the second lowest upland impact, and the highest TP reduction to Rice Marsh Lake. The BMP also avoids damage to any existing.
    b. The engineer opinion of probable cost for the design, permitting, and construction of Conceptual Design 2d is $569,000 with a potential range of $456,000 to $854,000 based on the current level of design. It is recommended that the upper end of the range be used when budgeting for the project. As plans and specifications for the design are advanced and the proposed MTD is further optimized, the District should continue to collaborate with city of Chanhassen staff about plan details. If the Board elects to pursue the project, it is recommended that coordination with the city of Chanhassen start in the near term to develop a cooperative agreement in advance of the project implementation. Over a 30-year period, long term maintenance will be needed which results in an anticipated annual cost per pound of phosphorus reduced of between $490 and $810.
    c. As shown in Figure 6-1, the optimal treatment flow rate of approximately 6 cfs is defined at the inflection point in the flow-TP load curve. Because a single KF-10-16 Kraken Filter can treat 2.9 cfs, the recommendation is to construct a Kraken Filter with the equivalent size and treatment potential of two of the KF-10-16 units. Optimization of the exact size of the system should be included during the final design phase.

d. Additionally, it is recommended that the RPBCWD monitor the Kraken for 2 to 4 years after construction. This monitoring will be used to optimize the system and evaluate the pollutant removal performance under typical annual variations.
e. Collection of a sediment boring within the existing RM_12 pond is recommended in order to better understand the potential sediment load from the upstream watershed and the anticipated maintenance frequency of the pretreatement chamber in the Kraken unit, or similar. A soil boring will help determine whether the existing pond bottom rebounded over time or was filled in with sediment. Depending on the boring results, a supplemental device, such as a sump manhole or SAFL baffle, may be needed to simplify long-term maintenance. This evaluation should be included during the final design phase.

2. Incorporating soil amendments (i.e., compost) into the disturbed area surrounding and above the BMP is recommended and has the potential to not only stimulate the soil food web, but also improve phosphorus reduction and volume abstraction to the lake. The disturbed area should also be revegetated with a pollinator lawn seed mix that typically include no-mow fescues and flowers. A pollinator lawn differs from a traditional lawn by incorporating flowering plants (e.g.,white clover, self-heal, and creeping thyme) as well as turfgrasses. Benefits of a pollinator lawn include: increased lawn resilience to environmental pressures, increased natural biodiversity that benefits bees and other pollinators and insects, improved soil health, filtering runoff for improved water quality, reduced need for herbicides, and the beauty of the flowers themselves. If implemented, performance monitoring of rehabilitated soil is recommended in order to document effectiveness of the BMP.
3. It is also recommended that RPBCWD undertake study as described in Section 6.5.3 to enhance the understanding of the health (structure) of soils throughout the watershed. The study would document the potential for healthy, well-structured soils to improve water quality, to reduced flood potential, and to enhance community resiliency. The majority this work could be undertaken by District service learners (i.e., interns) once a study outline has been developed. The outcomes of this study would:

a. enhance the data and logic behind the funding (cost-share efforts) of soil amendment projects,
b. provide permit applicants a mechanism to better understand the benefits of incorporating soil amendments as a BMP for meeting volume abstraction requirements, and
c. support RPBCWD groundwater and wetland function by providing means to improve surficial groundwater recharge and baseflows.




# RECOMMENDED CONCEPTUAL DESIGN: KRAKEN FILTER

## FIGURE 11-1

- Existing Sanitary Sewer
- Existing Trees
- Existing Manhole
- Existing Stormsewer
- Construction Entrance
- Estimated Construction Extents
- Highest Recorded Lake Level Extents (1976-2019)
- Normal Water Level
- Proposed Stormsewer
- Kraken Filter

**Site Survey Contours**

- 5-Foot Contour
- 1-Foot Contour

**Parcel Boundary**

- Privately-Owned
- City-Owned

N

0 20 40 80 Feet

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

# 12.0 References

Minnesota Pollution Control Agency. (2017, November 20). *Minnesota Administrative Rules: Chapter 7050, Waters of the State*. Retrieved from The Office of the Revisor of Statutes: https://www.revisor.mn.gov/rules/?id=7050&version=2017-12-14T11:07:06-06:00&format=pdf

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Protection, M. C. (2013). Underground Sand Filters. *Structural Maintenance*.

Riley Purgatory Bluff Creek Watershed District. (2018). *Sand Filter*. Retrieved from Riley Purgatory Bluff Creek Watershed District.

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University of New Hampshire Stormwater Center (UNHSC). (2009). *UNHSC Subsurface Gravel Wetland Design Specifications.*

University of New Hampshire Stormwater Center. (2010). *Investigation of Nutrient Removal Mechanisms of a Constructed Gravel Wetland Used for Stormwater Control in a Northern Climate.*

# Appendix A

## Engineer's Opinion of Probable Cost

# 1.0 Cost Estimate

Engineer's opinions of probable costs for design, permitting, and construction were developed for each conceptual design. These opinions of costs, project reserves, contingency, documentation and discussion are intended to provide background information for feasibility alternatives assessment, analysis purposes and budget authorization by the RPBCWD. The cost of time escalation is not included in the opinions of probable cost. All costs are presented in 2019 US dollars.

Quantities were estimated with calculations based on available information presented in previous sections. Dimensions, areas, and volumes for construction were estimated using excel, GIS and manufacturer information.

Unit costs are based on recent bid prices, published construction cost index resources, and similar stormwater BMP projects. Unit process were developed and compared to similar project prices. Costs associated with Base Planning Engineering and Design (PED) are based on percentages of estimated construction cost and are within a range similar to those used in past projects designed by Barr. Costs associated with Construction Management (CM) are based on estimated costs to manage the construction process, based on Barr's experience with similar projects, but may change depending on the services that are provided during construction. The estimates also include Permitting and Regulatory Approvals, which is intended to account for additional planning, coordination, and mitigation costs that are likely to be incurred as the project is permitted with environmental agencies.

The opinions of cost include tasks and items related to engineering and design, permitting, and constructing each conceptual design. The opinions of cost do not include other tasks following construction of each alternative presented such as operations and maintenance, or monitoring.

Contingency used in these opinions of probable cost are intended to help identify an estimated construction cost amount for the minor items included in the current Project scope, but have not yet been quantified or estimated directly during the feasibility evaluation. Stated another way, contingency is the resultant of the pluses and minuses that cannot be estimated at the level of project definition that exists. The contingency includes the cost of ancillary items not currently itemized in the quantity summaries but commonly identified in more detailed design and required for completeness of the work. A 25% contingency is applied to the estimated construction cost to account for the costs of these items.

