Feasibility Report for Ponderosa Woods Stream Restoration Project—FINAL

Plymouth, Minnesota

Prepared for
Bassett Creek Watershed Management Commission

June 2023

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Certifications

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.

Jessica C L Olson, PE	06/21/2023
	Date

PE #: 43102

1.0 Executive Summary

1.1 Project Overview

The Ponderosa Woods stream channel is a short stream with intermittent flows that is a tributary to the west side of Medicine Lake in the City of Plymouth. The stream drains about 4 square miles of land with mixed uses. The stream channel begins northeast of the intersection of Kirkwood Lane North and 18th Avenue North and flows northeast into West Medicine Lake Park, where it meets up with Plymouth Creek, flows through two water quality ponds, and then flows into Medicine Lake (Figure 1-1). During the spring, summer, and fall the naturally ephemeral stream generally has fairly consistent low flows with high, flashy flows during rain events due to the substantial watershed area. The upstream section of the stream channel has tall stream banks, minimal access to a floodplain, and receives stormwater runoff from surrounding neighborhoods; the downstream section of the stream channel, by comparison, has lower stream banks and access to a floodplain. In the winter the stream freezes over. The stream is not considered a public watercourse by the MN Department of Natural Resources (MnDNR). However, the City of Plymouth identified this eroding channel as contributing sediment and nutrient loads to Medicine Lake.

Medicine Lake is included on the Minnesota Pollution Control Agency's (MPCA) 303d list of impaired waters for mercury, chlorides, and excess nutrient (e.g., total phosphorus). The United States Environmental Protection Agency (EPA) approved a Total Maximum Daily Load (TMDL) Study for the excess nutrients impairment in 2011. Stabilizing the streambanks along the Ponderosa Woods stream channel would reduce pollutant loading, including total phosphorus, to Medicine Lake.

This feasibility study evaluates the potential restoration of the Ponderosa Woods stream channel. The length of the stream within the project area extends just over 1,100 feet. This feasibility study identifies four stream reaches and three stormwater side-channels for evaluation. All stream reaches are straight with little to no sinuosity. There are many areas with significant amounts of woody debris from fallen trees, with substantial areas of invasive buckthorn along the stream banks and throughout the riparian area.

The Ponderosa Woods Stream Restoration Project is included in the BCWMC's current CIP (2024 ML-22), with construction scheduled for 2024. The project would stabilize stream banks to reduce erosion along the existing stream, improve and restore in-stream and riparian habitat, and improve water quality and reduce sediment and phosphorus entering Medicine Lake. Additional stormwater features would also trap sediment from road runoff, decreasing the amount of sediment flowing into the stream reach.

1.2 Project Alternatives

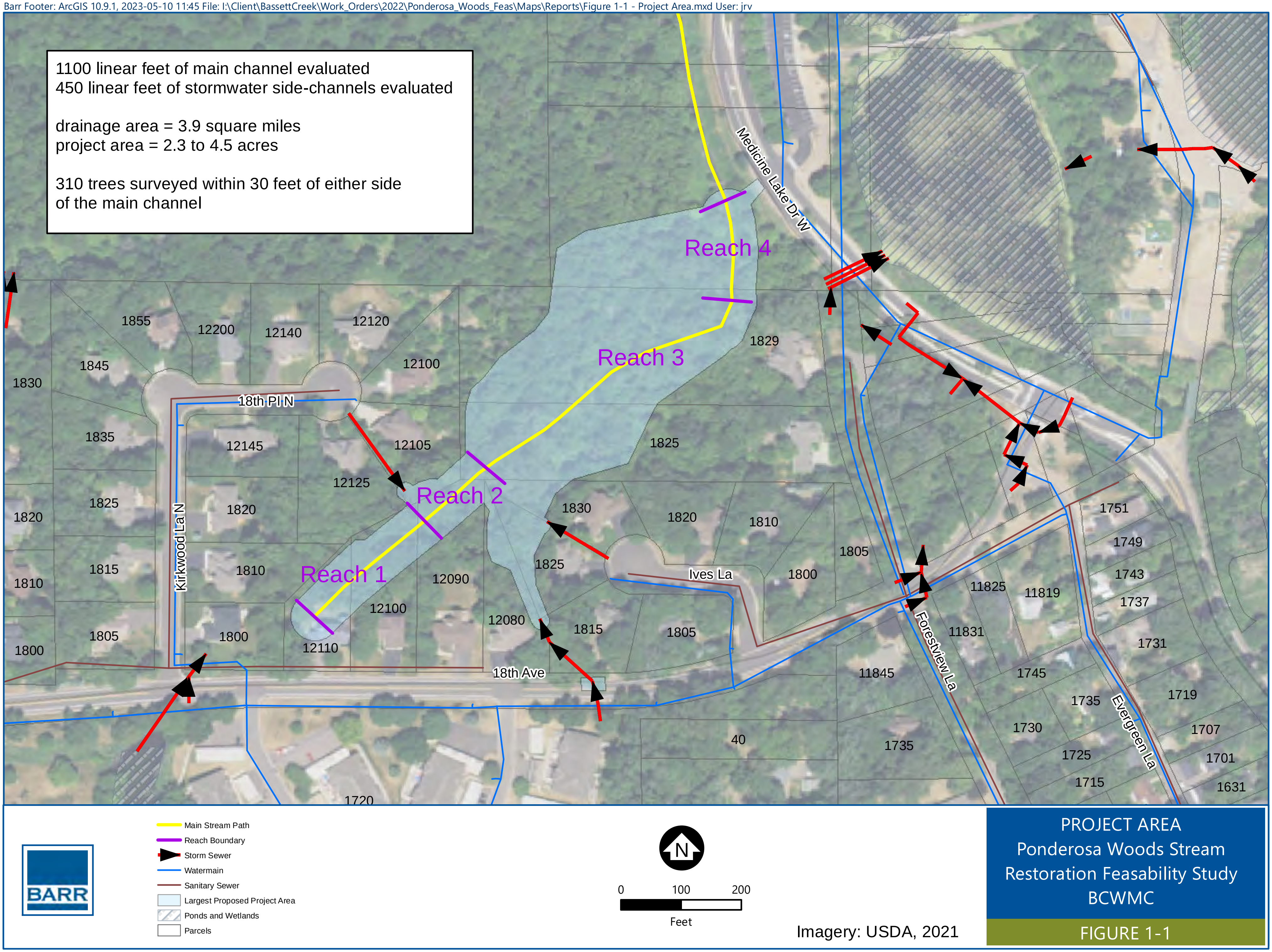
This feasibility study evaluates alternatives for the stabilization of the Ponderosa Woods Stream Restoration project area. Each alternative considers the following stream stabilization methods:

- Hard armoring bank and channel stabilization methods:

- Rock riprap channel or banks (including lengthening and deepening upstream plunge pool at the stormwater outfall)
    - Rock toe, consisting of boulders buried and extending partially up the toe of the bank
    - Replacement of existing stormwater side-channel structure on 18th Ave with a sump for trapping sediment, trash, and other debris
- Bioengineering bank and channel stabilization methods:
    - Stream bank and channel grading
    - Stormwater side-channel grading
    - Coir blanket with live stakes and plantings
    - Vegetated swale for stormwater side-channels
    - In-channel grade controls (boulder cross vanes)
    - Re-meander the stream channel
- Vegetation and woody debris measures:
    - Removing in-channel woody debris
    - Removing fallen, dead, and dying trees including ash, box elder, and cottonwood; ash trees are a primary focus for removal since many are in poor health and affected by the Emerald Ash Borer, which was first confirmed in the area in 2015
    - Removing invasive buckthorn
    - Restoring vegetated buffer
    - Opening the tree canopy, which may include select healthy tree removal

Table 1-1 provides a summary of alternatives, including brief description and estimated costs, pollutant load reductions, and tree removals. Buckthorn removal is approximately 11% to 22% of total project costs depending on the alternative.

Section 5.0 provides more detailed discussion of the measures considered and alternatives evaluated (Alternatives 1, 2, and 3), and Section 8.0 includes more information on Alternative 1.5, which is the same as Alternative 1 plus additional buckthorn removal.



PROJECT AREA
Ponderosa Woods Stream Restoration Feasability Study
BCWMC

FIGURE 1-1

Table 1-1 Feasibility Study Alternatives Summary

Alternative	Description	Project Cost Estimate(1)	Annualized Cost(2)	TP Loading		TSS Loading		Trees Removed	
				Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)	Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)	Healthy	Dead, Dying, and Fallen
Alternative 1 – Small Footprint Design	Stream stabilization using bioengineering techniques, bank and channel grading, and in-channel controls. This alternative also includes installation of and reinforcement of existing riprap. Buckthorn removal occurs at or near streambanks and tributary stormwater channels. Tributary stormwater channels are regraded and stabilized with riprap. Alternative 1 prioritizes minimal land disturbance and tree removal.	$252,000 ($202,000–$328,000)	$17,000	7.4	$2,300	14,770	$1.15	27	11
Alternative 1.5 - Small Footprint Design (with added buckthorn removal)	Alternative 1 techniques plus the same buckthorn removal as Alternative 2.	$297,000 ($238,000-$387,000)	$20,000	7.4	$2,700	14,770	$1.35	27	11
Alternative 2 – Medium Footprint Design	Alternative 1 techniques but with more hard armoring; plus two additional acres of buckthorn removal and additional overbank grading.	$429,000 ($344,000-$558,000)	$27,000	7.4	$3,650	14,770	$1.83	34	13
Alternative 3 – Large Footprint Design	Alternative 1 and 2 techniques plus a stream channel re-meander in the downstream reach. The re-meandered section includes grading and bioengineering stabilization throughout.	$506,000 ($405,000–$658,000)	$34,000	10.8	$3,150	21,580	$1.58	72	28

1.3 Relationship to Watershed Management Plan

The Bassett Creek Watershed Management Commission (BCWMC) included the Ponderosa Woods Stream Restoration project area in its Capital Improvement Plan (CIP), based on the following "gatekeeper" policy from the BCWMC Plan. The items in bold italics directly apply to these projects.

110. The BCWMC will consider including projects in the CIP that meet one or more of the following "gatekeeper" criteria.

- Project is part of the BCWMC trunk system (see Section 2.8.1, Figure 2-14 and Figure 2-15 of the report)
- ***Project improves or protects water quality in a priority waterbody***
- ***Project addresses an approved TMDL or watershed restoration and protection strategy (WRAPS)***
- Project addresses flooding concern

The BCWMC will use the following criteria, in addition to those listed above, to aid in the prioritization of projects:

- Project protects or restores previous Commission investments in infrastructure
- Project addresses intercommunity drainage issues
- ***Project addresses erosion and sedimentation issues***
- ***Project will address multiple Commission goals (e.g., water quality, runoff volume, aesthetics, wildlife habitat, recreation, etc.)***
- Subwatershed draining to project includes more than one community
- Addresses significant infrastructure or property damage concerns

The BCWMC will place a higher priority on projects that incorporate multiple benefits and will seek opportunities to incorporate multiple benefits into BCWMC projects, as opportunities allow.

This project meets several gatekeeper criteria—the project will improve water quality as its primary goal by reducing the amount of sediment and pollutants that enter Medicine Lake. This project will also help address multiple BCWMC goals by enhancing water quality and improving wildlife habitat.

1.4 Project Impacts

Section 6.0 discusses the potential impacts resulting from the restoration and stabilization project, which include tree removals and temporary wetland impacts. Tree removal will be limited to only those necessary to complete the project along with more expansive buckthorn removal, depending on the alternative chosen. Woody debris from the removed trees will not be re-used on site as part of stream bank stabilization measures. Because this is an intermittent flowing stream with a lower water level, the woody material would rot since it would not be continuously submerged below the water level.

The proposed stream stabilization project will result in reduced stream bank erosion and, therefore, reduced sediment and phosphorus loading to the downstream water quality ponds and Medicine Lake. Section 6.0 presents the estimated existing erosion rates and pollutant loading along with pollutant load reductions expected with each alternative.

1.5 Recommendations

Based on review of the project impacts; feedback from residents, representatives of the City of Plymouth, and regulators; the overall project costs and benefits; and existing stream restoration improvement needs; the Commission Engineer recommends implementing either Alternative 1 or 1.5: stream stabilization with a combination of bioengineering and hard armoring, habitat improvement with dead and dying tree removal and buckthorn clearing, stormwater sump structure for trapping sediment, and significant woody debris removal). Alternative 1.5 is the same as Alternative 1, but with additional buckthorn removal (similar level of buckthorn removal as in Alternatives 2 and 3).

Table 1-2 below shows the planning-level estimated costs for the recommended alternatives. The Commission Engineer recommends the BCWMC use the opinion of cost identified in this study to develop a levy request for the recommended project and that it proceed to design and construction through an agreement with the City of Plymouth. The BCWMC CIP funding (ad valorem tax levied by Hennepin County on behalf of the BCWMC) will be the sole source of funding for this project. Following the typical BCWMC CIP process and through an agreement with the BCWMC, the City would design and construct the project and then be reimbursed for all eligible project costs as completed.

Table 1-2 Recommended Stream Restoration Alternatives Cost Summary

Alternative Description	Project Cost Estimate(1)	Annualized Cost(2)	TP Loading		TSS Loading	
			Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)	Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)
Alternative 1 (Small Footprint Design)	\$252,000 (\$202,000 - \$328,000)	\$17,000	7.4	\$2,300	14,770	\$1.15
Alternative 1.5 (Small Footprint Design with additional buckthorn removal)	\$297,000 (\$238,000 - \$387,000)	\$20,000	7.4	\$2,700	14,770	\$1.35

1) A Class 4 screening-level opinion of probable cost, as defined by the American Association of Cost Engineers International (AACE International), has been prepared for these alternatives. The opinion of probable construction cost provided in this table is based on the Commission Engineer's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. The cost opinion is based on project-related information available to the Commission Engineer at this time and includes a conceptual-level design of the project. It includes 20% project contingency and 30% for planning, engineering, design, and construction administration. The lower bound is assumed at -20% and the upper bound is assumed at +30%.
2) Assumed to be 15% of the total project cost for annual maintenance, plus replacement cost associated with major repairs and the initial project cost distributed evenly over a 30-year project lifespan. The City pays for the annual maintenance costs.
3) Annualized cost divided by estimated annual pollution load reduction.

2.0 Background and Objectives

Medicine Lake is included on the Minnesota Pollution Control Agency's (MPCA) 303d list of impaired waters for mercury, chlorides, and excess nutrient (e.g., total phosphorus). The United States Environmental Protection Agency (EPA) approved a Total Maximum Daily Load (TMDL) Study for the excess nutrients impairment in 2011. The City of Plymouth identified an eroding channel near West Medicine Lake Park, called Ponderosa Woods, as contributing sediment, and nutrient loads to Medicine Lake.

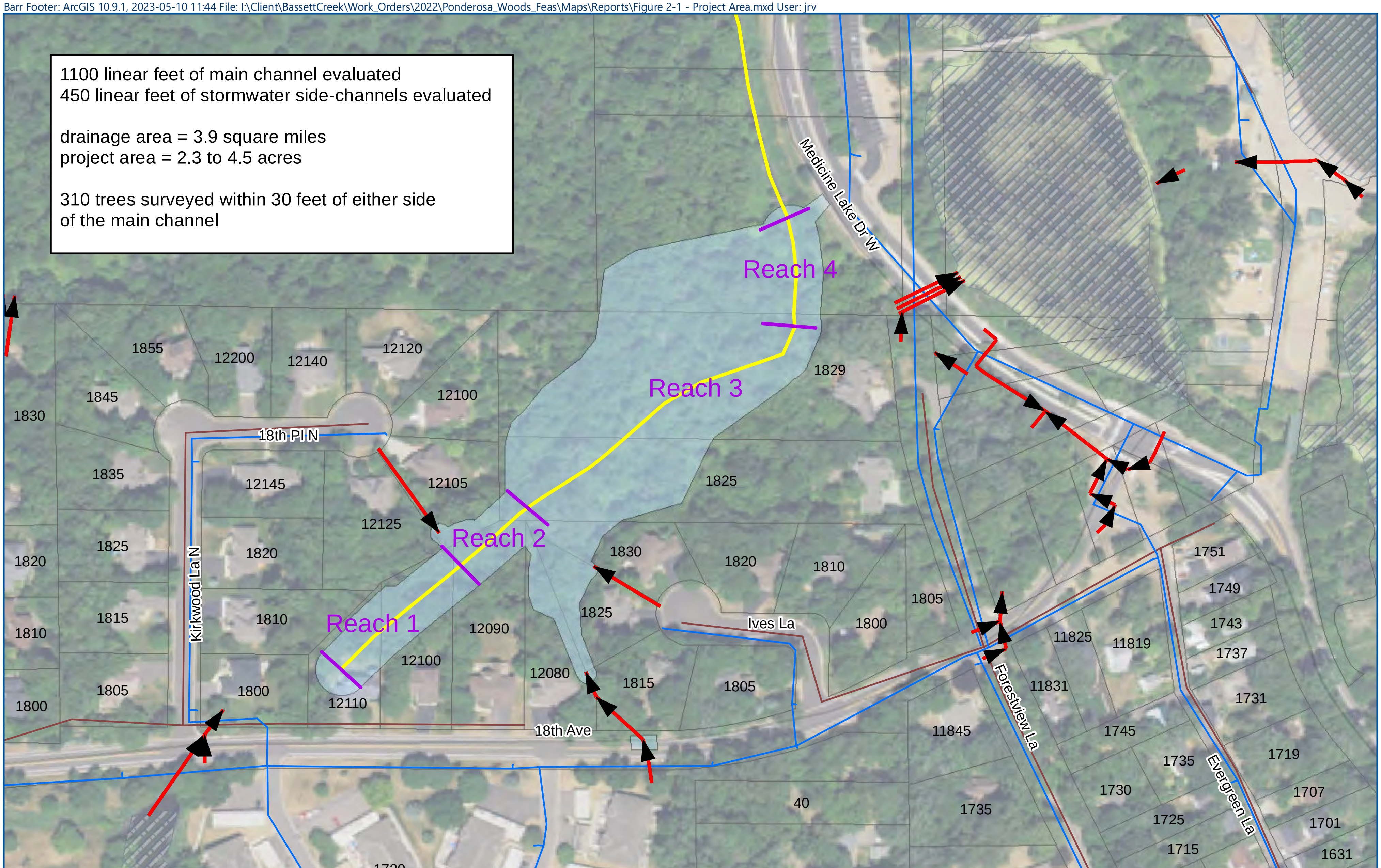
This feasibility study evaluates the potential restoration of the Ponderosa Woods stream channel located in the neighborhood just south of West Medicine Lake Park in Plymouth, Minnesota. The stream reach begins northeast of the intersection of Kirkwood Lane North and 18th Avenue North and flows northeast into West Medicine Lake Park, where it flows through two water quality ponds, meets up with Plymouth Creek, and then flows into Medicine Lake. The Ponderosa Woods Stream Restoration Project is included in the BCWMC's current CIP (2024 ML-22), with construction scheduled for 2024. The project would stabilize stream banks to reduce erosion along the existing stream, improve and restore in-stream and riparian habitat, and improve water quality and reduce sediment and phosphorus entering Medicine Lake. Additional stormwater features would also trap sediment from road runoff, decreasing the amount of sediment flowing into the stream reach.

This study was developed with input from the City of Plymouth, which owns or maintains drainage and utility easements along this stream reach. Figure 2-1 provides an overview of the project location.

1100 linear feet of main channel evaluated
450 linear feet of stormwater side-channels evaluated

drainage area = 3.9 square miles
project area = 2.3 to 4.5 acres

310 trees surveyed within 30 feet of either side of the main channel



- Main Stream Path
- Reach Boundary
- Storm Sewer
- Watermain
- Sanitary Sewer
- Largest Proposed Project Area
- Ponds and Wetlands
- Parcels

N

0 100 200
Feet

Imagery: USDA, 2021

BARR

PROJECT AREA
Ponderosa Woods Stream Restoration Feasability Study
BCWMC

FIGURE 2-1

2.1 Project Area Description

2.1.1 Ponderosa Woods Stream Restoration

The Ponderosa Woods Stream Restoration project area is located in the City of Plymouth in and along an unnamed, low-flowing stream with frequent low flows and flashy high flows during rain events (Figure 2-1). The project area borders single-family private properties along the whole length of the stream in this project area, except for the downstream portion that feeds into Plymouth Creek before flowing through two water quality ponds and into Medicine Lake. Historically, this stream flowed into Medicine Lake prior to the construction of the water quality ponds.

The Ponderosa Woods Stream Restoration area extends just over 1,100 feet along the stream. The section of stream inspected experiences intermittent flows throughout the year, with higher flows accompanying large rain events. This feasibility study identifies four stream reaches and three stormwater side-channels for evaluation, based on physical and geomorphic distinguishing features. All stream reaches are straight with little to no sinuosity. There are many areas with significant amounts of woody debris from fallen trees, with substantial areas of invasive buckthorn along the stream banks and throughout the riparian area. Below are descriptions of the reaches and stormwater side-channels (Figure 2-1).

- Reach 1 begins at the culvert on the southwest/upstream end of the project area near residential private property just northeast of the intersection of Kirkwood Lane North and 18th Avenue North. Water flows from an upstream pond into Reach 1, where it runs through a channelized area with incised banks and minimal access to the floodplain. Reach 1 is a straight channel, semi-wooded with minimal vegetation, primarily flowing through single-family residential backyards, and with significant channel degradation due to steep banks and frequent high flow events.

- Reach 1 flows into Reach 2, which has less incised banks, more access to the floodplain in a heavily wooded area with minor channel degradation due to three stormwater side-channels entering the stream. Portions of the channel are over widened and degraded due to significant amounts of in-channel woody debris. This reach is a straight channel flowing between single-family residential backyards with trees, shrubs and other understory vegetation along the banks and floodplain.

- Reach 3 is downstream of where the three stormwater side-channels enter the stream. Reach 3 is the middle section and represents about half of the stream channel evaluated as part of this project. This reach continues to be straight and has access to the floodplain in a heavily wooded area with some vegetation mostly consisting of trees, shrubs, and other understory vegetation. This reach has moderate channel degradation and over widening due to significant amounts of in-channel woody debris. The single-family residential homes are located farther away from the stream in this reach than they are in Reaches 1 and 2.

