Appendix D

Cultural and Historical Resources

APPENDIX D.

ARCHAEOLOGICAL INVESTIGATION CONDUCTED FOR THE

PLYMOUTH CREEK STREAM CHANNEL RESTORATION FEASIBILITY STUDY,

CITY OF PLYMOUTH,

HENNEPIN COUNTY, MINNESOTA

Prepared for:

Bassett Creek Watershed Management Commission

and

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January 2016

SHPO File Number: 2014-....

Minnesota Archaeological License Number: 15-057

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MANAGEMENT SUMMARY

During the fall of 2015, Archaeological Research Services (ARS) conducted an archaeological Phase I survey along a segment of Plymouth Creek in the City of Plymouth, Hennepin County, Minnesota. The investigation is part of a feasibility study that is being completed by Barr Engineering (Barr) for the Bassett Creek Watershed Management Commission (BCWMC) Watershed Management Plan.

The study examines the feasibility of restoring damaged areas along the channel of Plymouth Creek within the Plymouth Creek Park and between Fernbrook Lane North and Annapolis Lane North. It aims to identify sites that need some form of stabilization to address damage caused by erosion, scouring and other reasons for bank failure.

The feasibility study follows the protocols developed by the U.S. Army Corps of Engineers (USACE) and the BCWMC for projects within the BCWMC Resource Management Plan (RMP). As the implementation of these efforts would involve public land and funding as well as federal permitting of wetland impacts, the project proposers anticipate that the State Historic Preservation Office (SHPO) and the Office of the State Archaeologist (OSA) both will request an archaeological review of the project route. Consequently, a records and literature search and preliminary field assessment were incorporated into the feasibility study.

Retained to conduct the review, ARS completed a field inspection during late October, mid November and early December 2015 following records and literature searches at SHPO and OSA. Methodology and results are described below in Sections 2.0 and 3.0 and the conclusions provided in Section 4.0.

The study area measures approximately 2800 feet as it extends from from Annapolis Lane on the downstream end to a control structure in Plymouth Creek Playfields Park on the upstream end. Fernbrook Lane crosses the creek roughly half way through the study reach. The site is located just northwest of the intersection of I-494 and Hwy 55 in Plymouth, in SWSW 1/4 Section 15, SESE 1/4 Section 16, NENE 1/4 Section 21 and NWNW 1/4 Section 22, T118N, R22W.

Visual inspection of existing erosion exposure, in some areas supplemented by shovel testing, provided enough survey coverage to conclude that neither the banks of the creek nor the areas close enough to be affected by proposed stabilization measures feature any archaeological evidence. However, should final design of needed stabilization measures change the now proposed areas of project impact, this initial inspection will need to be supplemented with further survey conducted in a manner that meets previously referenced federal and state guidelines.

1.0 INTRODUCTION AND PROJECT DESCRIPTION

During the fall of 2015, Archaeological Research Services (ARS) conducted an archaeological Phase I survey along a segment of Plymouth Creek in the City of Plymouth, Hennepin County, Minnesota. The investigation is part of a feasibility study that is being completed by Barr Engineering (Barr) for the Bassett Creek Watershed Management Commission (BCWMC) Watershed Management Plan.

This study examines the feasibility of restoring damaged areas along the channel of Plymouth Creek within the Plymouth Creek Park and between Fernbrook Lane North and Annapolis Lane North. It aims to identify sites that need some form of stabilization to address damage caused by erosion, scouring and other reasons for bank failure.

The feasibility study follows the protocols developed by the U.S. Army Corps of Engineers (USACE) and the BCWMC for projects within the BCWMC Resource Management Plan (RMP). As the implementation of these efforts would involve public land and funding as well as federal permitting of wetland impacts, the project proposers anticipate that the State Historic Preservation Office (SHPO) and the Office of the State Archaeologist (OSA) both will request an archaeological review of the project route. Consequently, a cultural resources records and literature search and a Phase One archaeological field assessment are incorporated into the feasibility study.

Retained to conduct these reviews, ARS completed a field inspection during late October, mid November and early December 2015 following records and literature searches at SHPO and OSA.

The project area is located just northwest of the intersection of I-494 and Hwy 55 in Plymouth, in SWSW 1/4 Section 15, SESE 1/4 Section 16, NENE 1/4 Section 21 and NWNW 1/4 Section 22, T118N, R22W.

The study reach of the creek measures approximately 2800 feet as it extends from from Annapolis Lane on the downstream end to a control structure in Plymouth Creek Playfields Park on the upstream end. Fernbrook Lane crosses the creek roughly half way.

The project is divided into three sub-reaches as shown below in Figure D:1. Land use immediately adjacent to Reaches 1 and 2 is predominantly a disc golf course. Reach 1 has heavy tree cover and sparse vegetation below the canopy, in part due to traffic from the disc golf course. Reach 2 is a mix of tree cover and a grassy riparian area. The land use adjacent to Reach 3 is primarily a wooded valley on both sides of the creek, which is located adjacent to a residential neighborhood.

Barr staff walked the entire study reach in September 2015 and identified sites that require stabilization to address bank erosion, scour, and/or bank failure. Additional site visits were conducted through October and November to meet with stakeholders on site, check conceptual stabilization alternatives, and observe the creek during different flow conditions. Resulting recommendations are shown below.

Stabilization techniques used to prevent additional bank erosion and improve in-stream and riparian habitat may include riprap, j-vanes, cross vanes, biolog, live stakes, vegetated reinforced soil stabilization (VRSS), live fascines, selective tree removal, re-establishment of riparian vegetation, and planting native trees and shrubs.

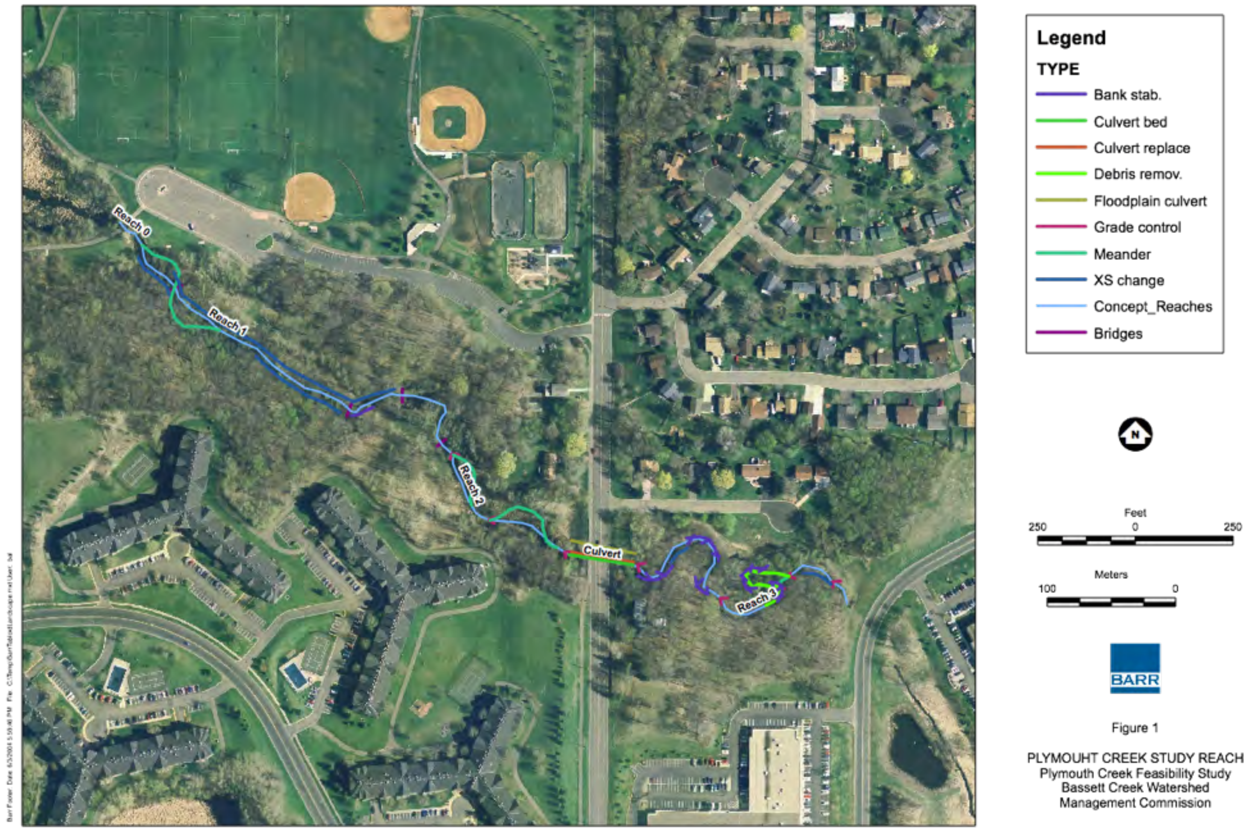

Figure D:1 Plymouth Creek Study Area

2.0 ENVIRONMENTAL AND HISTORIC SETTING

The survey area is located within the Emmons-Faribault Moraine -- a geomorphic region dominated by glacial features left by the advancing and receeding of the Des Moines Lobe during the Late Wisconsin glaciation approximately 18,000 to 13,000 B.P.: irregular loam mantled moraines and numerous ice disintegration features which have created deep, often isolated, now water- or peat-filled depressions (UMAES 1973:18).

At the time of the original land survey, i.e. prior to more extensive impact by Euroamerican settlement, the survey area supported primarily oak openings and barrens, with small pockets of either deciduous hardwoods (“big woods”) or open prairie (Marschner 1974). A few miles to the northeast/east/southeast, the Mississippi River valley supported river bottom forest (primarily elm, ash, cottonwood, boxelder, basswood, maple, willow and hackberry) alternating with wet prairie, marshes and slough grasslands.

Easy access to a range of habitats would have provided early inhabitants of the area with a rich variety of plant and animal resources. At the time of Euroamerican settlement, the forest areas supported species such as white-tailed deer, cottontail rabbit, woodchuck, raccoon and bear.

The prairie and prairie/woodland border would have sustained large mammals such as bison and elk, as well as numerous small species. The rivers, lakes, sloughs, and marshes contained muskrat and beaver, numerous types of waterfowl, and many species of fish and turtle (Anfinson 1990).

Reaching farther back in time, pollen cores and macrobotanic evidence attest to quite dramatic changes in the regional environment throughout the postglacial period. A periglacial parkland of spruce and larch followed the retreat of the Wisconsin glaciers and the tundra vegetation associated with their margins. By 11,500 B.P., rapid climatic change had caused the spruce to be succeeded by pine forest (by approximately 10,000 B.P.) and then by a deciduous forest composed primarily of oak and elm. A warming and drying trend, which characterized the early to middle Holocene, peaked at 7,000 to 6,000 B.P., causing the prairie and its transitional prairie-woodland margin to expand some 75 miles north and east of their normal limits. Linked with these climatic warming trends were an increase in the frequency of prairie fires and a marked decline of the water table which caused many small lakes to dry up completely (Wright 1972, 1974; Anfinson and Wright 1990).

Pollen cores from Hennepin County have provided quite specific environmental data for the more immediate study area, charting changes from the middle Holocene to the present (Grimm 1983). They suggest that woodlands prevailed throughout the Holocene in the northeastern Big Woods area which includes much of what is now Hennepin County. This is perhaps best explained by local infrequency of fire due to a rolling topography with numerous deep lakes which would have retained water even during the middle Holocene. Just as significant was probably the protection provided by major firebreaks such as the main rivers and large bodies of water like Lake Minnetonka. Local vegetation consisted of a fairly balanced mixture of woodland and prairie from 6,330 to 3,810 B.P., followed by oak- dominated woodlands from 3,810 to 280 B.P. The onset of cooler and wetter climatic conditions encouraged the development of the Big Woods (dominated by elm, maple and basswood) from 280 B.P to the mid-1800s and the beginning of Euroamerican clearing and settlement (ibid. 1983).

Until the late 1800s, the area around Plymouth and upper Bassett Creeks remained quite rural: all woodlands and farmed fields with a smattering of farms and the western edge of Minneapolis still well to the east (Andreas 1874). As the city expanded west and north, a segment of Bassett Creek was protected as part of Theodore Wirth Park and the historic Grand Rounds Scenic Byway system (Harrison 2002). Beyond that, urban and suburban growth has changed most of the area and although other segments of the creek since have been protected as designated parkland, long stretches of the stream have been confined to channels which have been narrowed and straightened to accommodate residential and industrial developent. Old photographs and topographic maps, along with less urbanized segments of the drainage, indicate that the historic appearance was that of a naturally meandering stream which at times was flanked by quite pronounced glacial knolls but elsewhere traversed quite wide and often marshy stretches of floodplain.

As the Twin Cities metropolitan area was one of the first to be cleared for farming or developed for residential and commercial use, much archaeological evidence can be presumed to have been destroyed before it could be recorded and studied but some of it has survived in parks and otherwise protected areas around the metropolitan lakes and rivers especially in the lake country of the southwestern metro region and also on the uplands along the Mississippi River valley and its confluence with the Minnesota River -- all of which, along with the current project area, are part of the so-called “Central Deciduous Lakes South” archaeological region (Anfinson 1990).

Easy access to a wide range of habitats would have provided a rich variety of plant and animal resources throughout this region. In the the forested areas were species such as white-tailed deer, cottontail rabbit, woodchuck, raccoon and bear, and on the prairie -- or along the prairie/woodland border -- larger game such as bison and elk as well as numerous smaller species. The rivers, lakes, sloughs, and marshes harbored muskrat and beaver, numerous types of waterfowl, clams and many species of fish and turtle (Anfinson 1990).

Archaeological evidence indicates that this rich environment attracted Native Americans to the area throughout the postglacial period. While no archaeological sites have been recorded in close proximity to the survey segment of Plymouth Creek, such evidence is known to exist elsewhere in the Plymouth-Bassett Creek watershed. In May of 2011, ARS completed a cultural resource Phase IA review for the Bassett Creek Watershed Management Commission Resource Management Plan. The results were intended to provide a preliminary understanding of the archaeological and historic potential of six Plymouth and Bassett Creek segments that were considered to warrant channel restoration, sediment removal and/or other water quality improvement measures. OSA site files were reviewed by ARS for information about archaeological sites identified within a mile of these project areas. Information from the history/architecture data base that is maintained by SHPO was provided by that office directly to Barr. Both sets of data are presented in the 2011 report. In addition, ARS reviewed SHPO report files for cultural resource surveys previously conducted within and near the project area. ARS staff also examined historical maps and aerial photographs at the Minnesota Historical Society and the University of Minnesota-Borchert Map Library.

Although the results of the records search indicated that a number of archaeological surveys had been conducted within the watershed, many of them had proven negative. Archaeological sites had primarily been identified on larger bodies of water that drain into Bassett Creek: on the shores of Medicine Lake and, a few miles downstream, the Sweeney and Twin Lakes as well as Birch Pond by Wirth Lake. Most of these sites are quite distant from the current project area but a few are close enough to indicate a possible relationship to the latter:

> 21-HE-0068 (Medicine Lake Mounds) -- seven mounds recorded in 1887 on a hogback ridge on the west side of Medicine Lake (Winchell 1911:255). No longer visible, they may have been destroyed by house and road construction as burial authentication efforts proved negative (Mather et al. 1997). Located in T118N, R22W, Section 26 (SW-NE and W-SW-NE).
>
> 21-HE-0261 -- a corner-notched point reported as found on a cultivated terrace that overlooks the marshy Plymouth Creek floodplain in T118N, R22W, Section 22 (W-SW-SE-NE).

The fact that relatively few cultural resources have been recorded in the vicinity of Plymouth and Bassett Creeks more than likely reflects a lack of systematic inventory survey rather than an actual lack of archaeological and historic potential, considering that most of the areas that have been inventoried proved positive. Existing data for the few areas that have been investigated suggest that most uplands that overlook these streams and associated lakes/wetlands would have attracted Native Americans as well as early Euro-American settlers.

Drawing on our understanding of the sites that do exist here as well as in neighboring parts of the "Central Deciduous Lakes South" archaeological region, we know that the following main cultural manifestations are known or likely to be represented in the archaeological record of the general study area: the **Paleoindian and Early Archaic periods** (ca. 10,000 to 3000 B.C.); the **Middle to Late Archaic periods** (ca. 3000 to 800 B.C.); the **Woodland period** (ca. 800 B.C. to the time of the time of early Euro-American contact); the **Oneota and Plains Village traditions**, which emerged around A.D. 950-1000; the **period of initial contact between Native Americans** (the Eastern Dakota) **and 18th/19th century Euro-Americans** (French, British and American explorers, military men, traders and missionaries); the **period of Euro-American settlement and home-steading**. As this investigation did not produce any archaeological evidence that needs to be evaluated within a larger cultural framework, more detailed discussion of the regional cultural sequence seems redundant in this report. More detailed discussions of the characteristics of each context can be found in Minnesota History in Sites and Structures: Pre-Contact and Contact Period Contexts, compiled and updated as needed by the State Historic Preservation Office (SHPO). A somewhat more comprehensive description is appended to the 2011 report.

3.0 SURVEY METHODOLOGY AND RESULTS

As the project will need a Section 404 U.S. Army Corps of Engineers permit to fill jurisdictional wetlands, it will require compliance with Section 106 of the National Historic Preservation Act of 1966 and consultation with SHPO. As an undertaking that involves non-federal public land and funding, the project will also come under the purview of OSA and Minnesota Statutes 138.31-.42. More encompassing, the Minnesota Private Cemeteries Act (MnST 307.07) protects all human remains and burials that are older than 50 years and located on private or public lands outside of platted, recorded or identified cemeteries.

In view of the above, the archaeological research done for this project has been conducted in a manner that meets the requirements of the Secretary of the Interior's Standards for Identification and Evaluation of cultural resources as well as the standards specified in the State Archaeologist's Manual for Archaeological Projects in Minnesota.

3.1 Records/Literature Search

Prior to the field review, ARS updated information they had already compiled for the Plymouth Creek study area as part of the above-mentioned 2011 Phase IA review. According to OSA staff, no new archaeological site information has been received by that office, nor do their records show that any studies have been or are being conducted in that area since 2011.

3.2 Plymouth Creek west of Fernbrook Lane

As shown in Figure D:1 and described above on page 2, the project route parallels the southern edge of a disc golf course. The medium blue line in the figure shows the existing stream centerline while the darker blue lines indicate the extent of the stream valley and the areas where its banks may be somewhat modified. The green lines show places where minor re-routing of the stream are being considered. Those concepts do not show the exact route, but rather the vicinity and rough extent of a re-route/remeander.

Although the field survey primarily focused on the areas that seemed likely to be affected by the undertaking, the entire length of this creek segment was visually reviewed including all areas adjacent to the stream banks up to a distance of 75 feet from the stream. The field review was conducted following the flow of the creek downstream.

From the bottom of the stream valley, ARS staff checked erosion exposure along the banks as well as erosion residue deposited at their base and in the creek. Following the top of the creek bank and covering all adjacent ground, the team then inspected the surface for evidence of any signs of past cultural activity as well as any existing subsoil exposure in the form of animal burrows, wind falls and erosion around tree roots. Because of good lateral visibility even in wooded areas as well as the ubiquitous presence of good erosion exposure all along the disc golf course and the creek banks, ARS could rely on visual inspection to provide sufficient survey coverage without supplementary shovel testing. Figures D:3 to D:5 illustrate the type of good ground exposure encountered all along this stretch. The last approximately 200 feet long segment west of Fernbrook Lane flows through low, quite marshy terrain without any archaeological potential. The area that then would be disturbed by the proposed culvert replacement under Ferndale Avenue has been completely disturbed by road construction and is also completely lacking in archaeological potential.