Industry resources for cost estimating (*AACE International Recommended Practice No. 18R-97, and ASTM E2516-06 Standard Classification for Cost Estimate Classification System*) provide guidance on cost uncertainty, depending on the level of project design developed. The opinion of probable cost for the alternatives evaluated generally corresponds to a Class 4 estimate characterized by completion of limited engineering and use of deterministic estimating methods. As the level of design detail increases, the level of uncertainty is reduced. Figure A-1 provides a graphic representation of how uncertainty (or accuracy) of cost estimates can be expected to improve as more detailed design is developed.

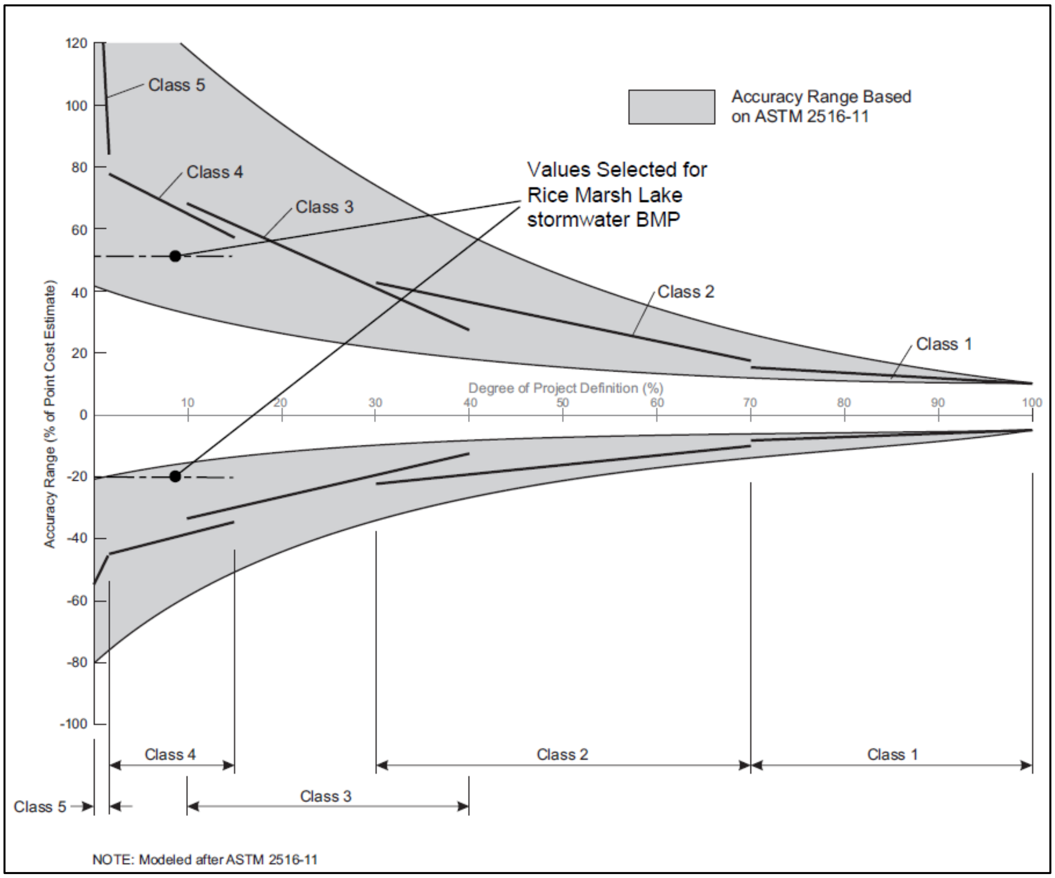



**Figure A-1 Relationship between Cost Accuracy and Degree of Project Definition**

At this early stage of design, the range of uncertainty of total project cost is high. Due to the early stage of design, it is standard practice to place a broad accuracy range around the point cost estimate.

The accuracy range is based on professional judgment considering the level of design completed, the complexity of the project, and the uncertainties in the project scope; the accuracy range does not include costs for future scope changes that are not part of the project as currently defined or risk contingency. The estimated accuracy range for this point estimate is -20% to +50%.

The opinion of probable cost provided in this memorandum is made on the basis of Barr Engineering's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. It is acknowledged that additional investigations and additional site specific information that becomes available in the next stage of design may result in changes to the proposed configuration, cost and functioning of project features. This opinion is based on project-related information available to Barr Engineering at this time and includes a conceptual-level feasibility design of the project. The opinion of cost may change as more information becomes available and further design is completed. In addition, because we have no control over the eventual cost of labor, materials, equipment or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, Barr Engineering cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinion of probable cost presented in this memorandum. If the RPBCWD wishes greater assurance as to the probable project cost, the RPBCWD should authorize further investigation and design of a selected alternative.

Table A-1 provides a comparison of the opinion of costs for each of the alternatives. These costs assume that all work will be completed within City owned parcels or in private parcels where permission to work has been granted. These costs also assume that no purchase of additional easements will be required. Table A-3 through Table A-13 include opinion of cost for each design alternative.

**Table A-1 Engineer's Opinion of Probable Cost – Feasibility Estimate Summary**

| Conceptual Design | Engineer's Opinion of Probable Cost ($)(1) |
|---|---|
| Conceptual Design 1a<br>Iron-Enhanced Filtration Basin (small) | $303,000<br>($243,000 - $455,000) |
| Conceptual Design 1b<br>Iron-Enhanced Filtration Basin (small) with NRFS | $1,210,000<br>($968,000 - $1,815,000) |
| Conceptual Design 1c<br>Iron-Enhanced Filtration Basin (large) | $428,000<br>($343,000 - $642,000) |
| Conceptual Design 1d<br>Iron-Enhanced Filtration Basin (large) with NRFS | $1,310,000<br>($1,048,000 - $1,965,000) |
| Conceptual Design 2a<br>Modular Wetland System | $273,000<br>($219,000 - $410,000) |
| Conceptual Design 2b<br>Modular Wetland System with Underground Storage | $682,000<br>($546,000 - $1,023,000) |
| Conceptual Design 2c<br>Modular Wetland System with Underground IESF | $927,000<br>($742,000 - $1,391,000) |
| Conceptual Design 2d<br>Kraken Filter | $569,000<br>($456,000 - $854,000) |
| Conceptual Design 3a<br>Subsurface Gravel Wetland | $335,000<br>($268,000 - $503,000) |
| Conceptual Design 3b<br>Subsurface Gravel Wetland with NRFS | $1,106,000<br>($885,000 - $1,659,000) |
| Conceptual Design 4<br>Dredging of RM12 Pond | $680,000<br>($544,000 - $1,020,000) |
| (1) Approximate values based on available information. Soil borings are required during the next phase of design to identify existing soil characteristics and estimate the groundwater elevation. Estimate includes all BMP costs with the exception of optional soil amendments. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. | |

The opinions of costs above do not include the cost to maintain the stormwater BMP following construction. The planning level cost to maintain each BMP over a 30 year period are provided in Table A-2.