- Reach 4 is the furthest downstream reach with access to the floodplain and dense vegetation along the stream banks consisting mainly of reed canary grass along with trees and shrubs and other understory vegetation. Reach 4 is in an open, non-wooded area, flowing north along West Medicine Lake Drive, with minimal channel degradation.

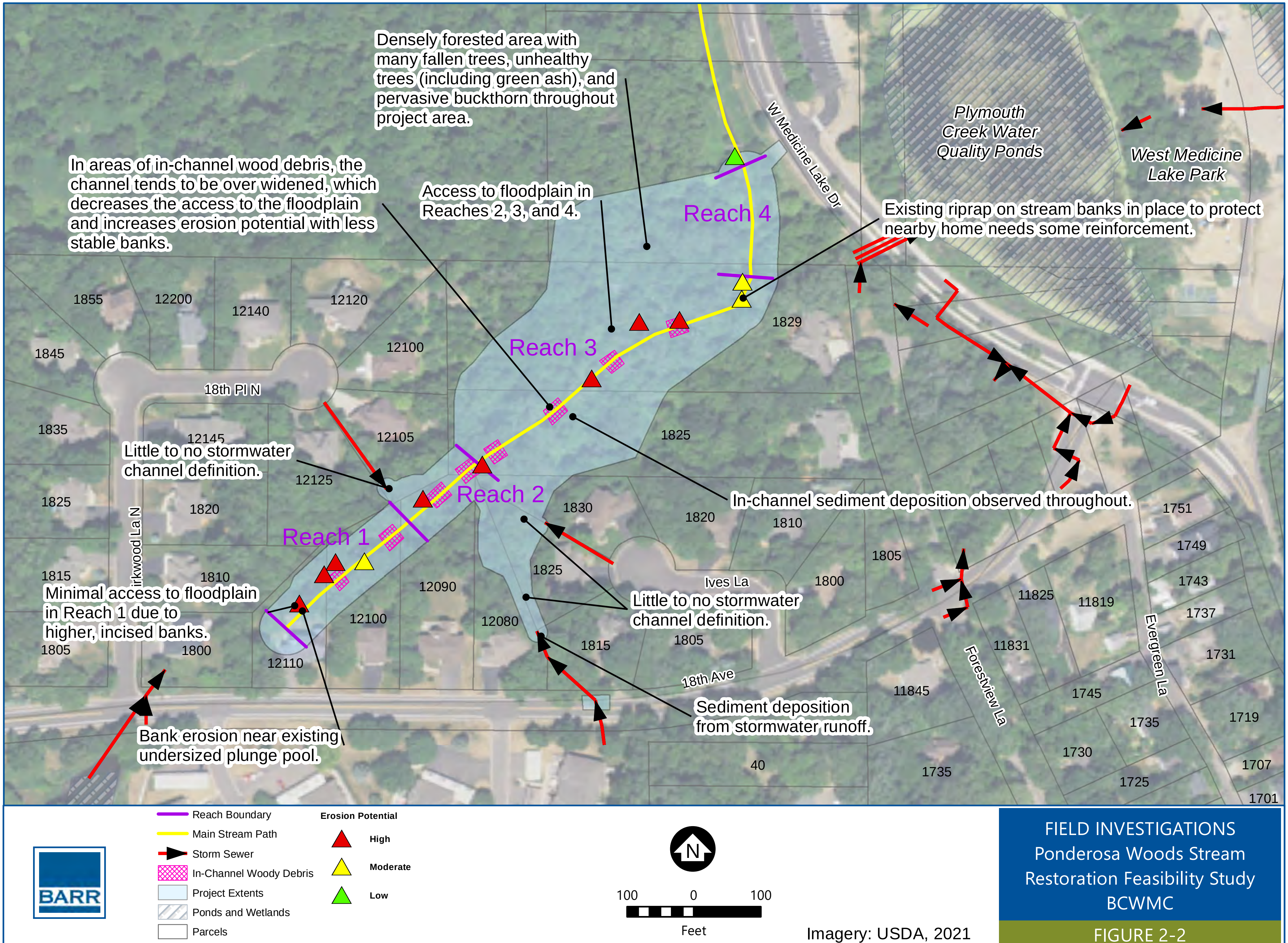
- There is one stormwater side-channel from 18th Place North, one from 18th Avenue North, and one from Ives Lane. All three stormwater side-channels convey road runoff and flow through single-family residential backyards prior to entering the stream in Reach 2. The stormwater side-channel from 18th Place North and the one from Ives Lane are very similar, with minor flows that enter into a forested area and spread out along the riparian area until flowing into the stream. The stormwater side-channel from 18th Avenue North includes significant sediment deposition from the road runoff and has partially formed a channel prior to spreading out over the riparian area and into the stream. These stormwater side-channels, especially the one from 18th Avenue North, contribute additional flow and sediment to the stream channel, leading to additional stream channel degradation.

The Commission Engineer, Administrator, Commissioner Cesnik, and City of Plymouth staff walked the entire project area in November 2022 and identified areas with bank erosion, scour, and/or bank failure, sediment deposition and vegetation concerns (invasive buckthorn, tree debris, dead and dying trees, etc.). The Commission Engineer conducted further inspection to verify erosion locations, identify stabilization alternatives, and perform a site evaluation. Photos of identified bank erosion locations are included in Appendix A. Figure 2-2 shows specific areas of concern identified during the site visit, which are briefly discussed above and will be included in the subsequent design sections of this report. The primary methods used to estimate erosion potential were Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), which are typical stream erosion and stabilization evaluation methods. A site's BEHI rating indicates susceptibility to erosion based on its stream bank condition. NBS characterizes the energy distribution along a segment of stream bank. The combination of a high susceptibility to erosion and concentrated high bank stress indicates high erosion potential. The erosion potential shown on Figure 2-2 is based on BEHI and NBS rating systems. See Section 6.1.2 for a detailed discussion of BEHI and NBS.

During the November 2022 inspection, all stream channel reaches and stormwater side-channels within the project area were primarily dry, with many areas having exposed channel bed or a few inches of snow. Most vegetation was also dormant for the winter season, so identifying understory vegetation was minimal. Recent aerial photos show visible flow in the spring, fall, and summer months. Results from the Bassett Creek watershed XP-SWMM model suggest that the stream can experience high flows during large rainfall events.

Stream bank erosion is a natural process that occurs to some extent on all stream channels. However, the natural erosion rate can be accelerated by local and regional changes in land use and hydrology. The bank erosion and failures present throughout the project area appear to be caused by a combination of natural stream erosion processes, problems associated with changing watershed hydrology, changes to vegetation distribution and condition (invasive buckthorn and emerald ash borer), direct historical impacts to the stream channel, and effects of riparian land use. Of the approximately 1,100 linear feet of stream bank in the project area, approximately 720 feet showed erosion issues to some degree. The sediment load from the erosion and scour increases phosphorus loading to downstream water bodies, decreases the clarity of water in the stream, impacts aquatic habitat, and causes sediment accumulation in downstream waters.

Stable stream channels are often said to be in a state of “dynamic equilibrium” with their watersheds, adjusting to changes in the watershed hydrology. It may take many years or decades for a stream to fully adjust to a rapid change in watershed hydrology. The use of stormwater best management practices (BMPs) helps reduce the impact of development on streams. Nonetheless, development and land-use changes fundamentally change the hydrology of the watershed. These changes to hydrology often include increased magnitude and frequency of high-flow events, which subsequently can increase erosion rates. Continued development upstream of the stream reach and the stormwater side-channels entering Reach 2 may increase the frequency of the high flow events and sediment load to the stream. The heavily wooded area also hinders the growth of more groundcover and understory vegetation on the stream banks, which can increase the erosion potential.



Imagery: USDA, 2021

FIELD INVESTIGATIONS
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC

FIGURE 2-2

2.2 Goals and Objectives

The goals of the feasibility study are to:

1. Review the feasibility of alternatives that will stabilize the eroding stream in the Ponderosa Woods project area (see Figure 2-1) and protect and/or improve water quality in the downstream receiving water body (Medicine Lake) through the development of three conceptual alternatives.

2. Provide a planning-level opinion of cost for design and construction of the alternatives.

3. Identify potential project impacts and permitting requirements.

4. Develop visual representations of the alternatives for public input.

5. Identify recommended alternative for implementation.

The goals of the project are to:

1. Stabilize streambanks to reduce total suspended solids (TSS) and total phosphorus (TP) loading and re-establish desirable vegetation within the project area.

2. Preserve natural beauty along the streams, enhance vegetation, improve natural habitat quality and species diversification by planting eroded areas with native vegetation.

3. Prevent both future channel erosion along the stream reach and subsequent degradation of water quality downstream by establishing a stable channel dimension, pattern, and profile. A stable channel dimension is the cross-sectional area of the channel sized to handle the bankfull event (approximately 1.5-year event) and to allow water to access the floodplain for flows exceeding the bankfull event. An unstable channel dimension with a cross-sectional area sized to handle a larger or smaller flow than the bankfull event could lead to channel degradation.

2.2.1 Scope

The City of Plymouth identified the portion of the stream included in this feasibility study near West Medicine Lake Park as suffering from stream bank and channel erosion. As a result, the BCWMC included this project in its current CIP (2024 ML-22). This project is consistent with the goals (Section 4.1) and policies (Sections 4.2.1, 4.2.5, 4.2.8, and 4.2.10) in the 2015–2025 Plan.

In 2009, the BCWMC completed a Resource Management Plan (RMP) in which the U.S. Army Corps of Engineers (USACE) and the BCWMC agreed on a series of steps, work items, and deliverables (called "protocols") that must be accomplished and submitted to complete the RMP process and USACE review/approval process. Although this project (ML-22) was not included in the RMP, the USACE has allowed the RMP protocols to be applied to other projects not specifically included in the RMP. With the completion of the protocols, we expect the USACE permit application process to move more quickly than it would otherwise. Most of the protocols must be addressed as part of the feasibility study, In general, the protocols require compliance with Section 106 of the National Historic Preservation Act, compliance with Section 404 of the Clean Water Act, and Clean Water Act Section 401 Water Quality Certification. Compliance with Section 106 typically requires a cultural resources inventory.

As required for BCWMC CIP projects, a feasibility study must be completed prior to the BCWMC holding a hearing and ordering the project. This Ponderosa Woods Stream Restoration feasibility study estimates the amount of erosion taking place within each reach and discusses the feasibility of different options to stabilize each reach. The study also reviews the permitting requirements and develops a concept plan and cost estimate for each alternative.

2.2.2 Considerations

Key considerations for project alternatives included:

- Maximizing the stability of the streams to reduce long-term erosion concerns.
- Providing solutions that minimize long-term maintenance requirements.
- Providing in-stream habitat improvements for aquatic vegetation and organisms.
- Maintaining visually appealing stream corridors for adjacent landowners, and adjacent single-family housing.
- Minimizing valuable tree loss where possible and/or improving tree habitat (invasive buckthorn removal and management of degraded trees, many of which are green ash and susceptible to the Emerald Ash Borer).
- Minimizing the permitting required to construct the project.
- Minimizing wetland impacts.
- Reviewing a possible construction access path from West Medicine Lake Drive.

The considerations listed above played a key role in determining final recommendations and will continue to play a key role through final design.

3.0 Site Conditions

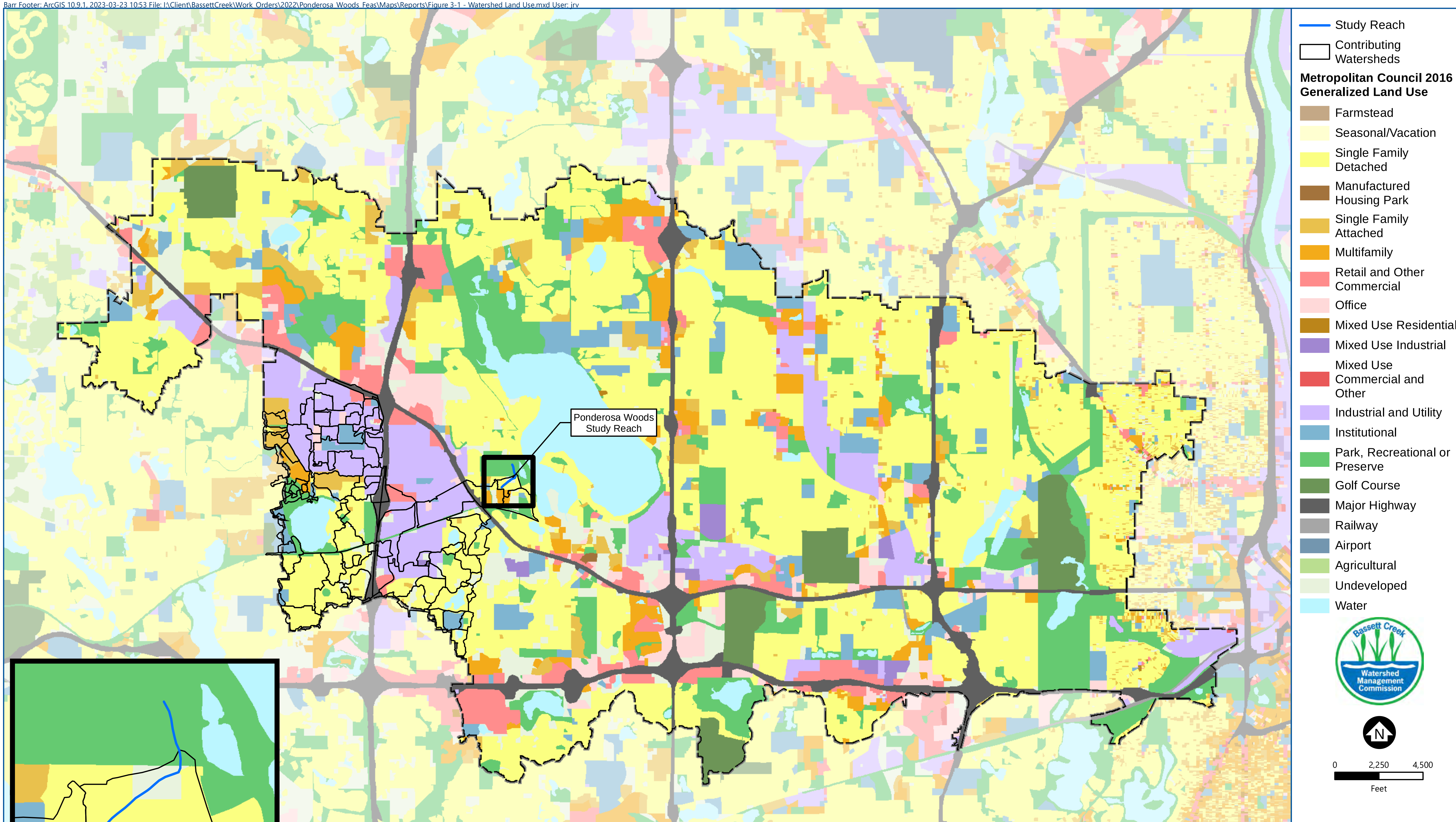
3.1 Ponderosa Woods Stream Stabilization Project Watershed

The watershed area tributary to the Ponderosa Woods project area is approximately 3.9 square miles (2,496 acres) and drains portions of the City of Plymouth (Figure 3-1). The watershed is nearly fully developed; existing land use includes single-family residential, roadway, parks and undeveloped land, multi-family residential, and open water.

3.1.1 Surrounding Land Use

3.1.1.1 Ponderosa Woods Stream Restoration

All four reaches of the project area are adjacent to land with a variety of uses, and the reaches are primarily forested, as shown in Figure 3-1. Upstream of Reach 1, water flows through undeveloped, park, institutional, multi-family residential, and single-family residential land. Reaches 1, 2, and 3 flow through single-family land, which includes mainly residential yards and a variety of understory vegetation (mature trees, young trees, unhealthy or fallen trees, invasive buckthorn shrubs and trees, shrubs, and shade-tolerant grasses and forbs). Reach 4 comprises single-family residential and park land, which includes mainly wetland vegetation (grasses and shrubs) and some understory vegetation (young trees, shrubs, and some grasses and forbs).



PROJECT AREAS
LAND USE/LAND COVER
Ponderosa Woods Stream
Restoration Feasibility Study
BCWMC

FIGURE 3-1

3.1.2 Stream Geomorphic Assessment

3.1.2.1 Ponderosa Woods Stream Stabilization

Within the Ponderosa Woods Stream Restoration project area, the stream is a low-gradient stream with limited sinuosity and channel development (riffle/run/pool sequences). The channel bed and banks are primarily silty sand with some loam. Gravel deposits can be found in the stream bed in the upstream reaches. For most of the upstream reach, the channel is confined by moderately tall banks between single-family backyards with no access to the floodplain. The downstream reaches are located in single-family residential backyards with lower banks and more access to the floodplain. The furthest downstream section of the project area also includes parkland. The project area is bounded on the upstream end by a culvert under 18th Avenue North that contributes flow to the creek. In the center and at the downstream end of the project area, the stream flows into West Medicine Lake Park and discharges through two water quality ponds before entering Medicine Lake. The stream channel evaluated as part of this project is an intermittent flowing stream, with higher flows accompanying rain events. During the field visit in November 2022, most of the stream was dry with much of the channel bed exposed or covered with one to two inches of snow.

The Commission Engineer performed a qualitative geomorphic assessment for the entire project area during a field visit, including an erosion inventory shown on Figure 2-2. Within the project area, the stream has an approximate average bankfull depth of 1 foot and an approximate bankfull width of 13 to 30 feet. Descriptions of the reaches are below:

- Within Reach 1 the stream is relatively straight—in part a result of past channelization or ditching. The channel appears to have a moderate slope through Reach 1 with some apparent elevation change. With banks approximately 4.5 feet high, the stream is incised in this reach and does not have access to the floodplain.

- Reach 2 continues to be relatively straight in a heavily forested area, with a moderate slope and some elevation change. With banks approximately 2.5 feet high, the stream does not appear to be incised in this reach and has access to the floodplain. The presence of large woody debris in the channel, which increases bank scour and sediment accumulation is also causing stream bank erosion and decreasing water quality.

- Reach 3 continues to be relatively straight in a heavily forested area, with a very mild slope with little apparent elevation change. With banks approximately 2 feet high, the stream does not appear to be incised in this reach and has access to the floodplain. The presence of large woody debris in the channel, which increases bank scour and sediment accumulation is also causing stream bank erosion and decreasing water quality. At the end of Reach 3, there is a nearly 90-degree bend; the banks are armored with riprap to protect the nearby home.

- Reach 4 is primarily straight within a vegetated area with some tree cover, with good access to the floodplain before discharging into water quality ponds a bit farther downstream and eventually into Medicine Lake. The banks are approximately 1.5 feet high and the stream does not appear to be incised in this reach and has access to the floodplain.

Figure 3-2 through Figure 3-5 show a few examples of erosion and general conditions along the stream.

Figure 3-2 Upstream Section with Channel Debris and Bank Erosion (Reach 1)

Figure 3-3 Left Bank Erosion (Reach 1)

Figure 3-4 Debris and Left Bank Erosion (Reaches 1 and 2, downstream of upstream flared end section)

Figure 3-5 Erosion and Sediment Deposition at a Stormwater Side-channel

3.1.3 Historical Channel Alignments

The Ponderosa Woods stream alignment has changed since the shift of the surrounding land use from agricultural to residential. In 2006, the downstream end of the reach was diverted to the north along West Medicine Lake Road intersecting with the downstream reach of Plymouth Creek. Prior to this, the stream flowed directly underneath West Medicine Lake Road into the adjacent wetland to the east. Based on historical imagery, a channel at this project location has existed since sometime between 1964 and 1969. From 1969 to the present, the riparian area around the stream has become more forested since the conversion from agricultural land use to residential, along with an increase in stream sinuosity at the downstream portion of the stream compared to the original straightened channel. Prior to the late 1960's, a channel is not visible in historical imagery. From the available imagery, it is unknown how the stream channel developed, though potentially due to human land development. Figure 3-6 provides a comparison of historical areal imagery with images of the stream reach from 2020, 1969, 1964, and 1937 (References (2), (3), (4), and (5), respectively.

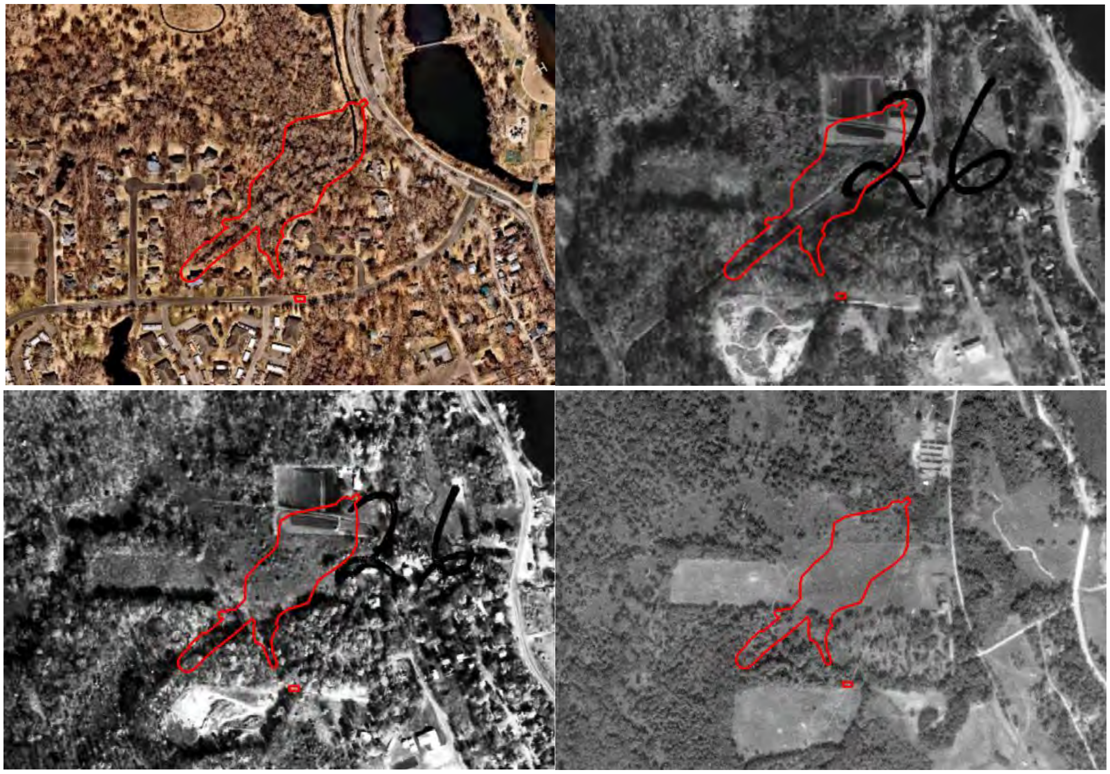


Figure 3-6 Ponderosa Woods Historical Channel Alignments (Top Left – 2020, Top Right – 1969, Bottom Left – 1964, Bottom Right – 1937)

3.2 Site Access

The Ponderosa Woods Stream Restoration project area is primarily surrounded by single-family residential properties and borders West Medicine Lake Park on the downstream end of the project area. Based on input from City of Plymouth staff, we assume the primary access route for construction will be from West Medicine Lake Drive, with staging areas in the parking lot of West Medicine Lake Park, and construction vehicles crossing the road and entering the downstream end of the project area on City of Plymouth owned land upstream of the pedestrian bridge. Construction crews and equipment will traverse up the channel to conduct the project work, so construction access from private property will not be necessary. The City has permanent easements along the stream channel, but additional temporary and permanent easements may need to be obtained from the adjacent property owners to cover the full width of the project area and the stormwater side-channels, and to access parts of the riparian areas and the stormwater side-channels included in this work. Potential site access locations and staging areas are presented in the figures in Section 5.2.