3.3 Plymouth Creek east of Fernbrook Lane

This eastern segment of the project -- Reach 3 on Figure D:1 -- is primarily a wooded valley which, along its northern side, abuts a residential neighborhood with newer homes on landscaped lots north of east-trending 35th Avenue. South of the avenue, wooded terrain slopes quite rapidly down to Plymouth Creek. South of the creek, however, there are several fairly level terraces that overlook the creek and could have invited enough historic use to have considerable archaeological potential (Figures D:8 and D:9). Considering that many of these terraces by now have been quite badly impacted by erosion, slumping and undercutting as shown in Figures D:6 and D:7, they are likely to be in need of bank stabilization, debris removal and some rerouting of the channel.

Consequently, ARS staff decided to supplement thorough visual inspection along the creek with systematic shovel testing of areas that lacked subsoil exposure. An initial series of tests was approximately one meter in from the south side of the creek and at approximate ten meter intervals. A second series was placed six-seven meters south of the creek, again at ten meter intervals but now staggered for more complete coverage with tests placed approximately between the ones to the north.

All tests measured approximately 40 centimeters in diameter. Each unit was taken down to sterile mineral soil, removing the soil contents by 10-centimeter levels and screening them through quarter-inch hardware cloth. It was then backfilled once soil profiles had been noted. Individual test records will be kept on file by ARS. GPS readings were used to record all test locations. All test profiles were very similar, with 40 t0 50 centimeters of dark grayish brown sandy silt loam over a substratum of coarser, more sandy and gravely, lighter colored grayish brown silt loam.

Like the preceding visual inspection of all areas affected by erosion, all test results proved negative.

4.0 CONCLUSION AND RECOMMENDATIONS

Visual inspection of existing erosion exposure, in some areas supplemented by shovel testing, has provided enough survey coverage to conclude that none of the bank segments that are prioritized for stabilizing feature any archaeological evidence.

However, should final design of needed stabilization measures change the now proposed areas of project impact, this initial inspection will need to be supplemented with further survey conducted in a manner that meets previously referenced federal and state guidelines.

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Appendix E

Wetland Delineation

Wetland Delineation Report - DRAFT

Plymouth Creek Feasibility Study

Prepared for
Bassett Creek Watershed Management Commission

January 2016

Wetland Delineation Report

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January 2016

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1.0 Introduction

Basset Creek Watershed Management Commission (BCWMC) is submitting a Wetland Delineation Report as part of a study that examines the feasibility of restoring sites along Plymouth Creek reaches damaged by erosion or affected by sedimentation. The project area is located along several reaches of Plymouth Creek beginning at Plymouth Creek Park and continues between Fernbrook Lane North and Annapolis Lane North, Plymouth, Hennepin County, Minnesota. The project area is within Sections 16, 21 and 22 of Township 118 North, Range 21 West (**Figure 1**).

A field wetland delineation was conducted along the fringes of these stream reaches to include delineation of creek edges. Two wetland boundaries were delineated along the creek fringes and are depicted in **Figure 6**.

This Wetland Delineation Report has been prepared in accordance with the U.S. Army Corps of Engineers 1987 Wetland Delineation Manual ("1987 Manual", USACE, 1987), the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region (USACE, 2010) and the requirements of the Minnesota Wetland Conservation Act (WCA) of 1991. Barr delineated the wetland boundaries and determined wetland types within the project area on September 22, 2015.

This report includes a project overview (Section 2.0), general environmental information (Section 3.0), descriptions of the delineated wetlands (Section 4.0), and a discussion of regulations and the administering authorities (Section 5.0). The Tables section includes the precipitation data. The Figures section includes the Site Location Map, Topography Map, National Wetland Inventory (NWI), Public Waters Inventory (PWI), Hydric Soils Map and the Wetland Boundary Map. **Appendix A** includes Wetland Data Forms, and site photographs are included in **Appendix B**.

2.0 Project Description

The entire Plymouth Creek project area (Error! Reference source not found.) extends approximately 2,800 feet from Annapolis Lane North on the downstream end to approximately 1,700 feet upstream of Fernbrook Lane North on the upstream end. The upstream boundary of the project area is a water-level-control structure (**Photo 1**). Originally known as the Central Park Pond Outlet, this structure runs under an access road that connects the Plymouth Creek Park parking lot on the north and the Plymouth Creek Center on the south.

The BCWMC Engineer walked the entire project area in September 2015 and identified sites with bank erosion, scour, and/or bank failure. Additional site visits were conducted in October and November 2015 to meet with stakeholders, check conceptual stabilization alternatives, and observe the creek during different flow conditions. Restoration/stabilization of the sites were considered critically important to meeting BCWMC goals and objectives cost effectively.

Stream bank erosion is a natural process that occurs at some rate on all alluvial channels, and the natural erosion rate can be accelerated by local and regional changes in land use and hydrology. The bank erosion and bank failures throughout the project area appear to be caused by a combination of natural stream erosion processes, problems associated with changing watershed hydrology, and effects of riparian land use. Of the 5,600 feet of stream bank in the project area, approximately 2,850 feet (more than half) showed some degree of erosion.

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 best management practices (BMPs) helps reduce the impact of development projects 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 increases erosion rates. In addition, the heavy use of golf course in the riparian area of Reaches 1 and 2 has decreased groundcover on the stream banks and adjacent wooded areas, increasing the potential for erosion.

3.0 General Environmental Setting

3.1 Site Description

The proposed project area is located within City of Plymouth property. The project area west of Fernbrook Lane North is bordered by medium density apartment property to the south and Plymouth Creek Park to the north and west. The project area located east of Fernbrook Lane North has medium density housing to the North and office building space to the south. Lands surrounding the project area are forested with deciduous trees (**Figure 1**).

3.2 Topography

The project area has moderately undulating to flat topography throughout and in most areas along Plymouth creek there is an abrupt topographic break leading into the creek due to erosion. Topography surrounding the project area further away is relatively flat (**Figure 2**).

3.3 Precipitation

Recent precipitation data were compared to historic data for evaluating annual and monthly deviations from normal conditions. Simulated precipitation data were obtained from the Minnesota Climatology Working Group, Wetland Delineation Precipitation Data Retrieval from a Gridded Database (http://climate.umn.edu/gridded_data/precip/wetland/wetland.asp) for wetlands in Hennepin County, Township 118 North, Range 22 West, Section 21.

In 2015, antecedent moisture conditions were within the normal range based on precipitation for the three months prior to the September 22, 2015 site visit. These data were obtained from NRCS climate station 215838, New Hope Weather Station (**Table 1**). The water year has varied between normal and wet for the past six years but fell mostly into the wet range from 2010 through 2015 (**Table 2**).

3.4 National Wetland Inventory

The National Wetland Inventory (NWI) Map has identified a portion of the Plymouth Creek Study Reach as riverine wetland located west of Fernbrook Lane North. It was identified as a riverine (R) wetland, lower perennial (2), with an unconsolidated bottom (UB) that has an intermittently exposed hydrologic regime (G) or an R2UBG riverine wetland. No other NWI wetlands were mapped within the Plymouth Creek Study Reach (**Figure 3**).

3.5 Water Resources

The Minnesota Department of Natural Resources (MnDNR) Public Waters Inventory (PWI) has identified Plymouth Creek as a public water inventory watercourse (**Figure 4**). Reaches of Plymouth Creek located within the project area were delineated along with two wetland fringe areas. Plymouth Creek is not identified by the Minnesota Pollution Control Agency (MPCA) as an impaired water.

3.6 Soil Resources

Soil information for the wetland evaluation area was obtained from the Soil Survey of Hennepin County, Minnesota (USDA, 1974). Three soil map units were identified within the project area along the Plymouth Creek reaches: Hamel overwash-Hamel complex, 1 to 4 percent slopes (L36A), Lester loam, 6 to 10 percent slopes, moderately eroded (L22C2) and Hamel-Glencoe depressional, complex, 0 to 3 percent slopes (L132A). The Hamel overwash-Hamel complex and Lester loam are mapped as predominately Non-Hydric. The Hamel-Glencoe depressional is mapped as predominately hydric (**Figure 5**).

4.0 Wetland Delineation

4.1 Wetland Delineation and Classification Methods

Wetlands within the site were delineated and classified during a site visit on September 22, 2015. The wetland delineation was established according to the Routine On-Site Determination Method specified in the U.S. Army Corps of Engineers Wetlands Delineation Manual (1987 Edition) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region (USACE, 2010).

The delineated wetland boundaries and sample points were surveyed using a Global Positioning System (GPS) with sub-meter accuracy (**Figure 6**).

Wetlands were classified using the U.S. Fish and Wildlife Service (USFWS) Cowardin System (Cowardin et al., 1979), the USFWS Circular 39 system (Shaw and Fredine, 1956), and the Eggers and Reed Wetland Classification System (Eggers and Reed, 1977).

Soil borings were placed in and around the wetland, to a depth of at least 20 inches below the ground surface where possible. Representative soil samples from each boring were examined for the presence of hydric soil indicators using the Natural Resources Conservation Service (NRCS) hydric soil indicators (Version 6.0). Soil colors (e.g., 7.5YR 4/2, etc.) were determined using a Munsell® soil color chart and noted on the Wetland Data Forms **Appendix A**.

Hydrologic conditions were evaluated at each soil boring, and this information was also noted on the Wetland Data Forms. The dominant plant species were identified, and the corresponding wetland indicator status of each plant species was determined and noted on the Wetland Data Forms (**Appendix A**). Photographs taken at the time of the site visit are provided in **Appendix B**.

4.2 Wetland Descriptions

Two wetlands were delineated within the project site. Descriptions and assessments of the wetland areas are provided below, with representative photographs in **Appendix B**.

4.2.1 Wetland 1

Wetland 1 is a Type 1 (PEMA), seasonally flooded basin within floodplain located on the right bank of Plymouth Creek within Plymouth Creek Park (**Figure 6**). The surrounding area has steep and abrupt slopes leading into Wetland 1. There is an upland island between Wetland 1 and Plymouth creek approximately 8 feet higher in elevation than the surface of the wetland. Flood waters may periodically enter the north end of Wetland 1 between the upland island and the adjacent forested uplands to the south, which flow through and back to Plymouth Creek further downstream.

Dominant plants within wetland 1 and at Wetland Sample Point 1-1 (SP 1-1 WET) was reed canary grass (*Phalaris arundinacea*, FACW). Sub-dominant species included green bulrush (*Scirpus atrovirens*, OBL), stinging nettle (*Urtica dioica*, FACW) and a species of sedge (*Carex sp*.) that could not be identified. Tree and shrub species were present within 30 feet of SP 1-1 WET but were not directly within the basin.

Primary indicators of hydrology that were observed were high water table (A2), and saturation (A3). Secondary indicators of hydrology present included geomorphic position (D2) and a positive FAC-Neutral test (D5).

Soils mapped at SP 1-1 WET and throughout Wetland 1 were identified as Lester loam, 6-10% slopes. Sampled soils were black at the surface with 2 percent redoximorphic concentrations down to 9 inches with sandy loam textures. Soils from 9 inches to 18 inches were dark grayish brown with 5 percent redoximorhic features and had fine sandy loam textures. At 18 inches soils transitioned to black and sandy mucky mineral textures down to 25 inches. The hydric soil indicator at SP 1-1 WET is sandy redox (S5).

The transition to upland was defined by the lack of vegetation, hydrology and hydric soil indicators. Dominant vegetation in upland areas consisted of sugar maple (*Acer saccharum*, FACU), common dandelion (*Taraxacum offcinale*, FACU) and a species of sedge.

4.2.2 Wetland 2

Wetland 2 is a Type 2 (PEMB), fresh meadow located on the left bank of Plymouth Creek approximately 300 feet downstream from Wetland 1 (**Figure 6**). Wetland 2 may occasionally flood during the growing season but in most year's water likely remains within 12 inches of the soil surface. Two sample points were taken within Wetland 1 along the same transect. Data from SP 2-1 WET-A was collected close to the wetland boundary and data from SP 2-1 WET-B was collected closer to the creek channel.

Reed canary grass and eastern cottonwood (*Populus deltoides*, FAC) is dominant at both SP 2-1 WET-A and SP 2-1 WET-B with a sub-dominance of water smartweed (*Persicaria amphibia*, OBL).

There were no primary indicators of hydrology observed within Wetland 2. Secondary indicators of hydrology present included geomorphic position (D2) and a positive FAC-Neutral test (D5).

Soils mapped at both sample locations and throughout Wetland 2 were identified as Lester loam, 6-10% slopes. Soils at SP 2-1 WET-A were very dark gray clay loams down to 8 inches and transitioned to dark grayish brown with 20 percent redoximorphic features down to 14 inches. From 14 to 20 inches soils transitioned to more yellow hues that were dark gray. Textures were clay loam throughout the soil profile. The hydric soil indicator at SP 2-1 WET-A is redox dark surface (F6).

Soils at SP 2-1 WET-B were sandy clay and gleyed down to 15 inches with 2 percent redoximorphic concentrations. Soils transitioned to sand and dark gray colors with yellower hues from 15 to 25 inches. The hydric soil indicators at SP 2-1 WET-B are sandy gleyed matrix (S4) and sandy redox (S5).

The transition to upland was defined by the lack of vegetation, hydrology and hydric soil indicators. Dominant vegetation in upland areas consisted of sugar maple and European buckthorn (*Rhamnus cathartica*, FAC).

5.0 Regulatory Overview

The USACE regulates the placement of dredge or fill materials into wetlands that are located adjacent to or are hydrologically connected to interstate or navigable waters under the authority of Section 404 of the Clean Water Act. If the USACE has jurisdiction over any portion of a project, they may also review impacts to wetlands under the authority of the National Environmental Policy Act.

Filling, excavating, and draining wetlands are also regulated by the Minnesota Wetland Conservation Act (WCA), and the Minnesota Public Waters Inventory Program, which are administered by the City of Plymouth and the Minnesota Department of Natural Resources (DNR) respectively. The USACE, the City of Plymouth and the DNR should be contacted before altering any wetlands on the site. In addition, delineated wetland boundaries may be reviewed, if needed, by a Technical Evaluation Panel (TEP) consisting of representatives from the Minnesota Board of Water and Soil Resources, and Hennepin County, along with the City of Plymouth, DNR and USACE.

6.0 References

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Tables

Table 1
Antecedent Moisture Conditions Prior to September 22, 2015 Site Visit
Plymouth Creek Feasibility Study Wetland Delineation
Plymouth, MN

Precipitation Worksheet Using Gridded Database

Precipitation data for target wetland location:

County: Hennepin
Township Name: Plymouth
Nearest Community: Plymouth
Township Number: 118N
Range Number: 22W
Section Number: 21

Aerial photograph or site visit date:
Tuesday September 22, 2015

Score using 1971-2000 normal period

(value are in inches)	first prior month: **August 2015**	second prior month: **July 2015**	third prior month: **June 2015**
estimated precipitation total for this location:	**3.6**	**7.02**	**3.56**
there is a 30% chance this location will have less than:	3.18	3.04	2.92
there is a 30% chance this location will have more than:	4.72	5.28	5.28
type of month: **dry** **normal** **wet**	**normal**	**wet**	**normal**
monthly score	**3 * 2 = 6**	**2 * 3 = 6**	**1 * 2 = 2**
multi-month score: 6 to 9 (**dry**) 10 to 14 (**normal**) 15 to 18 (**wet**)	14 (**normal**)		

Score using 1981-2010 normal period

(value are in inches)	first prior month: **August 2015**	second prior month: **July 2015**	third prior month: **June 2015**
estimated precipitation total for this location:	**3.6**	**7.02**	**3.56**
there is a 30% chance this location will have less than:	2.94	2.7	2.93
there is a 30% chance this location will have more than:	4.93	4.98	5.33
type of month: **dry** **normal** **wet**	**normal**	**wet**	**normal**
monthly score	**3 * 2 = 6**	**2 * 3 = 6**	**1 * 2 = 2**
multi-month score: 6 to 9 (**dry**) 10 to 14 (**normal**) 15 to 18 (**wet**)	14 (**normal**)		

Table 2
Precipitation in Comparison to WETS Data
Plymouth Creek Feasibility Study Wetland Delineation
Plymouth, MN

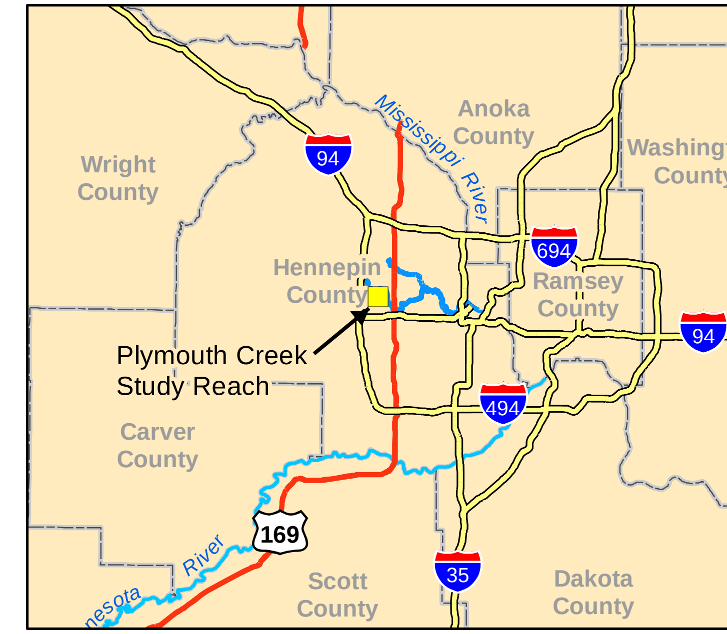
Precipitation data for target wetland location:

County: Hennepin
Township Name: Plymouth
Nearest Community: Plymouth
Township Number: 118N
Range Number: 22W
Section Number: 21

Precipitation Totals are in Inches	
Color Key	**Multi-month Totals**:
total is in lowest 30th percentile of the period-of-record distribution	**WARM** = warm season (May thru September)
total is => 30th and <= 70th percentile	**ANN** = calendar year (January thru December)
total is in highest 30th percentile of the period-of-record distribution	**WAT** = water year (Oct. previous year thru Sep. present year)