**Table A-2 Engineer's Opinion of Probable Maintenance Cost – Feasibility Estimate Summary**

| Conceptual Design | Engineer's Opinion of Probable Maintenance Cost Over a 30 Year Lifecycle ($)(1) |
|---|---|
| Conceptual Design 1a<br>Iron-Enhanced Filtration Basin (small) | $2,100<br>($1,800 - $3,200) |
| Conceptual Design 1b<br>Iron-Enhanced Filtration Basin (small) with NRFS | $8,000<br>($6,600 - $11,900) |
| Conceptual Design 1c<br>Iron-Enhanced Filtration Basin (large) | $4,500<br>($3,800 - $6,800) |
| Conceptual Design 1d<br>Iron-Enhanced Filtration Basin (large) with NRFS | $10,400<br>($8,600 - $15,500) |
| Conceptual Design 2a<br>Modular Wetland System | $2,400<br>($2,000 - $3,600) |
| Conceptual Design 2b<br>Modular Wetland System with Underground Storage | $2,400<br>($2,000 - $3,600) |
| Conceptual Design 2c<br>Modular Wetland System with Underground IESF | $4,000<br>($3,400 - $6,000) |
| Conceptual Design 2d<br>Kraken Filter | $12,800<br>($10,600 - $19,100) |
| Conceptual Design 3a<br>Subsurface Gravel Wetland | $4,400<br>($3,700 - $6,600) |
| Conceptual Design 3b<br>Subsurface Gravel Wetland with NRFS | $12,200<br>($10,100 - $18,200) |
| Conceptual Design 4<br>Dredging of RM12 Pond | $5,600<br>($4,600 - $8,300) |

(1) Anticipated maintenance cost includes annual filter inspections, replacement and maintenance of filter media, replacement and maintenance of filter components, and BMP vegetation evaluated over a 30-year period. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%.

# 2.0 References

American Society for Testing and Materials. 2006. ASTM E2516-06 Standard Classification for Cost Estimate Classification System. ASTM International, West Conshohocken, PA, DOI: 10.1520/E2516-06

Association for the Advancement of Cost Estimating. 2005. *AACE International Recommended Practice NO. 18R-97*, February 2, 2005

Table A-3 Engineer's Opinion of Probable Project Cost: Conceptual Design 1a – Small Iron Enhanced Filtration Basin

| | | | | | |
|---|---|---|---|---|---|
| BARR | PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: 1 | OF | 12 |
| | | | BY: HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | | CHECKED BY: | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | | APPROVED BY: SAS | DATE: | |
| PROJECT: | Rice Marsh Lake BMP | ISSUED: | | DATE: | |
| LOCATION: | City of Chanhassen, MN | ISSUED: | | DATE: | |
| PROJECT #: | 23/27-0053.19-028 | ISSUED: | | DATE: | |
| OPINION OF COST - SUMMARY | | ISSUED: | | DATE: | |

# Engineer's Opinion of Probable Project Cost
# Conceptual Design 1a – Small Iron Enhanced Filtration Basin
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 12,800.00 | $ 12,800.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| C | Clearing & Grubbing | Acre | 0.05 | $ 15,000.00 | $ 750.00 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 153 | $ 9.55 | $ 1,457.41 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 310 | $ 5.00 | $ 1,550.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 10 | $ 125.00 | $ 1,250.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 458 | $ 40.00 | $ 18,316.19 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0.07 | $ 10,000.00 | $ 690.91 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 120 | $ 30.00 | $ 3,600.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 95 | $ 50.00 | $ 4,750.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 16 | $ 1,135.00 | $ 17,819.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 210 | $ 20.00 | $ 4,200.00 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 248 | $ 3.54 | $ 877.58 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 60 | $ 12.00 | $ 720.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| X | Import Iron Enhanced Sand (5% iron by weight) | C.Y. | 165 | $ 45.00 | $ 7,437.14 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 33 | $ 45.00 | $ 1,487.43 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| OO | Native Tree Restoration | S.Y. | 330 | $ 36.75 | $ 12,127.50 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 168,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 42,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 210,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 66,000.00 | 1,2,3,4,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 21,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 303,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$243,000.00** | 5,7,8 |
| | | **50%** | | | **$455,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-4 Engineer's Opinion of Probable Project Cost: Conceptual Design 1b – Small Iron Enhanced Filtration Basin with NRFS

| | |
|---|---|
| BARR — PREPARED BY: BARR ENGINEERING COMPANY | REV 1 SHEET: 2 OF 12 |
| | BY: HNH DATE: 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | CHECKED BY: DATE: |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | APPROVED BY: SAS DATE: |
| PROJECT: Rice Marsh Lake BMP | ISSUED: DATE: |
| LOCATION: City of Chanhassen, MN | ISSUED: DATE: |
| PROJECT #: 23/27-0053.19-028 | ISSUED: DATE: |
| **OPINION OF COST - SUMMARY** | ISSUED: DATE: |

# Engineer's Opinion of Probable Project Cost
# Conceptual Design 1b - Small Iron Enhanced Filtration Basin with NRFS
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 114,400.00 | $ 114,400.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| C | Clearing & Grubbing | Acre | 0.07 | $ 15,000.00 | $ 1,020.00 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 176 | $ 9.55 | $ 1,680.20 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 310 | $ 5.00 | $ 1,550.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 10 | $ 125.00 | $ 1,250.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 528 | $ 40.00 | $ 21,116.19 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0.10 | $ 10,000.00 | $ 1,040.91 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 199 | $ 30.00 | $ 5,970.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 95 | $ 50.00 | $ 4,750.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 16 | $ 1,135.00 | $ 17,819.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 280 | $ 20.00 | $ 5,600.00 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 248 | $ 3.54 | $ 877.58 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 60 | $ 12.00 | $ 720.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| X | Import Iron Enhanced Sand (5% iron by weight) | C.Y. | 165 | $ 45.00 | $ 7,437.14 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 33 | $ 45.00 | $ 1,487.43 | 1,2,3,4,5 |
| AA | Nutrient Removing Filtration System® | Each | 1 | $ 409,500.00 | $ 409,500.00 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| OO | Native Tree Restoration | S.Y. | 330 | $ 36.75 | $ 12,127.50 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 686,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 172,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 858,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 260,000.00 | 1,2,3,4,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 86,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 1,210,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$968,000.00** | 5,7,8 |
| | | **50%** | | | **$1,815,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-5 Engineer's Opinion of Probable Project Cost: Conceptual Design 1c - Large Iron Enhanced Filtration Basin

| | | | |
|---|---|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: 3 | OF 12 |
| | BY: HNH | | DATE: 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | CHECKED BY: | | DATE: |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | APPROVED BY: SAS | | DATE: |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | DATE: |
| LOCATION: City of Chanhassen, MN | ISSUED: | | DATE: |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | DATE: |
| OPINION OF COST - SUMMARY | ISSUED: | | DATE: |