3.3 Environmental Review

As part of our desktop environmental review, we reviewed historical imagery and the Minnesota Pollution Control Agency's (MPCA's) "What's In My Neighborhood?" database. Historical aerial imagery shows the surrounding area as primarily undeveloped. In the late 1990's, the area around the creek began to develop as residential. Historical aerial images were reviewed from as early as 1937.

A review of MPCA's What's In My Neighborhood database identified two inactive construction stormwater listings within 500 feet of Bassett Creek: Plymouth Creek Water Quality Ponds and Parkwood Townhomes. No listings indicative of a pollutant release to the environment were identified within a 1,000-foot radius of the project area.

Figure 3-7 below shows the locations of all identified environmental activities within approximately 1,000 feet of the proposed project.

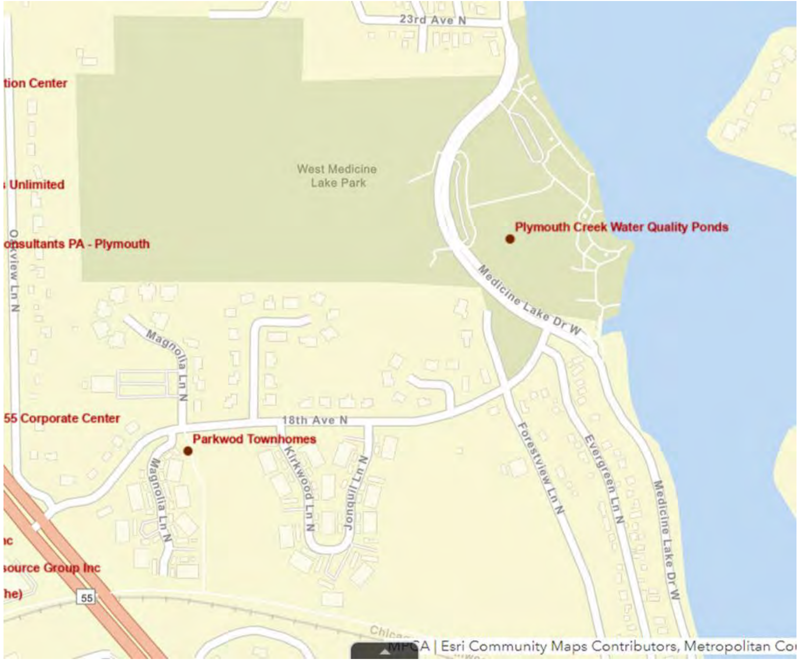


Figure 3-7 **MPCA's "What's in My Neighborhood?" Database Results**

3.4 Tree Surveys

The Commission Engineer performed a tree survey in the fall of 2022 to develop and evaluate concepts. A Minnesota state-licensed landscape architect with extensive tree identification and survey experience collected species, condition, and diameter data for trees greater than 6 inches in diameter. Table 3-1 summarizes the tree survey, including species and count within the immediate project area (approximately 40 feet from the center of the stream). Dominant species surveyed include ash, box elder, buckthorn, cottonwood, elm, and maple. The full tree survey results can be found in Appendix B. Section 5.0 provides details regarding the proposed tree removals for each concept.

Table 3-1 Tree Survey Summary

Species Name	Count
Willow/Black	3
Birch/River	12
Birch/Paper	1
Ash/Green(1)	44
Box Elder	115
Cottonwood	30
Buckthorn(2)	20
Elm/American	39
Maple/Sugar	31
Basswood/American	6
Hackberry	1
Elm/Siberian2	1
Cedar/White	4
Tamarack	1
Amur Chokecherry	1
Chokecherry	1
Total	**310**

1) Susceptible to Emerald Ash Borer, which has been identified in this area.
2) Invasive species.

3.5 Aquatic Resources

The Commission Engineer completed a Level 1 desktop wetland assessment for the project area in October 2022. The review included an assessment of multiple years of aerial imagery in addition to hydric soil indicators from the Natural Resources Conservation Service (NRCS) Web Soil Survey, LiDAR topography data, the United States Fish and Wildlife Service (USFWS), National Wetland Inventory (NWI), and the Minnesota Department of Natural Resources (MnDNR) Public Water Inventory (PWI).

According to the NRCS Web Soil Survey, the soils within the project area are classified as Muskego, Blue Earth, and Houghton Soils, a hydric soil (Reference (6)).

There are no PWI wetlands or watercourses within the project area. The USFWS NWI identified a large wetland complex located on the northeastern side of the project area classified as a floodplain forest (PFO1A) and freshwater pond (PUBHx). The nearest PWI watercourse is Plymouth Creek (PWI 27032a), located 750 feet north of the project area. This creek drains into Medicine Lake, a PWI basin (PWI 27010400).

The Level 1 review indicates that the hydrology around the project area has been significantly altered over the years. Several drainage ditches have been constructed adjacent to the project area. These drainage ditches convey water from the project area north towards a larger wetland complex that drains into Medicine Lake. The desktop delineation identified 3.57 acres of potential floodplain forest wetland (PFO1A) located around the Ponderosa Woods Stream. The desktop delineation also separately identified approximately and 0.36 acres of riverine/stream bed aquatic resources (R4SB).

A field wetland delineation may be required to confirm the wetland delineation boundaries but will be confirmed with the LGU during consultation. The field wetland delineation would follow the U.S. Army Corps of Engineers (USACE) 1987 Wetland Delineation Manual (Reference (7)), the Regional Supplement to the USACE Wetland Delineation Manual: Midwest Region (Reference (8)) and the requirements of the Minnesota Wetland Conservation Act (WCA) of 1991.

Figure 3-8 shows the desktop aquatic resources delineation.

DESKTOP AQUATIC RESOURCES DELINEATION
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC

FIGURE 3-8

3.6 Threatened and Endangered Species

The Commission Engineer completed a desktop review for federal and state-listed species and associated habitats that may be found in the Ponderosa Woods project area to evaluate potential impacts on listed species. The federal government protects federally listed species under the Endangered Species Act and requires consideration of the impacts on these species for projects involving federal permits. State-listed species are protected under Minnesota's Endangered and Threatened Species Law and the impacts on these species must be considered for state-level permitting requirements. We completed the desktop review in October 2022 using a combination of data available from the United States Fish and Wildlife Service (USFWS) and the Minnesota Department of Natural Resources (MnDNR), as further described below and updated the information on the northern long-eared bat April 2023.

3.6.1 Federally Listed Species

The Commission Engineer queried the USFWS' Information, Planning, and Conservation System (IPaC) website to identify federally listed species that may occur within the project area. The IPaC identified one federally listed species and one candidate species potentially occurring in the project area: the northern long-eared bat (*Myotis septentrionalis;* endangered species) and the monarch butterfly (*Danaus plexippus*, candidate species). No designated critical habitat for any federally listed species is located within the project area.

The northern long-eared bat hibernates in caves during the winter and utilizes forested areas for roosting and foraging during the bat's active season of April through September. Suitable roost trees for this species have trunks measuring greater than 3 inches in diameter at breast height with loose, peeling bark or crevices. According to data provided by the MnDNR, no known occupied roost trees or hibernacula are located within the project area. The nearest known hibernacula are located over 14 miles southeast of the project area. However, because the project occurs within the range of the northern long-eared bat and will require tree removal, impacts on the northern long-eared bat cannot be completely discounted. To avoid direct impacts on the northern long-eared bat, it is recommended that tree removal occur during the inactive period (October 15 to early April). Consultation with USFWS would be required if tree removal were to occur during the northern long-eared bat's active season (mid-April – October 14).

The monarch butterfly is listed as a candidate species and is not legally protected under the Endangered Species Act. No avoidance or minimization measure would be required for the monarch butterfly, but avoidance measures will be considered during project design if considerable monarch habitat is observed. A monarch butterfly habitat assessment was not conducted for this feasibility study.

3.6.2 State-Listed Species

Through a license agreement (LA-898) with the MnDNR for access to the Natural Heritage Information System (NHIS) database, the Commission Engineer queried the NHIS database in October 2022 to evaluate if any rare species could potentially be affected by the proposed project. The NHIS review identified one state-listed threatened species as occurring within one mile of the project area, the Blanding's turtle (*Emydoidea blandingii*). For the design of this project, the MnDNR should be consulted with as early as possible to avoid permit delays during construction.

The Blanding's turtle habitat includes shallow, slow-moving waters with abundant vegetation such as grassy marsh, mesic prairies, slow-moving rivers, and shallow lakes and ponds. Adult turtles prefer shallow water during the active season and prefer deeper water, at least 3 feet deep, for overwintering. Nesting occurs in open areas with sandy soils within 900 feet of a wetland or waterbody. The Ponderosa Woods stream may provide suitable summer habitat for the Blanding's turtle. However, it is unlikely for the turtle to utilize the stream for overwintering habitat because the stream is less than 3 feet deep during the winter months. The surrounding wooded plant community would not be considered suitable nesting habitat for the Blanding's turtle. It is unlikely for the project to adversely impact the Blanding's turtle therefore no minimization measures are proposed. Information about protecting Blanding's turtles and their habitat should be distributed to all contractors working on site (Appendix C).

3.6.3 Additional Sensitive Resources

According to GIS data obtained from the MnDNR, there are no Minnesota County Biological Survey (MCBS) Sites located within one mile of the proposed project site. Additionally, no state-owned wildlife management areas (WMA), Scientific Natural Areas (SNA), or native plant communities are present within one mile of the proposed project area.

3.7 Cultural and Historical Resources

The Commission Engineer completed a cultural resources literature review of the project area and within a one-mile buffer in November 2022. The literature review was directed toward identifying previously recorded archaeological sites, historic structures, and other cultural resources. The Commission Engineer requested data from the Minnesota State Historic Preservation Office (SHPO) to identify previously recorded archaeological sites and historic architectural resources located within one mile of the project area. We also reviewed the Minnesota Office of the State Archaeologist (OSA) Portal for archaeological sites.

Data provided by the Minnesota SHPO indicates that within one mile of the project area, 19 historic architectural resources have been documented. These consist primarily of houses, but also include one resort, Trunk Highway 55, and the Plymouth Segment of the Electric Short Line Railroad Corridor (Luce Line). Table 3-2 below lists the historic architectural resources within one mile of the project.

Table 3-2 Documented Historic Architectural Resources within One Mile of the Project Area

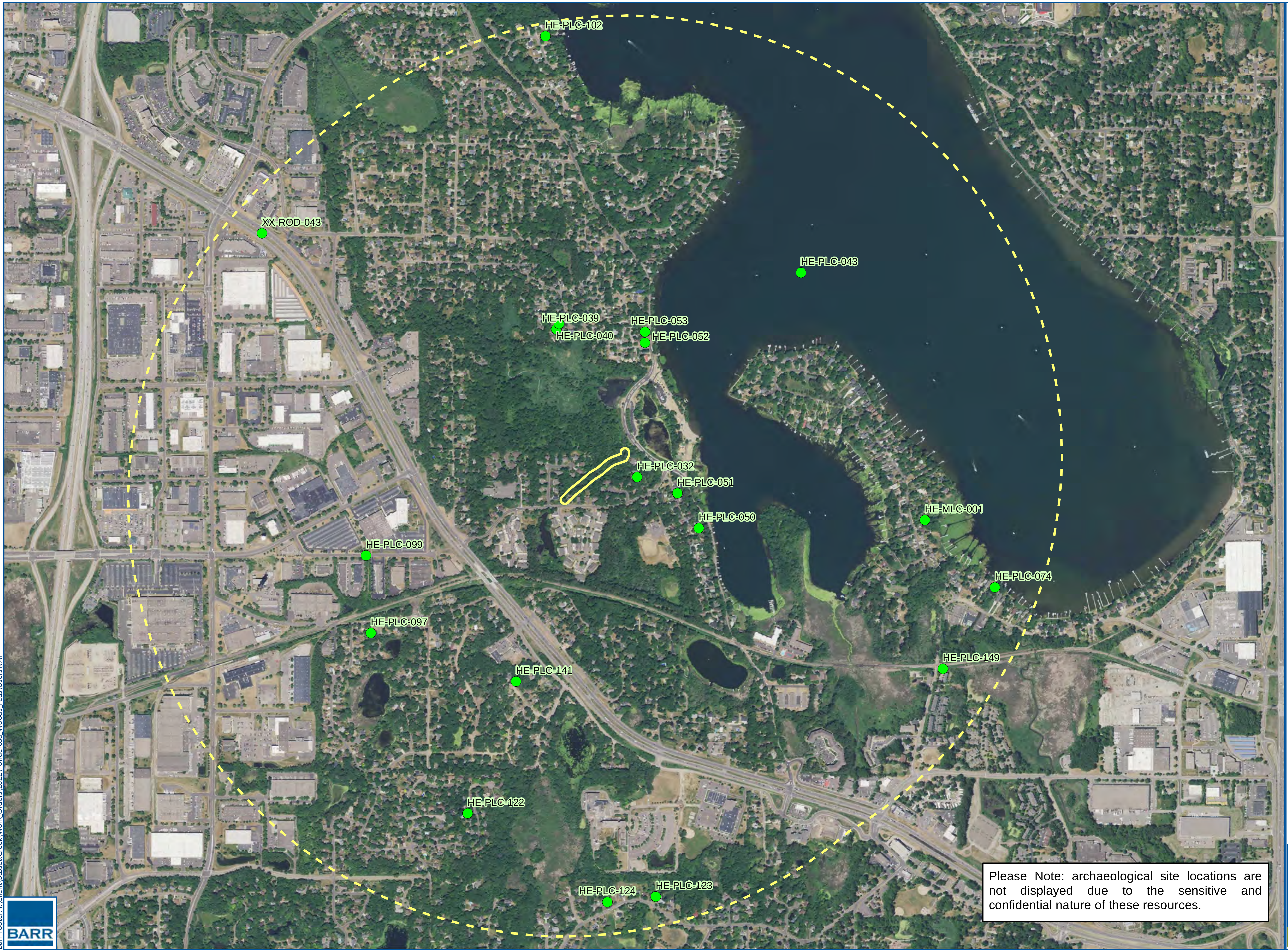
Inventory Number	Property Name	Address
HE-PLC-099	house (razed)	12811 16th Ave. N.
XX-ROD-043	Trunk Highway 55	TH 55
HE-MLC-001	resort	134-156 Peninsula Rd.
HE-PLC-032	house	1825 Forestview Lane
HE-PLC-039	house	2307 Kirkwood
HE-PLC-040	house	2315 Kirkwood
HE-PLC-043	house	2430 Magnolia Lane
HE-PLC-050	house	1701 Medicine Lake Dr. W
HE-PLC-051	house	1743 Medicine Lake Dr. W.
HE-PLC-052	house	2301 Medicine Lake Dr. W.
HE-PLC-053	house	2319 Medicine Lake Dr. W.
HE-PLC-074	house	10620 South Shore Dr.
HE-PLC-097	house	12905 15th Ave. N.
HE-PLC-102	house	12000 29th Ave. N.
HE-PLC-122	house	10820 Co. Rd. 15
HE-PLC-123	house	11310 Co. Rd. 15
HE-PLC-124	house	12206 Co. Rd. 15
HE-PLC-141	house	12235 Highway 55
HE-PLC-149	Electric Short Line Railroad Corridor (Luce Line): Plymouth Segment	n/a

The OSA Portal as well as data from the Minnesota SHPO identified one previously recorded archaeological site within one mile of the project area. According to the site record on file at OSA, site 21HE0068 consists of the Medicine Lake Mounds. The Medicine Lake Mounds were recorded by T.H. Lewis in 1887 as a series of seven earthworks. Burial authentication investigations completed in 1996 prior to the proposed removal of West Medicine Lake Drive found no evidence of the mounds; they are presumed destroyed by house and road construction. Due to its location approximately 800 feet from the project area, impacts to site 21HE0068 are not anticipated. However, if work should occur within 250 feet of site boundaries, coordination with the SHPO and Minnesota Indian Affairs Council (MIAC) is recommended. Table 3-3 below shows the archaeological resources within one mile of the project.

Table 3-3 Documented Archaeological Sites within One Mile of the Project Area

Site Number	Site Name	Site Type
21HE0068	Medicine Lake Mounds	Precontact burial mounds (7)

None of the previously recorded cultural resources are located within or directly adjacent to the project area. The project area does not appear to have been previously surveyed for archaeological resources. If the project constitutes an undertaking subject to Section 106 of the National Historic Preservation Act through federal permitting, funding, or oversight, additional work to identify significant cultural resources may be required.



Please Note: archaeological site locations are not displayed due to the sensitive and confidential nature of these resources.

CULTURAL RESOURCES
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC

FIGURE 3-9

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BARR

3.8 Topography and Utilities

An important consideration for stream restoration is the existing topography and proximity to utilities. The topography we used for this feasibility study was LiDAR from 2011, while utility information was provided by the City of Plymouth. Utilities reviewed as part of this feasibility study include storm sewer, sanitary sewer, and drinking water mains. There are no known sanitary sewers or water mains impacted by this project. Figure 2-1 shows nearby sanitary sewer and water main locations.

4.0 Stakeholder Input

4.1 Project Kickoff Meeting with BCWMC and City of Plymouth Representatives

A project kickoff meeting with BCWMC representatives (Administrator, Commissioner Cesnik, Alternate Commissioner Vadali, Engineer) and City of Plymouth staff was conducted virtually on October 3, 2022. At this meeting, we reviewed the project scope and schedule, reviewed key tasks, and identified data needs. Discussions also included preferences regarding preliminary stream stabilization concepts.

4.2 Technical Stakeholder/Agency Meeting

A technical stakeholder meeting was held virtually on December 12, 2022. Attendees included representatives from the City of Plymouth, BCWMC (Administrator, Engineer), US Army Corps of Engineers (USACE), MnDNR, and the MPCA. The attendees reviewed the design concepts at the Ponderosa Woods Stream Restoration project site and provided technical and permitting feedback. Items discussed included:

- Review of the project schedule and meeting objectives.
- Review of the erosion sites and other creek deficiencies.
- Review of water quality issues.
- Review and discussion of the design concepts.
- Discussion of permit requirements for potential wetland and stream impacts.
- Discussion of potential habitat improvements.

The meeting provided an opportunity to review the project site and discuss options, considering ideal restoration scenarios and practical aspects of maintenance and construction. The USACE expressed their preference to include all aquatic resources and stream type as part of the wetland delineation review. A field wetland delineation would likely be required by the local government unit (LGU) to verify the wetland boundaries and inform project design and permitting. Additional discussion on the upcoming federal change for the northern long-eared bat was also included and has be tracked by the Commission Engineer; Section 3.0 of this report is updated with the most recent information as of April 2023. Additional specific outcomes of the discussion are incorporated into the appropriate sections below.

4.3 Public Meeting

A public stakeholder meeting was held at Plymouth City Hall on February 13, 2023, with 5 members of the public attending the meeting (3 different property owners). During the meeting, preliminary design concepts were presented to local residents. Attendees asked questions and provided some of their observations of the creek, tree and invasive buckthorn removal, and general project areas. There were no significant concerns raised about the project and the restoration methods proposed; however, most of the public’s comments and support focused on improving the vegetated habitat of the project area by removal of diseased and hazardous trees as well as invasive buckthorn. General discussions included tree removal, invasive buckthorn removal, habitat improvements, water quality benefits, and project cost.

All members of the public who attended supported removing invasive buckthorn, unhealthy trees (including green ash), and additional trees, where needed to open the tree canopy and get more light into the understory to increase understory vegetation. Nearby homeowners use this area for recreational purposes. The project area currently has a lower-quality forested environment with significant amounts of invasive buckthorn and green ash, and a minimal understory, which negatively affect the stream and riparian habitats, as well as the recreational use of the area. Based on discussions with the homeowners, they would support a larger amounts of tree and invasive buckthorn removal than currently proposed. In follow-up discussions with Plymouth staff, the proposed buckthorn removal areas were adjusted to include more area south of the stream and less area on the north of the stream. However, the overall buckthorn removal area was not increased in size due to costs and to keep the focus of the project on the stream restoration rather than forest management. The City of Plymouth will assist with buckthorn management on City parcels during or after construction.

Section 6.0 includes further discussion and information related to homeowner comments, homeowner impacts, and the need for additional easements.

5.0 Potential Improvements

This section provides a summary of the alternatives considered for the Ponderosa Woods stream restoration site and includes a general description of the stabilization techniques evaluated for the stream restoration.