Period-of-Record Summary Statistics															
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*WARM*	*ANN*	*WAT*
30%	0.53	0.53	1.13	1.50	2.62	3.25	2.41	2.94	1.92	1.16	0.75	0.59	16.18	26.29	25.98
70%	1.07	1.24	1.95	2.76	4.28	5.66	4.50	4.44	3.75	2.65	1.92	1.31	20.94	32.47	32.04
mean	0.90	0.92	1.65	2.40	3.70	4.50	3.82	3.62	3.04	2.18	1.50	1.03	18.67	29.24	29.30
1971-2000 Summary Statistics															
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*WARM*	*ANN*	*WAT*
30%	0.63	0.35	1.25	1.33	2.70	3.24	2.83	3.34	1.98	0.98	1.12	0.60	17.43	28.26	27.09
70%	1.13	0.98	1.96	2.62	4.03	5.53	4.89	4.84	3.28	2.80	2.24	1.28	20.78	32.84	33.70
mean	1.00	0.82	1.82	2.31	3.47	4.41	4.43	4.08	2.94	2.18	1.90	0.96	19.33	30.33	30.47
1981-2010 Summary Statistics															
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*WARM*	*ANN*	*WAT*
30%	0.53	0.40	1.27	2.03	2.70	3.32	2.50	3.16	2.27	1.29	1.05	0.69	17.17	28.50	27.09
70%	1.06	0.91	1.96	2.84	4.08	5.44	4.41	4.91	3.73	3.35	2.02	1.45	21.56	34.09	34.04
mean	0.83	0.80	1.81	2.66	3.56	4.44	4.14	4.16	3.39	2.45	1.72	1.17	19.70	31.14	30.95
Year-to-Year Data															
Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*WARM*	*ANN*	*WAT*
2015	0.38	0.34	0.67	1.84	4.44	3.56	7.02	3.60	3.76	2.84	-	-	22.38	-	28.86
2014	1.33	1.46	0.75	7.49	4.63	11.07	3.27	2.99	2.01	1.10	1.16	0.99	23.97	38.25	41.53
2013	0.65	1.17	1.89	4.05	5.17	7.78	4.72	1.53	1.45	4.37	0.58	1.58	20.65	34.94	32.40
2012	0.46	2.13	1.20	2.95	9.96	4.25	4.35	1.38	0.54	1.62	0.83	1.54	20.48	31.21	29.04
2011	0.92	0.96	1.57	3.00	6.50	4.13	6.45	3.64	0.60	0.94	0.16	0.72	21.32	29.59	34.81
2010	0.57	0.80	0.95	1.85	3.00	5.77	3.46	5.61	6.08	2.02	1.98	3.04	23.92	35.13	36.51
2009	0.43	0.91	1.92	1.18	0.49	3.80	0.89	6.62	0.87	5.62	0.60	2.20	12.67	25.53	21.26
2008	0.16	0.52	2.00	3.71	2.51	4.46	2.21	3.05	2.66	1.49	1.21	1.45	14.89	25.43	28.32
2007	0.71	1.29	3.31	2.37	3.22	1.30	2.02	6.86	4.96	5.24	0.09	1.71	18.36	33.08	30.45
2006	0.57	0.41	1.54	3.18	3.27	4.05	1.57	4.42	3.27	0.68	1.13	2.60	16.58	26.69	29.85
2005	1.31	0.88	1.23	2.47	3.50	6.25	2.47	3.08	6.59	4.60	1.61	1.36	21.89	35.35	32.81
2004	0.45	1.33	2.18	2.54	6.36	5.73	4.35	1.45	5.17	3.55	1.05	0.43	23.06	34.59	32.41
2003	0.22	0.92	1.62	2.77	4.66	6.73	2.36	0.47	2.52	0.92	1.13	0.80	16.74	25.12	26.26
2002	0.55	0.55	1.81	3.86	3.95	8.13	6.51	7.09	4.24	3.66	0.07	0.26	29.92	40.68	41.01
2001	1.25	1.25	0.89	7.93	5.27	5.07	2.51	3.17	3.46	0.87	2.86	0.59	19.48	35.12	36.01
2000	0.88	1.12	0.99	1.33	3.43	3.32	6.17	3.07	2.06	0.86	3.23	1.12	18.05	27.58	24.16
1999	1.19	0.32	1.54	3.12	6.57	5.31	4.49	4.06	2.33	0.66	0.81	0.32	22.76	30.72	33.69
1998	1.07	0.78	3.54	1.66	3.77	4.53	2.86	4.94	1.25	2.52	1.63	0.61	17.35	29.16	27.14
1997	1.60	0.26	1.39	1.04	1.73	2.62	9.74	4.54	2.86	1.95	0.57	0.22	21.49	28.52	36.05
1996	2.26	0.34	1.95	0.64	4.26	3.89	1.66	1.57	1.60	3.96	4.74	1.57	12.98	28.44	25.72

Figures



Legend

- Study Reach
- Streams

N

Feet

250 0 250 500

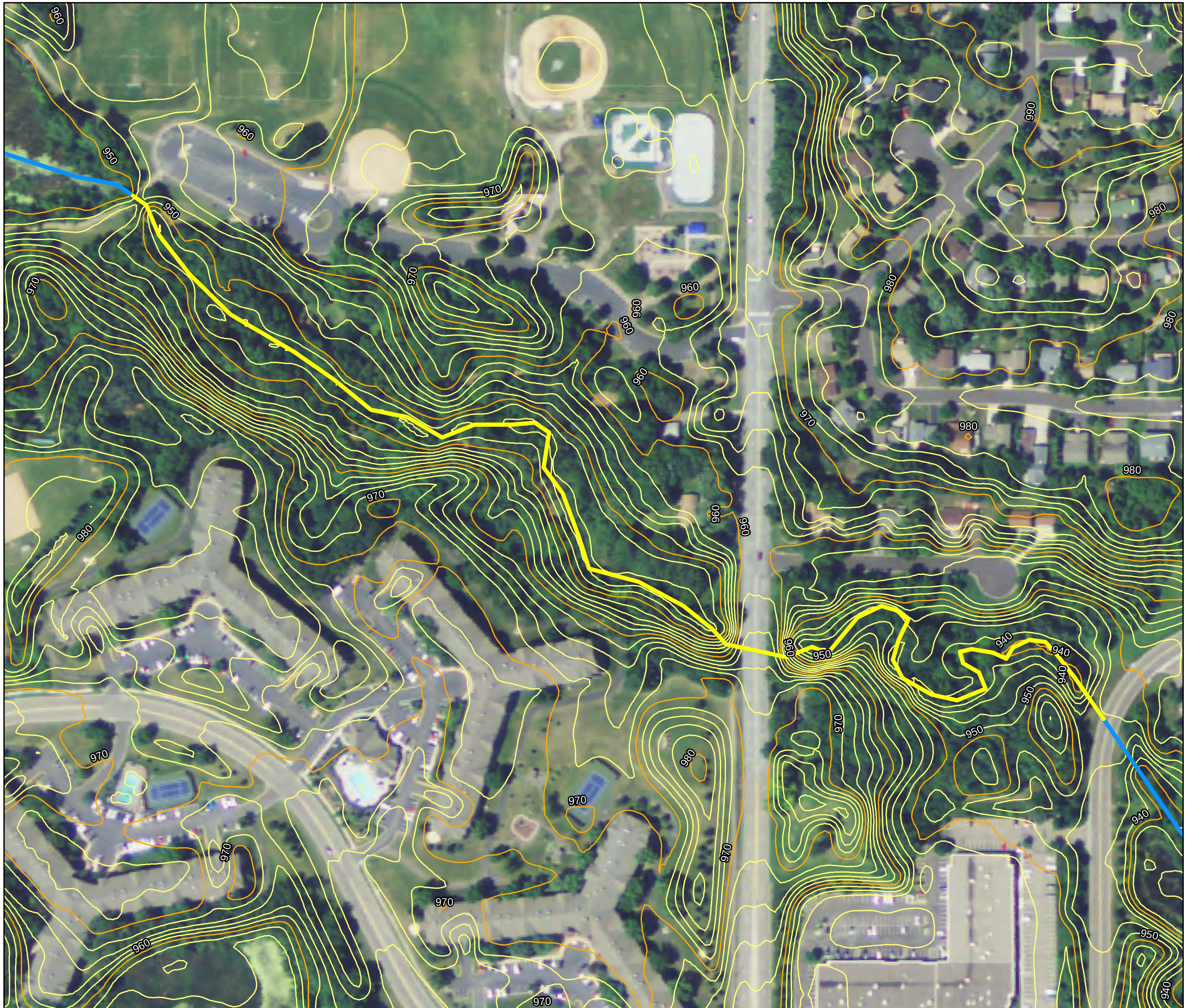
Meters

100 0 100

BARR

Figure 1

PROJECT LOCATION MAP
Plymouth Creek Feasibility Study
Wetland Delineation
Bassett Creek Watershed
Management Commission



Legend

- Plymouth Creek
- Plymouth Creek Study Reach

Contours

- 10-Foot Contour
- 2-Foot Contour

N

Feet

400 0

Meters

100 0

BARR

Figure 2

TOPOGRAPHY MAP
Plymouth Creek Feasibility Study
Wetland Delineation
Bassett Creek Watershed
Management Commission

Legend

- Plymouth Creek
- Plymouth Creek Study Reach
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine

N

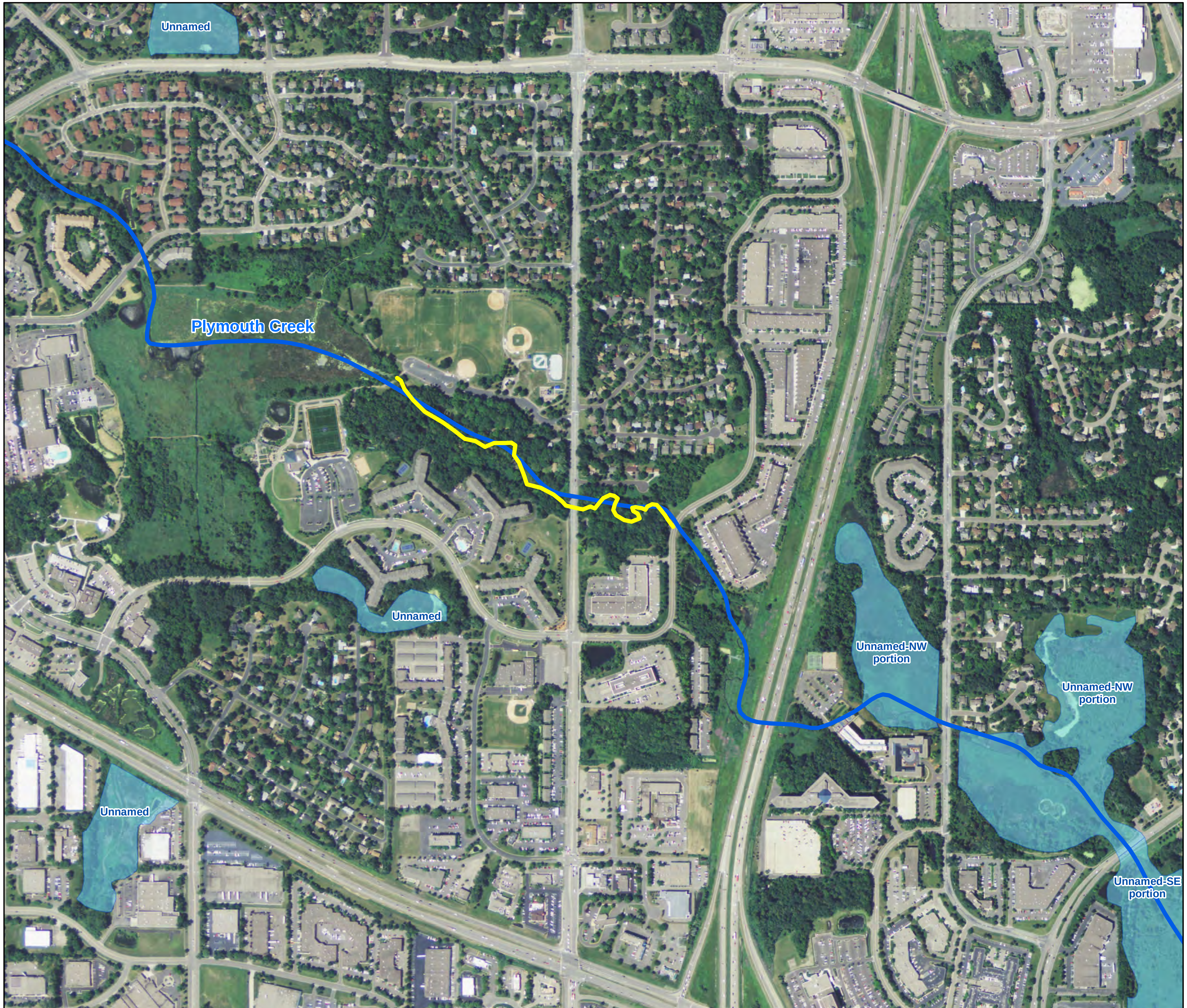
Feet
400 0

Meters
100 0

BARR

Figure 3

NATIONAL WETLAND INVENTORY
Plymouth Creek Feasibility Study
Wetland Delineation
Bassett Creek Watershed
Management Commission



Legend

- Plymouth Creek Study Reach
- Public Water Inventory Watercourses
- Public Water Inventory Basins

N

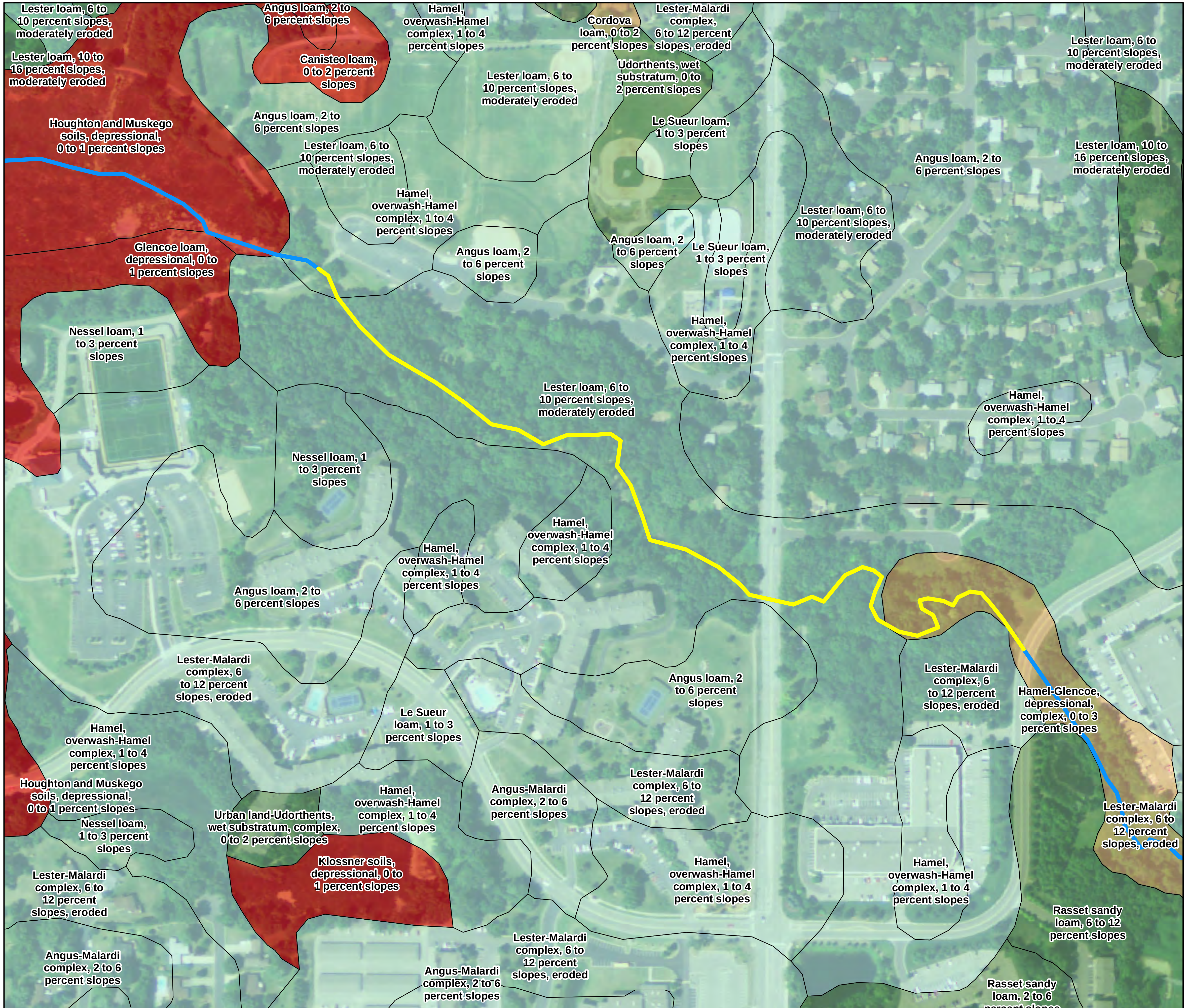
Feet
400 0 400 800

Meters
100 0 100 200

BARR

Figure 4

PUBLIC WATER INVENTORY
Plymouth Creek Feasibility Study
Wetland Delineation
Bassett Creek Watershed
Management Commission



Legend

Plymouth Creek Study Reach

Plymouth Creek

Soils Hydric Rating

- Hydric
- Predominately Hydric
- Predominately Non-Hydric
- Non-Hydric

N

Feet

500 0

Meters

100 0

BARR

Figure 5

SOIL SURVEY
Plymouth Creek Feasibility Study
Wetland Delineation
Bassett Creek Watershed
Management Commission

Legend

Sample Points

Feature Type

Creek

Upland Island

Wetland

N

Feet
100 0 100 200

Meters
50 0 50

BARR

Figure 6

WETLAND & CREEK DELINEATION
Plymouth Creek Feasibility Study
Wetland Delineation
Bassett Creek Watershed
Management Commission

Appendix A

Wetland Data Forms

WETLAND DETERMINATION DATA FORM - Midwest Region

Project/Site: Plymouth Creek   Applicant/Owner: BCWMC   City/County: Plymouth/Hennepin   State: MN   Sampling Date: 10/16/15

Investigator(s): BKB   Section: 16   Township: 118   Range: 22   Sampling Point: 1-1 UPL

Land Form: Footslope   Local Relief: None   Slope %: 2   Soil Map Unit Name: Lester loam, 1 to 3 percent slopes

Subregion (LRR): M   Latitude: 4985548   Longitude: 463337   Datum: UTM Nad 83 Zone 15N Meters

Cowardin Classification: Upland   Circular 39 Classification: Upland   Mapped NWI Classification: Upland

Are climatic/hydrologic conditions on the site typical for this time of year? Yes (If no, explain in remarks)   Eggers & Reed (primary): Upland

Are vegetation No Soil No Hydrology No significantly disturbed?   Are "normal circumstances" present? Yes   Eggers & Reed (secondary):

Eggers & Reed (tertiary):

Are vegetation No Soil No Hydrology No naturally problematic?   Eggers & Reed (quaternary):

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic vegetation present?	No	General Remarks (explain any answers if needed):
Hydric soil present?	No	
Indicators of wetland hydrology present?	No	
Is the sampled area within a wetland?	No	If yes, optional Wetland Site ID: Upland

VEGETATION

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot Size: 30 ft)			
1. Acer saccharum	25	Yes	FACU
2.	0		
3.	0		
4.	0		
Total Cover:	25		
Sapling/Shrub Stratum (Plot Size: 15 ft)			
1. Acer saccharum	10	Yes	FACU
2.	0		
3.	0		
4.	0		
5.	0		
Total Cover:	10		
Herb Stratum (Plot Size: 5 ft)			
1. Taraxacum officinale	15	Yes	FACU
2. Carex sp.	10	Yes	
3. Plantago major	5	No	FAC
4. Trifolium pratense	5	No	FACU
5. Cirsium arvense	2	No	FACU
6. Arctium minus	2	No	FACU
7. Solanum dulcamara	2	No	FAC
8. Verbascum thapsus	1	No	UPL
Total Cover:	42		
Woody Vine Stratum (Plot Size: 30 ft)			
1.	0		
2.	0		
Total Cover:	0		

% Bare Ground in Herb Stratum: ____   % Sphagnum Moss Cover: ____

Vegetation Remarks: (include photo numbers here or on a separate sheet)

50/20 Thresholds:	20%	50%
Tree Stratum	5	12.5
Sapling/Shrub Stratum	2	5
Herb Stratum	8.4	21
Woody Vine Stratum	0	0

Dominance Test Worksheet:

Number of Dominant Species That Are OBL, FACW or FAC:	0	(A)
Total Number of Dominant Species Across All Strata:	4	(B)
Percent of Dominant Species That Are OBL, FACW or FAC:	0.00%	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:	
OBL Species	0	X 1	0
FACW Species	0	X 2	0
FAC Species	7	X 3	21
FACU Species	59	X 4	236
UPL Species	1	X 5	5
Column Totals:	67 (A)		262 (B)

Prevalence Index = B/A = 3.91

Hydrophytic Vegetation Indicators:

No	Rapid Test for Hydrophytic Vegetation
No	Dominance Test is >50%
No	Prevalence Index ≤ 3.0 [1]
No	Morphological Adaptations [1] (provide supporting data in vegetation remarks or on a separate sheet)
No	Problematic Hydrophytic Vegetation [1] (Explain)

[1] Indicators of hydric soil & wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic vegetation present? No

1/25/2016 12:21:11 PM

WETLAND DETERMINATION DATA FORM - Midwest Region

SOIL

Sampling Point: 1-1 UPL

Profile Description: (Describe to the depth needed to document the indicator or confirm the abscence of indicators).

	Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
1.	0 - 11	10YR 2/1						Silt Loam	
2.	11 - 17	10YR 2/1	99	10YR 5/1	1	D	M	Sandy Loam	1% coarse depletions
3.	17 - 20	10YR 3/1	98	10YR 4/2	2	D	M	Sandy Loam	
4.	20 - 24	10YR 2/2	98	7.5 YR 3/4	2	C	M	Sandy Clay Loam	
5.	-								
6.	-								

[1] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2] Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (applicable to all LRRs, unless otherwise noted)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils [3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (explain in soil remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present): Type: ______ Depth (inches): ______

Hydric soil present? No

Soil Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (explain in remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ FAC-Neutral Test (D5)

Field Observations:

- Surface water present? ☐ Surface Water Depth (inches): ______
- Water table present? ☐ Water Table Depth (inches): ______
- Saturation present? (includes capillary fringe) ☐ Saturation Depth (inches): ______

Indicators of wetland hydrology present? No

Describe Recorded Data:

Recorded Data: ☐ Aerial Photo ☐ Monitoring Well ☐ Stream Gauge ☐ Previous Inspections

Hydrology Remarks:

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WETLAND DETERMINATION DATA FORM - Midwest Region

Project/Site: Plymouth Creek | Applicant/Owner: BCWMC | City/County: Plymouth/Hennepin | State: MN | Sampling Date: 10/16/15

Investigator(s): BKB | Section: 16 | Township: 118 | Range: 22 | Sampling Point: 1-1 WET

Land Form: Flat | Local Relief: None | Slope %: 0 | Soil Map Unit Name: Lester loam, 1 to 3 percent slopes

Subregion (LRR): M | Latitude: 4985553 | Longitude: 463342 | Datum: UTM Nad 83 Zone 15N Meters

Cowardin Classification: PEMA | Circular 39 Classification: Type 1 | Mapped NWI Classification: Upland

Are climatic/hydrologic conditions on the site typical for this time of year? Yes (If no, explain in remarks)

Eggers & Reed (primary): Seasonally Flooded Basin

Are vegetation No Soil No Hydrology No significantly disturbed?

Are "normal circumstances" present? Yes

Eggers & Reed (secondary):

Eggers & Reed (tertiary):

Are vegetation No Soil No Hydrology No naturally problematic?

Eggers & Reed (quaternary):

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic vegetation present?	Yes
Hydric soil present?	Yes
Indicators of wetland hydrology present?	Yes
Is the sampled area within a wetland?	Yes

General Remarks (explain any answers if needed):

If yes, optional Wetland Site ID: Wetland 1

VEGETATION

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot Size: 30 ft)			
1. Ulmus americana	20	Yes	FACW
2. Acer saccharum	5	Yes	FACU
3.	0		
4.	0		
Total Cover:	25		
Sapling/Shrub Stratum (Plot Size: 15 ft)			
1. Rhamnus cathartica	1	No	FAC
2.	0		
3.	0		
4.	0		
5.	0		
Total Cover:	1		
Herb Stratum (Plot Size: 5 ft)			
1. Phalaris arundinacea	60	Yes	FACW
2. Scirpus atrovirens	15	No	OBL
3. Urtica dioica	10	No	FACW
4. Carex sp.	5	No	
5.	0		
6.	0		
7.	0		
8.	0		
Total Cover:	90		
Woody Vine Stratum (Plot Size: 30 ft)			
1.	0		
2.	0		
Total Cover:	0		

% Bare Ground in Herb Stratum: ____ % Sphagnum Moss Cover: ____

Vegetation Remarks: (include photo numbers here or on a separate sheet)

50/20 Thresholds:	20%	50%
Tree Stratum	5	12.5
Sapling/Shrub Stratum	0.2	0.5
Herb Stratum	18	45
Woody Vine Stratum	0	0

Dominance Test Worksheet:

Number of Dominant Species That Are OBL, FACW or FAC:	2	(A)
Total Number of Dominant Species Across All Strata:	3	(B)
Percent of Dominant Species That Are OBL, FACW or FAC:	66.67%	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:	
OBL Species	15	X 1	15
FACW Species	90	X 2	180
FAC Species	1	X 3	3
FACU Species	5	X 4	20
UPL Species	0	X 5	0
Column Totals:	111 (A)		218 (B)

Prevalence Index = B/A = 1.96

Hydrophytic Vegetation Indicators:

No	Rapid Test for Hydrophytic Vegetation
Yes	Dominance Test is >50%
Yes	Prevalence Index ≤ 3.0 [1]
No	Morphological Adaptations [1] (provide supporting data in vegetation remarks or on a separate sheet)
No	Problematic Hydrophytic Vegetation [1] (Explain)

[1] Indicators of hydric soil & wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic vegetation present? Yes

WETLAND DETERMINATION DATA FORM - Midwest Region

SOIL

Sampling Point: 1-1 WET

Profile Description: (Describe to the depth needed to document the indicator or confirm the abscence of indicators).

	Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
1.	0 - 9	10YR 2/1	98	7.5YR 3/4	2	C	M	Sandy Loam	
2.	9 - 18	10YR 4/2	95	7.5YR 3/4	5	C	M	Fine Sandy Loam	
3.	18 - 25	N 2.5/0	100					Sandy Mucky Mineral	
4.	-								
5.	-								
6.	-								

[1] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2] Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (applicable to all LRRs, unless otherwise noted)

- [ ] Histosol (A1)
- [ ] Histic Epipedon (A2)
- [ ] Black Histic (A3)
- [ ] Hydrogen Sulfide (A4)
- [ ] Stratified Layers (A5)
- [ ] 2 cm Muck (A10)
- [ ] Depleted Below Dark Surface (A11)
- [ ] Thick Dark Surface (A12)
- [ ] Sandy Mucky Mineral (S1)
- [ ] 5 cm Mucky Peat or Peat (S3)
- [ ] Sandy Gleyed Matrix (S4)
- [x] Sandy Redox (S5)
- [ ] Stripped Matrix (S6)
- [ ] Loamy Mucky Mineral (F1)
- [ ] Loamy Gleyed Matrix (F2)
- [ ] Depleted Matrix (F3)
- [ ] Redox Dark Surface (F6)
- [ ] Depleted Dark Surface (F7)
- [ ] Redox Depressions (F8)

Indicators for Problematic Hydric Soils [3]:

- [ ] Coast Prairie Redox (A16)
- [ ] Dark Surface (S7)
- [ ] Iron-Manganese Masses (F12)
- [ ] Very Shallow Dark Surface (TF12)
- [ ] Other (explain in soil remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present): Type: Depth (inches):

Hydric soil present? Yes

Soil Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- [ ] Surface Water (A1)
- [x] High Water Table (A2)
- [x] Saturation (A3)
- [ ] Water Marks (B1)
- [ ] Sediment Deposits (B2)
- [ ] Drift Deposits (B3)
- [ ] Algal Mat or Crust (B4)
- [ ] Iron Deposits (B5)
- [ ] Inundation Visible on Aerial Imagery (B7)
- [ ] Sparsely Vegetated Concave Surface (B8)
- [ ] Water-Stained Leaves (B9)
- [ ] Aquatic Fauna (B13)
- [ ] True Aquatic Plants (B14)
- [ ] Hydrogen Sulfide Odor (C1)
- [ ] Oxidized Rhizospheres on Living Roots (C3)
- [ ] Presence of Reduced Iron (C4)
- [ ] Recent Iron Reduction in Tilled Soils (C6)
- [ ] Thin Muck Surface (C7)
- [ ] Gauge or Well Data (D9)
- [ ] Other (explain in remarks)

Secondary Indicators (minimum of two required)

- [ ] Surface Soil Cracks (B6)
- [ ] Drainage Patterns (B10)
- [ ] Dry-Season Water Table (C2)
- [ ] Crayfish Burrows (C8)
- [ ] Saturation Visible on Aerial Imagery (C9)
- [ ] Stunted or Stressed Plants (D1)
- [x] Geomorphic Position (D2)
- [x] FAC-Neutral Test (D5)

Field Observations:

	Present		Depth
Surface water present?	[ ]	Surface Water Depth (inches):	
Water table present?	[x]	Water Table Depth (inches):	8
Saturation present? (includes capillary fringe)	[x]	Saturation Depth (inches):	0

Indicators of wetland hydrology present? Yes

Describe Recorded Data:

Recorded Data: [ ] Aerial Photo [ ] Monitoring Well [ ] Stream Gauge [ ] Previous Inspections

Hydrology Remarks:

WETLAND DETERMINATION DATA FORM - Midwest Region

Project/Site: Plymouth Creek Applicant/Owner: BCWMC City/County: Plymouth/Hennepin State: MN Sampling Date: 10/16/15

Investigator(s): BKB Section: 21 Township: 118 Range: 22 Sampling Point: 2-1 UPL

Land Form: Hillslope Local Relief: Concave Slope %: 3 Soil Map Unit Name: Lester loam, 1 to 3 percent slopes

Subregion (LRR): M Latitude: 4985472 Longitude: 463549 Datum: UTM Nad 83 Zone 15N Meters

Cowardin Classification: Upland Circular 39 Classification: Upland Mapped NWI Classification: Upland

Are climatic/hydrologic conditions on the site typical for this time of year? Yes (If no, explain in remarks) Eggers & Reed (primary): Upland

Are vegetation No Soil No Hydrology No significantly disturbed? Are "normal circumstances" present? Yes Eggers & Reed (secondary):

Eggers & Reed (tertiary):

Are vegetation No Soil No Hydrology No naturally problematic? Eggers & Reed (quaternary):

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic vegetation present?	No
Hydric soil present?	No
Indicators of wetland hydrology present?	No
Is the sampled area within a wetland?	No

General Remarks (explain any answers if needed):

If yes, optional Wetland Site ID: Upland

VEGETATION

Tree Stratum (Plot Size: 30 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Acer saccharum	90	Yes	FACU
2.		0		
3.		0		
4.		0		
	Total Cover:	90		

Sapling/Shrub Stratum (Plot Size: 15 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Rhamnus cathartica	20	Yes	FAC
2.		0		
3.		0		
4.		0		
5.		0		
	Total Cover:	20		

Herb Stratum (Plot Size: 5 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Acer saccharum	40	Yes	FACU
2.	Rhamnus cathartica	10	Yes	FAC
3.		0		
4.		0		
5.		0		
6.		0		
7.		0		
8.		0		
	Total Cover:	50		

Woody Vine Stratum (Plot Size: 30 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.		0		
2.		0		
	Total Cover:	0		

% Bare Ground in Herb Stratum: % Sphagnum Moss Cover:

Vegetation Remarks: (include photo numbers here or on a separate sheet)

50/20 Thresholds:

	20%	50%
Tree Stratum	18	45
Sapling/Shrub Stratum	4	10
Herb Stratum	10	25
Woody Vine Stratum	0	0

Dominance Test Worksheet:

Number of Dominant Species That Are OBL, FACW or FAC:	2	(A)
Total Number of Dominant Species Across All Strata:	4	(B)
Percent of Dominant Species That Are OBL, FACW or FAC:	50.00%	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:	
OBL Species	0	X 1	0
FACW Species	0	X 2	0
FAC Species	30	X 3	90
FACU Species	130	X 4	520
UPL Species	0	X 5	0
Column Totals:	160	(A)	610 (B)

Prevalence Index = B/A = 3.81

Hydrophytic Vegetation Indicators:

- No — Rapid Test for Hydrophytic Vegetation
- No — Dominance Test is >50%
- No — Prevalence Index ≤ 3.0 [1]
- No — Morphological Adaptations [1] (provide supporting data in vegetation remarks or on a separate sheet)
- No — Problematic Hydrophytic Vegetation [1] (Explain)

[1] Indicators of hydric soil & wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic vegetation present? No

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WETLAND DETERMINATION DATA FORM - Midwest Region

SOIL

Sampling Point: 2-1 UPL

Profile Description: (Describe to the depth needed to document the indicator or confirm the abscence of indicators).

	Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
1.	0 - 8	10YR 2/1						Clay Loam	
2.	8 - 15	10YR 3/2						Clay	
3.	15 - 20	10YR 5/4	98	10YR 5/8	2	C	M	Sandy Clay Loam	
4.	-								
5.	-								
6.	-								

[1] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2] Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (applicable to all LRRs, unless otherwise noted)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils [3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (explain in soil remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present): Type: Depth (inches):

Hydric soil present? No

Soil Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (explain in remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ FAC-Neutral Test (D5)

Field Observations:

- Surface water present? ☐ Surface Water Depth (inches):
- Water table present? ☐ Water Table Depth (inches):
- Saturation present? (includes capillary fringe) ☐ Saturation Depth (inches):

Indicators of wetland hydrology present? No

Describe Recorded Data:

Recorded Data: ☐ Aerial Photo ☐ Monitoring Well ☐ Stream Gauge ☐ Previous Inspections

Hydrology Remarks:

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WETLAND DETERMINATION DATA FORM - Midwest Region

Project/Site: Plymouth Creek | Applicant/Owner: BCWMC | City/County: Plymouth/Hennepin | State: MN | Sampling Date: 10/16/15

Investigator(s): BKB | Section: 21 | Township: 118 | Range: 22 | Sampling Point: 2-1 WET-A

Land Form: Flat | Local Relief: None | Slope %: 0 | Soil Map Unit Name: Lester loam, 1 to 3 percent slopes

Subregion (LRR): M | Latitude: 4985467 | Longitude: 463541 | Datum: UTM Nad 83 Zone 15N Meters

Cowardin Classification: PEMB | Circular 39 Classification: Type 2 | Mapped NWI Classification: Upland

Are climatic/hydrologic conditions on the site typical for this time of year? Yes (If no, explain in remarks)

Eggers & Reed (primary): Fresh (Wet) Meadow

Eggers & Reed (secondary):

Eggers & Reed (tertiary):

Eggers & Reed (quaternary):

Are vegetation No Soil No Hydrology No significantly disturbed?

Are vegetation No Soil No Hydrology No naturally problematic?

Are "normal circumstances" present? Yes

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic vegetation present?	Yes
Hydric soil present?	Yes
Indicators of wetland hydrology present?	Yes
Is the sampled area within a wetland?	Yes

General Remarks (explain any answers if needed):

If yes, optional Wetland Site ID: Wetland 2

VEGETATION

Tree Stratum (Plot Size: 30 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Populus deltoides	15	Yes	FAC
2.		0		
3.		0		
4.		0		
	Total Cover:	15		

Sapling/Shrub Stratum (Plot Size: 15 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.		0		
2.		0		
3.		0		
4.		0		
5.		0		
	Total Cover:	0		

Herb Stratum (Plot Size: 5 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Phalaris arundinacea	100	Yes	FACW
2.		0		
3.		0		
4.		0		
5.		0		
6.		0		
7.		0		
8.		0		
	Total Cover:	100		

Woody Vine Stratum (Plot Size: 30 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.		0		
2.		0		
	Total Cover:	0		

% Bare Ground in Herb Stratum:

% Sphagnum Moss Cover:

Vegetation Remarks: (include photo numbers here or on a separate sheet)

50/20 Thresholds:

	20%	50%
Tree Stratum	3	7.5
Sapling/Shrub Stratum	0	0
Herb Stratum	20	50
Woody Vine Stratum	0	0

Dominance Test Worksheet:

Number of Dominant Species That Are OBL, FACW or FAC:	2	(A)
Total Number of Dominant Species Across All Strata:	2	(B)
Percent of Dominant Species That Are OBL, FACW or FAC:	100.00%	(A/B)

Prevalence Index Worksheet:

	Total % Cover of:	Multiply by:	
OBL Species	0	X 1	0
FACW Species	100	X 2	200
FAC Species	15	X 3	45
FACU Species	0	X 4	0
UPL Species	0	X 5	0
Column Totals:	115 (A)		245 (B)

Prevalence Index = B/A = 2.13

Hydrophytic Vegetation Indicators:

No	Rapid Test for Hydrophytic Vegetation
Yes	Dominance Test is >50%
Yes	Prevalence Index ≤ 3.0 [1]
No	Morphological Adaptations [1] (provide supporting data in vegetation remarks or on a separate sheet)
No	Problematic Hydrophytic Vegetation [1] (Explain)

[1] Indicators of hydric soil & wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic vegetation present? Yes

WETLAND DETERMINATION DATA FORM - Midwest Region

SOIL

Sampling Point: 2-1 WET-A

Profile Description: (Describe to the depth needed to document the indicator or confirm the abscence of indicators).

	Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
1.	0 - 8	10YR 3/1						Clay Loam	
2.	8 - 14	10YR 4/2	80	7.5YR 3/4	20	C	M	Clay Loam	
3.	14 - 20	5Y 4/1						Clay Loam	Gravelly
4.	-								
5.	-								
6.	-								

[1] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2] Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (applicable to all LRRs, unless otherwise noted)

- [ ] Histosol (A1)
- [ ] Histic Epipedon (A2)
- [ ] Black Histic (A3)
- [ ] Hydrogen Sulfide (A4)
- [ ] Stratified Layers (A5)
- [ ] 2 cm Muck (A10)
- [ ] Depleted Below Dark Surface (A11)
- [ ] Thick Dark Surface (A12)
- [ ] Sandy Mucky Mineral (S1)
- [ ] 5 cm Mucky Peat or Peat (S3)
- [ ] Sandy Gleyed Matrix (S4)
- [ ] Sandy Redox (S5)
- [ ] Stripped Matrix (S6)
- [ ] Loamy Mucky Mineral (F1)
- [ ] Loamy Gleyed Matrix (F2)
- [ ] Depleted Matrix (F3)
- [x] Redox Dark Surface (F6)
- [ ] Depleted Dark Surface (F7)
- [ ] Redox Depressions (F8)

Indicators for Problematic Hydric Soils [3]:

- [ ] Coast Prairie Redox (A16)
- [ ] Dark Surface (S7)
- [ ] Iron-Manganese Masses (F12)
- [ ] Very Shallow Dark Surface (TF12)
- [ ] Other (explain in soil remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present): Type: ______ Depth (inches): ______

Hydric soil present? Yes

Soil Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- [ ] Surface Water (A1)
- [ ] High Water Table (A2)
- [ ] Saturation (A3)
- [ ] Water Marks (B1)
- [ ] Sediment Deposits (B2)
- [ ] Drift Deposits (B3)
- [ ] Algal Mat or Crust (B4)
- [ ] Iron Deposits (B5)
- [ ] Inundation Visible on Aerial Imagery (B7)
- [ ] Sparsely Vegetated Concave Surface (B8)
- [ ] Water-Stained Leaves (B9)
- [ ] Aquatic Fauna (B13)
- [ ] True Aquatic Plants (B14)
- [ ] Hydrogen Sulfide Odor (C1)
- [ ] Oxidized Rhizospheres on Living Roots (C3)
- [ ] Presence of Reduced Iron (C4)
- [ ] Recent Iron Reduction in Tilled Soils (C6)
- [ ] Thin Muck Surface (C7)
- [ ] Gauge or Well Data (D9)
- [ ] Other (explain in remarks)

Secondary Indicators (minimum of two required)

- [ ] Surface Soil Cracks (B6)
- [ ] Drainage Patterns (B10)
- [ ] Dry-Season Water Table (C2)
- [ ] Crayfish Burrows (C8)
- [ ] Saturation Visible on Aerial Imagery (C9)
- [ ] Stunted or Stressed Plants (D1)
- [x] Geomorphic Position (D2)
- [x] FAC-Neutral Test (D5)

Field Observations:

- Surface water present? [ ] Surface Water Depth (inches): ______
- Water table present? [ ] Water Table Depth (inches): ______
- Saturation present? (includes capillary fringe) [ ] Saturation Depth (inches): ______

Indicators of wetland hydrology present? Yes

Describe Recorded Data:

Soils were moist at 5 inches below ground surface

Recorded Data: [ ] Aerial Photo [ ] Monitoring Well [ ] Stream Gauge [ ] Previous Inspections

Hydrology Remarks:

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WETLAND DETERMINATION DATA FORM - Midwest Region

Project/Site:	Plymouth Creek	Applicant/Owner:	BCWMC	City/County:	Plymouth/Hennepin	State:	MN	Sampling Date:	10/16/15
Investigator(s):	BKB	Section:	21	Township:	118	Range:	22	Sampling Point:	2-1 WET-B
Land Form:	Flat	Local Relief:	None	Slope %:	0	Soil Map Unit Name:	Lester loam, 1 to 3 percent slopes		
Subregion (LRR):	M	Latitude:	4985463	Longitude:	463535	Datum:	UTM Nad 83 Zone 15N Meters		
Cowardin Classification:	PEMB	Circular 39 Classification:	Type 2	Mapped NWI Classification:	R2UBG				

Are climatic/hydrologic conditions on the site typical for this time of year? Yes (If no, explain in remarks)

Eggers & Reed (primary): Fresh (Wet) Meadow

Are vegetation No Soil No Hydrology No significantly disturbed?

Are vegetation No Soil No Hydrology No naturally problematic?

Are "normal circumstances" present? Yes

Eggers & Reed (secondary):

Eggers & Reed (tertiary):

Eggers & Reed (quaternary):

SUMMARY OF FINDINGS - Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic vegetation present?	0
Hydric soil present?	Yes
Indicators of wetland hydrology present?	Yes
Is the sampled area within a wetland?	Yes

General Remarks (explain any answers if needed):

If yes, optional Wetland Site ID: Wetland 2

VEGETATION

Tree Stratum (Plot Size: 30 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Populus deltoides	10	Yes	FAC
2.		0		
3.		0		
4.		0		
	Total Cover:	10		

Sapling/Shrub Stratum (Plot Size: 15 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.		0		
2.		0		
3.		0		
4.		0		
5.		0		
	Total Cover:	0		

Herb Stratum (Plot Size: 5 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.	Phalaris arundinacea	100	Yes	FACW
2.	Persicaria amphibia	1	No	OBL
3.		0		
4.		0		
5.		0		
6.		0		
7.		0		
8.		0		
	Total Cover:	101		

Woody Vine Stratum (Plot Size: 30 ft)

	Species	Absolute % Cover	Dominant Species?	Indicator Status
1.		0		
2.		0		
	Total Cover:	0		

% Bare Ground in Herb Stratum: ____ % Sphagnum Moss Cover: ____

Vegetation Remarks: (include photo numbers here or on a separate sheet)

50/20 Thresholds:

	20%	50%
Tree Stratum	2	5
Sapling/Shrub Stratum	0	0
Herb Stratum	20.2	50.5
Woody Vine Stratum	0	0

Dominance Test Worksheet:

Number of Dominant Species That Are OBL, FACW or FAC:	2	(A)
Total Number of Dominant Species Across All Strata:	2	(B)
Percent of Dominant Species That Are OBL, FACW or FAC:	100.00%	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:	
OBL Species	1	X 1	1
FACW Species	100	X 2	200
FAC Species	10	X 3	30
FACU Species	0	X 4	0
UPL Species	0	X 5	0
Column Totals:	111 (A)		231 (B)

Prevalence Index = B/A = 2.08

Hydrophytic Vegetation Indicators:

No	Rapid Test for Hydrophytic Vegetation
Yes	Dominance Test is >50%
Yes	Prevalence Index ≤ 3.0 [1]
No	Morphological Adaptations [1] (provide supporting data in vegetation remarks or on a separate sheet)
No	Problematic Hydrophytic Vegetation [1] (Explain)

[1] Indicators of hydric soil & wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic vegetation present? 0

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WETLAND DETERMINATION DATA FORM - Midwest Region

SOIL

Sampling Point: 2-1 WET-B

Profile Description: (Describe to the depth needed to document the indicator or confirm the abscence of indicators).

	Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type [1]	Loc [2]	Texture	Remarks
1.	0 - 15	5GY 4/1 Gley	40	7.5 YR 3/4	2	C	M	Sandy Clay	
2.	0 - 15	10Y 3/1 Gley	60						
3.	15 - 25	5Y 4/1						Sand	
4.	-								
5.	-								
6.	-								

[1] Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains   [2] Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (applicable to all LRRs, unless otherwise noted)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☑ Sandy Gleyed Matrix (S4)
- ☑ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils [3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (explain in soil remarks)

[3] Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present): Type: ______ Depth (inches): ______

Hydric soil present? Yes

Soil Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (explain in remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☑ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface water present?	☐	Surface Water Depth (inches):	
Water table present?	☐	Water Table Depth (inches):	
Saturation present? (includes capillary fringe)	☑	Saturation Depth (inches):	20

Indicators of wetland hydrology present? Yes

Describe Recorded Data:

Recorded Data: ☐ Aerial Photo ☐ Monitoring Well ☐ Stream Gauge ☐ Previous Inspections

Hydrology Remarks:

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Appendix B

Site Photographs

Appendix B – Plymouth Creek Feasibility Study Wetland Delineation Site Photos

Photo 1 – September 22, 2015 Study Reach (West of Fernbrook Ln. N) Water-level-control structure at start of the survey within Plymouth Creek Park.	
Photo 2 – September 22, 2015 Study Reach (West of Fernbrook Ln. N) Bridge crossing and typical view of Plymouth Creek in this area.	
Photo 3 – September 22, 2015 Wetland 1 Facing southeast. This photo shows the eroded edge of Wetland 1 and saturated soils.	

Appendix B – Plymouth Creek Feasibility Study Wetland Delineation Site Photos

Photo 4 – September 22, 2015

Wetland 2

Facing northwest. The upland island is located on the right side of the photo.

Photo 5 – September 22, 2015

Study Reach
(West of Fernbrook Ln. N)

Typical view of the stream reach between Wetlands 1 and 2

Photo 6 – September 22, 2015

Wetland 2

Facing south at the north edge of Wetland 2. Wetland 2 is located on the left side of this photo.

Appendix B – Plymouth Creek Feasibility Study Wetland Delineation Site Photos

Photo 7 – September 22, 2015 Wetland 2 Another view of wetland 2 facing southeast. Wetland 2 is dominated by reed canary grass.	
Photo 8 – September 22, 2015 Study Reach (East of Fernbrook Ln. N) This photo shows an undercut portion of stream channel, which is typical along many areas of Plymouth Creek.	
Photo 9 – September 22, 2015 Study Reach (East of Fernbrook Ln. N) Many areas within the stream reach east of Fernbrook Lane have snags that obstruct water flow	

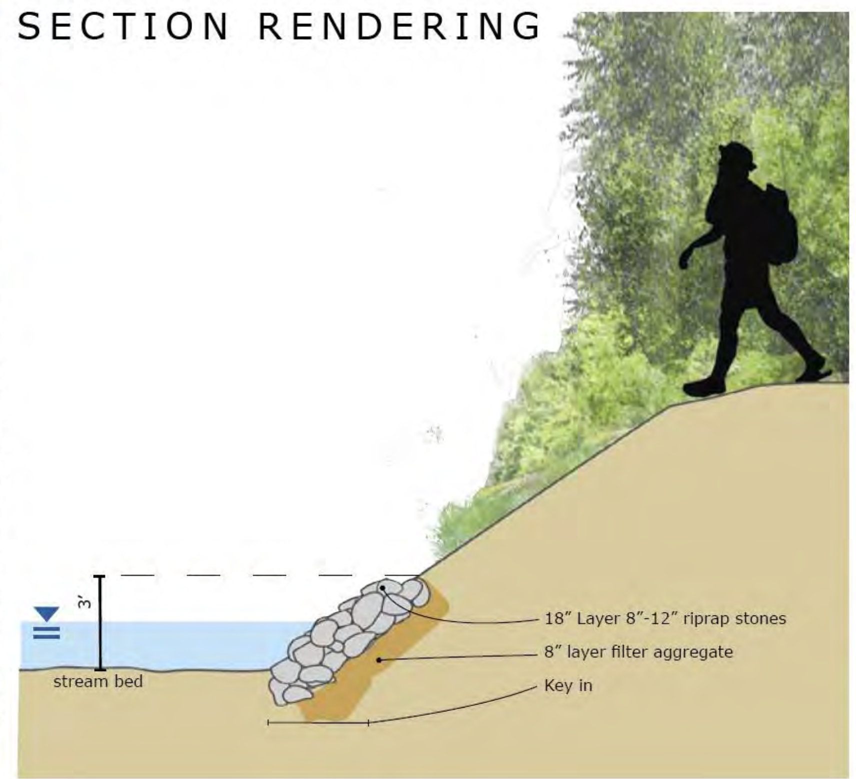
Appendix F

Stream Stabilization Technique Examples

Stream Stabilization Plan

Stone Toe Protection is constructed from cobble-sized rock on the creek edges. It extends to approximately the bankfull level, which will protect the channel banks for flow events that occur every 1 to 2 years or less. The material will extend into the ground to resist scour. Coarse gravel is used to separate the larger rock material from underlying soil. Stone toe protection is typically used in conjunction with revegetation of the upper banks.

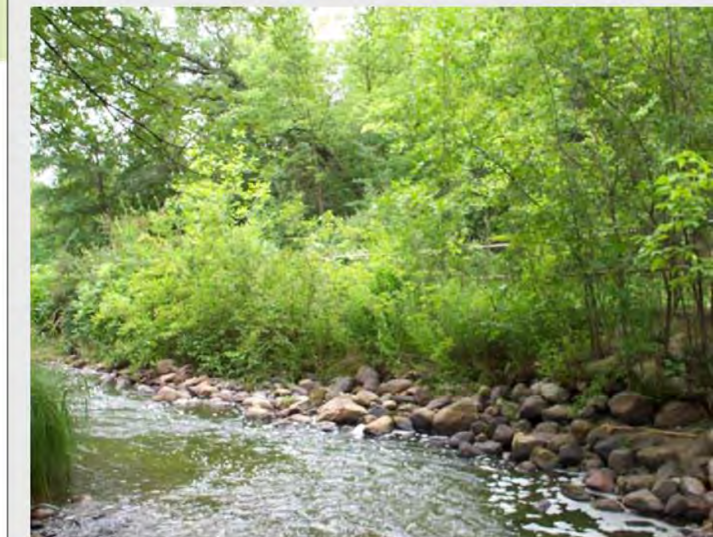
SECTION RENDERING



EXISTING CONDITIONS

Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams. Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion. In many cases, it appears to be a part of the natural process of stream evolution. In places where the channel is confined by the valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.

SIMILAR PROJECTS



Stone toe protection has been used extensively in Nine Mile Creek's Lower Valley, in conjunction with deflector dikes, grade control measures and stabilization of large bank failures. Following the 1987 "super storm," the proposed design allowed the stream to continue its course while taking measures to protect areas where water flow was eroding valley walls. The resulting measures have stabilized the stream channel and valley walls while blending seamlessly with the natural environment.

MATERIALS

Materials will consist of cobble-sized material with coarse gravel filter layer to provide separation from the underlying soil. Natural fieldstone material will be used.

Stone Toe Protection

Bank Protection

BARR

Stream Stabilization Plan

EXISTING CONDITIONS

Channel incision occurs when there is an imbalance between the sediment supply and the sediment carrying capacity of the stream. Erosion will occur when the sediment carrying capacity of a stream exceeds the sediment supply. In streams with cohesive banks and steep channel slope, the erosion will first occur primarily on the channel bottom because that is where the erosive forces are the strongest. As the channel deepens, the stream will gradually become wider as the banks eventually fail. The stream will gradually return to equilibrium; however, the process can take many years and significant amounts of erosion will occur during the process.

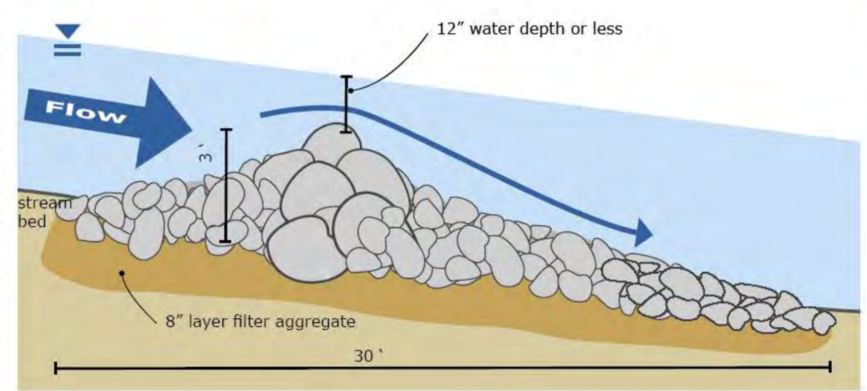
Grade control measures are used where channel downcutting has occurred. Various types of weirs are commonly used to provide grade control on streams, particularly in steeper systems. Weirs can be constructed of sheetpile, concrete, or natural materials such as rock. In most cases, natural rock is used to emulate natural riffles. Large boulders would comprise the core of the structure, with smaller rock material placed on the upstream and downstream sides of the boulders to provide a gradual transition to the channel.

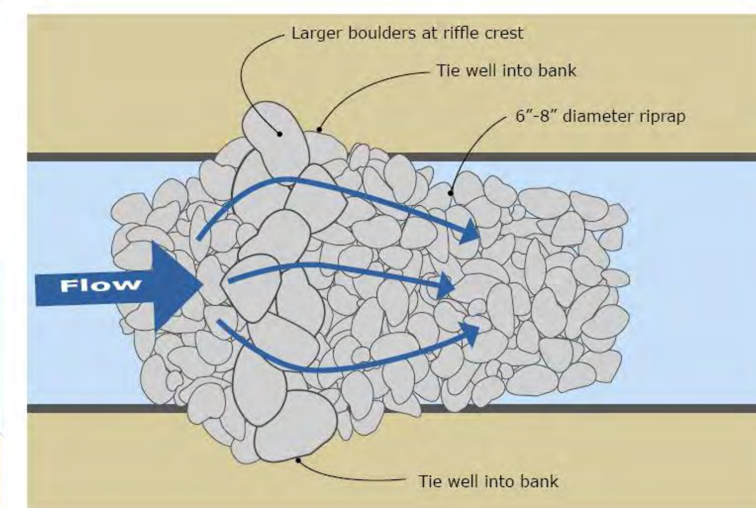
The riffles will serve to raise the surface of the water profile, and will reconnect the stream to its floodplain areas. Following the installation of the riffles, pools will be created upstream of the riffles. However, these pools will fill with sediment over time, which will in effect raise the channel bottom to the desired elevation.

MATERIALS

Materials will consist of various gradations of rock, ranging from large, 3-foot boulders to coarse gravel.

SECTION/PLAN RENDERING





SIMILAR PROJECTS

Following the 1987 "super storm," a rapids was constructed on Nine Mile Creek downstream of the 106th Street Bridge. The rapids was one of several grade-control structures that were installed on a three-mile stretch of creek in the lower valley. The proposal allowed the stream to continue its course while taking measures to protect areas where water flow was eroding valley walls. Protection measures included applying porous deflector dikes, burying sheetpile walls parallel to the creek to prevent undercutting of slopes, installing weirs (rock or capped sheetpile) to limit stream-bed degradation, and improving storm-sewer outlets.

Constructed Riffle

Grade Control

BARR

Stream Stabilization Plan

Rock vanes are constructed from boulders on the creek bottom. They function by diverting channel flow toward the center and away from the bank. They are typically oriented in the upstream direction and occupy no more than one third of the channel width. Vanes are largely submerged and inconspicuous. The rocks are chosen such that they will be large enough to resist movement during flood flows or by vandalism, with additional smaller rock material to add stability. Rock vanes function in much the same way as root wads in that they push the stream thalweg (zone of highest velocity) away from the outside bend. They also promote sedimentation behind the vane, which adds to the toe protection.

Vanes can also be constructed from both banks, forming an upstream-pointing "V." In this configuration, the vane protects both banks and also provides grade control.

MATERIALS

Materials will consist of various gradations of rock, ranging from large, 3-foot boulders to coarse gravel.

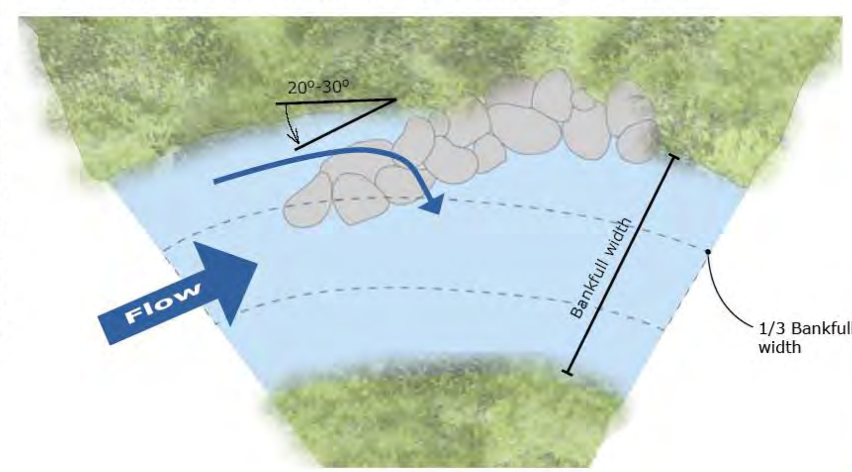
SIMILAR PROJECTS

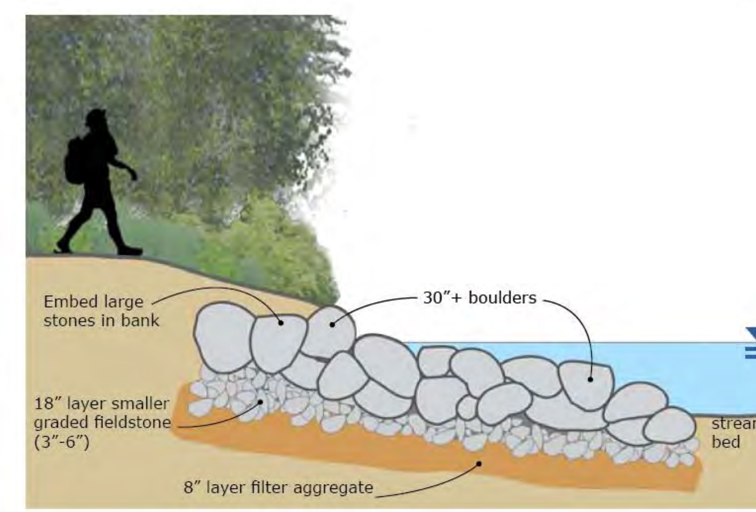
Here is an example of a stabilization project designed for a 1,000-foot long, 20-foot high streambank that was severely eroded. The channel was directed away from the bank toe by installing six rock vanes. The bank was planted with native vegetation and protected with erosion control blanket, while the terrace above the bank was graded to redirect surface runoff to a less vulnerable area. The restored streambank withstood significant flooding during 2001, and has become nicely vegetated (see picture above).