## Engineer's Opinion of Probable Project Cost
## Conceptual Design 1c – Large Iron Enhanced Filtration Basin
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 39,900.00 | $ 39,900.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| C | Clearing & Grubbing | Acre | 0.17 | $ 15,000.00 | $ 2,550.00 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 323 | $ 9.55 | $ 3,088.04 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 400 | $ 5.00 | $ 2,000.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 10 | $ 125.00 | $ 1,250.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 970 | $ 40.00 | $ 38,809.39 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0.13 | $ 10,000.00 | $ 1,280.22 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 115 | $ 30.00 | $ 3,450.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 55 | $ 50.00 | $ 2,750.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 7 | $ 1,135.00 | $ 7,377.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 150 | $ 20.00 | $ 3,000.00 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 820 | $ 3.54 | $ 2,903.63 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 138 | $ 12.00 | $ 1,656.00 | 1,2,3,4,5 |
| V | 10" Under Drain CPEP-DW Header Pipe | L.F. | 122 | $ 60.00 | $ 7,320.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| X | Import Iron Enhanced Sand (5% iron by weight) | C.Y. | 547 | $ 45.00 | $ 24,607.04 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 109 | $ 45.00 | $ 4,921.41 | 1,2,3,4,5 |
| CC | 18 inch HDPE Flared-end-section (F&I) | Each | 1 | $ 701.46 | $ 701.46 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| OO | Native Tree Restoration | S.Y. | 375 | $ 36.75 | $ 13,781.25 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 239,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 60,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 299,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 93,000.00 | 1,2,3,4,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 30,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 428,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$343,000.00** | 5,7,8 |
| | | **50%** | | | **$642,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-6 Engineer's Opinion of Probable Project Cost: Conceptual Design 1d - Large Iron Enhanced Filtration Basin with NRFS

| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: | 4 | OF | 12 |
|---|---|---|---|---|---|
| BARR | | BY: | HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: | SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | | DATE: | |
| LOCATION: City of Chanhassen, MN | ISSUED: | | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | | DATE: | |
| OPINION OF COST - SUMMARY | ISSUED: | | | DATE: | |

## Engineer's Opinion of Probable Project Cost
## Conceptual Design 1d – Large Iron Enhanced Filtration Basin with NRFS
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 124,000.00 | $ 124,000.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| C | Clearing & Grubbing | Acre | 0.21 | $ 15,000.00 | $ 3,075.00 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 357 | $ 9.55 | $ 3,406.32 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 400 | $ 5.00 | $ 2,000.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 10 | $ 125.00 | $ 1,250.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 1,100 | $ 40.00 | $ 44,009.39 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0.18 | $ 10,000.00 | $ 1,810.98 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 147 | $ 30.00 | $ 4,410.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 55 | $ 50.00 | $ 2,750.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 7 | $ 1,135.00 | $ 7,377.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 280 | $ 20.00 | $ 5,600.00 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 820 | $ 3.54 | $ 2,903.63 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 138 | $ 12.00 | $ 1,656.00 | 1,2,3,4,5 |
| V | 10" Under Drain CPEP-DW Header Pipe | L.F. | 122 | $ 60.00 | $ 7,320.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| X | Import Iron Enhanced Sand (5% iron by weight) | C.Y. | 547 | $ 45.00 | $ 24,607.04 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 109 | $ 45.00 | $ 4,921.41 | 1,2,3,4,5 |
| AA | Nutrient Removing Filtration System® | Each | 1 | $ 409,500.00 | $ 409,500.00 | 1,2,3,4,5 |
| CC | 18 inch HDPE Flared-end-section (F&I) | Each | 2 | $ 701.46 | $ 1,402.92 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| OO | Native Tree Restoration | S.Y. | 375 | $ 36.75 | $ 13,781.25 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 744,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 186,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 930,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 282,000.00 | 1,2,3,4,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 93,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 1,311,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$1,049,000.00** | 5,7,8 |
| | | **50%** | | | **$1,967,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-7 Engineer's Opinion of Probable Project Cost: Conceptual Design 2a - Modular Wetland System

| | | | | | |
|---|---|---|---|---|---|
| BARR | PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: 5 | OF | 12 |
| | | | BY: HNH | DATE: | 4/8/2020 |
| | PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | DATE: | |
| | ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: SAS | DATE: | |
| | PROJECT: Rice Marsh Lake BMP | ISSUED: | | DATE: | |
| | LOCATION: City of Chanhassen, MN | ISSUED: | | DATE: | |
| | PROJECT #: 23/27-0053.19-028 | ISSUED: | | DATE: | |
| | **OPINION OF COST - SUMMARY** | ISSUED: | | DATE: | |

## Engineer's Opinion of Probable Project Cost
## Conceptual Design 2a - Modular Wetland System
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 25,500.00 | $ 25,500.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 98 | $ 9.55 | $ 939.68 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 320 | $ 5.00 | $ 1,600.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 224 | $ 40.00 | $ 8,971.85 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0.06 | $ 10,000.00 | $ 610.00 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 49 | $ 30.00 | $ 1,470.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 84 | $ 50.00 | $ 4,200.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 18 | $ 1,135.00 | $ 20,656.21 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 224 | $ 20.00 | $ 4,485.93 | 1,2,3,4,5 |
| Z | Modular Wetland System | Each | 1 | $ 75,000.00 | $ 75,000.00 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 153,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 38,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 191,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 57,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 19,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 273,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$219,000.00** | 5,7,8 |
| | | **50%** | | | **$410,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-8 Engineer's Opinion of Probable Project Cost: Conceptual Design 2b - Modular Wetland System with Underground Storage Vault

| | | | | | |
|---|---|---|---|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: | 6 | OF | 12 |
| BARR | | BY: | HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: | SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | | DATE: | |
| LOCATION: City of Chanhassen, MN | ISSUED: | | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | | DATE: | |
| OPINION OF COST - SUMMARY | ISSUED: | | | DATE: | |