5.1 Description of Potential Improvements

There are many possible combinations of alternatives that would provide stabilization benefits throughout the entire project area. This section provides an overview of the stabilization concepts reviewed by the project stakeholders in this feasibility study. Detailed design efforts later in the project implementation may identify and include stabilization techniques or combinations of techniques that are not specifically included in this feasibility study.

5.1.1 Hard Armoring vs. Bioengineering Stream Stabilization Techniques

Techniques for stream stabilization generally fall into two categories: hard armoring and bioengineering (also known as soft armoring). Hard armoring techniques include the use of engineered materials such as stone (riprap or boulders), gabions, or concrete to stabilize slopes and prevent erosion. Bioengineering techniques employ biological and ecological concepts to control erosion, using vegetation or a combination of vegetation and construction materials, including logs and boulders. Techniques that do not use vegetative material but are intended to achieve stabilization of natural flow patterns and create in-stream habitat, such as boulder or log vanes, are generally included under the umbrella of bioengineering.

Hard armoring and bioengineering techniques present different challenges, costs, and benefits for stream stabilization design. Hard armoring methods are viewed as standard and time-tested and typically have a longer life span due to the permanence of the materials used. Hard armoring is usually effective in preventing erosion where it is installed; however, placement must consider downstream impacts, understanding that the armoring may push the erosive stresses downstream. Hard armoring typically requires little maintenance; however, if the armoring fails, maintenance or replacement can be expensive, particularly if the armoring materials need to be removed from the site.

Bioengineering techniques maintain more of a stream's natural function and provide better habitat and a more natural appearance than hard armoring. If vegetation is well-established this approach can also be self-maintaining. Due to biodegradation of construction materials and variable vegetation establishment success, it is typically assumed that bioengineering installations have a shorter life span and may need more frequent (although less expensive) maintenance, particularly as the vegetation is becoming established. Compared to hard armoring, the success of bioengineering techniques is more dependent on the skill of the designer and installer—sometimes making bioengineering construction more expensive.

Technical stakeholders for this feasibility study, including the USACE, expressed a preference for bioengineering over hard armoring for stream stabilization where possible. In addition, the current BCWMC Watershed Management Plan (see Section 4.2.5 of Reference (1)) states: "recognizing their benefits to biodiversity and more natural appearance, the BCWMC will strive to implement stream and stream bank restoration and stabilization projects that use soft armoring techniques (e.g., plants, logs, vegetative mats) as much as possible and wherever feasible." However, the BCWMC also recognizes that soft armoring techniques can require significant tree removal, which can be a negative consequence, depending on the type and condition of trees in the project area. Therefore, the BCWMC seeks to balance soft armoring with preserving desirable tree species.

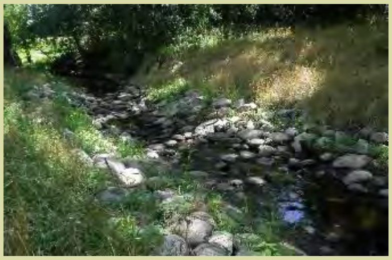
5.1.2 Stream Stabilization Techniques Evaluated

The Commission Engineer evaluated several techniques for stabilizing the stream within the project areas. Both hard armoring and bioengineering methods were considered; a mix of both methods types are included in the following design alternatives, but all have a focus on more bioengineering methods. Rock riffles or boulder cross vanes could be used to stabilize the channel bed and introduce flow variability and an improved riffle/pool sequence. The deeper pools will improve habitat, especially during winter months. The use of grading and installation of live stakes on eroding banks would stabilize these areas from further sediment loss and improve habitat within the pools that have become overly shallow; too many live stakes may create more shade than desired and decrease some of the benefits created by opening the tree canopy with the desired design alternative. Vegetation establishment in the overbanks would include enhanced buffers with native vegetation that have deeper roots for improved sediment-loss reduction and new riparian habitat. The installation of rock toe and additional riprap, along with the reconstruction of existing riprap will help stabilize the stream banks.

Table 5-1 summarizes the project restoration techniques included in this feasibility study. We also considered using woody debris for root wads, log vanes, and toe wood; however, with the low water levels, the wood would decompose and would not provide the same longevity of bank stability that it would under submerged conditions.

Table 5-1 Project Design Elements

Design Element	Purpose	Ecological Benefits
Rock Toe Bank Stabilization (hard armoring element) 	Boulders buried and extending partially up the toe of the bank to protect the bank from high velocity flows and bank erosion.	Prevents sediment deposition into the stream channel, improving water quality for aquatic species.

Rock Riffles **(bioengineering element)** 	Gravel or cobble-sized material installed in the stream bed to create natural flow patterns and to control stream bed elevations.	The variety in flow and channel substrate size provides habitat diversity for aquatic species.
Cross Vanes **(bioengineering element)** 	Boulders buried in the stream bed and extending partially ("vanes") or entirely across the stream ("cross vanes") to achieve one or more of the following goals: re-direct flows away from banks, encourage sediment deposition in selected areas, and control stream bed elevations	Scour pools develop over time near the vane, which provide habitat diversity for species that prefer pools to faster flowing in-channel habitat.
Coir Blanket/Live Stakes Bank Stabilization **(bioengineering element)** 	Long-lasting, biodegradable fabric with seeding and live stakes to stabilize slopes and encourage establishment of root systems for further stabilization	The vegetation, once established, will increase the diversity of the riparian habitat, and improve aquatic habitat.
Vegetated Buffer (includes removal of trees, invasive buckthorn, and in-channel debris) **(bioengineering element)** 	Establish vegetation along a stream bank or overbank area to stabilize bare soils and increase resistance to fluvial erosion. Remove unhealthy trees and invasive species, including buckthorn, to open the tree canopy to allow understory vegetation to grow and stabilize the banks. Remove in-channel debris to stabilize banks and prevent additional erosion.	Using trees, shrubs, and a seed mix of grass and forbs provides a diverse array of vegetation and habitat types. Allows for more naturalized aesthetics, with emphasis on native species. Removal of in-channel debris prevents erosive flows from being routed into the bank and also eliminates locations for sediment accumulation, improving water quality for aquatic species.

5.2 Concepts Evaluated

This section provides a summary of the three conceptual designs developed and evaluated for the Ponderosa Woods Stream Restoration project and presented at the public outreach meeting February 13, 2023. Table 5-2 provides a summary of the alternatives evaluated and further discussed in the following sections.

Table 5-2 Feasibility Study Alternatives Summary

Alternative	Description
Alternative 1 – Small Footprint Design	Stream stabilization using bio-engineering techniques, bank and channel grading, and in-channel controls. This alternative also includes installation of and reinforcement of existing riprap. Buckthorn removal occurs at or near streambanks and tributary stormwater channels. Tributary stormwater channels are regraded and stabilized with riprap. Alternative 1 prioritizes minimal land disturbance and tree removal.
Alternative 2 – Medium Footprint Design	Alternative 1 techniques but with more hard armoring; plus, two additional acres of buckthorn removal and additional overbank grading.
Alternative 3 – Large Footprint Design	Alternative 1 and 2 techniques plus a stream channel re-meander in the downstream reach. The re-meandered section includes grading and bioengineering stabilization throughout.

Section 5.0 summarizes the impacts of the conceptual designs, Section 6.0 summarizes the project modeling and estimated water quality improvements, and Section 7.0 provides a summary of the cost for each alternative.

5.3 Analyzed Alternatives for Ponderosa Woods Stream Restoration Project

5.3.1 Alternative 1— Small Footprint Design

The primary focus of the Alternative 1 design is stabilizing the stream with a bioengineering approach, which will decrease erosion as well as phosphorus and total suspended solids (TSS) loading, improve water quality, improve stream and downstream habitat, and protect single-family residences. Figure 5-1 shows a representation of the proposed features of Alternative 1, which is the smallest project footprint of the three alternatives. This alternative includes the following design components:

- Remove large in-channel debris, which will decrease localized bank and scour erosion as well as sediment accumulation. These areas have over-widened banks, which destabilize the banks and decrease the floodplain connectivity. The banks will be graded in such a way as to narrow the over-widened channel, so the stream flows are able to access the floodplain; accessing the floodplain slows the water flow via the vegetation and decreases downstream flooding potential.

Restoring floodplain connectivity also increases the system resiliency and ability to manage and slow flows during storm events.

- Minimize tree removal (especially of larger, healthier trees). This alternative proposes removal of 27 healthy trees to make way for construction work and open up the tree canopy to allow sunlight into the understory, enhancing growing conditions for the understory vegetation, which then assists with stabilizing the banks. Details of replanting trees and other restoration will be determined during the final design process. Removed species (with range of diameters) include American elm (6 to 16 inches), ash (7 to 16 inches), box elder (6 to 18 inches), buckthorn (6 to 8 inches), cottonwood (23 to 33 inches), and maple (6 to 7 inches). The majority of the trees to be removed are less than 12 inches in diameter. Note, the tree survey only includes trees within approximately 40 feet of the stream centerline. Additional tree survey will be necessary if the construction work expands beyond this area. Appendix D contains a tabulation of trees removed by each species.

- Remove invasive buckthorn within 40 feet on either side of the stream channel and 15 feet on either side of the stormwater side-channels within the project area. Buckthorn is pervasive in this area, so removal will allow additional sunlight and space into the understory, which will allow native species to establish, improve habitat in the project area, and improve bank stability along the stream channel. Buckthorn removal methods will be determined during design.

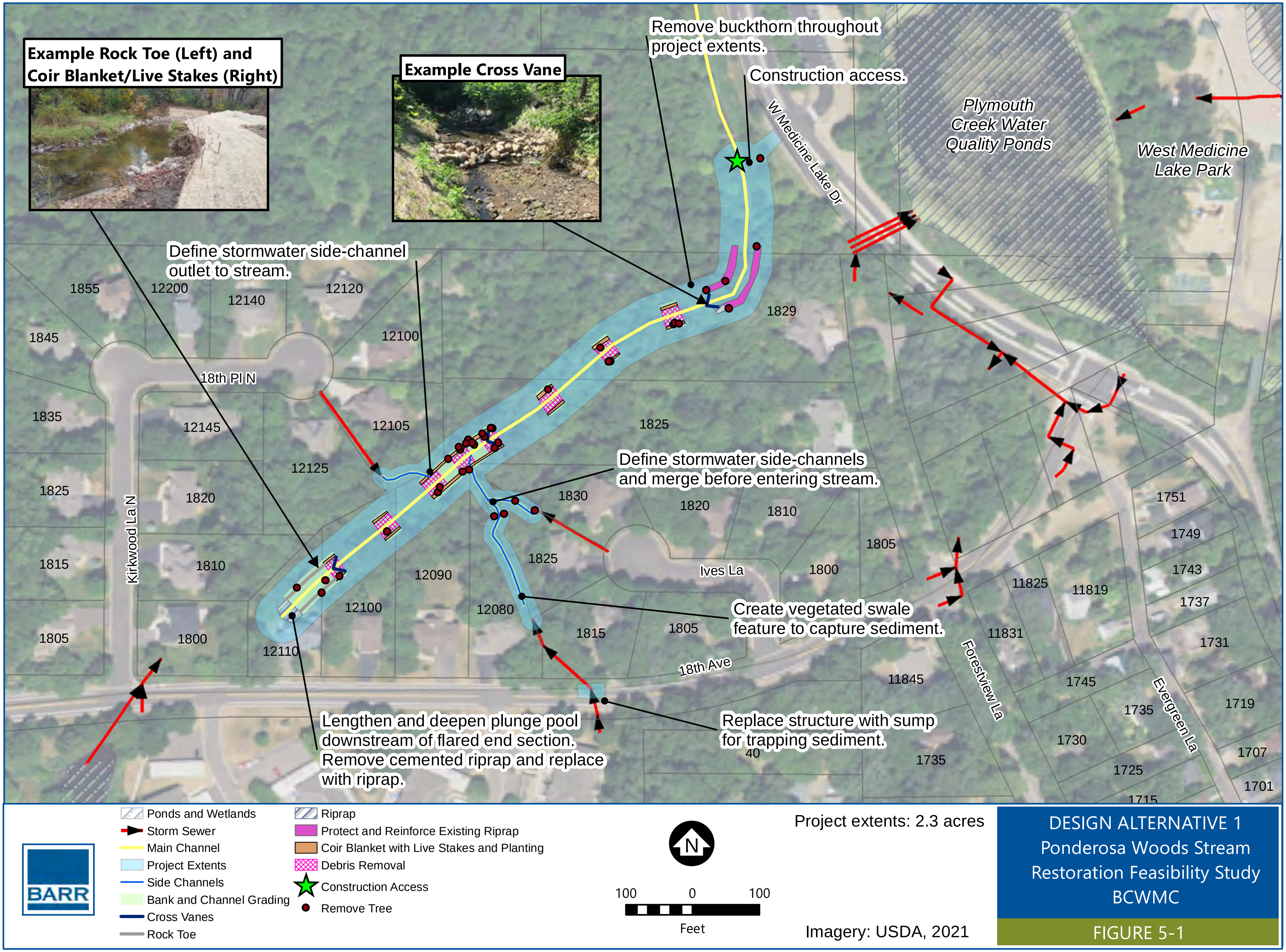
- Expand and re-stabilize the plunge pool at the upstream end of the stream channel to stabilize the banks and build in additional resiliency during high flow events, which can minimize bank erosion that is occurring near single-family residential homes. This area is near single-family residences, so further stabilizing this section of the stream will also protect the nearby homes.

- Manage stormwater side-channels with regrading and riprap stabilization to guide water more directly to the stream channel. One location will also include a sediment trap sump structure (replacing an existing structure), which will minimize sediment deposition from the stream channel and its transport to Plymouth Creek and Medicine Lake.

- Stabilize targeted bank and channel locations with bioengineering (vegetated) and hard armoring (stone) methods, which will decrease erosion. These methods include grading and placing either coir blankets with live stakes or rock toe to improve stream bank stability and decrease erosion. This alternative includes more bioengineered than hard armored methods.

- Install boulder cross vanes to limit erosion of the channel bed, redirect flow from the banks, and create flow diversity.

- Reinforce existing downstream riprap area to protect the downstream homeowner’s property. This property is near the nearly 90-degree bend in the stream; this part of the stream can experience higher velocities and increased erosion potential. Additional riprap reinforcement will further protect this home.



Example Rock Toe (Left) and Coir Blanket/Live Stakes (Right)
Example Cross Vane
Remove buckthorn throughout project extents.
Construction access.
W Medicine Lake Dr
Plymouth Creek Water Quality Ponds
West Medicine Lake Park
Define stormwater side-channel outlet to stream.
Define stormwater side-channels and merge before entering stream.
Create vegetated swale feature to capture sediment.
Replace structure with sump for trapping sediment.
Lengthen and deepen plunge pool downstream of flared end section. Remove cemented riprap and replace with riprap.
18th Pl N
Kirkwood La N
Ives La
18th Ave
Forestview La
Evergreen La
1855
12200
12140
12120
12100
1845
1835
12145
12105
12125
1825
1820
1815
1810
1805
1800
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1725
1719
1707
1701
1715
1735
40
Ponds and Wetlands
Storm Sewer
Main Channel
Project Extents
Side Channels
Bank and Channel Grading
Cross Vanes
Rock Toe
Riprap
Protect and Reinforce Existing Riprap
Coir Blanket with Live Stakes and Planting
Debris Removal
Construction Access
Remove Tree
N
100
0
100
Feet
Project extents: 2.3 acres
Imagery: USDA, 2021
BARR
DESIGN ALTERNATIVE 1
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC
FIGURE 5-1

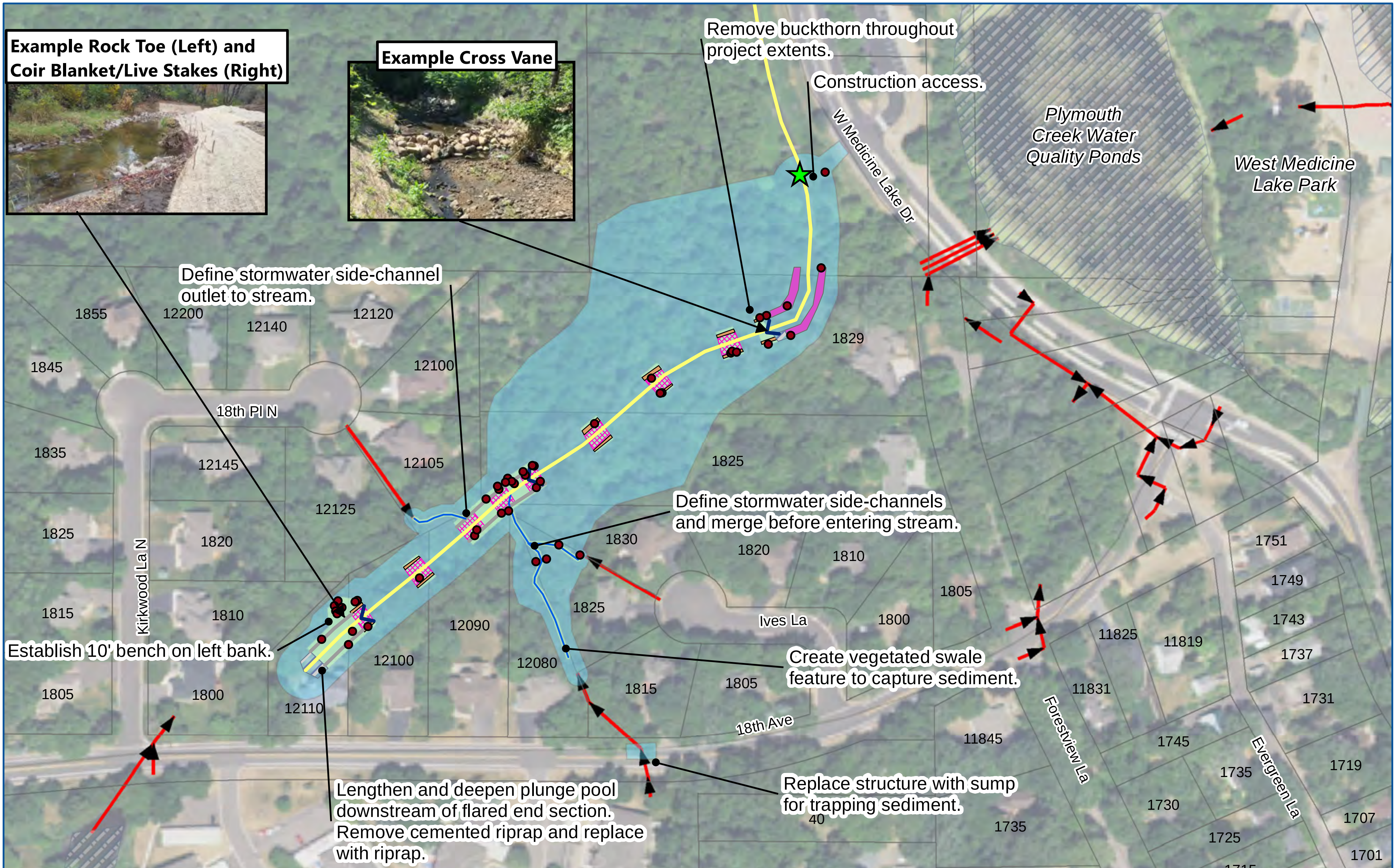
5.3.2 Alternative 2— Medium Footprint Design

The primary focus of the Alternative 2 design is stabilizing the stream with hard armoring and bioengineering, which will decrease erosion as well as phosphorus and total suspended solids (TSS) loading, improve water quality, improve stream and downstream habitat, and protect single-family residences Figure 5-2 shows a representation of the proposed features of Alternative 2, which has a medium-sized project footprint compared to the other alternatives. Alternative 2 aims to provide additional habitat improvement through increased buckthorn removal, and to use more hard armoring than Alternative 1. It is similar to Alternative 1, except it also includes the following design components:

- Minimize tree removal (especially of larger, healthier trees), but with slightly more tree removal compared to Alternative 1. This alternative proposes removal of 34 healthy trees to make way for construction work and open up the tree canopy to allow sunlight into the understory, increasing the understory vegetation, which then assists with stabilizing the banks. Details of replanting trees and other restoration will be determined during the final design process. Removed species (with range of diameters in inches) include American elm (6 to 16 inches), ash (7 to 24 inches), basswood (8 to 13 inches), box elder (6 to 18 inches), buckthorn (6 to 8 inches), cottonwood (23 to 33 inches), and maple (6 to 7 inches). The majority of the trees to be removed are less than 12 inches in diameter. Note, the tree survey only includes trees within approximately 40 feet of the stream centerline. Additional tree survey will be necessary if the construction work expands beyond this area. Appendix D contains a tabulation of trees removed by each species.

- Remove additional invasive buckthorn. Buckthorn removal will extend beyond 40 feet on either side of the stream channel on both the north and south sides of the downstream half of the reach within the project area. This additional buckthorn removal provides additional riparian habitat improvements. Buckthorn removal methods will be determined during design.

- Stabilize targeted bank and channel locations with bioengineering (vegetated) and hard armoring (stone) methods, which will decrease erosion. These methods include grading and placing either coir blankets with live stakes or rock toe to improve stream bank stability and decrease erosion. This alternative includes more hard armoring than bioengineering methods, compared to Alternative 1. There is also some additional grading in the upstream reach to establish a 10-foot bench on the left bank, which can help reduce velocities during higher flow storm events.