EXISTING CONDITIONS

Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams. Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion. In places where the channel is confined by the valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.

PLAN/SECTION RENDERING





Rock Vanes

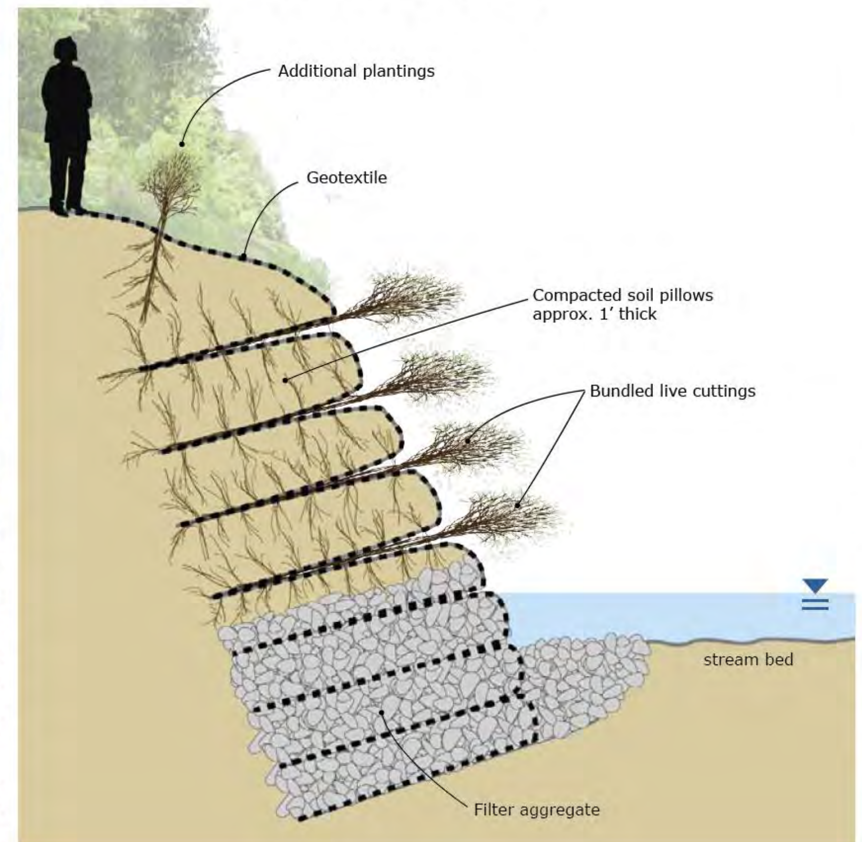
Bank Protection

BARR

Stream Stabilization Plan

Soil Pillows are utilized in a bioengineering method known as Vegetated Reinforced Slope Stabilization (VRSS). The method combines rock, geosynthetics, soil and plants to stabilize steep, eroding slopes in a structurally sound manner. VRSS typically involves protecting layers of soils with a blanket or geotextile material (e.g. erosion control blanket) and vegetating the slope by either planting selected species (often willow or dogwood species) between the soil layers or by seeding the soil with desired species before it is covered by the protective material. In either case, with adequate light and moisture, the vegetation grows quickly and provides significant root structure to strengthen the bank. This method tends to be labor intensive and, therefore, relatively expensive.

SECTION RENDERING



In places where the channel is confined by the steep valley walls, however, fluvial bank erosion can lead to failure of the high banks. It can also undermine storm sewer inlets.
For sites where groundwater seepage is a problem and where it is desirable to maintain steep banks, soil pillows are a feasible solution.

EXISTING CONDITIONS

Fluvial bank erosion is caused by water in the stream moving past the streambanks. The shear stress caused by the flow entrains soil particles into the flow, causing the stream bank to erode away. This is the most common type of erosion that occurs in streams.
Virtually all streams experience this type of erosion as their flow path evolves over time. However, the rate of fluvial bank erosion can increase when the stream is out of equilibrium with its watershed. Increased flow from a watershed will increase the rate of fluvial bank erosion.

SIMILAR PROJECTS

The Mill Creek Restoration Project utilized soil bioengineering design to stabilize 175 linear feet of severely eroding streambanks within the Caldwell Recreation Park in southeastern Ohio. The work included two 25-foot vegetated reinforced soil slope (VRSS) sections, two 50-foot fill bank sections protected with woven coir and direct woody plantings, and a 12.5-foot tie-in on the upstream and downstream end of streambank work area.

MATERIALS

Materials consist of graded rock for the lower layers of the structure and for internal drainage, if necessary. Geotextile fabric is used to wrap the soil. Plants, such as willow or dogwood, or seed mixture is used for planting in and between the soil pillows.

Soil Pillows

Bank Protection

BARR

Stream Stabilization Plan

Culvert Stabilization is somewhat unique to each situation, depending on the site circumstances. Most sites require additional rock placement with a granular filter layer (rather than filter fabric). Some cases may require re-alignment and/or lowering of the outlet to better align with the stream channel. Typically, outlets should be aligned in the downstream channel direction so that flow doesn't impinge on the opposite bank. It is usually desireable for the culvert to enter the stream at or just above the normal water level in order to minimze the potential for undercutting.

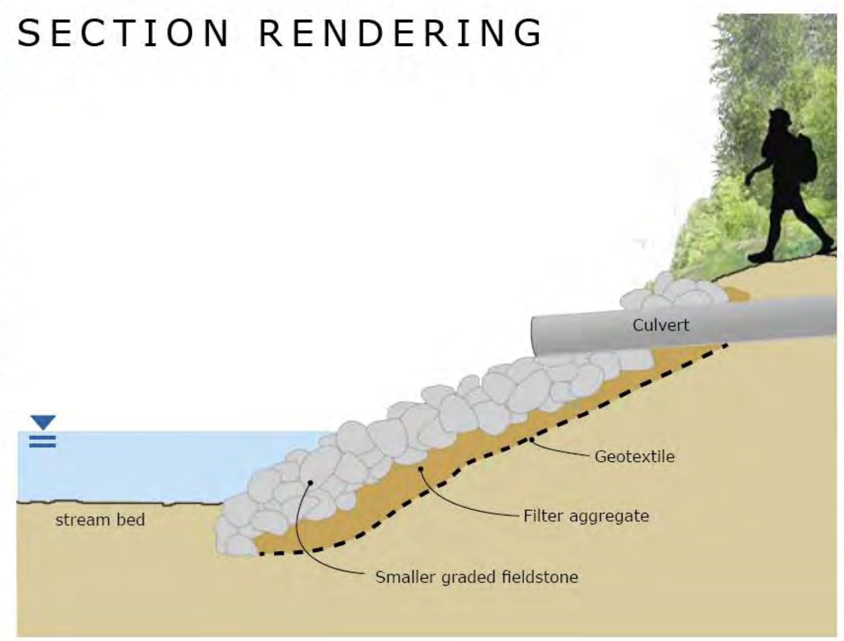
SIMILAR PROJECTS

There are many culvert stabilization designs used on various streams and rivers. Because they are often small projects, the work is often performed by local municipalities or completed as part of a larger project.

EXISTING CONDITIONS

Erosion is frequently observed at culvert outlets for a variety of reasons, including insufficient erosion protection at the culvert outlet, streambank erosion, and channel downcutting, which leaves the culvert perched above the channel. Filter fabric is often used at culvert outlets to separate riprap protection from underlying soils, however the fabric provides a slippery surface for the riprap, which commonly slides into the channel.

SECTION RENDERING



MATERIALS

Materials consist of rock materials ranging from graded riprap (either fieldstone, or, for steep slopes, angular) and granular filter material (typically coarse gravel). If necessary, additional pipe, manholes and end sections may be necessary.

Culvert Stabilization

Bank Protection

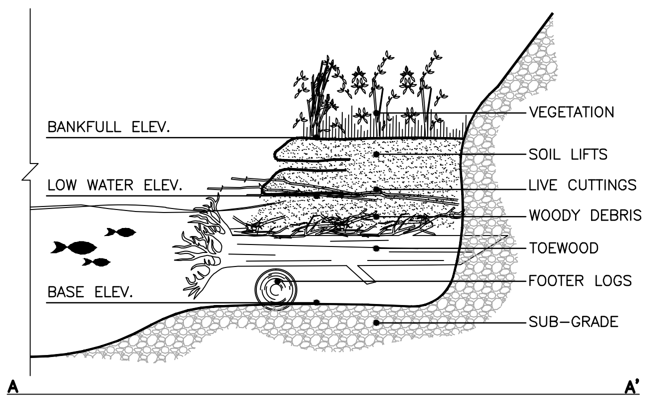
BARR

1. INSTALLATION SUMMARY

TOEWOOD BENCH CONSTRUCTION WILL BE DONE IN DRY WEATHER CONDITIONS AFTER STREAM HAS BEEN DIVERTED AND SITE DEWATERED.

ENGINEER OR OWNER'S REPRESENTATIVE MUST BE PRESENT FOR INSTALLATION OF TOEWOOD BENCH.

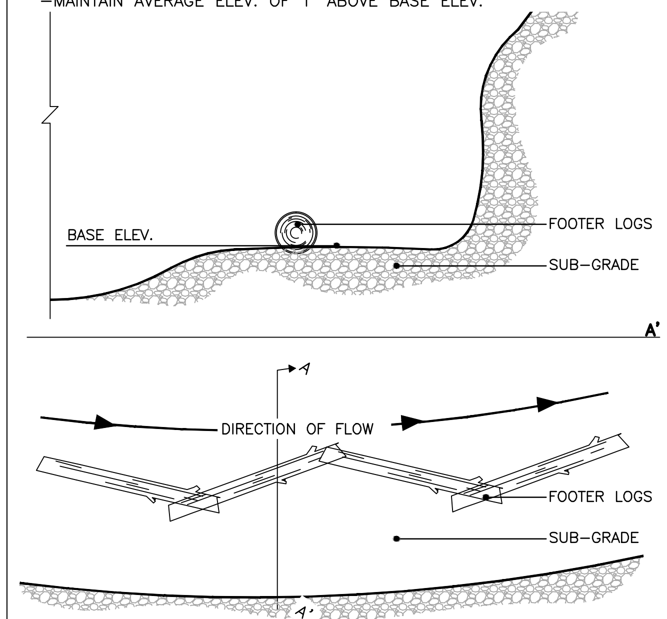
THE DRAWINGS ON THIS PAGE ARE NOT TO SCALE.



2. SUBGRADE AND FOOTER LOGS

SPECIFICATION:
- 8" TO 1' DIAMETER
- LIMBS REMOVED
- APPROX 10' LENGTH

PLACEMENT:
- EXCAVATE TO BASE ELEVATION – CONTRACTOR SHALL MAKE EFFORT TO SEPARATE GRANULAR AND FINE FILL NATIVE MATERIAL FOR USE IN STEPS 4 AND 6.
- PLACE FOOTER LOGS 30 DEGREES FROM PARALLEL TO STREAM FLOW WITH ENDS STACKED CREATING A ZIG ZAG PATTERN (PLAN VIEW BELOW)
- MAINTAIN AVERAGE ELEV. OF 1' ABOVE BASE ELEV.

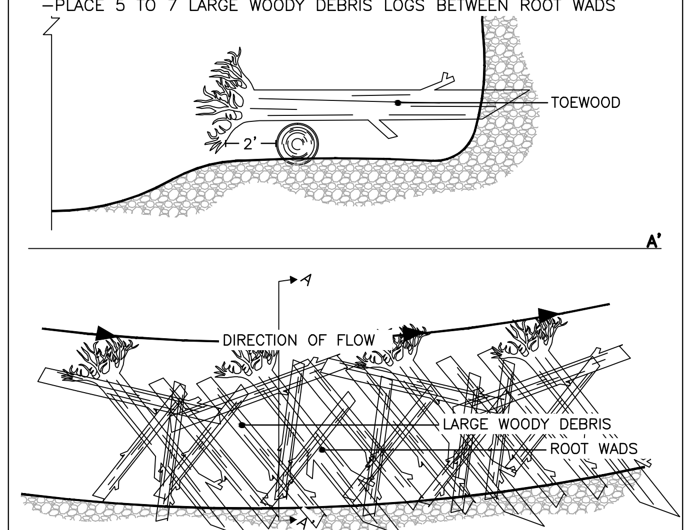


3. ROOT WADS & LRG WOODY DEBRIS

ROOT WAD SPECIFICATION:
- 10" MIN DIAMETER
- LENGTH INDICATED IN DESIGN CROSS SECTION OR 10' MIN.
- LIMBS REMOVED
- ROOT WADS LEFT INTACT
- ENDS SHARPENED TO A POINT

LARGE WOODY DEBRIS SPECIFICATION:
- 8" MIN DIAMETER

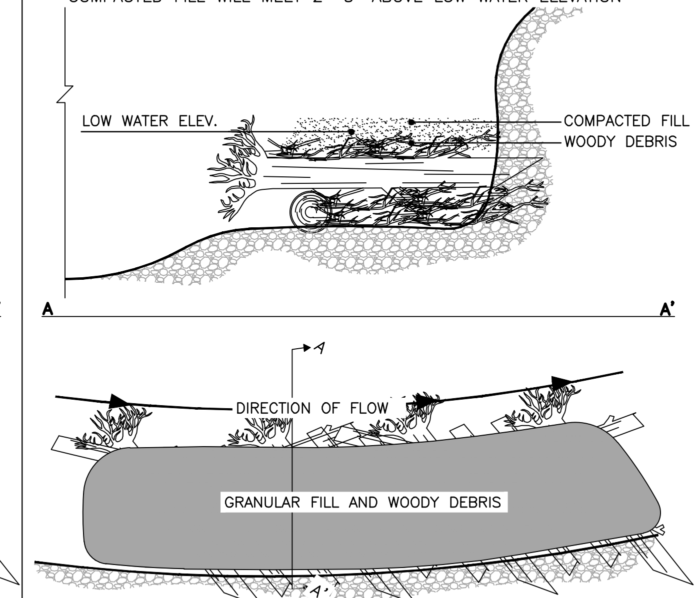
PLACEMENT:
- PLACE ROOT WADS HORIZONTALLY ON TOP OF FOOTER LOGS, OVERHANG ROOT WAD LOGS 2'
- ANGLE ROOTWADS UPSTREAM
- DRIVE SHARPENED TRUNKS MIN. 3' INTO BANK OR DIG IN .
- PLACE 1 ROOT WAD PER FOOTER LOG
- PLACE 5 TO 7 LARGE WOODY DEBRIS LOGS BETWEEN ROOT WADS



4. WOODY DEBRIS & GRANULAR FILL

SPECIFICATION:
- WOODY MATERIAL (COMPOSED OF SMALL LIMBS AND BRANCHES, APPROX. 4" MAX DIAMETER AND SMALLER)
- DO NOT USE ROTTEN WOODY MATERIAL
- NATIVE GRANULAR FILL

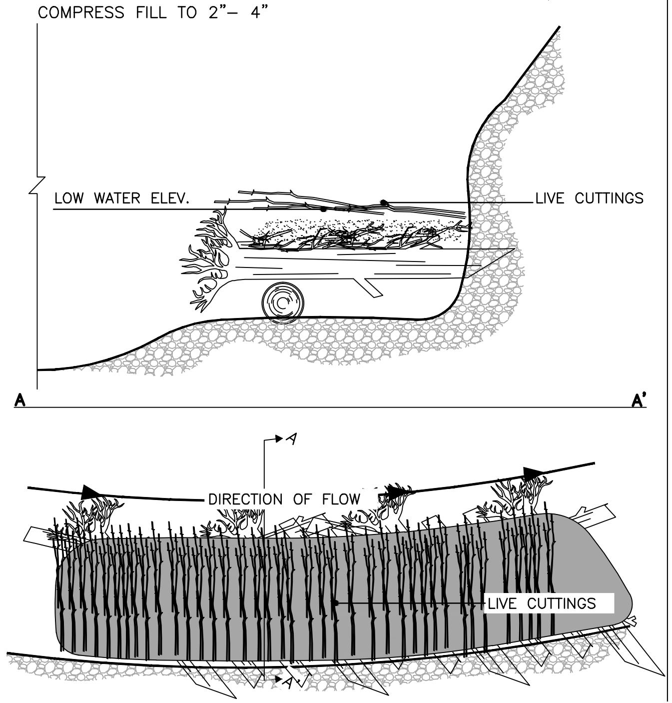
PLACEMENT:
- FILL BETWEEN FOOTER LOGS AND TOEWOOD WITH WOODY DEBRIS
- STACK WOODY DEBRIS TO LOW WATER ELEVATION
- LAYER NATIVE GRANULAR FILL ON TOP OF WOODY DEBRIS
- COMPACT SO THAT SETTLING OF FILL IS MINIMIZED BUT DEBRIS IS NOT DISPLACED
- COMPACTED FILL WILL MEET 2"–5" ABOVE LOW WATER ELEVATION



5. LIVE CUTTINGS

SPECIFICATION:
- SEE LIVE CUTTING DETAIL

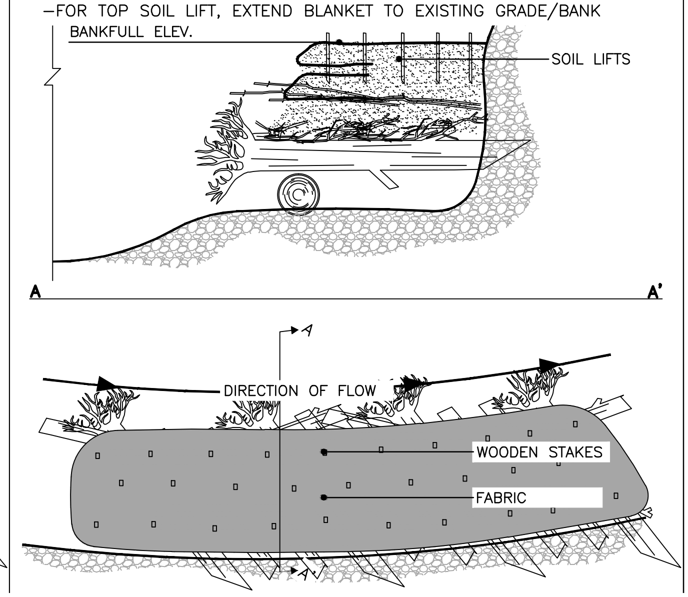
PLACEMENT:
- LAY CUTTINGS WITH A DENSITY OF 10 CUTTINGS PER LINEAL FOOT
- TOPS OF CUTTING WILL POINT TOWARD CHANNEL
- TRIM EXPOSED ENDS OF CUTTINGS, LEAVE NO MORE THAN 6" EXPOSED
- DEPOSIT NATIVE FILL OVER CUTTINGS AND WATER LIBERALLY, COMPRESS FILL TO 2"– 4"