# Engineer's Opinion of Probable Project Cost
# Conceptual Design 2b - Modular Wetland System with Underground Storage Vault
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 18,900.00 | $ 18,900.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 258 | $ 9.55 | $ 2,464.74 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 390 | $ 5.00 | $ 1,950.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 115 | $ 85.00 | $ 9,775.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 970 | $ 40.00 | $ 38,791.11 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0.16 | $ 10,000.00 | $ 1,600.00 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 38 | $ 30.00 | $ 1,140.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 84 | $ 50.00 | $ 4,200.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 7 | $ 1,135.00 | $ 7,377.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 970 | $ 20.00 | $ 19,395.56 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 283 | $ 3.54 | $ 1,003.00 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 19 | $ 45.00 | $ 850.00 | 1,2,3,4,5 |
| Z | Modular Wetland System | Each | 1 | $ 75,000.00 | $ 75,000.00 | 1,2,3,4,5 |
| BB | 60" Perforated HDPE Storm Sewer (F&I) | L.F. | 340 | $ 500.00 | $ 170,000.00 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| II | 3/4" Diameter Crushed Stone (No. 57) | C.Y. | 319 | $ 45.00 | $ 14,373.53 | 1,2,3,4,5 |
| JJ | Curb and Gutter with Base | L.F. | 25 | $ 25.00 | $ 625.00 | 1,2,3,4,5 |
| KK | Precast Concrete Catch Basin w/ 3-ft Sump | Each | 1 | $ 7,000.00 | $ 7,000.00 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 385,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 96,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 481,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 147,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 48,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 682,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$546,000.00** | 5,7,8 |
| | | **50%** | | | **$1,023,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance costs are not included.

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars

| | |
|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 SHEET: 7 OF 12 |
| BARR | BY: HNH DATE: 4/8/2020 |
| **PRELIMINARY ENGINEERING REPORT** | CHECKED BY: DATE: |
| **ENGINEER'S OPINION OF PROBABLE PROJECT COST** | APPROVED BY: SAS DATE: |
| PROJECT: Rice Marsh Lake BMP | ISSUED: DATE: |
| LOCATION: City of Chanhassen, MN | ISSUED: DATE: |
| PROJECT #: 23/27-0053.19-028 | ISSUED: DATE: |
| **OPINION OF COST - SUMMARY** | ISSUED: DATE: |

# Engineer's Opinion of Probable Project Cost
# Conceptual Design 2c - Modular Wetland System with Underground IES Filtration
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 72,200.00 | $ 72,200.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 258.133 | $ 9.55 | $ 2,464.74 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 390 | $ 5.00 | $ 1,950.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 115 | $ 85.00 | $ 9,775.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 970 | $ 40.00 | $ 38,791.11 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0 | $ 10,000.00 | $ 1,600.00 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 38 | $ 30.00 | $ 1,140.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 84 | $ 50.00 | $ 4,200.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 7 | $ 1,135.00 | $ 7,377.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 970 | $ 20.00 | $ 19,395.56 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 283 | $ 3.54 | $ 1,003.00 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 72 | $ 12.00 | $ 864.00 | 1,2,3,4,5 |
| V | 10" Under Drain CPEP-DW Header Pipe | L.F. | 159 | $ 60.00 | $ 9,540.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| X | Import Iron Enhanced Sand (5% iron by weight) | C.Y. | 189 | $ 45.00 | $ 8,500.00 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 38 | $ 45.00 | $ 1,700.00 | 1,2,3,4,5 |
| Z | Modular Wetland System | Each | 1 | $ 75,000.00 | $ 75,000.00 | 1,2,3,4,5 |
| BB | 60" Perforated HDPE Storm Sewer (F&I) | L.F. | 340 | $ 500.00 | $ 170,000.00 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| II | 3/4" Diameter Crushed Stone (No. 57) | C.Y. | 319 | $ 45.00 | $ 14,373.53 | 1,2,3,4,5 |
| JJ | Curb and Gutter with Base | L.F. | 25 | $ 25.00 | $ 625.00 | 1,2,3,4,5 |
| KK | Precast Concrete Catch Basin w/ 3-ft Sump | Each | 1 | $ 7,000.00 | $ 7,000.00 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 524,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 131,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 655,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 200,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 66,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 927,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$742,000.00** | 5,7,8 |
| | | **50%** | | | **$1,391,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-10 Engineer's Opinion of Probable Project Cost: Conceptual Design 2d - Kraken Filter

| | | | | | |
|---|---|---|---|---|---|
| BARR PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: | 8 | OF | 12 |
| | | BY: | HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: | SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | | DATE: | |
| LOCATION: City of Chanhassen, MN | ISSUED: | | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | | DATE: | |
| OPINION OF COST - SUMMARY | ISSUED: | | | DATE: | |

# Engineer's Opinion of Probable Project Cost
# Conceptual Design 2d - Kraken Filter
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 53,400.00 | $ 53,400.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 196.827 | $ 9.55 | $ 1,879.37 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 320 | $ 5.00 | $ 1,600.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 436 | $ 40.00 | $ 17,445.93 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0 | $ 10,000.00 | $ 1,220.00 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 49 | $ 30.00 | $ 1,470.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 84 | $ 50.00 | $ 4,200.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 18 | $ 1,135.00 | $ 20,656.21 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 436 | $ 20.00 | $ 8,722.96 | 1,2,3,4,5 |
| QQ | Kraken Filter | Each | 2 | $ 100,000.00 | $ 200,000.00 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 320,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 80,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 400,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 123,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 40,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 569,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$456,000.00** | 5,7,8 |
| | | **50%** | | | **$854,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-11 Engineer's Opinion of Probable Project Cost: Conceptual Design 3a - Subsurface Gravel Bed Wetland

| | | | | |
|---|---|---|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: 9 | OF | 12 |
| BARR | | BY: HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | DATE: | |
| LOCATION: City of Chanhassen, MN | ISSUED: | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | DATE: | |
| OPINION OF COST - SUMMARY | ISSUED: | | DATE: | |