Ponds and Wetlands
Storm Sewer
Main Channel
Project Extents
Side Channels
Bank and Channel Grading
Cross Vanes
Rock Toe
Riprap
Protect and Reinforce Existing Riprap
Coir Blanket with Live Stakes and Planting
Debris Removal
Construction Access
Remove Tree

N

100 0 100

Feet

Project extents: 4.4 acres

Imagery: USDA, 2021

BARR

DESIGN ALTERNATIVE 2
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC

FIGURE 5-2

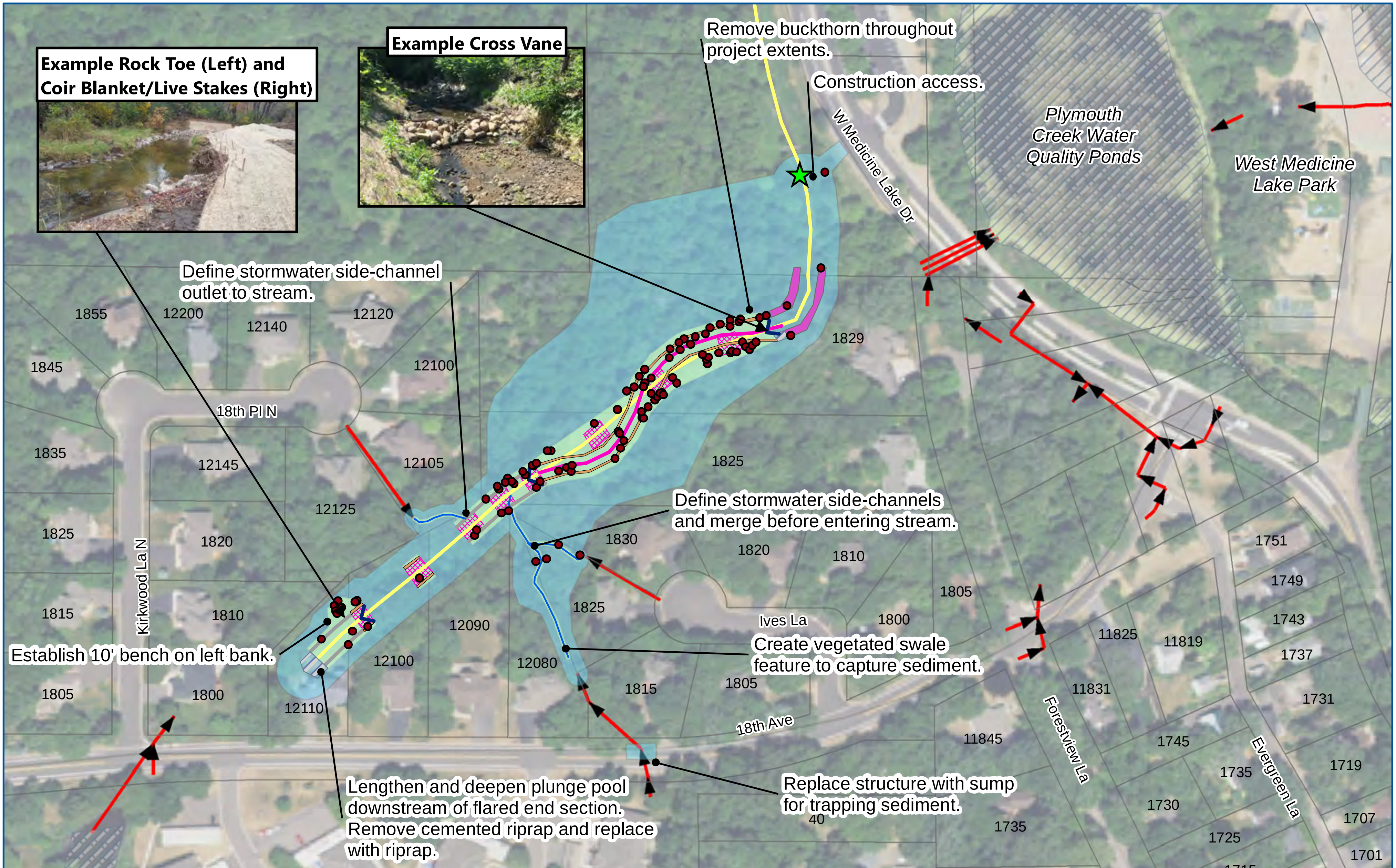
5.3.3 Alternative 3— Large Footprint Design

The primary focus of the Alternative 3 design is stabilizing the stream with a bioengineering approach, which will decrease erosion as well as phosphorus and total suspended solids (TSS) loading, improve water quality, improve stream and downstream habitat, and protect single-family residences. Figure 5-3 shows a representation of the proposed features of Alternative 3, which has the largest project footprint compared to the other alternatives. Alternative 3 aims to provide additional resiliency to the management of the stream flows by re-meandering a portion of the reach (and therefore elongating the stream reach), and to use more bioengineering than hard armoring bank stabilization methods. Alternative 3 is similar to Alternative 2, except it also includes the following design components:

- Additional tree removal to construct the re-meandering of the stream channel, resulting in the most tree removal of the three alternatives. This alternative proposes removal of 72 healthy trees to make way for construction work and open up the tree canopy to allow sunlight into the understory, increasing the understory vegetation, which then assists with stabilizing the banks. Details of replanting trees and other restoration will be determined during the final design process and will prioritize protecting larger, healthier trees. Removed species (with range of diameters in inches) include American elm (6 to 16 inches), ash (7 to 24 inches), basswood (8 to 13 inches), box elder (6 to 18 inches), buckthorn (6 to 8 inches), cottonwood (23 to 33 inches), and maple (6 to 7 inches). The majority of the trees to be removed are less than 12 inches in diameter. Note, the tree survey only includes trees within approximately 40 feet of the stream centerline. Additional tree survey will be necessary if the construction work expands beyond this area. Appendix D contains a tabulation of trees removed by each species.

- Re-meander a downstream section of the stream channel with bioengineering stabilization methods along the re-meandered stream channel section. Re-meandering this section of the stream channel increases stream length and sinuosity, which slows flows, decreases the likelihood of bank erosion, and increases resiliency during higher flow storm events (especially with increasing impacts of climate change).

- Stabilize targeted bank and channel locations with bioengineering (vegetated) and hard armoring (stone) methods, which will decrease erosion. These methods include grading and placing either coir blankets with live stakes or rock toe to improve stream bank stability and decrease erosion. Both Alternatives 2 and 3 propose similar amounts of hard armoring. However, Alternative 3 includes more bioengineered than hard armored methods, compared to Alternative 2, due to the re-meander of the stream channel. There are also some additional grading and stabilization methods due to the re-meandering of the stream channel mentioned above.



Ponds and Wetlands
Storm Sewer
Main Channel
Remeandered Channel
Project Extents
Side Channels
Bank and Channel Grading
Cross Vanes
Rock Toe
Riprap
Protect and Reinforce Existing Riprap
Coir Blanket with Live Stakes and Planting
Debris Removal
Construction Access
Remove Tree

BARR

N

100 0 100

Feet

Project extents: 4.5 acres

Imagery: USDA, 2021

DESIGN ALTERNATIVE 3
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC

FIGURE 5-3

6.0 Project Modeling Results, Anticipated Pollutant Removals, and Potential Impacts

6.1 Hydrologic, Hydraulic, and Water Quality Modeling

This section discusses the available results of the hydrologic and hydraulic modeling and provides information on calculated anticipated pollutant removals for each alternative.

6.1.1 Hydrologic and Hydraulic Modeling

For this analysis, the Commission Engineer utilized the BCWMC 2021 XP-SWMM model, which is the most current version of the model. The Commission Engineer used the model to evaluate the Atlas 14, 2- and 100-year, 24-hour design storm events to estimate flood elevations, flows, and velocities.

Hydrologic and hydraulic information is available, though there are not available results for the exact reach evaluated in this project. However, the following locations from the model are described below and included in the table below and on Figure 6-1.

- Location 1: West inflow under 18th Ave North (upstream of Ponderosa Woods stream reach). Representative of flow at upstream end of stream channel.
- Location 2: East inflow under 18th Ave North (near 12080 18th Avenue North, flows into middle of Ponderosa Woods stream reach). Representative of flow at southwest stormwater side-channel.
- Location 3: Inflow from Plymouth Creek (approximately 3000 feet upstream of where the Ponderosa Woods stream reach flows into the water quality ponds within Plymouth Creek)
- Location 4: Combined outflow to Medicine Lake (approximately 2,400 feet downstream of Reach 4, includes Plymouth Creek, Ponderosa Woods stream reach, and two water quality ponds)

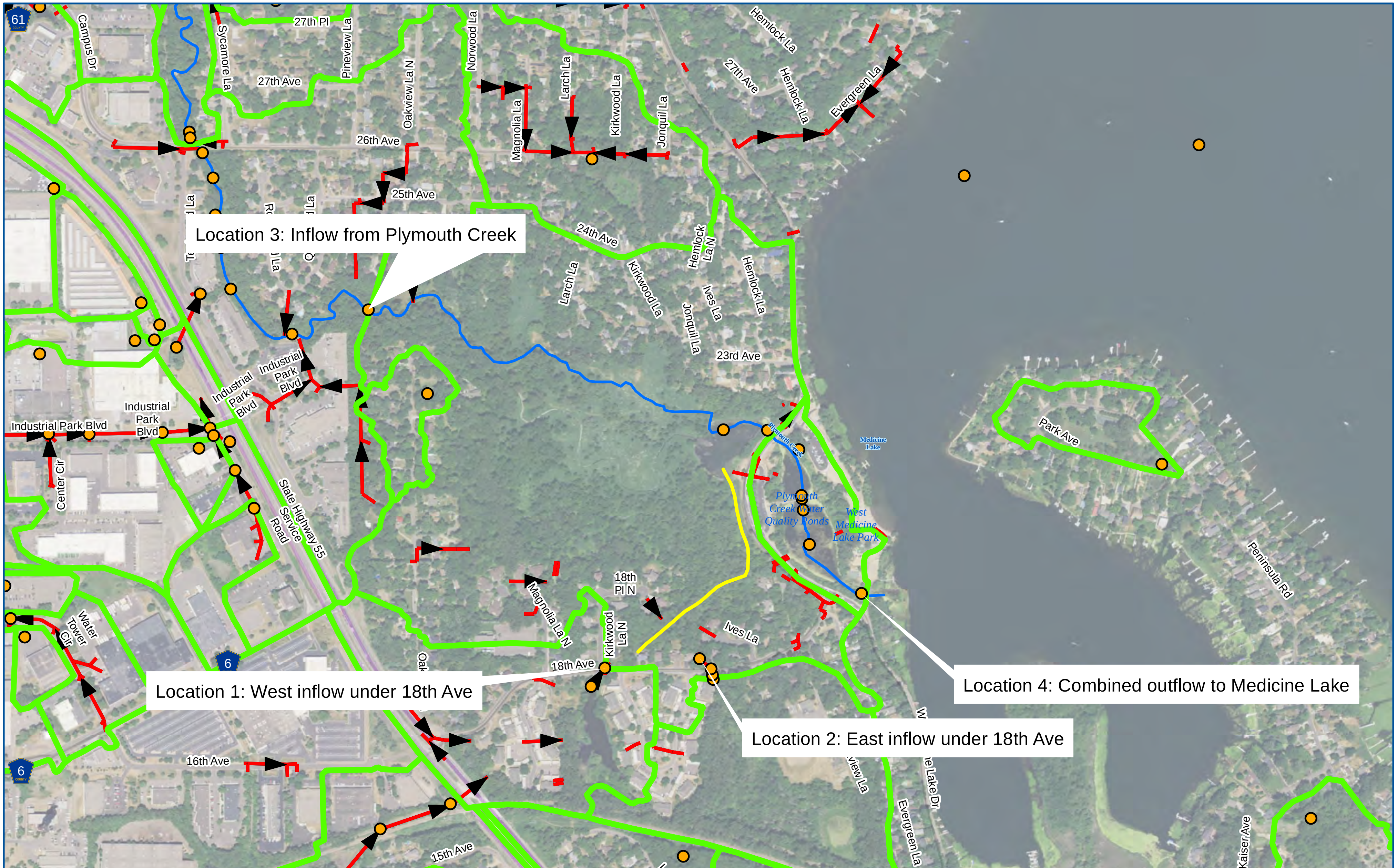
Table 6-1 Hydraulic Model Results for the 100-Year, 24-Hour Event

Model Location[1]	Contributing Drainage Area, acres	100-Year Discharge, cubic feet per second	100-Year Peak Velocity, feet per second
1	2,180	102	10.7
2	40	3.1	2.7
3	4,825	502	12.54
4	7,030	756	1.6

1) Locations 1 and 2 are the most representative of flows in the project area stream reach.

Final design should include refining the XP-SWMM model. Refinements should include explicitly modeling the Ponderosa Woods stream reach and subdividing the larger Plymouth Creek subwatershed to reflect drainage to the Ponderosa Woods stream reach instead of to Plymouth Creek. A review of the final design water surface profile to ensure the project does not impact adjacent properties will also be necessary.

Similarly, the stability thresholds for shear stress for the proposed features should be reviewed to ensure the final design will be stable. The constructed improvements should be incorporated into the next update of the BCWMC XP-SWMM model after project completion.



- BCWMC Model Nodes
- Modeled Subwatersheds
- Ponderosa Main Stream Path
- Storm Sewer
- Plymouth Creek

400 0 400

Feet

Imagery: USDA, 2021

MODEL LOCATIONS
Ponderosa Woods Stream Restoration Feasibility Study
BCWMC

FIGURE 6-1

6.1.2 Anticipated Pollutant Removals

The pollutant (total phosphorus (TP) and total suspended solids (TSS)) removals for the Ponderosa Woods Stream Restoration design alternatives were quantified using approaches developed by Rosgen, et al. (Reference (9)) and BWSR (Reference (10)).

The proposed stabilization measures will result in reduced stream bank erosion and, therefore, reduced sediment and phosphorus loading to the Ponderosa Woods stream and downstream water bodies, including Medicine Lake, Bassett Creek, the Mississippi River, and Lake Pepin. The existing stream bank erosion rate (in units of feet per year) for each stabilization site was estimated based on a field assessment method known as the Bank Assessment for Non-Point Source Consequences of Sediment (BANCS) model (Reference (9)).

The BANCS model uses two erosion-estimation tools to develop risk ratings for the Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS). The BEHI rating evaluates the susceptibility of a segment of stream bank to erosion as a result of multiple processes: surface erosion, fluvial entrainment, and mass erosion (wasting). The NBS rating characterizes the energy distribution against a segment of stream bank; disproportionate energy distribution in the near-bank region can accelerate bank erosion; this field assessment used the ratio of radius of curvature to bankfull width NBS method. The BEHI and NBS estimation tools are applied in a field assessment for each segment of stream bank potentially contributing sediment to the stream channel. The Commission Engineer performed BEHI and NBS assessments for multiple segments of the Ponderosa Woods stream channel during an October 2022 field visit. The BEHI and NBS ratings for the Ponderosa Woods stream are shown in Table 6-2. Table 6-3, and Table 6-4.

For the Ponderosa Woods stream channel within the project area, sites in Reaches 2, 3, and 4 from stationing 0+00 to 9+00, were rated “High” for the BEHI assessment, indicating a heightened erosion potential. Sites in Reach 1, from stationing 9+00 to 10+60 were rated “Low” for the BEHI assessment, indicating a reduced erosion potential. For the NBS assessment, the ratio of curvature to bankfull width method was used. Sites in all reaches were rated very low NBS rating, also indicating reduced erosion from bank stress. The stormwater side-channels were rated “Very Low” and “Low” on the BEHI and NBS scales, respectively.

To convert BEHI and NBS ratings into a stream bank erosion rate estimate, the BANCS model relies on measured bank erosion data to develop relationships applicable to various hydrologic and geologic conditions. No such relationship is currently available for Minnesota; this feasibility study uses relationships developed from data collected in sedimentary and metamorphic geologic regions in North Carolina (Figure 5-34 of Reference (9)). The estimated bank erosion rate for each stabilization site is shown in Table 6-2. Table 6-3, and Table 6-4 estimated erosion rates range from 0.008 to 0.08 feet per year for the Ponderosa Woods site.

The estimated total sediment load from bank erosion is calculated using the approximate dimensions of the eroding stream banks at each site. The effects of stabilization alternatives on water quality are estimated based on the assumption that each stabilization alternative successfully addresses erosion at the site and brings erosion to a low rate, representative of a stable stream in this geologic setting. For this analysis, a stable low erosion rate is assigned a nominal value of 0.02 feet per year (low NBS). The resulting estimated sediment load reduction for stabilization at each site is shown in Table 6-2. Table 6-3, and Table 6-4. The corresponding TSS and TP load reductions are calculated using an estimation tool developed by BWSR (Reference (10)). The BWSR tool assumes that all eroded sediment becomes TSS, which is conservative because eroded sand and gravel are typically not suspended but transported as bedload. The BWSR tool also assumes that TP load is equivalent to 1.0 pound of TP per ton of eroded sediment.

The total reduction in pollutant loading resulting from the stabilization methods outlined in Alternatives 1 and 2 is estimated to be 14,770 lb/year of TSS and 7.4 lb/year of TP. The total loading reduction for Alternative 3 is 21,580 lb/year of TSS and 10.8 lb/year of TP. The load reduction achieved by any of the three alternative designs may assist in meeting the load reduction goals for TP described in the Medicine Lake Excess Nutrients TMDL Implementation Plan (Reference (11)).

Table 6-2 Estimated Existing Bank Erosion and Pollutant Loading at Ponderosa Woods Stream Restoration Site - Alternative 1 (Small Footprint)

Alternative 1: Small Footprint

Reach (Stationing)	Field Reach	Site Description	Alternative Description	Site Length (ft)	Length of Eroding Banks (ft)	Est. Avg. Bank Height (ft)	BEHI rating	NBS rating	Est. Erosion Rate* (ft/yr)	Est. Erosion Rate (CF/yr)	Est. Sed. Load (ton/yr)	"Stable" Sed. Load (ton/yr)	Est. Sed. Load Reduction (ton/yr)	TSS Reduction (lb/yr)	TP Reduction (lb/yr)
Reach 1 (Station 0+00 To 1+80)	4	Upstream reach with straight channel with minimal access to floodplane and vegetation, incised banks, and significant channel degredation	Stabilize channel by increasing size of plunge pool, grading/bank stabilization measures, and debris removal	180	240	4.5	High	Very low	0.08	86.4	4.2	1.0	3.1	6,240	3.12
Reach 2 (Station 1+80 To 3+30)	3	Upstream reach where 3 stormwater outfalls with access to floodplain in heavily wooded area with moderate degradation	Stabilize channel with debris removal and minor grading/stabilization measures at stormwater outfalls	150	150	2.5	High	Very low	0.08	30.0	1.4	0.4	1.1	2,170	1.08
Reach 3 (Station 3+30 To 9+00)	2	Middle reach with access to floodplain in heavily wooded area with significant degradation especially in the downstream half of this reach	Stabilize channel with debris removal, rock vanes, grading/bank stabilization measures, and reinforcing existing rip rap	570	550	2	High	Very low	0.08	88.0	4.2	1.1	3.2	6,360	3.18
Reach 4 (Station 9+00 To 10+60)	1	Downstream reach with access to floodplain and lots of vegetation	No stream restoration along this reach	160	0	1.5	Low	Very low	0.008	0.0	0.0	0.0	0.0	0	0.00
Stormwater Side-Channels	0	3 side channels from stormwater outlets that do not have defined channels to the stream	Define channels to control water and replace one structure with sumped structre to trap sediment	450	0	0.5	Very Low	Low	0.008	0.0	0.0	0.0	0.0	0	0.00
				Totals	**940.0**						**9.8**	**2.5**	**7.4**	**14,770.0**	**7.4**

Table 6-3 Estimated Existing Bank Erosion and Pollutant Loading at Ponderosa Woods Stream Restoration Site - Alternative 2 (Medium Footprint)

Alternative 2: Medium Footprint

Reach (Stationing)	Field Reach	Site Description	Alternative Description	Site Length (ft)	Length of Eroding Banks (ft)	Est. Avg. Bank Height (ft)	BEHI rating	NBS rating	Est. Erosion Rate* (ft/yr)	Est. Erosion Rate (CF/yr)	Est. Sed. Load (ton/yr)	"Stable" Sed. Load (ton/yr)	Est. Sed. Load Reduction (ton/yr)	TSS Reduction (lb/yr)	TP Reduction (lb/yr)
Reach 1 (Station 0+00 To 1+80)	4	Upstream reach with straight channel with minimal access to floodplane and vegetation, incised banks, and significant channel degredation	Stabilize channel by increasing size of plunge pool, grading/bank stabilization measures (including adding a graded bench), and debris removal	180	240	4.5	High	Very low	0.08	86.4	4.2	1.0	3.1	6,240	3.12
Reach 2 (Station 1+80 To 3+30)	3	Upstream reach where 3 stormwater outfalls with access to floodplain in heavily wooded area with moderate degradation	Stabilize channel with debris removal, minor grading/stabilization measures at stormwater outfalls, and expanded buckthorn remova area	150	150	2.5	High	Very low	0.08	30.0	1.4	0.4	1.1	2,170	1.08
Reach 3 (Station 3+30 To 9+00)	2	Middle reach with access to floodplain in heavily wooded area with significant degradation especially in the downstream half of this reach	Stabilize channel with debris removal, rock vanes, grading/bank stabilization measures, reinforcing existing rip rap, and expanded buckthorn removal area	570	550	2	High	Very low	0.08	88.0	4.2	1.1	3.2	6,360	3.18
Reach 4 (Station 9+00 To 10+60)	1	Downstream reach with access to floodplain and lots of vegetation	No stream restoration along this reach except for expanded buckthorn removal area	160	0	1.5	Low	Very low	0.008	0.0	0.0	0.0	0.0	0	0.00
Stormwater Side-Channels	0	3 side channels from stormwater outlets that do not have defined channels to the stream	Define channels to control water and replace one structure with sumped structre to trap sediment	450	0	0.5	Very Low	Low	0.008	0.0	0.0	0.0	0.0	0	0.00
				Totals	**940.0**						**9.8**	**2.5**	**7.4**	**14,770.0**	**7.4**

Table 6-4 Estimated Existing Bank Erosion and Pollutant Loading at Ponderosa Woods Stream Restoration Site - Alternative 3 (Large Footprint)

Alternative 3: Large Footprint

Reach (Stationing)	Field Reach	Site Description	Alternative Description	Site Length (ft)	Length of Eroding Banks (ft)	Est. Avg. Bank Height (ft)	BEHI rating	NBS rating	Est. Erosion Rate* (ft/yr)	Est. Erosion Rate (CF/yr)	Est. Sed. Load (ton/yr)	"Stable" Sed. Load (ton/yr)	Est. Sed. Load Reduction (ton/yr)	TSS Reduction (lb/yr)	TP Reduction (lb/yr)
Reach 1 (Station 0+00 To 1+80)	4	Upstream reach with straight channel with minimal access to floodplane and vegetation, incised banks, and significant channel degredation	Stabilize channel by increasing size of plunge pool, grading/bank stabilization measures (including adding a graded bench), and debris removal	180	240	4.5	High	Very low	0.08	86.4	4.2	1.0	3.1	6,240	3.12
Reach 2 (Station 1+80 To 3+30)	3	Upstream reach where 3 stormwater outfalls with access to floodplain in heavily wooded area with moderate degradation	Stabilize channel with debris removal, minor grading/stabilization measures at stormwater outfalls, expanded buckthorn remova area, re-meander stream channel, and additonal tree removal	150	150	2.5	High	Very low	0.08	30.0	1.4	0.4	1.1	2,170	1.08
Reach 3 (Station 3+30 To 9+00)	2	Middle reach with access to floodplain in heavily wooded area with significant degradation especially in the downstream half of this reach	Stabilize channel with debris removal, rock vanes, grading/bank stabilization measures, reinforcing existing rip rap, expanded buckthorn removal area, re-meander stream channel, and additional tree removal	570	1140	2	High	Very low	0.08	182.4	8.8	2.2	6.6	13,170	6.59
Reach 4 (Station 9+00 To 10+60)	1	Downstream reach with access to floodplain and lots of vegetation	No stream restoration along this reach except for expanded buckthorn removal area	160	0	1.5	Low	Very low	0.008	0.0	0.0	0.0	0.0	0	0.00
Stormwater Side-Channels	0	3 side channels from stormwater outlets that do not have defined channels to the stream	Define channels to control water and replace one structure with sumped structre to trap sediment	450	0	0.5	Very Low	Low	0.008	0.0	0.0	0.0	0.0	0	0.00
				Totals	**1,530.0**						**14.4**	**3.6**	**10.8**	**21,580.0**	**10.8**

6.2 Project Impacts

This section discusses the impacts of each alternative, including the land ownership and permitting requirements. Section 6.0 summarizes the estimated pollution reduction of each alternative.