6. SOIL LIFTS

SPECIFICATION:
- NATIVE FILL (FINE)
- 1' FORMS
- MIN 6.5' WIDE ROLANKA BIOD-MAT 70, GEOCOIR 700, OR EQUAL LINED WITH MNDOT CAT II EROSION CONTROL BLANKET WITH NATURAL NETTING
- 18" WOODEN STAKES (2X4 CUT AT ANGLE), PLACED AT 3' SPACING

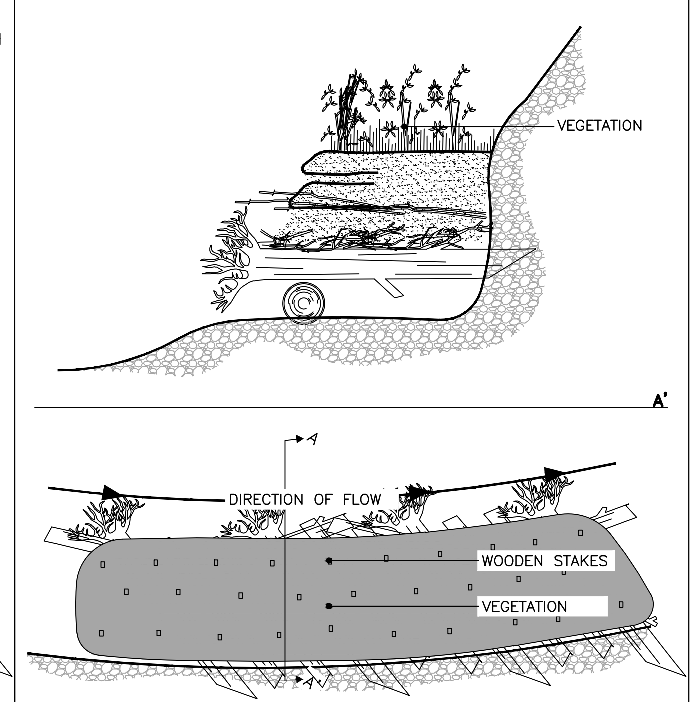
PLACEMENT:
- PLACE FORM
- LAY MIN 2.5' OF FABRIC (COCONUT BLANKET AND LINER) ALONG BENCH
- PLACE 1' OF FILL ON TOP OF MAT AND COMPACT
- WRAP FILL WITH REMAINING BLANKET AND SECURE WITH STAKES
- REPEAT UNTIL BANKFUL ELEVATION IS MET, STEP EACH LIFT BACK 1'
- FOR TOP SOIL LIFT, EXTEND BLANKET TO EXISTING GRADE/BANK



7. VEGETATION

SEE VEGETATION PLAN FOR DETAIL

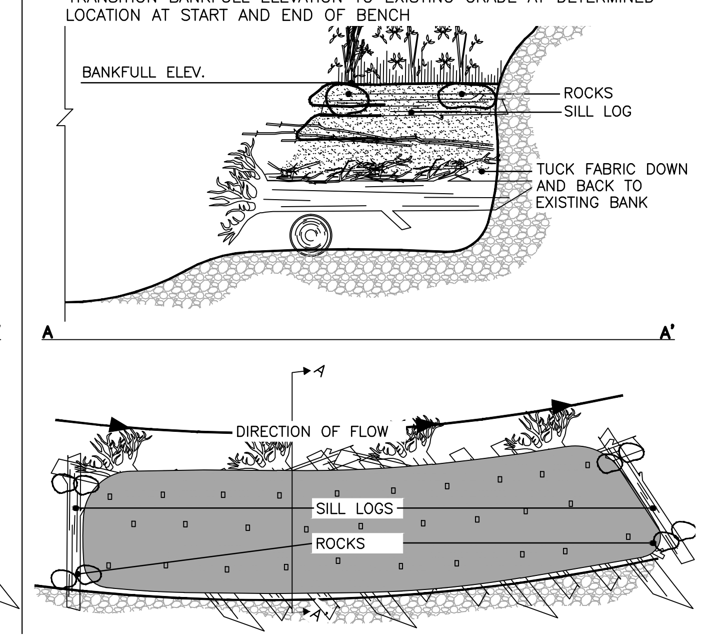
IF SEED IS CALLED FOR:
- PLANT SEED INSIDE OF SOIL LIFT PRIOR TO COVERING IN FABRIC
- PLANT SEED ON THE FACE OF EACH SOIL LIFT AS WELL AS ACROSS THE TOP SOIL LIFT



8. SILL LOGS & TERMINATION

SPECIFICATION:
- 10" MIN DIAMETER
- LIMBS REMOVED
- LENGTH DETERMINED BY WIDTH OF TOEWOOD BENCH

PLACEMENT:
- PLACE ONE SILL LOG AT THE START AND END OF THE TOEWOOD BENCH PERPENDICULAR TO THE DIRECTION OF FLOW.
- PLACE LARGE ROCKS ON TOP OF SILL LOG, TOP OF ROCK WILL MEET BANKFULL ELEVATION
- TUCK SOIL LIFT BLANKET DOWN AND BACK TOWARDS EXISTING BANK
- TRANSITION BANKFULL ELEVATION TO EXISTING GRADE AT DETERMINED LOCATION AT START AND END OF BENCH



NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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

SIGNATURE ____
PRINTED NAME ____
DATE ____ REG. NO. ____

CLIENT / BID / CONSTRUCTION

RELEASED TO/FOR: A B C 0 1 2 3 — DATE RELEASED

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

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

Scale	AS SHOWN
Date	2/10/2015
Drawn	GGN
Checked	JDW
Designed	GGN
Approved	JDW

TOE WOOD

EXAMPLE DETAIL

BARR PROJECT No.

CLIENT PROJECT No.

DWG. No. C1.0 REV. No. 0

CADD USER: Adam K. Howard FILE: P:\MPLS\23 MN\27\2327051\WORKFILES\CIP\CAPITAL PROJECTS\2017 PLYMOUTH CREEK ANNAPOLIS THRU PLYMOUTH CR PK 2017CR-P\FEASIBILITY STUDY\REPORT\APPENDICES\APPENDIX E\TOEWOOD.DWG PLOT SCALE: 1:2 PLOT DATE: 12/17/2015 12:31 PM

Images in Drawing ...\JDW.tif
gph M:\Design\23270140.00\23270140000_C9.dwg Plot at 1 07/06/2015 16:12:46

Appendix G

Detailed Alternative Assessments

G. Detailed alternatives for stabilization

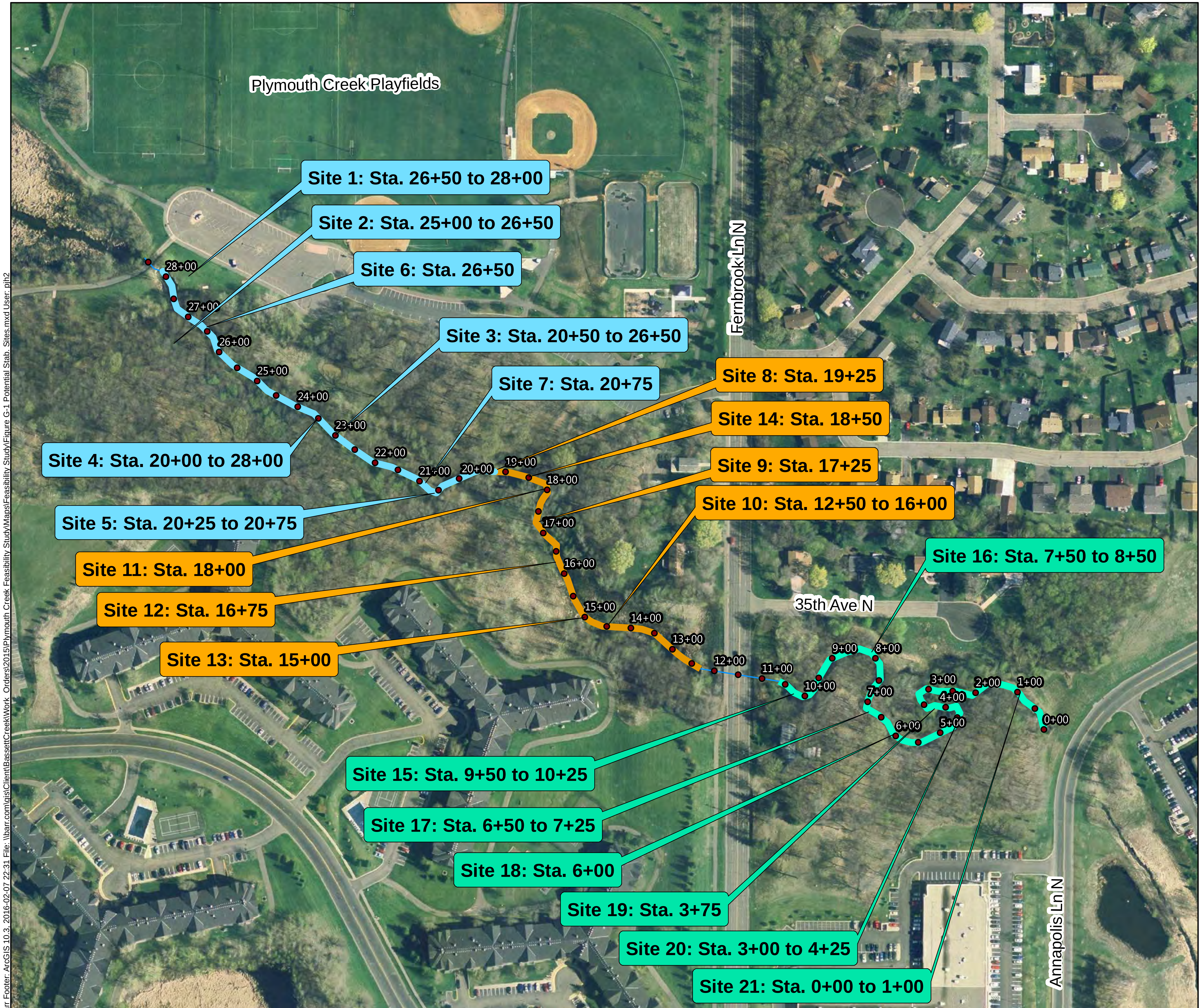
The following discussion is organized by location within each reach, referred to as "stabilization sites." The stabilization sites for the entire project area are shown in Figure G-1. Potential stabilization alternatives for each reach are summarized in Figure G-2 through Figure G-4 and in Table G-1. Stabilization sites within each reach with similar characteristics and stabilization alternatives are discussed together.

For each stabilization site (or group of sites), the following discussion includes:

- A brief description of the site characteristics.
- The issues to be addressed.
- Potential feasible alternatives for stabilization, with the advantages and disadvantages of each.
- A brief description of alternatives deemed infeasible after consideration.

A variety of factors or combinations of factors may make a "do-nothing" option viable for an individual site; however, it may not be cost-effective—particularly if the intent is to stabilize the site in the near future. If a "do-nothing" approach is ultimately chosen for a particular site, the potential need for future site stabilization should be evaluated. This evaluation should consider whether likely access routes could damage the measures already installed.

Although the sites for stabilization are discussed here individually, final design for the project will likely result in a nearly continuous implementation of stabilization techniques through all three stream reaches. The stabilization sites identified in Figure G-1 generally abut and overlap one another, although not all stream banks within each reach need stabilization and the recommended stabilization techniques may differ between adjacent sites.



Legend

- Non-Reach Creek
- Reach 3
- Reach 2
- Reach 1

N

Feet

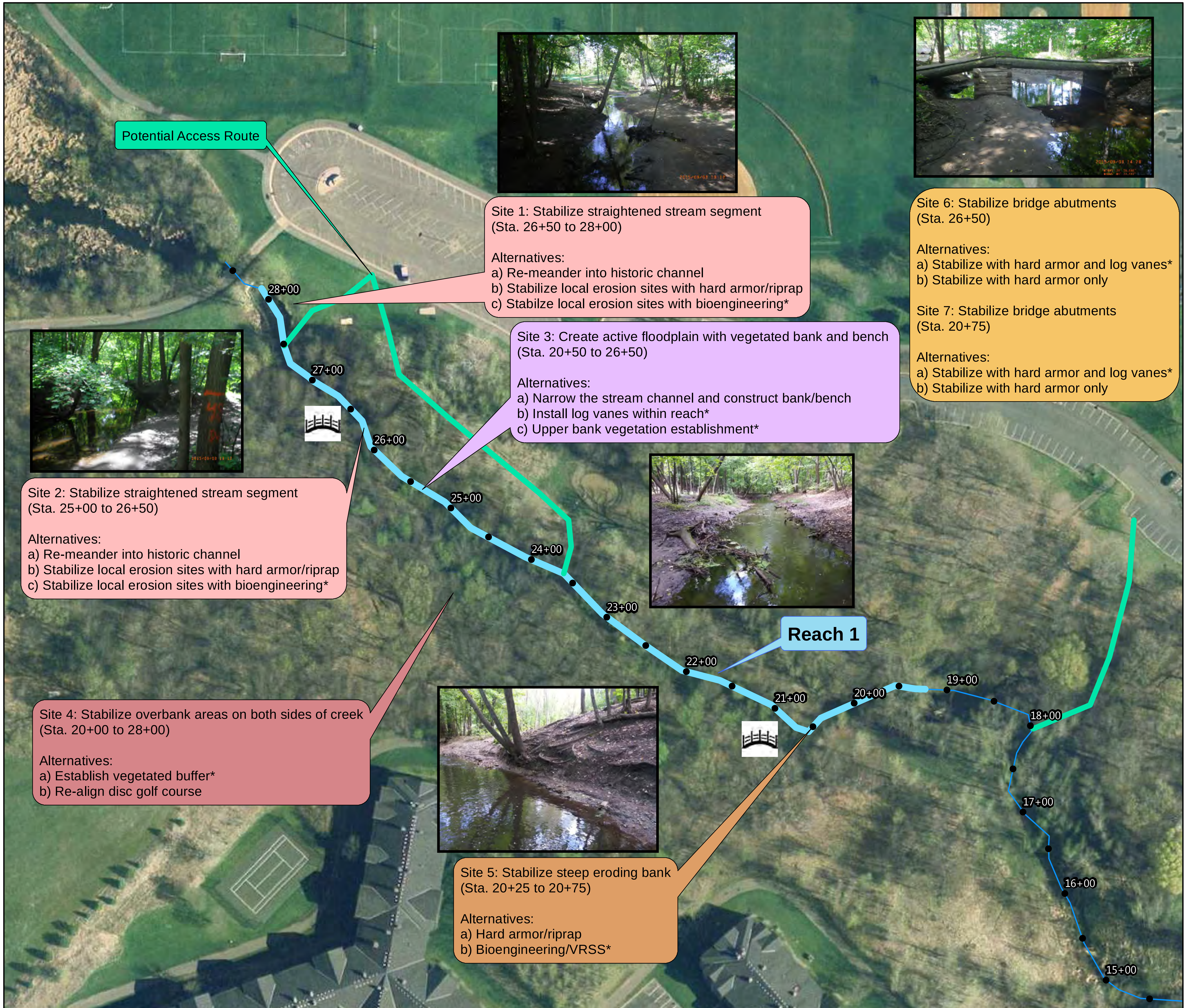
100 0 100 200

Meters

30 0 30 60

Figure G-1

PLYMOUTH CREEK POTENTIAL STABILIZATION SITES
Plymouth Creek Feasibility Study
Bassett Creek Watershed Management Commission



Reach 1

Issues: Appears to be historically straightened; channel is overwide with bare banks. Significant bare overbank areas due to disc golf usage. High clay content of soils helps reduce bank movement.

Constraints: Restoration must be compatible with disc golf course; need for bridge crossings. Narrow valley and low slope limit meandering potential. Deep shade limits vegetation options.

Legend

Pedestrian Bridge

Culvert Outfall

Note: Individual alternatives are defined as a, b, or c for many of the sites. One or more alternatives will be chosen for each site.

*Indicates recommended alternative

N

Feet

100 0 100 200

Meters

30 0 30 60

Figure G-2

PLYMOUTH CREEK REACH 1 ALTERNATIVES
Plymouth Creek Feasibility Study
Bassett Creek Watershed
Management Commission

G.1 Sites 1 and 2

Sites 1 and 2 (shown in Photo 1 and 2 in Appendix A) consist of a relatively straight reach that appears to have straightened over time as evidenced by the low sinuosity and the presence of abandoned meanders from Station 26+50 to 28+00 (Site 1) and 25+00 to 26+50 (Site 2), shown on Figure G-2. The abandoned channels have vegetated banks and are situated at an elevation above typical flow levels in Plymouth Creek. The abandoned stream section in Site 1 no longer conveys flow during most flow events; however, the section in Site 2 is active during flood events. The existing stream between the historical channels has some bare lower stream banks; a footbridge for the disc golf course crosses the stream. The erosion on the banks of the existing channel is relatively minor. Immediately upstream of Site 1, the existing water level control structure impedes sediment flow through Plymouth Creek and may represent a "clear water" discharge that could potentially increase scour through the downstream reaches.

Alternatives 1A and 2A—Re-meander into historical channel

Alternative summary: Re-meander the stream into the historical channels.

Advantages: Re-meandering will improve habitat by adding stream length, improve stream aesthetics, reduce erosion by slowing water flow, and improve water quality through stream bank stabilization.

Disadvantages: Lengthening the stream will decrease the already mild slope and may reduce stream conveyance and sediment transport capacity. Tree removals will be necessary at both Site 1 and Site 2. Hydraulic modeling will be required during final design to ensure the flood profile is not impacted. The foot bridge between the sites will likely need to be replaced or realigned to avoid adverse impacts from an altered flow pattern.

Feasibility: This alternative is feasible given the existence of the historical channels and the ability for the existing footbridge between these sites to be realigned, if necessary; however, it may be more cost effective to consider this option when the footbridge needs to be replaced.

Alternatives 1B and 2B—Stabilize local erosion sites with hard armor/riprap

Alternative summary: Install riprap along the outer banks to reduce the sediment loading and loss of bank.

Advantages: Riprap is relatively inexpensive, effective in reducing bank erosion, and can be resilient to large flood events if properly designed.

Disadvantages: Stabilizing the stream channel in-place does not take advantage of the existing historical meander channels and may be less aesthetically pleasing, especially for Site 2 where a disc golf tee box is adjacent to the historical channel. Hard armoring does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the riprap, maintenance costs tend to be higher than for bioengineering techniques.

Feasibility: This alternative is feasible if detailed modeling indicates there are high velocities at these sites and bioengineering options are determined to be infeasible.

Alternatives 1C and 2C—Stabilize local erosion sites with bioengineering

Alternative summary: Install root wads and log vanes to stabilize eroding areas. Use log vanes to reshape the channel bottom and narrow the low-flow channel while maintaining the overall channel cross section. Establish vegetation on bare banks.