## Engineer's Opinion of Probable Project Cost
## Conceptual Design 3a - Subsurface Gravel Bed Wetland

**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 12,800.00 | $ 12,800.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| C | Clearing & Grubbing | Acre | 0.17 | $ 15,000.00 | $ 2,550.00 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 267 | $ 9.55 | $ 2,554.10 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 410 | $ 5.00 | $ 2,050.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 10 | $ 125.00 | $ 1,250.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 802 | $ 40.00 | $ 32,098.94 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0 | $ 10,000.00 | $ 614.09 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 146 | $ 30.00 | $ 4,380.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 58 | $ 50.00 | $ 2,900.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 7 | $ 1,135.00 | $ 7,377.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 115 | $ 20.00 | $ 2,300.00 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 687 | $ 3.54 | $ 2,433.66 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 153 | $ 12.00 | $ 1,836.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 35 | $ 45.00 | $ 1,575.00 | 1,2,3,4,5 |
| CC | 18 inch HDPE Flared-end-section (F&I) | Each | 2 | $ 701.46 | $ 1,402.92 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| HH | Low Hydraulic Conductivity Wetland Soil | C.Y. | 93 | $ 32.26 | $ 3,011.24 | 1,2,3,4,5 |
| II | 3/4" Diameter Crushed Stone (No. 57) | C.Y. | 280 | $ 45.00 | $ 12,600.00 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| OO | Native Tree Restoration | S.Y. | 375 | $ 36.75 | $ 13,781.25 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 186,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 47,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 233,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 73,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 23,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 335,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$268,000.00** | 5,7,8 |
| | | **50%** | | | **$503,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-12 Engineer's Opinion of Probable Project Cost: Conceptual Design 3b - Subsurface Gravel Bed Wetland with NRFS

| | | | | | |
|---|---|---|---|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: | 10 | OF | 12 |
| BARR | | BY: | HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: | SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | | DATE: | |
| LOCATION: City of Chanhassen, MN | ISSUED: | | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | | DATE: | |
| OPINION OF COST - SUMMARY | ISSUED: | | | DATE: | |

# Engineer's Opinion of Probable Project Cost
# Conceptual Design 3b - Subsurface Gravel Bed Wetland with NRFS
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 18,800.00 | $ 18,800.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| C | Clearing & Grubbing | Acre | 0 | $ 15,000.00 | $ 3,000.00 | 1,2,3,4,5 |
| D | Remove & Salvage Topsoil | C.Y. | 311 | $ 9.55 | $ 2,967.86 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 410 | $ 5.00 | $ 2,050.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 10 | $ 125.00 | $ 1,250.00 | 1,2,3,4,5 |
| J | Remove/Replace Ex. Bit. | S.Y. | 15 | $ 85.00 | $ 1,275.00 | 1,2,3,4,5 |
| K | Common Excavation | C.Y. | 932 | $ 40.00 | $ 37,298.94 | 1,2,3,4,5 |
| L | Site Restoration (Seed & Mulch) | Acre | 0 | $ 10,000.00 | $ 862.81 | 1,2,3,4,5 |
| M | 12" HDPE Storm Sewer (F&I) | L.F. | 201 | $ 30.00 | $ 6,030.00 | 1,2,3,4,5 |
| N | 18" HDPE Storm Sewer (F&I) | L.F. | 58 | $ 50.00 | $ 2,900.00 | 1,2,3,4,5 |
| O | Outlet Control Structure | Each | 1 | $ 2,500.00 | $ 2,500.00 | 1,2,3,4,5 |
| P | 84 inch Precast Manhole with Casting (F&I) | L.F. | 20 | $ 1,135.00 | $ 22,359.50 | 1,2,3,4,5 |
| Q | 7-ft wide, Precast Concrete Weir (F&I) | Each | 1 | $ 2,632.75 | $ 2,632.75 | 1,2,3,4,5 |
| S | Backfill and Grading (Excav. Borrow) | C.Y. | 245 | $ 20.00 | $ 4,900.00 | 1,2,3,4,5 |
| T | Geotextile Liner | S.Y. | 687 | $ 3.54 | $ 2,433.66 | 1,2,3,4,5 |
| U | 6" Under Drain Perforated Pipe | L.F. | 153 | $ 12.00 | $ 1,836.00 | 1,2,3,4,5 |
| W | Under Drain Fittings & Appurtanances | L.S. | 1 | $ 1,000.00 | $ 1,000.00 | 1,2,3,4,5 |
| Y | Pea Rock | C.Y. | 35 | $ 45.00 | $ 1,575.00 | 1,2,3,4,5 |
| AA | Nutrient Removing Filtration System® | Each | 1 | $ 409,500.00 | $ 409,500.00 | 1,2,3,4,5 |
| CC | 18 inch HDPE Flared-end-section (F&I) | Each | 2 | $ 701.46 | $ 1,402.92 | 1,2,3,4,5 |
| DD | 12 inch Stainless Steel Plug Valve w/Box ASM (F&I) | Each | 1 | $ 3,948.33 | $ 3,948.33 | 1,2,3,4,5 |
| HH | Low Hydraulic Conductivity Wetland Soil | C.Y. | 93 | $ 32.26 | $ 3,011.24 | 1,2,3,4,5 |
| II | 3/4" Diameter Crushed Stone (No. 57) | C.Y. | 280 | $ 45.00 | $ 12,600.00 | 1,2,3,4,5 |
| MM | Hydrodynamic Separator | Each | 1 | $ 65,000.00 | $ 65,000.00 | 1,2,3,4,5 |
| OO | Native Tree Restoration | S.Y. | 375 | $ 36.75 | $ 13,781.25 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 627,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 157,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 784,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 238,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 78,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 1,106,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$885,000.00** | 5,7,8 |
| | | **50%** | | | **$1,659,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-13 Engineer's Opinion of Probable Project Cost: Conceptual Design 4 - Dredge RM_12 Pond

| | | | | |
|---|---|---|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | REV 1 | SHEET: 11 | OF | 12 |
| BARR | | BY: HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | CHECKED BY: | DATE: | |
| ENGINEER'S OPINION OF PROBABLE PROJECT COST | | APPROVED BY: SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | ISSUED: | | DATE: | |
| LOCATION: City of Chanhassen, MN | ISSUED: | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | ISSUED: | | DATE: | |
| OPINION OF COST - SUMMARY | ISSUED: | | DATE: | |