6.2.1 Easement Acquisition

For the Ponderosa Woods Stream Restoration project, the proposed construction access off of West Medicine Lake Drive, across from the West Medicine Lake Park parking lot, is on City-owned property, so no additional easements are needed for construction access.

However, some construction and buckthorn removal work extends beyond the City's 80-foot wide easement (centered on the stream channel). Thus, additional temporary or permanent easements will need to be obtained, especially for the stormwater side-channels, the additional buckthorn removals in Alternatives 2 and 3 and the stream channel re-meander in Alternative 3. Temporary easements will be needed for the temporary construction impacts, such as the stormwater side-channels and additional construction working space along the stream banks. Permanent easements may be necessary for the stream channel re-meander in Alternative 3; as designed, the stream channel re-meander is within the City easement, however, the proposed re-meandered banks are within several feet of the easement extents.

The single-family homeowners potentially affected by additional easements are shown in Table 6-5 below, along with a brief description of the level of project impact on their property, and if they attended the public outreach meeting and provided comments. Overall, three of the more impacted property owners attended the public outreach meeting and supported all three alternatives – especially Alternatives 2 and 3 with the expanded buckthorn removal. The Commission Engineer assumes most properties impacted by the project will be willing to work with the City on easement agreements because the property owners who attended the public stakeholder meeting expressed support for the project. The Commission Engineer assumes these could be temporary easements for the duration of construction and maintenance periods for all three alternatives, and potentially a permanent easement for only Alternative 3 with the stream channel re-meander.

Table 6-5 Summary of Properties Impacted by Alternatives and Additional Easements

Street Address(1)	Alternatives Requiring Additional Easements(2)	Type of Additional Easement	Relative Size of Additional Easement(3)	Attended Public Outreach Meeting? (Comments)
12110 18th Avenue	2	Temporary(4)	Small	No
12100 18th Avenue	2	Temporary(4)	Small	No
12090 18th Avenue	None	Temporary(4)	None	No
12080 18th Avenue	1, 2, 3	Temporary(4)	Medium	No
12125 18th Place North	1, 2, 3	Temporary(4)	Small	No
12105 18th Place North	1, 2, 3	Temporary(4)	Small	No
1815 Ives Lane	1, 2, 3	Temporary(4)	Small	No
1825 Ives Lane	1, 2, 3	Temporary(4)	Medium	Yes (supports all alternatives; prefers Alternatives 2 and 3 with larger buckthorn and ash tree management)
1830 Ives Lane	1, 2, 3	Temporary(4)	Medium	Yes (supports all alternatives; prefers Alternatives 2 and 3 with larger buckthorn and ash tree management)
1825 Forestview Lane	2, 3	Temporary / Permanent(4,5)	Large(6)	Yes (supports all alternatives; prefers Alternatives 2 and 3 with larger buckthorn and ash tree management; supports stream channel re-meander from Alternative 3)
1829 Forestview Lane	2, 3	Temporary / Permanent(4,5)	Large(6)	No

1) Only includes properties impacted by project.
2) Only includes alternatives that require additional easement area beyond the City's existing 80-foot easement.
3) Relative size of additional easement required, based on the design alternative with the most impact on the homeowner.
4) City will consider additional easements to manage planted or invasive vegetation.
5) Temporary or permanent easements are dependent on if Alternatives 2 or 3, respectively, are selected for design.
6) Properties are heavily impacted by Alternative 3; most of the stream channel re-meander occurs on these properties.

6.2.2 Permits Required for the Project

The proposed project is expected to require the following permits/approvals, regardless of the selected concept:

- Clean Water Act Section 404 and Section 401 Water Quality Certification
- Construction Stormwater General Permit from the MPCA
- Compliance with the Minnesota Wetland Conservation Act
- City permitting

6.2.2.1 Federal and State Permits

6.2.2.1.1 Section 404 Permit

According to Section 404 of the Clean Water Act (CWA), the USACE regulates the placement of fill into wetlands if they are hydrologically connected to a Water of the United States. In addition, the USACE may regulate all proposed wetland alterations if any wetland fill is proposed. The MPCA may be involved in wetland mitigation requirements as part of the CWA Section 401 water quality certification process for the 404 Permit.

The BCWMC developed its Resource Management Plan (RMP), with the goal of completing a conceptual-level USACE permitting process for proposed projects. The RMP was submitted to the USACE in April 2009 and revised in July 2009. This feasibility study follows the protocols for projects within the BCWMC RMP.

The USACE 404 permit requires a Section 106 review for historic and cultural resources. The results of the archeological reconnaissance study are included in Section 3.0. If the State Historic Preservation Office (SHPO) requests more detailed information, a Phase I Archaeological Survey may need to be completed. A Phase I Archaeological Survey can be completed in 45 days or less during a frost-free period. The USACE staff anticipates that the 404 permit review and approval process could require 120 days to complete. These projects may fit under the USACE Nationwide Permit 13 for bank stabilization or Nationwide Permit 27 for restoration or a Regional General Permit. Verification of the USACE Nationwide Permit requirements and comparison to the proposed project features/impacts will be necessary during the project design phase to determine which permit is most applicable.

6.2.2.1.2 Minnesota Pollution Control Agency (MPCA) Permits

Construction of the proposed project will require a National Pollutant Discharge Elimination System/State Disposal System Construction Stormwater (CSW) General Permit issued by the MPCA. The CSW permit will require the preparation of a Stormwater Pollution Prevention Plan (SWPPP) that explains how stormwater will be controlled within the project area during construction.

Based on the findings of the desktop review of the MPCA's "What's In My Neighborhood?" database, it is not anticipated that environmental impacts such as contaminated soil and debris will be encountered during stream restoration activities; therefore, it is not anticipated that the project will require additional minimization measures for disposing of contaminated soil. In the unlikely event that environmental impacts are encountered during the creek restoration earthwork, contaminated materials will need to be handled and managed appropriately. The response to discovery of contamination typically includes entering the MPCA's voluntary program. A construction contingency plan could be prepared for the project in accordance with MPCA guidance. This would include specifying initial procedures for handling potentially impacted materials, collecting analytical samples, and working with the MPCA to determine a method for managing impacted materials.

6.2.2.2 Local Permits

The City of Plymouth also has a permitting process and the requirements should be reviewed within the context of the specific work to be performed at each site. Potential local permits include:

- Wetland Conversation Act (WCA)
- Floodplain Impacts

6.2.2.2.1 Minnesota Wetland Conservation Act

The Minnesota Wetland Conservation Act (WCA) regulates the filling and draining of wetlands and excavation within Type 3, 4, and 5 wetlands—and may regulate any other wetland type if fill is proposed. The WCA is administered by local government units (LGUs), which include cities, counties, watershed management organizations, soil and water conservation districts, and townships. The City of Plymouth is the LGU for the entire project area. The Minnesota Board of Water and Soil Resources (BWSR) oversees administration of the WCA statewide.

As described in Minnesota rules 8420, the WCA is applicable to the types of wetland impacts that will be a part of this project and a permit related to wetland impacts may be required; however, the LGU will have the final determination.

6.2.3 Temporary Closure and Traffic Impacts

Depending on the construction access, staging area, and time of year, a portion of the West Medicine Lake Park southern parking lot may need to be temporarily closed to the public during the construction. Additionally, traffic controls along West Medicine Lake Drive (and the pedestrian sidewalks) between the southern parking lot of West Medicine Lake Park and the construction access may be in effect during the construction.

6.2.4 Other Project Impacts

6.2.4.1 Tree Loss Impacts

The proposed project includes the removal of trees; the final number will depend on the alternative selected. Tree removal estimates for each alternative are:

- Alternative 1: 27 healthy trees, including 3 ash and 4 buckthorn
- Alternative 2: 34 healthy trees, including 5 ash and 4 buckthorn
- Alternative 3: 72 healthy trees, including 6 ash and 12 buckthorn

All trees are located in areas of bank grading or where site access is needed. Refer to each of the alternatives' descriptions in Section 5.0 and Appendix D for more details.

The Commission Engineer completed a detailed tree inventory for this feasibility study, which should be used during final design to specify tree replacement, if necessary, and to verify specific trees to be preserved. If construction impacts (not including invasive buckthorn removal) expand outside of the tree inventory area (40 feet from center of stream channel), then additional trees will need to be surveyed and inventoried. Required tree removals should first target dying or diseased and undercut trees, followed by less desirable or disease-susceptible species such as box elder, cottonwood, and green ash. Close coordination with the City of Plymouth forestry department will be important during design. The City will conduct public stakeholder input on tree loss during the design.

6.2.4.2 Impacts to Bats

Preservation of bat species in Minnesota has recently become an important issue. White-nose syndrome (WNS) has been attributed to the deaths of millions of bats in recent years across the United States, and all four species that hibernate in Minnesota are susceptible to the disease (Reference (12)). Bats typically hibernate in sheltered areas such as caves, but some bats nest in trees during summer months. Extensive tree removal should be avoided when bats are not hibernating to avoid inadvertently destroying nests. If tree clearing is required during the bats active season, additional consultation with the US Fish and Wildlife Service would be recommended. Tree removals would begin outside of the bats' active season during very late fall or early winter.

6.2.4.3 Sanitary Sewer and Water Main Impacts

There are no known sanitary sewers or water mains impacted by this project. Figure 2-1 shows nearby sanitary sewer and water main locations.

6.2.4.4 Impacts to West Medicine Lake Park

The project alternatives include construction access and staging within the southern parking lot of West Medicine Lake Park, with construction vehicles crossing West Medicine Lake Drive to the construction access point for the project. As described in Section 6.2.3 there may be temporary closure impacts to the parking lot, road crossing, and pedestrian sidewalks. Close coordination with City of Plymouth staff will be necessary to ensure limited impacts to park users, special events, and road users.

7.0 Project Cost Considerations

This section presents a screening-level cost estimate of the evaluated alternatives, discusses potential funding sources, and provides an approximate project schedule.

7.1 Cost Estimates

The cost estimate is a Class 4 feasibility-level cost estimate as defined by the American Association of Cost Engineers International (AACE International) and uses the assumptions listed below and detailed in the following sections.

- The cost estimate assumes a 20% construction contingency.
- Costs associated with design, permitting, and construction observation (collectively “engineering”) are assumed to be 30% of the estimated construction costs (excluding contingency).
- For Alternatives 1 and 2, we assume temporary construction easements may be necessary to construct the project; however, the cost is expected to be negligible since these are temporary and not permanent easements. For Alternative 3, we assume permanent and temporary construction easements may be needed for the project. The Alternative 3 cost estimate includes the estimated cost for the permanent easements.
- Additional work may be required to determine if cultural and/or historical resources are present at the project site.

The Class 4 level cost estimates have an acceptable range of between -15% to -30% on the low range and +20% to +50% on the high range. Based on the development of concepts and initial vetting of the concepts by the City of Plymouth, BCWMC, and MnDNR, it is not necessary to utilize the full range of the acceptable range for the cost estimate. We assume the final costs of construction may be between -15% and +30% of the estimated construction budget.

Table 7-1 summarizes the feasibility-level total construction cost estimates, the 30-year annualized total construction cost estimates, and the annualized costs per pound of TSS and TP removed for the Ponderosa Woods Stream Restoration Project. Appendix E provides the detailed cost-estimate tables for all alternatives.

Table 7-1 Ponderosa Woods Stream Restoration Project Alternatives Cost Summary

Alternative Description	Project Cost Estimate(1)	Annualized Cost(2)	TP Loading		TSS Loading	
			Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)	Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)
Alternative 1. (Small Footprint Design)	$252,000 ($202,000–$328,000)	$17,000	7.4	$2,303	14,770	$1.15
Alternative 2. (Medium Footprint Design)	$429,000 ($344,000–$558,000)	$27,000	7.4	$3,658	14,770	$1.83
Alternative 3. (Large Footprint Design)	$506,000 ($405,000–$658,000)	$34,000	10.8	$3,151	21,580	$1.58

1) A Class 4 screening-level opinion of probable cost, as defined by the American Association of Cost Engineers International (AACE International), was prepared for these alternatives. The opinion of probable construction cost provided in this table is based on the Commission Engineer's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. The cost opinion is based on project-related information available to the Commission Engineer at this time and includes a conceptual-level design of the project. It includes 20% project contingency and 30% for planning, engineering, design, and construction administration. The lower bound is assumed at -20% and the upper bound is assumed at +30%.
2) Assumed to be 15% of the total project cost for annual maintenance, plus replacement cost associated with major repairs and the initial project cost distributed evenly over a 30-year project lifespan.
3) Annualized cost divided by estimated annual pollution load reduction.

7.1.1 Temporary and Permanent Easements

Section 6.2.1 includes detailed discussion on recommended easements. The costs associated with temporary construction easements, if required, are typically negligible; no costs for temporary construction easements are included in this estimate. City may also consider additional easements to manage planted or invasive vegetation.

7.1.2 Off-Site Sediment Disposal

Based on the results of the desktop review of the MPCA's "What's In My Neighborhood?" database, we assumed that a Phase I assessment of bank material will not be necessary and that sediment disposed off-site will not require additional testing or special disposal as hazardous or dredged material. As such, these costs are not included in this estimate.

7.1.3 Wetland Mitigation

Stream banks are considered to be wetlands and disturbing the banks as part of a restoration project is a temporary wetland impact. Additionally, there is a small wetland area identified at the downstream area of the project site. However, because the purpose of restoration is to create a channel and permanent wetland that can support a riparian ecosystem, the impacts are considered to be self-mitigating.

Therefore, stream bank restoration projects do not typically require wetland mitigation and the associated additional costs.

7.1.4 Tree Replacement and Revegetation

We assume that the City of Plymouth will determine where tree replacements will be desired (based on estimated tree removals, long-term plans for this area, and discussions with private property owners) during final design. However, because this is a heavily forested area with a poor understory, the designs included in this report focus on tree removal rather than tree replacement. Through discussions with City staff, they indicated that tree removals associated with the project may open the canopy in such a way that it provides benefits for reestablishing vegetation, and it may not be desirable to replace trees along the project extents. Therefore, minimal tree replacements are anticipated.

Revegetation of the site will also include the removal of invasive buckthorn and planting of native species.

7.1.5 30-Year Cost

The 30-year cost for each alternative is based on anticipated maintenance and replacement costs. For alternatives with an estimated life span less than 30 years, significant maintenance is assumed to occur at the end of the estimated life span (i.e., 20 years for bioengineering, 30 years for hard armoring or storm sewer infrastructure); since all alternatives include a mix of hard armoring and bioengineering, but primarily bioengineering, the 30-year costs analysis will be based on the bioengineering lifespan to be conservative with costs. For bioengineering alternatives, the maintenance is assumed to equal 25% of the original construction cost. Annual maintenance estimates are based on maintenance costs associated with the initial "establishment" period; 15% is assumed for bioengineering alternatives and 2% for other alternatives incorporating hard armoring or storm sewer infrastructure.

The 30-year cost for each alternative is calculated as the future worth of the initial capital cost (including contingency and engineering costs) plus the future worth of annual maintenance and significant maintenance at the end of the alternative life span. A 3% rate of inflation is assumed. The annualized cost for each alternative is calculated as the value of 30 equal, annual payments of the same future worth as the 30-year cost.

7.1.6 Annualized Pollutant Reduction Cost

Estimated annual loading reductions for TSS and TP are included for each alternative in Table 7-1. The loading reductions assume that each alternative is successful in reducing bank erosion at each site. The annualized pollutant-reduction cost for each alternative is the annual load reduction divided by the annualized 30-year cost.

For the recommended stabilization alternatives presented in Table 7-1, the estimated total annualized pollutant reduction costs range from $2,303 to $3,658 per pound for TP and $1.15 to $1.83 per pound for TSS.

7.1.7 Miscellaneous Costs

Most site costs include miscellaneous items needed during construction (e.g., a rock construction entrance, a filter dike to control in-stream sediment disturbance, and restoration of access paths). Based on previous project experience, the estimate for each alternative includes some costs that could be applied to these miscellaneous items.

7.2 Funding Sources

The BCWMC will utilize the BCWMC CIP funds to implement these projects. The source of these funds is an ad valorem tax levied by Hennepin County over the entire Bassett Creek watershed on behalf of the BCWMC.

7.3 Project Schedule

The BCWMC is expected to hold a public hearing in September 2023 on this project. Pending the outcome of the hearing, the BCWMC will consider officially ordering the project, entering into an agreement with the City of Plymouth to design and construct the project, and certifying to Hennepin County a final 2024 tax levy for this project.

The construction work would likely begin in winter 2024/2025, as tree removal should occur in the period from October 15 to early April, outside of the northern long-eared bat's active season (mid-April – October 14). Additionally, excavation during the winter would be appropriate to complete the major earthwork during periods with less frequent runoff events. Final construction and restoration would be completed in spring/summer 2025.

For project construction to occur in winter 2024/2025, project design should begin in winter 2023/2024 or spring of 2024. The permit process may take 6 to 12 months, so begin permit process 6 to 12 months prior to start of construction. If project construction is scheduled for winter 2024/2025, summer 2024 bidding is recommended. This will give contractors adequate scheduling time to complete the project at a reasonable price. In the intervening time, the City would gather public input, prepare the final design, and obtain permits.

8.0 Alternatives Assessment and Recommendations

The final project will consist of a combination of the practices discussed in Section 5.0. The costs of the alternatives evaluated for the concept design are summarized in Section 1.0. The recommended alternatives were chosen based on if it met the goals and objectives outlined in Section 2.2. Since more than one alternative met these goals and objectives, priority was given to the alternatives that were cost-effective, stabilized stream banks, and used natural materials. The ability of the alternatives to improve stream habitat and vegetative surroundings (identified as priorities in stakeholder meetings) was also taken into consideration in choosing the recommended stream stabilization alternatives.

Stabilization and restoration of stream banks within the Ponderosa Woods Stream Restoration project area will provide water quality improvement by 1) repairing actively eroding sites and 2) preventing erosion at other sites by installing preemptive measures to protect existing stream banks. The Commission Engineer recommends implementation of Alternative 1 or Alternative 1 plus additional buckthorn removal (similar extents of buckthorn removal as in Alternatives 2 and 3), which will be referenced as Alternative 1.5. The Commission Engineer recommends Alternative 1 or 1.5 for this stabilization because it will achieve the water quality goals listed above and result in the stabilization of targeted sections of the stream reach, provide significant habitat enhancement and restore floodplain connectivity. Alternatives 1 and 1.5 are cost-effective options that improve stabilization of priority areas of the stream reach (minimizing erosion potential) while minimizing healthy tree removal. These recommended alternatives focus on bioengineering practices for stabilizing most of the eroded bank, installing rock cross vanes to minimize future erosion of the channel bed, managing sediment for one of the stormwater side-channels, and restoring aquatic and riparian habitat (including removing invasive buckthorn and green ash, and removing additional trees). Lastly, this alternative proposes design practices that will reduce the erosion threat for the nearby homes that are close to the stream.

The final design process should include continuing to work closely with the City of Plymouth and residents to develop a plan to successfully establish and maintain riparian vegetation on and near the banks within the project area.

The estimated design and construction costs for the recommended Alternatives 1 and 1.5 are $252,000 and $297,000, respectively, as shown in Table 8-1 below. The total estimated project capital cost for each of the recommended alternatives includes the following:

- Alternative 1: an estimated $150,000 in construction costs, $30,000 in construction contingency, and $72,000 for design, permitting, and construction observation.
- Alternative 1.5: an estimated $177,000 in construction costs, $35,000 in construction contingency, and $85,000 for design, permitting, and construction observation.

All costs are rounded to the nearest $1,000. We recommend that the BCWMC use these costs to develop a levy request for the selected alternative for this project and that it proceed to design and construction.

Table 8-1 Recommended Stream Restoration Alternatives Cost Summaries

Alternative Description	Project Cost Estimate(1)	Annualized Cost(2)	TP Loading		TSS Loading	
			Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)	Load Reduction (lb/yr)	Cost/lb/yr Reduced(3)
Alternative 1 (Small Footprint Design)	$252,000 ($202,000 - $328,000)	$17,000	7.4	$2,300	14,770	$1.15
Alternative 1.5 (Small Footprint Design with additional buckthorn removal)	$297,000 ($238,000 - $387,000)	$20,000	7.4	$2,700	14,770	$1.35

1) A Class 4 screening-level opinion of probable cost, as defined by the American Association of Cost Engineers International (AACE International), has been prepared for these alternatives. The opinion of probable construction cost provided in this table is based on the Commission Engineer's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. The cost opinion is based on project-related information available to the Commission Engineer at this time and includes a conceptual-level design of the project. It includes 20% project contingency and 30% for planning, engineering, design, and construction administration. The lower bound is assumed at -20% and the upper bound is assumed at +30%.
2) Assumed to be 15% of the total project cost for annual maintenance, plus replacement cost associated with major repairs and the initial project cost distributed evenly over a 30-year project lifespan.
3) Annualized cost divided by estimated annual pollution load reduction.

The estimated costs to remove the large area of buckthorn range from about 11% to 22% of the total project cost (including the additional percentages of construction contingency, design, permitting, and construction observation), as shown in Table 8-2 below.

Table 8-2 Buckthorn Removal Area and Relative Costs

Alternative	Area of Buckthorn Removal (acres)	Cost of Buckthorn Removal Compared to Total Project Cost
1	1.5 acres	11%
1.5	3.5 acres	22%
2	3.5 acres	15%
3	3.3 acres	12%

These significant buckthorn removal costs expand the project scope to incorporate a larger riparian habitat restoration area. The BCWMC could decide to reduce the buckthorn removal area to 1.5 acres to focus on the areas directly adjacent to the stream and stormwater side-channels. This would decrease the total project cost(including construction contingency, construction observation, design, permitting, and planning) by $44,000 for Alternatives 1.5 and 2, and by $39,000 for Alternative 3.

9.0 References

1. **Bassett Creek Watershed Management Commission.** 2015 Watershed Management Plan. September 2015.

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11. **Minnesota Pollution Control Agency and Bassett Creek Watershed Management Commission.** *Medicine Lake Excess Nutrients Total Maximum Daily Load Implementation Plan.* September 2010.

12. **Minnesota Department of Natural Resources.** White-nose Syndrome and Minnesota's bats. [http://www.dnr.state.mn.us/wns/index.html]. 2023.

Appendices

Appendix A

Stream Erosion Site Photos

Figure A- 1 Upstream end of reach with in-channel debris and bank erosion.

Figure A- 2Right bank erosion.

Figure A- 3 Left bank erosion.

Figure A- 4 Bank erosion with undercutting.

Figure A- 5 Bank erosion and in-channel debris.

Figure A- 6 Upstream end of north stormwater side-channel.

Figure A- 7 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 8 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 9 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 10 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 11 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 12 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 13 In-channel (same location but different angle as figure above).

Figure A- 14 Upstream end of southwest stormwater side-channel.

Figure A- 15   Southwest stormwater side-channel looking downstream.

Figure A- 16   Upstream end of southeast stormwater side-channel.

Figure A- 17 Left bank undercutting with in-channel debris.

Figure A- 18 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 19 Right bank erosion.

Figure A- 20 Right bank erosion.

Figure A- 21 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 22 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 23 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 24 Left bank erosion with undercutting.

Figure A- 25 Right bank erosion with undercutting.

Figure A- 26 In-channel debris leading to bank erosion and sediment aggradation.

Figure A- 27 In-channel debris leading to bank erosion (close up of bank at same location as above figure).

Figure A- 28 Downstream end of reach (looking upstream)

Appendix B

Tree Survey Results

Ponderosa Woods Stream Tree Survey - 2023

Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_15N	
						X_Cor	Y_Cor
0	Willow/Black	7		Healthy		1528729	16348741
1	Birch/River	10		Healthy		1528727	16348706
2	Birch/River	8		Healthy		1528727	16348706
3	Birch/Paper	5		Healthy	multi-stem 6 at 4in	1528744	16348685
4	Birch/River	11		Healthy		1528745	16348664
5	Ash/Green	13		Healthy		1528728	16348644
6	Box Elder	14		Healthy		1528728	16348642
7	Cottonwood	30		Healthy		1528735	16348565
8	Ash/Green	16		Healthy		1528730	16348557
9	Buckthorn	6		Healthy		1528706	16348552
10	Cottonwood	20		Dead	fallen	1528697	16348549
11	Box Elder	11		Healthy		1528670	16348547
12	Cottonwood	13		Healthy		1528669	16348544
13	Cottonwood	27		Healthy		1528671	16348547
14	Cottonwood	15		Healthy		1528656	16348546
15	Box Elder	8		Healthy		1528657	16348537
16	Cottonwood	28		Healthy		1528642	16348540
17	Box Elder	14		Dying	fallen	1528628	16348535
18	Cottonwood	25		Dead	fallen	1528622	16348527
19	Box Elder	15		Healthy		1528608	16348523
20	Box Elder	6		Healthy		1528602	16348513
21	Box Elder	11		Dying	fallen	1528593	16348520
22	Box Elder	15		Healthy		1528586	16348515
23	Box Elder	6		Healthy		1528587	16348505
24	Box Elder	10		Dying	fallen	1528573	16348506
25	Buckthorn	6		Healthy		1528573	16348494
26	Box Elder	14		Healthy		1528539	16348479
27	Cottonwood	20		Dead	fallen across creek	1528531	16348469
28	Box Elder	9		Healthy		1528548	16348466
29	Cottonwood	28		Healthy		1528538	16348459
30	Ash/Green	6		Healthy		1528536	16348455
31	Ash/Green	12		Dead		1528524	16348454
32	Cottonwood	25		Dead	fallen	1528513	16348449
33	Ash/Green	9		Healthy		1528507	16348441
34	Box Elder	6		Healthy		1528501	16348423
35	Cottonwood	31		Healthy		1528494	16348431
36	Box Elder	13		Healthy		1528491	16348437
37	Cottonwood	15		Healthy		1528485	16348445
38	Box Elder	18		Dead	fallen across creek	1528469	16348405
39	Ash/Green	11		Healthy		1528427	16348395
40	Box Elder	15		Healthy		1528425	16348374
41	Cottonwood	34		Healthy		1528409	16348367
42	Cottonwood	33		Healthy		1528404	16348367
43	Elm/American	12		Dead		1528397	16348367
44	Buckthorn	6		Healthy		1528393	16348369
45	Box Elder	8		Healthy		1528384	16348380
46	Box Elder	11		Dead	fallen	1528385	16348346
47	Box Elder	8		Dead		1528383	16348347

Ponderosa Woods Stream Tree Survey - 2023

Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_15N	
						X_Cor	Y_Cor
48	Box Elder	12		Dead	fallen across creek	1528389	16348350
49	Box Elder	14		Dead		1528374	16348334
50	Cottonwood	33		Healthy		1528370	16348339
51	Box Elder	12		Dead	fallen	1528349	16348330
52	Cottonwood	14		Dead	fallen across creek	1528358	16348322
53	Cottonwood	23		Healthy		1528355	16348325
54	Box Elder	10		Dead	fallen	1528346	16348324
55	Elm/American	11		Healthy		1528337	16348314
56	Elm/American	6		Healthy		1528335	16348319
57	Cottonwood	35		Healthy		1528328	16348318
58	Cottonwood	31		Healthy		1528314	16348307
59	Buckthorn	6		Healthy		1528320	16348302
60	Elm/American	12		Dead	fallen	1528302	16348296
61	Box Elder	8		Healthy		1528296	16348301
62	Box Elder	6		Healthy		1528278	16348295
63	Elm/American	7		Healthy		1528254	16348268
64	Box Elder	26		Dead	fallen across creek	1528249	16348268
65	Box Elder	17		Dead	fallen	1528246	16348270
66	Box Elder	8		Healthy		1528253	16348262
67	Ash/Green	25		Healthy		1528246	16348261
68	Elm/American	14		Healthy		1528236	16348256
69	Maple/Sugar	8		Healthy		1528221	16348256
70	Box Elder	16		Healthy		1528203	16348253
71	Maple/Sugar	6		Healthy		1528207	16348243
72	Ash/Green	16		Dead	fallen across creek	1528215	16348237
73	Maple/Sugar	8		Healthy		1528223	16348234
74	Box Elder	15		Healthy		1528202	16348238
75	Ash/Green	17		Healthy		1528185	16348250
76	Maple/Sugar	9		Healthy		1528188	16348257
77	Basswood/American	25		Dead	fallen	1528175	16348283
78	Ash/Green	20		Dead		1528182	16348300
79	Maple/Sugar	16		Healthy		1528197	16348283
80	Ash/Green	28		Healthy		1528201	16348291
81	Elm/American	18		Healthy		1528221	16348291
82	Maple/Sugar	6		Healthy		1528234	16348281
83	Elm/American	8		Healthy		1528188	16348224
84	Elm/American	6		Healthy		1528201	16348222
85	Elm/American	7		Healthy		1528190	16348217
86	Ash/Green	10		Healthy		1528195	16348213
87	Maple/Sugar	6		Healthy		1528194	16348208
88	Elm/American	10		Dead		1528178	16348203
89	Box Elder	8		Healthy		1528167	16348199
90	Maple/Sugar	15		Dead	fallen across creek	1528165	16348198
91	Basswood/American	28		Dead	fallen across creek	1528147	16348202
92	Elm/American	18		Healthy		1528147	16348191
93	Elm/American	9		Healthy		1528142	16348173
94	Maple/Sugar	6		Healthy		1528142	16348163
95	Ash/Green	14		Dead	fallen across creek	1528138	16348161

Ponderosa Woods Stream Tree Survey - 2023

Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_15N	
						X_Cor	Y_Cor
96	Ash/Green	24		Healthy		1528120	16348153
97	Ash/Green	22		Healthy		1528115	16348162
98	Basswood/American	8		Healthy		1528110	16348156
99	Basswood/American	8		Healthy		1528112	16348148
100	Basswood/American	13		Healthy		1528114	16348145
101	Elm/American	10		Healthy		1528094	16348132
102	Elm/American	15		Healthy		1528092	16348110
103	Elm/American	9		Healthy		1528089	16348115
104	Elm/American	15		Healthy		1528062	16348108
105	Box Elder	12		Healthy		1528012	16347976
106	Box Elder	11		Healthy		1528014	16347974
107	Box Elder	12		Healthy		1528010	16347978
108	Cottonwood	28		Healthy		1528018	16347996
109	Maple/Sugar	15		Healthy		1528020	16348022
110	Box Elder	15		Healthy		1528129	16348102
111	Maple/Sugar	9		Healthy		1528136	16348094
112	Maple/Sugar	12		Healthy		1528138	16348101
113	Box Elder	12		Healthy		1528135	16348120
114	Elm/American	15		Dead	stump	1528148	16348112
115	Box Elder	13		Dying	stump	1528156	16348116
116	Ash/Green	11		Dead	stump	1528163	16348118
117	Maple/Sugar	7		Healthy		1528156	16348127
118	Basswood/American	14		Healthy		1528170	16348150
119	Hackberry	21		Healthy		1528173	16348156
120	Elm/American	16		Healthy		1528183	16348153
121	Elm/American	6		Healthy		1528187	16348162
122	Box Elder	13		Healthy		1528229	16348166
123	Ash/Green	14		Healthy		1528221	16348174
124	Ash/Green	11		Healthy		1528215	16348179
125	Box Elder	13		Healthy		1528214	16348186
126	Box Elder	6		Healthy		1528218	16348186
127	Ash/Green	16		Dead		1528227	16348193
128	Box Elder	14		Healthy		1528238	16348179
129	Box Elder	18		Healthy		1528264	16348181
130	Box Elder	12		Healthy		1528276	16348182
131	Box Elder	7		Healthy		1528287	16348220
132	Ash/Green	18		Healthy		1528302	16348201
133	Elm/American	17		Healthy		1528299	16348196
134	Box Elder	8		Healthy		1528308	16348208
135	Box Elder	200		Healthy		1528320	16348214
136	Box Elder	14		Healthy		1528309	16348237
137	Box Elder	14		Healthy		1528312	16348229
138	Ash/Green	15		Healthy		1528303	16348251
139	Buckthorn	8		Healthy		1528306	16348259
140	Box Elder	16		Healthy		1528325	16348247
141	Buckthorn	6		Healthy		1528328	16348244
142	Box Elder	13		Dead	fallen	1528333	16348231
143	Box Elder	16		Dead	fallen	1528330	16348226

Ponderosa Woods Stream Tree Survey - 2023

Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_15N	
						X_Cor	Y_Cor
144	Maple/Sugar	8		Healthy		1528347	16348235
145	Box Elder	6		Healthy		1528344	16348227
146	Elm/American	8		Healthy		1528364	16348222
147	Elm/American	9		Healthy		1528364	16348220
148	Box Elder	15		Healthy		1528369	16348232
149	Ash/Green	12		Healthy		1528379	16348226
150	Ash/Green	21		Healthy		1528376	16348217
151	Ash/Green	20		Healthy		1528375	16348211
152	Elm/American	13		Healthy		1528372	16348208
153	Elm/Siberian	6		Healthy		1528380	16348206
154	Ash/Green	7		Healthy		1528388	16348215
155	Box Elder	6		Healthy		1528402	16348219
156	Ash/Green	13		Dead	stump	1528392	16348194
157	Elm/American	6		Healthy		1528396	16348190
158	Box Elder	6		Healthy		1528400	16348187
159	Box Elder	6		Healthy		1528360	16348189
160	Box Elder	7		Healthy		1528362	16348197
161	Ash/Green	21		Healthy		1528357	16348190
162	Ash/Green	23		Healthy		1528354	16348197
163	Ash/Green	21		Healthy		1528364	16348204
164	Ash/Green	20		Healthy		1528355	16348203
165	Box Elder	10		Healthy		1528374	16348175
166	Box Elder	7		Healthy		1528384	16348172
167	Maple/Sugar	20		Healthy		1528382	16348136
168	Ash/Green	23		Healthy		1528366	16348151
169	Ash/Green	22		Healthy		1528367	16348154
170	Maple/Sugar	6		Healthy		1528397	16348136
171	Maple/Sugar	20		Healthy		1528395	16348116
172	Maple/Sugar	11		Healthy		1528405	16348096
173	Ash/Green	25		Healthy		1528398	16348099
174	Maple/Sugar	6		Healthy		1528405	16348090
175	Ash/Green	15		Healthy		1528395	16348086
176	Maple/Sugar	6		Healthy		1528416	16348073
177	Ash/Green	9		Healthy		1528416	16348072
178	Ash/Green	19		Healthy		1528403	16348079
179	Maple/Sugar	10		Healthy		1528431	16348050
180	Maple/Sugar	9		Healthy		1528443	16348037
181	Maple/Sugar	27		Healthy		1528441	16348026
182	Maple/Sugar	5		Healthy		1528452	16348023
183	Maple/Sugar	23		Healthy		1528433	16348016
184	Maple/Sugar	6		Healthy		1528452	16348006
185	Maple/Sugar	18		Healthy		1528436	16347994
186	Maple/Sugar	6		Healthy		1528441	16347991
187	Maple/Sugar	18		Healthy		1528440	16347983
188	Maple/Sugar	6		Healthy		1528446	16347991
189	Maple/Sugar	8		Healthy		1528459	16348013
190	Elm/American	6		Dead		1528458	16348043
191	Elm/American	8		Healthy		1528457	16348028

Ponderosa Woods Stream Tree Survey - 2023

Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_15N	
						X_Cor	Y_Cor
192	Elm/American	10		Healthy		1528469	16348037
193	Elm/American	12		Healthy		1528449	16348055
194	Ash/Green	12		Healthy		1528425	16348152
195	Ash/Green	13		Healthy		1528417	16348176
196	Ash/Green	16		Dead	fallen	1528419	16348238
197	Ash/Green	13		Healthy		1528448	16348224
198	Box Elder	12		Dead	stump	1528446	16348231
199	Box Elder	10		Dead	fallen	1528449	16348254
200	Box Elder	13		Dead	fallen	1528453	16348260
201	Elm/American	9		Healthy		1528416	16348269
202	Elm/American	14		Healthy		1528398	16348284
203	Cottonwood	33		Healthy		1528391	16348292
204	Elm/American	6		Healthy		1528386	16348285
205	Cottonwood	29		Healthy		1528379	16348293
206	Cottonwood	32		Healthy		1528375	16348299
207	Cottonwood	28		Healthy		1528373	16348292
208	Ash/Green	12		Dead	fallen	1528365	16348287
209	Ash/Green	12		Dead	fallen	1528372	16348286
210	Box Elder	15		Dying	fallen	1528350	16348285
211	Elm/American	9		Healthy		1528340	16348282
212	Box Elder	16		Healthy		1528336	16348267
213	Elm/American	11		Healthy		1528388	16348317
214	Cottonwood	23		Dead	fallen	1528394	16348314
215	Elm/American	16		Healthy		1528394	16348325
216	Elm/American	15		Dead		1528419	16348339
217	Box Elder	8		Healthy		1528430	16348344
218	Box Elder	18		Healthy		1528436	16348338
219	Box Elder	16		Healthy		1528438	16348347
220	Box Elder	12		Healthy		1528489	16348337
221	Box Elder	18		Healthy		1528485	16348333
222	Elm/American	15		Healthy		1528497	16348356
223	Elm/American	9		Healthy		1528504	16348370
224	Box Elder	20		Healthy		1528509	16348381
225	Box Elder	15		Dead	fallen across creek	1528501	16348394
226	Box Elder	16		Healthy		1528503	16348391
227	Box Elder	12		Dead	fallen	1528527	16348378
228	Box Elder	23		Healthy		1528527	16348362
229	Box Elder	13		Dead		1528529	16348384
230	Box Elder	8		Healthy		1528535	16348412
231	Box Elder	12		Healthy		1528536	16348411
232	Box Elder	16		Healthy		1528551	16348403
233	Box Elder	8		Healthy		1528543	16348427
234	Buckthorn	8		Healthy		1528534	16348420
235	Buckthorn	7		Healthy		1528552	16348436
236	Box Elder	11		Healthy		1528556	16348440
237	Buckthorn	6		Healthy		1528548	16348445
238	Buckthorn	8		Healthy		1528562	16348446
239	Cottonwood	27		Dead	stump	1528560	16348446

Ponderosa Woods Stream Tree Survey - 2023

Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_15N	
						X_Cor	Y_Cor
240	Buckthorn	6		Healthy		1528564	16348443
241	Box Elder	10		Healthy		1528570	16348443
242	Box Elder	12		Healthy		1528562	16348420
243	Box Elder	12		Healthy		1528593	16348423
244	Box Elder	25		Healthy		1528593	16348417
245	Ash/Green	14		Dead	fallen	1528583	16348459
246	Box Elder	8		Healthy		1528582	16348462
247	Box Elder	8		Healthy		1528577	16348467
248	Box Elder	11		Healthy		1528589	16348456
249	Cottonwood	30		Healthy		1528585	16348462
250	Buckthorn	6		Healthy		1528583	16348470
251	Box Elder	13		Healthy		1528601	16348474
252	Buckthorn	7		Healthy		1528611	16348479
253	Buckthorn	6		Healthy		1528616	16348476
254	Box Elder	8		Healthy		1528632	16348471
255	Box Elder	12		Healthy		1528632	16348461
256	Box Elder	8		Healthy		1528641	16348472
257	Ash/Green	17		Dead	fallen	1528624	16348486
258	Box Elder	8		Healthy		1528622	16348485
259	Cottonwood	23		Dead	fallen	1528624	16348492
260	Buckthorn	7		Healthy		1528626	16348495
261	Buckthorn	6		Healthy		1528618	16348498
262	Buckthorn	6		Healthy		1528640	16348500
263	Box Elder	15		Healthy		1528657	16348501
264	Cottonwood	33		Healthy		1528659	16348503
265	Box Elder	8		Healthy		1528664	16348502
266	Box Elder	8		Healthy		1528679	16348476
267	Box Elder	7		Dead		1528695	16348488
268	Box Elder	23		Healthy		1528690	16348467
269	Buckthorn	9		Healthy		1528683	16348493
270	Box Elder	7		Healthy		1528673	16348516
271	Box Elder	6		Healthy		1528677	16348509
272	Cottonwood	20		Dead	fallen across creek	1528683	16348504
273	Box Elder	12		Healthy		1528687	16348511
274	Box Elder	13		Dead		1528692	16348515
275	Box Elder	14		Healthy		1528714	16348477
276	Box Elder	14		Healthy		1528732	16348495
277	Box Elder	13		Healthy		1528708	16348512
278	Willow/Black	30		Dead	fallen across creek	1528760	16348494
279	Box Elder	30		Healthy		1528767	16348510
280	Box Elder	10		Healthy		1528768	16348516
281	Box Elder	6		Healthy		1528739	16348524
282	Buckthorn	6		Healthy		1528768	16348540
283	Buckthorn	6		Healthy		1528769	16348540
284	Willow/Black	33		Healthy		1528792	16348547
285	Cedar/White	5	11-20	Healthy		1528786	16348571
286	Cedar/White	5	11-20	Healthy		1528793	16348571
287	Cedar/White	5	11-20	Healthy		1528809	16348581