## Engineer's Opinion of Probable Project Cost
## Conceptual Design 4 - Dredge RM_12 Pond

**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT COST | ITEM COST | NOTES |
|---|---|---|---|---|---|---|
| A | Mobilization/Demobilization | L.S. | 1 | $ 63,800.00 | $ 63,800.00 | 1,2,3,4,5 |
| B | Rock Erosion Control Construction Entrance | Each | 1 | $ 1,739.17 | $ 1,739.17 | 1,2,3,4,5 |
| E | Erosion Control Silt Fence | L.F. | 1,800 | $ 5.00 | $ 9,000.00 | 1,2,3,4,5 |
| H | Riprap, MnDot Class III w/Type IV Geotextile | Ton | 14 | $ 125.00 | $ 1,750.00 | 1,2,3,4,5 |
| LL | Site Access Restoration (Seed & Mulch) | S.Y. | 300 | $ 5.46 | $ 1,638.00 | 1,2,3,4,5 |
| EE | Dredging and Excavation | C.Y. | 5,001 | $ 25.00 | $ 125,033.33 | 1,2,3,4,5 |
| FF | Dredged Material Handling, Dewatering, and Loading | C.Y. | 5,001 | $ 25.00 | $ 125,033.33 | 1,2,3,4,5 |
| GG | Dewatered Material Transport and Disposal | C.Y. | 5,001 | $ 11.00 | $ 55,014.67 | 1,2,3,4,5 |
| | CONSTRUCTION SUBTOTAL | | | | $ 383,000.00 | 1,2,3,4,5,8 |
| | CONSTRUCTION CONTINGENCY (25%) | | | | $ 96,000.00 | 1,5,8 |
| | ESTIMATED CONSTRUCTION COST | | | | $ 479,000.00 | 1,2,3,4,5,8 |
| | | | | | | |
| | PLANNING, ENGINEERING & DESIGN | | | | $ 147,000.00 | 1,2,3,5,8 |
| | PERMITTING & REGULATORY APPROVALS | | | | $ 6,000.00 | 1,5,6,8 |
| | CONSTRUCTION MANAGEMENT | | | | $ 48,000.00 | 1,5,8 |
| | ESTIMATED TOTAL PROJECT COST | | | | $ 680,000.00 | 1,2,3,4,5,7,8 |
| | **ESTIMATED ACCURACY RANGE** | **-20%** | | | **$544,000.00** | 5,7,8 |
| | | **50%** | | | **$1,020,000.00** | 5,7,8 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Quantities Based on Design Work Completed.

[3] Unit Prices Based on Information Available at This Time.

[4] No Soil Borings Available, Limited Field Investigation Completed, and no site survey.

[5] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include

[6] Estimate assumes that wetland mitigation/replacement is not required. Included are the cost for agency communication and application preparation for a permit from the City of Chanhassen, MN. If replacement/mitigation is required, the total cost may increase to approximately $20,000 plus an additional $100,000/acre of wetland disturbed.

[7] Estimate costs are to design, construct, and permit each alternative. The estimated costs do not include maintenance, monitoring or additional tasks following constuction.

[8] Estimate costs are reported to nearest thousand dollars.

Table A-14 Engineer's Opinion of Probable Project Cost: 30-Year Operation and Maintenance

| | | | | | |
|---|---|---|---|---|---|
| PREPARED BY: BARR ENGINEERING COMPANY | | REV 1 | SHEET: 12 | OF | 12 |
| BARR | | | BY: HNH | DATE: | 4/8/2020 |
| PRELIMINARY ENGINEERING REPORT | | | CHECKED BY: | DATE: | |
| ENGINEER'S OPINION OF PROBABLE O&M COST | | | APPROVED BY: SAS | DATE: | |
| PROJECT: Rice Marsh Lake BMP | | ISSUED: | | DATE: | |
| LOCATION: City of Chanhassen, MN | | ISSUED: | | DATE: | |
| PROJECT #: 23/27-0053.19-028 | | ISSUED: | | DATE: | |
| OPINION OF COST - SUMMARY | | ISSUED: | | DATE: | |

## Engineer's Opinion of Probable Project Cost
## 30-Year Operation and Maintenance Costs
**Rice Marsh Lake BMP**

| Cat. No. | ITEM DESCRIPTION | Conversion | Conceptual Design 1a | Conceptual Design 1b | Conceptual Design 1c | Conceptual Design 1d | Conceptual Design 2a | Conceptual Design 2b | Conceptual Design 2c | Conceptual Design 2d | Conceptual Design 3a | Conceptual Design 3b | Conceptual Design 4 | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | Vegetation Maintenance ($40/hr) | 9 - 39 hrs/yr | $ 23,100 | $ 23,100 | $ 46,200 | $ 46,200 | $ 15,400 | $ 15,400 | $ 15,400 | $ - | $ 92,400 | $ 138,600 | $ - | 1,2,3,4, 6 |
| B | Iron Enhanced Sand Filter Replacement ($45/C.Y.) | once every 15 years | $ 14,874 | $ 14,874 | $ 49,214 | $ 49,214 | $ - | $ - | $ 17,000 | $ - | $ - | $ - | $ - | 1,2, 3, 6 |
| C | MWS Pretreatment Filter Cartridges ($80/cartridge) | 8 cartridges per year | $ - | $ - | $ - | $ - | $ 24,000 | $ 24,000 | $ 46,200 | $ - | $ - | $ - | $ - | 1,2, 5, 6 |
| D | Clean Out Pre-Treatment Chamber ($150/hr) | 3 hrs/yr | $ - | $ 13,500 | $ - | $ 13,500 | $ 13,500 | $ 13,500 | $ 13,500 | $ 13,500 | $ - | $ 13,500 | $ - | 1,2, 5, 6 |
| E | Infrastructure Inspection ($150/hr) | 1 hr/yr | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | $ 4,500 | 1,2, 6 |
| F | Bold and Gold® Filter Media ($642/CY) | once every 3 years | $ - | $ 126,025 | $ - | $ 126,025 | $ - | $ - | $ - | $ - | $ - | $ 126,025 | $ - | 1,2, 5, 6 |
| G | Pond Clean Out ($1,610/hr) | 40 hrs once every 15 years | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 128,814 | 1,2, 6 |
| H | Native Tree Maintenance ($80/hr) | 9 - 39 hrs/yr | $ 9,000 | $ 9,000 | $ 9,000 | $ 9,000 | $ - | $ - | $ - | $ - | $ 9,000 | $ - | $ - | 1,2, 6 |
| I | Kraken Filter Cartridges ($75 replacement/3yr +$5 per cleaning) | 107 cartridges per year | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 288,000 | $ - | $ - | $ - | 1,2, 5, 6 |
| | O&M TOTAL COST | | $ 51,500 | $ 191,000 | $ 108,900 | $ 248,400 | $ 57,400 | $ 57,400 | $ 96,600 | $ 306,000 | $ 105,900 | $ 282,600 | $ 133,300 | |
| | CONTINGENCY (25%) | | $ 64,300 | $ 238,700 | $ 136,100 | $ 310,500 | $ 71,800 | $ 71,800 | $ 120,800 | $ 382,500 | $ 132,400 | $ 353,300 | $ 166,600 | |
| | **ESTIMATED ACCURACY RANGE** | | **$ 51,500** | **$ 191,000** | **$ 108,900** | **$ 248,400** | **$ 57,500** | **$ 57,500** | **$ 96,700** | **$ 306,000** | **$ 106,000** | **$ 282,700** | **$ 133,300** | 6 |
| | **(-20% to 50%)** | | **$ 96,500** | **$ 358,100** | **$ 204,200** | **$ 465,800** | **$ 107,700** | **$ 107,700** | **$ 181,200** | **$ 573,800** | **$ 198,600** | **$ 530,000** | **$ 249,900** | 6 |

Notes

[1] Limited Design Work Completed (10 - 15%).

[2] Prices Based on Information Available at This Time.

[3] Estimate based on maintenance costs for similar BMPs conducted by Barr staff.

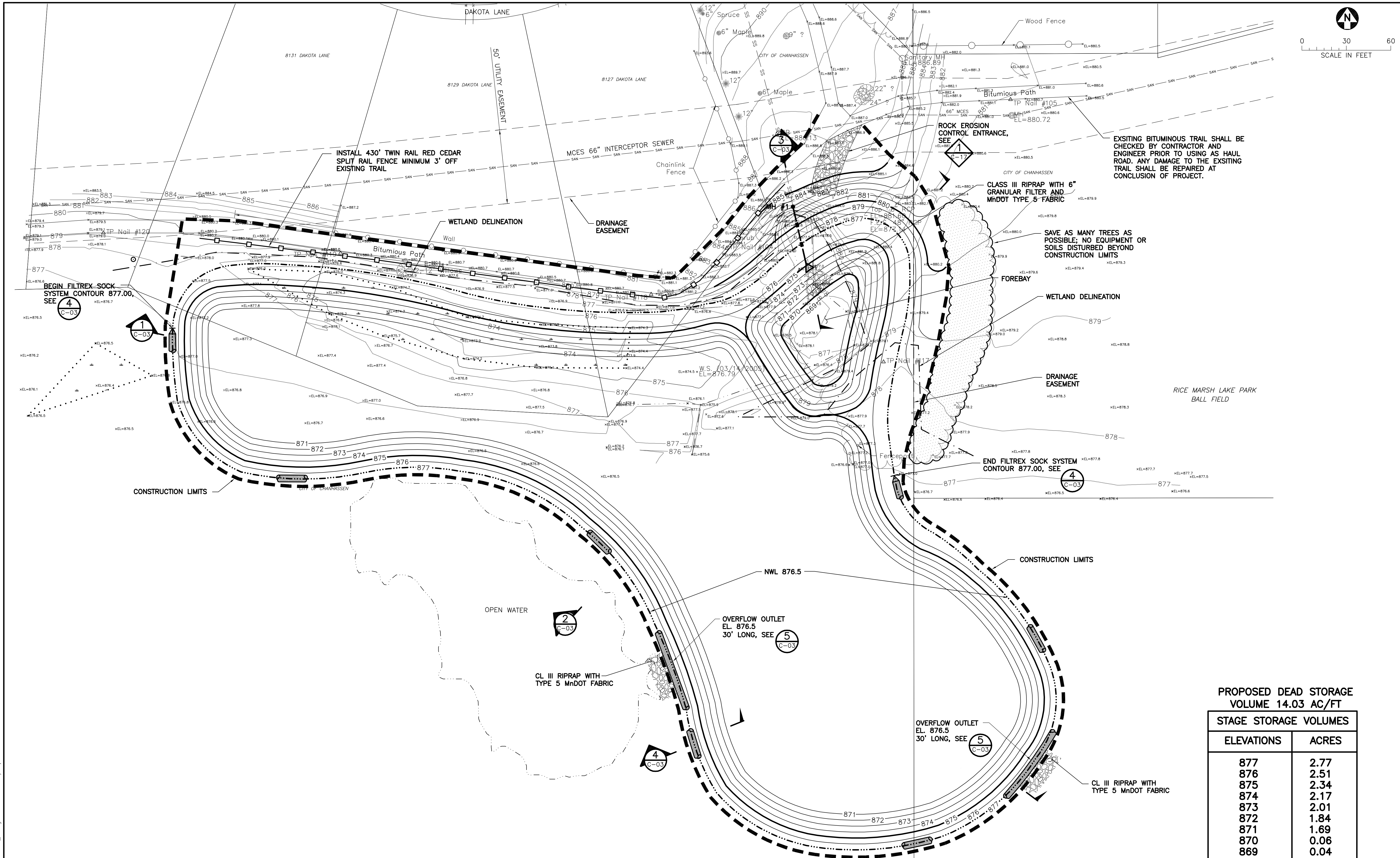
[4] Vegetation maintenance of Conceptual Design 1c and 1d is less than that of Conceptual Designs 1a and 1b as surface footprint is smaller.

[5] Estimate from manufacturer.

[6] This feasibility-level (Class 4, 10-15% design completion per ASTM E 2516-06) cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. Contingency is an allowance for the net sum of costs that will be in the Final O&M Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Operation and Maintenance Cost as the project is defined is -20% to +50%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.

# Appendix AB

## RM_12 Constructed Pond 2005 Site Plan




**PROPOSED DEAD STORAGE VOLUME 14.03 AC/FT**

**STAGE STORAGE VOLUMES**

| ELEVATIONS | ACRES |
|---|---|
| 877 | 2.77 |
| 876 | 2.51 |
| 875 | 2.34 |
| 874 | 2.17 |
| 873 | 2.01 |
| 872 | 1.84 |
| 871 | 1.69 |
| 870 | 0.06 |
| 869 | 0.04 |

Xrefs in Drawing – 21501_1.dwg 21520_1.DWG 21626_1.DWG 21628_1.DWG
nrd M:\CAD\2327E61\21523_1.dwg Plot at 1 11/23/2005 10:27:42

| NO. | BY | CHK. | APP. | DATE | REVISION DESCRIPTION |
|---|---|---|---|---|---|

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

SIGNATURE ______
PRINTED NAME ______
DATE ______ REG. NO. ______

| | A | B | C | 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|
| CLIENT | | | | | | | |
| BID | | | | | | | |
| CONSTRUCTION | | | | | | | |
| RELEASED TO/FOR | DATE RELEASED | | | | | | |

BARR

Corporate Headquarters: Minneapolis, Minnesota Ph: 1-800-632-2277

Project Office: BARR ENGINEERING CO. 4700 WEST 77TH STREET MINNEAPOLIS, MN. 55435-4803 Ph: 1-800-632-2277 Fax: (952) 832-2601 www.barr.com

| | |
|---|---|
| Scale | AS SHOWN |
| Date | 5-6-05 |
| Drawn | NRD |
| Checked | |
| Designed | |
| Approved | |

RILEY–PURGATORY–BLUFF CREEK WATERSHED DISTRICT
CHANHASSEN/EDEN PRAIRIE, MINNESOTA

LAKE RILEY/RICE MARSH LAKE WATER QUALITY IMPROVEMENTS
CHANHASSEN/EDEN PRAIRIE, MINNESOTA

SITE RM–1.1
PLAN

BARR PROJECT No. 23/27–E61
CLIENT PROJECT No.
DWG. No. C–01
REV. No. A