Ponderosa Woods Stream Tree Survey - 2023

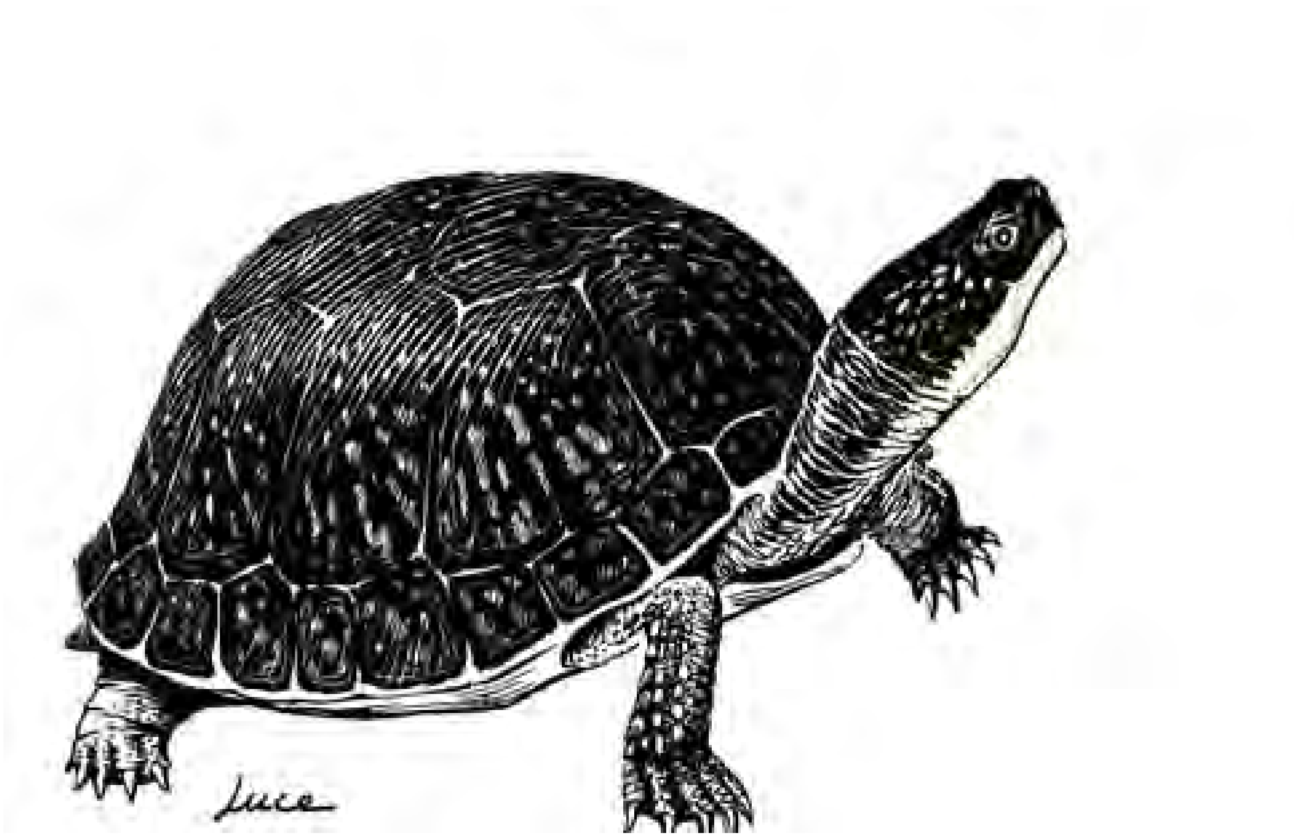
Completed by Brendan Dougherty, PLA

Feature ID Number	Tree Type	DBH (inches)	Height (Conifer Only) (feet)	Observed Health Condition	Comments	NAD_1983_UTM_Zone_ 15N	
						X_Cor	Y_Cor
288	Cedar/White	5	11-20	Healthy		1528807	16348588
289	Birch/River	12		Healthy		1528802	16348612
290	Birch/River	10		Healthy		1528800	16348614
291	Birch/River	13		Healthy		1528804	16348615
292	Birch/River	6		Healthy		1528791	16348605
293	Birch/River	8		Healthy		1528791	16348603
294	Birch/River	10		Healthy		1528791	16348607
295	Elm/American	6		Healthy		1528781	16348617
296	Birch/River	10		Healthy		1528791	16348631
297	Box Elder	7		Healthy		1528802	16348637
298	Box Elder	6		Healthy		1528805	16348637
299	Box Elder	7		Healthy		1528804	16348632
300	Box Elder	6		Healthy		1528814	16348640
301	Box Elder	15		Healthy		1528814	16348648
302	Box Elder	7		Healthy		1528819	16348650
303	Box Elder	9		Dead		1528820	16348646
304	Birch/River	15		Healthy		1528818	16348687
305	Tamarack	10	21-40	Healthy		1528799	16348699
306	Birch/River	16		Healthy		1528788	16348720
307	Box Elder	6		Healthy		1528787	16348722
308	Amur Chokecherry	20		Healthy		1528788	16348748
309	Chokecherry	14		Healthy		1528766	16348778

Appendix C

Blanding's Turtle Flyer

CAUTION



BLANDING'S TURTLES

MAY BE ENCOUNTERED IN THIS AREA

The unique and rare Blanding's turtle has been found in this area. Blanding's turtles are a State Threatened species and are protected under Minnesota Statute 84.095, Protection of Threatened and Endangered Species. Please be careful of turtles on roads and in construction sites. For additional information on turtles, or to report a Blanding's turtle sighting, contact the DNR Nongame Specialist nearest you: Bemidji (218-308-2641); Grand Rapids (218-327-4518); New Ulm (507-359-6033); Rochester (507-280-5070); or St. Paul (651-259-5764).

DESCRIPTION: The Blanding's turtle is a medium to large turtle (5 to 10 inches) with a black or dark blue, dome-shaped shell with muted yellow spots and bars. The bottom of the shell is hinged across the front third, enabling the turtle to pull the front edge of the lower shell firmly against the top shell to provide additional protection when threatened. The head, legs, and tail are dark brown or blue-gray with small dots of light brown or yellow. A distinctive field mark is the bright yellow chin and neck.

Illustration by Don Luce, from Turtles in Minnesota, Natural History Leaflet No. 9, June 1989, James Ford Bell Museum of Natural History

SUMMARY OF RECOMMENDATIONS FOR AVOIDING AND MINIMIZING IMPACTS TO BLANDING'S TURTLE POPULATIONS

(see Environmental Review Fact Sheet Series for full recommendations)

- A flyer with an illustration of an adult Blanding's turtle should be given to all contractors working in the area. Homeowners should also be informed of the presence of Blanding's turtles in the area.
- Turtles which are in imminent danger should be moved, by hand, out of harms way. Turtles which are not in imminent danger should be left undisturbed to continue their travel among wetlands and/or nest sites.
- If a Blanding's turtle nests in your yard, do not disturb the nest, and do not allow pets near the nest.
- Blanding's turtles do not make good pets. It is illegal to keep this threatened species in captivity.
- Silt fencing should be set up to keep turtles out of construction areas. It is <u>critical</u> that silt fencing be removed after the area has been revegetated.
- Small, vegetated temporary wetlands should not be dredged, deepened, or filled.
- All wetlands should be protected from pollution; use of fertilizers and pesticides should be avoided, and run-off from lawns and streets should be controlled. Erosion should be prevented to keep sediment from reaching wetlands and lakes.
- Roads should be kept to minimum standards on widths and lanes.
- Roads should be ditched, not curbed or below grade. If curbs must be used, 4" high curbs at a 3:1 slope are preferred.
- Culverts under roads crossing wetland areas, between wetland areas, or between wetland and nesting areas should be at least 36 in. diameter and flat-bottomed or elliptical.
- Culverts under roads crossing streams should be oversized (at least twice as wide as the normal width of open water) and flat-bottomed or elliptical.
- Utility access and maintenance roads should be kept to a minimum.
- Because trenches can trap turtles, trenches should be checked for turtles prior to being backfilled and the sites should be returned to original grade.
- Terrain should be left with as much natural contour as possible.
- Graded areas should be revegetated with native grasses and forbs.
- Vegetation management in infrequently mowed areas -- such as in ditches, along utility access roads, and under power lines -- should be done mechanically (chemicals should not be used). Work should occur fall through spring (after October 1st and before June 1st).

Compiled by the Minnesota Department of Natural Resources Division of Ecological Resources, Updated March 2008
Endangered Species Environmental Review Coordinator, 500 Lafayette Rd., Box 25, St. Paul, MN 55155 / 651-259-5109

Appendix D

Design Alternatives' Tree Removal Details

Total Tree Survey (Surveyed)				
Species	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
Willow/Black	3	1	0	2
Birch/River	12	0	0	12
Birch/Paper	1	0	0	1
Ash/Green	44	7	5	32
Box Elder	115	17	7	91
Cottonwood	30	8	1	21
Buckthorn	20	0	0	20
Elm/American	39	1	5	33
Maple/Sugar	31	1	0	30
Basswood/American	6	2	0	4
Hackberry	1	0	0	1
Elm/Siberian	1	0	0	1
Cedar/White	4	0	0	4
Tamarack	1	0	0	1
Amur Chokecherry	1	0	0	1
Chokecherry	1	0	0	1
Total	310	37	18	255

Alternative 1 (Removals)				
Species	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
Willow/Black	0	0	0	0
Birch/River	0	0	0	0
Birch/Paper	0	0	0	0
Ash/Green	5	1	1	3
Box Elder	14	5	2	7
Cottonwood	6	1	1	4
Buckthorn	4	0	0	4
Elm/American	7	0	0	7
Maple/Sugar	1	0	0	1
Basswood/American	0	0	0	0
Hackberry	0	0	0	0
Elm/Siberian	0	0	0	0
Cedar/White	0	0	0	0
Tamarack	0	0	0	0
Amur Chokecherry	1	0	0	1
Chokecherry	0	0	0	0
Total	38	7	4	27

Alternative 2 (Removals)				
Species	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
Willow/Black	0	0	0	0
Birch/River	0	0	0	0
Birch/Paper	0	0	0	0
Ash/Green	8	2	1	5
Box Elder	15	5	2	8
Cottonwood	7	2	1	4
Buckthorn	4	0	0	4
Elm/American	7	0	0	7
Maple/Sugar	2	0	0	2
Basswood/American	3	0	0	3
Hackberry	0	0	0	0
Elm/Siberian	0	0	0	0
Cedar/White	0	0	0	0
Tamarack	0	0	0	0
Amur Chokecherry	1	0	0	1
Chokecherry	0	0	0	0
Total	47	9	4	34

Alternative 3 (Removals)				
Species	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
Willow/Black	0	0	0	0
Birch/River	0	0	0	0
Birch/Paper	0	0	0	0
Ash/Green	12	4	2	6
Box Elder	41	10	3	28
Cottonwood	19	7	1	11
Buckthorn	12	0	0	12
Elm/American	10	0	1	9
Maple/Sugar	2	0	0	2
Basswood/American	3	0	0	3
Hackberry	0	0	0	0
Elm/Siberian	0	0	0	0
Cedar/White	0	0	0	0
Tamarack	0	0	0	0
Amur Chokecherry	1	0	0	1
Chokecherry	0	0	0	0
Total	100	21	7	72

Alternative 1 (Removals)				
Parcel Address	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
1935 Forestview Lane North	2	0	0	2
1829 Forestview Lane North	9	0	1	8
1825 Forestview Lane North	14	5	2	7
12105 18th Place North	0	0	0	0
12090 18th Avenue North	4	1	0	3
12125 18th Place North	0	0	0	0
12100 18th Avenue North	4	0	1	3
12110 18th Avenue North	1	0	0	1
1800 Kirkwood Lane North	0	0	0	0
12080 18th Avenue North	0	0	0	0
1825 Ives Lane North	4	1	0	3
1815 Ives Lane North	0	0	0	0
1830 Ives Lane North	0	0	0	0
Total	38	7	4	27

Alternative 2 (Removals)				
Parcel Address	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
1935 Forestview Lane North	2	0	0	2
1829 Forestview Lane North	11	1	1	9
1825 Forestview Lane North	14	5	2	7
12105 18th Place North	0	0	0	0
12090 18th Avenue North	4	1	0	3
12125 18th Place North	0	0	0	0
12100 18th Avenue North	6	1	1	4
12110 18th Avenue North	6	0	0	6
1800 Kirkwood Lane North	0	0	0	0
12080 18th Avenue North	0	0	0	0
1825 Ives Lane North	4	1	0	3
1815 Ives Lane North	0	0	0	0
1830 Ives Lane North	0	0	0	0
Total	47	9	4	34

Alternative 3 (Removals)				
Parcel Address	Total Count	Total Fallen	Total Dead & Standing	Total Healthy
1935 Forestview Lane North	2	0	0	2
1829 Forestview Lane North	50	11	3	36
1825 Forestview Lane North	28	7	3	18
12105 18th Place North	0	0	0	0
12090 18th Avenue North	4	1	0	3
12125 18th Place North	0	0	0	0
12100 18th Avenue North	6	1	1	4
12110 18th Avenue North	6	0	0	6
1800 Kirkwood Lane North	0	0	0	0
12080 18th Avenue North	0	0	0	0
1825 Ives Lane North	4	1	0	3
1815 Ives Lane North	0	0	0	0
1830 Ives Lane North	0	0	0	0
Total	100	21	7	72

Appendix E

Detailed Cost Estimates

Ponderosa Woods Site - Cost Estimate for Alternative 1

Item Description	Unit	Estimated Quantity	Unit Price	Extension
Mobilization	LS	1	$13,590	$13,600
Control of Water	LS	1	$5,000	$5,000
Erosion Control	LS	1	$6,200	$6,200
Clearing and Grubbing	ACRE	0.3	$20,800	$7,100
Clear and Grub Woody Invasive Plant Removal (<=6" DBH tree)	ACRE	1.5	$10,000	$14,800
Herbaceous vegetation herbicide treatment	ACRE	1.5	$1,000	$1,500
Select Tree Removal (>6")	EACH	27	$325	$8,800
Debris Removal	LS	1	$11,000	$11,000
48-inch Manhole Structure and Installation	EACH	1	$5,000	$5,000
Grading	SY	5267	$2	$10,600
Fieldstone Riprap	TON	120	$116	$14,000
Rock Boulder Vane	LF	48	$143	$6,900
Common Excavation	CY	585	$15	$8,800
Plant Trees	EACH	27	$290	$7,900
Plant Shrubs	EACH	180	$40	$7,200
Seeding and Mulch	ACRE	0.3	$9,200	$3,200
Coir Blanket	SY	733	$10	$7,600
Live Stakes	EACH	333	$6	$2,000
Erosion Control Blanket	SY	1,650	$4	$5,800
One-Year Establishment Maintenance Period	LS	1	$2,444	$2,500
			Construction Total	**$ 149,500**
			Construction Total w/ Contingency (20%)	$ 179,400
			Planning, Engineering & Design (30%)	$ 53,900
			Construction Management (10%)	$ 18,000
			Project Total	**$ 252,000**
			Total w/ Construction Lower Bound (-20%), Legal, and Engineering	**$ 202,000**
			Total w/ Construction Upper Bound (+30%), Legal, and Engineering	**$ 328,000**
			Annual Maintenance Cost (2%)	**$ 5,100**

Ponderosa Woods Site - Alternative 1

30-yr and Annualized Cost analysis		**Project Total**
Category:		Bioengineering
Estimated life span (years)		20
Number of major maint. Events		1
Annual maintenance % of original project cost		15%
End of life span % of original project cost		25%
Expected annual maintenance		$ 1,920
End of life span maintenance		$ 63,000
Future Capital Cost		$ 611,700
Future annual maintenance		$ 91,340
Future end of life span cost		$ 113,790
Total Future Worth		**$ 817,000**
Annualized Cost		**$ 17,000**
Annual Maintenance Cost		**$ 5,000**

Ponderosa Woods Site - Cost Estimate for Alternative 1.5

Item Description	Unit	Estimated Quantity	Unit Price	Extension
Mobilization	LS	1	$16,010	$16,100
Control of Water	LS	1	$5,000	$5,000
Erosion Control	LS	1	$7,300	$7,300
Clearing and Grubbing	ACRE	0.3	$20,800	$7,100
Clear and Grub Woody Invasive Plant Removal (<=6" DBH tree)	ACRE	3.5	$10,000	$35,400
Herbaceous vegetation herbicide treatment	ACRE	3.5	$1,000	$3,600
Select Tree Removal (>6")	EACH	27	$325	$8,800
Debris Removal	LS	1	$11,000	$11,000
48-inch Manhole Structure and Installation	EACH	1	$5,000	$5,000
Grading	SY	5267	$2	$10,600
Fieldstone Riprap	TON	120	$116	$14,000
Rock Boulder Vane	LF	48	$143	$6,900
Common Excavation	CY	585	$15	$8,800
Plant Trees	EACH	27	$290	$7,900
Plant Shrubs	EACH	180	$40	$7,200
Seeding and Mulch	ACRE	0.3	$9,200	$3,200
Coir Blanket	SY	733	$10	$7,600
Live Stakes	EACH	333	$6	$2,000
Erosion Control Blanket	SY	1,650	$4	$5,800
One-Year Establishment Maintenance Period	LS	1	$2,898	$2,900
			Construction Total	**$ 176,200**
			Construction Total w/ Contingency (20%)	$ 211,500
			Planning, Engineering & Design (30%)	$ 63,500
			Construction Management (10%)	$ 21,200
			Project Total	**$ 297,000**
			Total w/ Construction Lower Bound (-20%), Legal, and Engineering	**$ 238,000**
			Total w/ Construction Upper Bound (+30%), Legal, and Engineering	**$ 387,000**
			Annual Maintenance Cost (2%)	**$ 6,000**

Ponderosa Woods Site - Alternative 1

30-yr and Annualized Cost analysis		**Project Total**
Category:		Bioengineering
Estimated life span (years)		20
Number of major maint. Events		1
Annual maintenance % of original project cost		15%
End of life span % of original project cost		25%
Expected annual maintenance		$ 1,920
End of life span maintenance		$ 74,250
Future Capital Cost		$ 720,900
Future annual maintenance		$ 91,340
Future end of life span cost		$ 134,100
Total Future Worth		**$ 946,000**
Annualized Cost		**$ 20,000**
Annual Maintenance Cost		**$ 5,900**

Ponderosa Woods Site - Cost Estimate for Alternative 2

Item Description	Unit	Estimated Quantity	Unit Price	Extension
Mobilization	LS	1	$23,190	$23,200
Control of Water	LS	1	$20,000	$20,000
Erosion Control	LS	1	$9,900	$9,900
Clearing and Grubbing	ACRE	0.4	$20,800	$7,900
Clear and Grub Woody Invasive Plant Removal (<=6" DBH tree)	ACRE	3.5	$10,000	$35,400
Herbaceous vegetation herbicide treatment	ACRE	3.5	$1,000	$3,600
Select Tree Removal (>6")	EACH	34	$325	$11,100
Debris Removal	LS	1	$11,000	$11,000
48-inch Manhole Structure and Installation	EACH	1	$5,000	$5,000
Grading	SY	5800	$2	$11,600
Fieldstone Riprap	TON	480	$116	$55,700
Rock Boulder Vane	LF	96	$143	$13,800
Common Excavation	CY	644	$15	$9,700
Plant Trees	EACH	34	$290	$9,900
Plant Shrubs	EACH	200	$40	$8,000
Seeding and Mulch	ACRE	0.4	$9,200	$3,500
Coir Blanket	SY	400	$10	$4,200
Live Stakes	EACH	200	$6	$1,200
Erosion Control Blanket	SY	1,828	$4	$6,400
One-Year Establishment Maintenance Period	LS	1	$3,960	$4,000
			Construction Total	**$ 255,100**
			Construction Total w/ Contingency (20%)	$ 306,200
			Planning, Engineering & Design (30%)	$ 91,900
			Construction Management (10%)	$ 30,700
			Project Total	**$ 429,000**
			Total w/ Construction Lower Bound (-20%), Legal, and Engineering	**$ 344,000**
			Total w/ Construction Upper Bound (+30%), Legal, and Engineering	**$ 558,000**
			Annual Maintenance Cost (2%)	**$ 8,600**

Ponderosa Woods Site - Alternative 2

30-yr and Annualized Cost analysis		**Project Total**
Category:		Bioengineering
Estimated life span (years)		20
Number of major maint. Events		1
Annual maintenance % of original project cost		15%
End of life span % of original project cost		25%
Expected annual maintenance		$ 1,340
End of life span maintenance		$ 107,250
Future Capital Cost		$ 1,041,300
Future annual maintenance		$ 63,750
Future end of life span cost		$ 193,710
Total Future Worth		**$ 1,299,000**
Annualized Cost		**$ 27,000**
Annual Maintenance Cost		**$ 8,600**

Ponderosa Woods Site - Cost Estimate for Alternative 3

Item Description	Unit	Estimated Quantity	Unit Price	Extension
Mobilization	LS	1	$27,320	$27,400
Control of Water	LS	1	$20,000	$20,000
Erosion Control	LS	1	$11,825	$11,900
Clearing and Grubbing	ACRE	0.6	$20,800	$13,200
Clear and Grub Woody Invasive Plant Removal (<=6" DBH tree)	ACRE	3.3	$10,000	$32,900
Herbaceous vegetation herbicide treatment	ACRE	3.3	$1,000	$3,300
Select Tree Removal (>6")	EACH	72	$325	$23,400
Debris Removal	LS	1	$11,000	$11,000
48-inch Manhole Structure and Installation	EACH	1	$5,000	$5,000
Grading	SY	4467	$2	$9,000
Fieldstone Riprap	TON	480	$116	$55,700
Rock Boulder Vane	LF	80	$143	$11,500
Common Excavation	CY	496	$15	$7,500
Plant Trees	EACH	72	$290	$20,900
Plant Shrubs	EACH	320	$40	$12,800
Seeding and Mulch	ACRE	0.6	$9,200	$5,900
Coir Blanket	SY	967	$10	$10,100
Live Stakes	EACH	600	$6	$3,500
Erosion Control Blanket	SY	3,063	$4	$10,800
One-Year Establishment Maintenance Period	LS	1	$4,730	$4,800
			Construction Total	**$ 300,600**
			Construction Total w/ Contingency (20%)	$ 360,800
			Planning, Engineering & Design (30%)	$ 108,300
			Construction Management (10%)	$ 36,100
			Project Total	**$ 506,000**
			Total w/ Construction Lower Bound (-20%), Legal, and Engineering	**$ 405,000**
			Total w/ Construction Upper Bound (+30%), Legal, and Engineering	**$ 658,000**
			Annual Maintenance Cost (2%)	**$ 10,200**

Ponderosa Woods Site - Alternative 3

30-yr and Annualized Cost analysis		**Project Total**
Category:		Bioengineering
Estimated life span (years)		20
Number of major maint. Events		1
Annual maintenance % of original project cost		15%
End of life span % of original project cost		25%
Expected annual maintenance		$ 2,930
End of life span maintenance		$ 126,500
Future Capital Cost		$ 1,228,200
Future annual maintenance		$ 139,400
Future end of life span cost		$ 228,470
Total Future Worth		**$ 1,596,000**
Annualized Cost		**$ 34,000**
Annual Maintenance Cost		**$ 10,100**