Advantages: Bank stabilization with bioengineering techniques will improve aesthetics of the stream, reduce erosion by directing flow away from stream banks, and improve water quality through stream bank stabilization. One or more log vanes can extend across the entire channel to provide grade control and prevent downcutting due to the clear water discharge from the upstream control structure. The cost of bioengineering within these reaches is comparable to hard armoring and significantly lower than re-meandering.

Disadvantages: Stabilizing the stream channel in-place does not take advantage of the existing historical meander channels and may be less aesthetically pleasing, especially for Site 2 where a disc golf tee box is adjacent to the historical channel. Due to the shady conditions, vegetation will be limited to shade-tolerant species. The combination of extreme shade and disc golf traffic may hinder establishment of vegetation.

Feasibility: Shade-tolerant species are available and the stream banks can be feasibly vegetated.

Sites 1 and 2 infeasible alternatives

The creation of additional stream channels outside of the historical meanders is not considered feasible due to impacts to the disc golf course and significant grading/tree removal.

Sites 1 and 2 recommendations

Although re-meandering is feasible for Sites 1 and 2, Alternatives 1A and 2A have a high estimated cost, compared to the alternatives for stabilizing the stream in its current location. In addition, the tree removals and foot bridge realignment that would be necessary for the re-meandering alternatives are significant disadvantages. Given the expressed preference of the BCWMC and permitting agencies for bioengineering solutions, Alternatives 1C and 2C are recommended.

G.2 Site 3

Site 3 consists of an over-widened stream channel with a small active floodplain. It extends from Station 20+50 to 26+50, as shown on Figure G-2. There are many areas where sediment is being deposited near the banks and the channel is beginning to narrow. Due to the wide channel bottom, water depth is very low during low-flow conditions, resulting in poor aquatic habitat. The channel banks are bare and the dense tree canopy overhead creates consistent shade along the stream channel. Photo 3 in Appendix A illustrates a typical portion of this site.

Alternative 3A—Narrow stream channel and construct floodplain bench

Alternative summary: Narrow the stream channel by grading to establish a vegetated floodplain bench within the existing channel alignment; offset decreased channel cross section by cutting back the existing high banks. This alternative would include upper-bank vegetation as described in Alternative 3C.

Advantages: Narrowing the channel will deepen it during low flow, providing improved habitat. It will also create a larger floodplain and vegetated stream buffer soon after construction.

Disadvantages: Narrowing the channel will require significant grading—excavating from the upper banks to create a floodplain while maintaining the overall channel conveyance. To achieve the desired channel shape tree removals will likely be required in some locations. Hydraulic modeling will be required during final design to ensure the flood profile is not impacted.

Feasibility: If the design of the narrowed channel can maintain existing flood elevations, this alternative is technically feasible, although it will require significant and costly grading. The overall feasibility of this alternative depends on whether the work can be completed without removing a significant number of trees.

Alternative 3B—Install log vanes

Alternative summary: Install log vanes and reshape the channel bottom to narrow the low-flow channel while maintaining the overall channel cross section. The logs for this alternative would be obtained by removing trees leaning over and at high risk of falling into the creek. Pre-emptively removing the trunks but leaving the stumps and roots will prevent localized erosion—both on the bare bank where the tree might fall and on other banks which would, subsequently, receive redirected flows. This alternative will also include upper-bank vegetation as described in Alternative 3C.

Advantages: Narrowing the low-flow channel with log vanes will provide improved habitat by deepening the channel during low flows and reduce the stress on the upper banks during high flows. Natural materials available onsite will be used for much of the log vane construction and prevent future erosion. One or more log cross vanes can extend across the entire channel to provide grade control and prevent downcutting due to the clear water discharge from the upstream control structure.

Disadvantages: The bench created by the log vanes will remain below the bankfull flow elevation. Depending on the available light at a given location and the frequency of inundation, vegetation on the low benches may be thin. Exposed soil may be less aesthetically pleasing than a vegetated floodplain.

Feasibility: Providing the design of the narrowed channel can maintain existing flood elevations, this alternative is feasible.

Alternative 3C—Upper-bank vegetation establishment

Alternative summary: Vegetate existing bare upper banks above the bankfull flow elevation with shade-tolerant trees, shrubs, and seed mixes. This alternative would be implemented in conjunction with Alternative 3A or 3B.

Advantages: Establishing perennial vegetation will improve aesthetics of the stream and reduce erosion from flood flows or overland flow entering the stream.

Disadvantages: Due to the shady conditions, suitable species will need to be selected carefully; site preparation, seeding, and establishment maintenance will need to be tailored to the site.

Feasibility: Shade-tolerant species are available and the upper banks can be vegetated; relatively frequent maintenance may be required due to the impacts of disc golf activity. This alternative also requires the cooperation of disc golfers to stay off newly established vegetation.

Infeasible alternatives

Re-meandering Plymouth Creek throughout Site 3 is not considered feasible due to the impact on the adjacent disc golf course. In addition, considering the existing topography and high overbank areas, establishing a meandering stream channel and floodplain would require significant and prohibitively costly excavation and tree removal.

Narrowing the stream channel by importing soil or rock and without excavating the existing high banks is not considered feasible due to the inevitable increase in the flood profile, not permitted by BCWMC policies. In addition, shifting the stream type to a narrow step-pool channel with limited floodplain is not considered feasible due to the low stream slope that will not facilitate creation of step-pool features.

Given the City's desire to maintain a natural stream channel through the Plymouth Creek Park and BCWMC policies preferring bioengineering techniques, lining Plymouth Creek with riprap to decrease bank erosion is also infeasible.

Site 3 recommendations

Alternative 3B is recommended for stabilizing the stream bed and lower banks of Site 3 because it will require minimal tree removals/grading and will use natural materials available onsite. Removing trees leaning over and at high risk of falling into the channel will also prevent localized erosion. Alternative 3C is recommended for stabilizing the upper banks and providing long-term natural aesthetics to the stream corridor. These two alternatives, implemented together, will stabilize and establish natural vegetation along approximately one-quarter of the entire project area.

G.3 Site 4

Site 4 includes overbank areas on both sides of the creek, but primarily on the south (Figure G-2), outside of the stream channel areas described above for Site 3. Due to the heavy use of the disc golf course, this area is largely unvegetated, resulting in significant sediment transfer from the bare ground to the stream (see Photo 4 in Appendix A).

Alternative 4A—Establish vegetated buffer

Alternative summary: Install low fencing or other markers and shade-tolerant vegetation to establish a vegetative buffer on the creek banks, while allowing for controlled or stabilized stream access points so as to not inhibit the use of the disc golf course.

Advantages: A vegetated buffer will improve water quality in the stream by separating disc golf foot traffic from the stream, thereby reducing bank erosion and removing sediment from overland runoff entering the stream. The buffer will also result in improved aesthetics near the stream and provide an opportunity to educate park users on natural buffers and stream bank stability.

Disadvantages: Suitable, shade-tolerant species will need to be carefully selected; site preparation, seeding, and maintenance will need to be tailored to the location. The vegetated buffer and any fencing will inconvenience disc golf course users and may require user education and cooperation as well as frequent maintenance.

Feasibility: Shade-tolerant species are available and a vegetated buffer can be feasibly established; relatively frequent maintenance may be required due to the impact of disc golf course users.

Alternative 4B—Realign disc golf course

Alternative summary: Realign portions of the Plymouth Creek Park disc golf course to reduce the potential for golfers to enter the creek by placing pins away from the stream and eliminating holes that cross the stream. This alternative could be implemented alone or in conjunction with Alternative 4A. This alternative would also include upper-bank vegetation, as described for Alternative 4C.

Advantages: Placing pins away from the stream will cause golfers to throw away rather than toward the stream and reduce foot traffic on the stream banks. Some degree of hole realignment may be possible without tree removal or additional grading.

Disadvantages: Separating play from the stream channel by realigning holes may decrease some users' enjoyment of the natural amenities of the course. Any major adjustments to hole placement (for example, to decrease the overall density of the course) will require clearing and/or tree removal and may be relatively costly.

Feasibility: This alternative is feasible only if it can be done with minimal tree removal and provides an opportunity for public involvement in the stabilization of Plymouth Creek.

Site 4 recommendations

Establishing vegetated buffers on the overbank areas along Site 4 will maintain continuity with the upper-bank vegetation recommended for Site 3 (Alternative 3C), while allowing continued disc golf course usage. Alternative 4A is recommended.

G.4 Site 5

Site 5 is near the downstream end of Reach 1 (see Figure G-2 and Photo 5 in Appendix A). A steep eroding outer bank is present near this site. The high clay content of the soils limits the rate of bank migration, but stabilizing the bank would remove a source of sediment to the stream and improve its aesthetics near a footbridge crossing.

Alternative 5A—Stabilize with hard armor/riprap

Alternative summary: Install riprap or boulders along the lower slope of the outer bank to reduce the sediment loading and loss of bank.

Advantages: Riprap is relatively inexpensive and effective in reducing bank erosion; if properly designed it can be resilient to large flood events.

Disadvantages: Hard armoring does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the riprap, maintenance costs tend to be higher than for bioengineering techniques.

Feasibility: This alternative is feasible if bioengineering alternatives cannot be used.

Alternative 5B—Stabilize with VRSS

Alternative summary: Install bioengineering in the form of VRSS to encourage vegetative growth along the outer bank. Install VRSS in front of the existing bank to minimize grading into the bank.

Advantages: VRSS is aesthetically pleasing after the vegetated banks begin to thrive and uses renewable materials. If properly designed and installed, VRSS can be resilient to large flood events.

Disadvantages: Suitable, shade-tolerant species will need to be selected; site preparation, seeding, and maintenance will need to be tailored to the location. VRSS is more costly to install than hard armoring alone.

Feasibility: Shade-tolerant species are available and the VRSS area can be feasibly vegetated, though relatively frequent maintenance may be required during the vegetation-establishment period.

Infeasible alternatives

Re-grading of the stream bank to reduce the steep slope is not considered feasible. The regrading would remove several trees and reduce the areas available for the disc golf course.

Site 5 recommendations

Given the expressed preference of the BCWMC and permitting agencies for bioengineering solutions, Alternative 5B is recommended.

G.5 Sites 6, 7, 8, and 9

Four pedestrian bridges used by disc golfers are located within Reach 1 (Sites 6 and 7, Figure G-2) and Reach 2 (Sites 8 and 9, Figure G-3). Erosion around the bridge abutments is present at all four bridges (see Photos 6 through Photo 8 in Appendix A).

Alternatives 6A through 9A—Stabilize with hard armor and log vanes

Alternative summary: Install hard armor (riprap) around each abutment and log vanes upstream of each abutment to direct flow to the center of the river and encourage sedimentation around the bridge abutments.

Advantages: Riprap around each abutment will reduce erosion during high flows, while log vanes will reduce the erosive pressure on the abutments.

Disadvantages: Hard armor around bridge abutments does not appear natural or provide quality in-stream habitat. Adding log vanes to the bridge locations will add complexity and require more detailed design and construction oversight to achieve the desired flow patterns.

Feasibility: This alternative is feasible.

Alternative 6B through 9B—Stabilize with hard armor only

Alternative summary: Install hard armor (riprap) around each abutment.

Advantages: Riprap around each abutment will reduce erosion during high flows and will not require any in-stream work. Installing only riprap will cost less than combining riprap with log vanes.

Disadvantages: Armoring only the bridge abutments without reducing the erosive pressure by redirecting the flow may result in failure of the riprap or additional maintenance after large flood events. In addition, hard armor around bridge abutments does not appear natural or provide quality in-stream habitat.

Feasibility: This alternative is feasible.

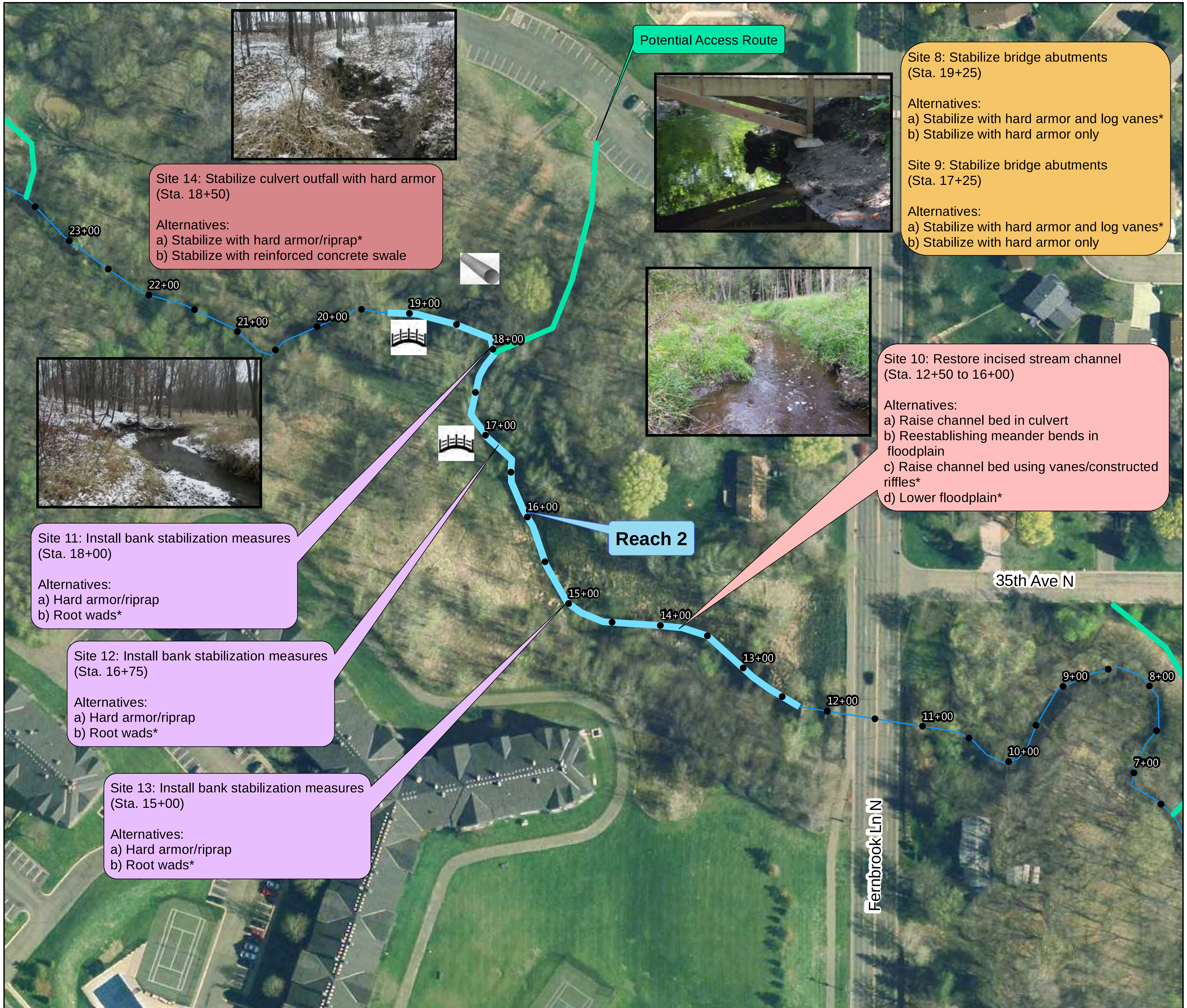
Infeasible alternatives

The cost of new footbridges—relative to the low consequences of erosion-related failure—is high. This makes widening the footbridges to put the abutments away from the channel on the floodplain infeasible.

Installing log vanes upstream of the abutment without riprap is not considered feasible. This would not provide the abutments with the required level of protection, especially during larger flow events.

Sites 6 through 9 recommendations

Alternatives 6A through 9A are recommended for stabilizing the pedestrian bridge abutments; both will improve resistance of the abutments to high flows and reduce the erosive pressure by redirecting flows toward the center of the stream.



Reach 2

Issues: Erosion of the stream bed (incision) has resulted in limited access to floodplain. Incision perhaps due to culvert grade on downstream end of reach. Pockets of granular soils prone to bank erosion.

Constraints: Culvert limits flow in floods. Nearby home impacted if flood levels increase. Low slope. Sanitary sewer manholes should be avoided and access to these manholes should be maintained.

Legend

- Pedestrian Bridge
- Culvert Outfall

Note: Individual alternatives are defined as a, b, c, or d for many of the sites. One or more alternatives will be chosen for each site.

*Indicates recommended alternative

N

Feet: 100 0 100 200

Meters: 30 0 30 60

Figure G-3

PLYMOUTH CREEK REACH 2 ALTERNATIVES
Plymouth Creek Feasibility Study
Bassett Creek Watershed
Management Commission

G.6 Site 10

Site 10 includes much of the stream channel located in the downstream half of Reach 2 (see Figure G-3). The stream bed in this section appears to be mildly incised (see Photo 8 in Appendix A), resulting in limited access to the floodplain. In addition, pockets of granular soils have facilitated bank erosion in some areas. Incised streams often have greater-than-average erosion; unlike streams that are well-connected to the floodplain, they do not effectively transfer flood energy. The excess energy causes bank erosion, suggesting the erosion at this site may continue to worsen. If the channel incision migrates upstream, additional banks and lengths of stream may be more prone to erosion.

Residential property exists on the downstream portion of the reach and cannot be further impacted by floodwaters. A portion of the overbank in this reach is defined as wetland (see Appendix E), which will necessitate additional permitting to ensure any impacts are mitigated.

Alternative 10A—Raise culvert bed elevation

Alternative summary: Add riprap and gravel to the bed of the culvert (grout select cobbles into place if necessary) under Fernbrook Lane North to act as a grade control and increase the bed elevation in the stream through Site 10. At the request of the MDNR, the culvert was installed 1 foot lower than the previous culvert, with the intent that it would fill with sediment and have a natural bottom. While a portion of the culvert has accumulated sediment, a natural bottom has not been fully established.

Advantages: Raising the stream bed in the Fernbrook Lane North culvert will decrease the slope of the creek and allow for improved access to the floodplain. This alternative will be relatively low-cost and may increase the ability of aquatic organisms to move through the culvert during low-flow conditions. It is assumed that a natural substrate will gradually accumulate in the culvert; this alternative would speed up the process.

Disadvantages: If too much material is added to the culvert bottom, its conveyance would be altered and the upstream flood profile could be affected.

Feasibility: Providing the design of the culvert can maintain existing flood elevations, this alternative is feasible.

Alternative 10B—Re-meander on floodplain

Alternative summary: Construct a meandering stream channel through the existing floodplain to improve connectivity of flood flows with the floodplain.

Advantages: The additional meander bends in the floodplain would allow for increased habitat by adding stream length and improve the aesthetics within this reach. The new channel will be constructed with a geomorphically appropriate cross section, which will help ensure ongoing channel stability.

Disadvantages: Adding stream length and raising the bed elevation of the stream will decrease the stream slope, reduce conveyance, and could affect the upstream flood profile. Hydraulic modeling will be required during final design to ensure the flood profile is not impacted. Impacts to the flood elevation could be offset by lowering the floodplain as described in Alternative 10D. In addition, construction of a new channel through the existing wetland floodplain may require mitigation for wetland impacts. Two sanitary manholes exist within this site. The re-meander must not impede vehicle access to the manholes or increase the potential for fluvial erosion around the manholes.

Feasibility: This alternative is feasible; however, there are multiple obstacles. It will be difficult to find a reasonable way to re-meander the stream while maintaining necessary vehicle access to the sewer manholes. This option will also be relatively costly compared to the other alternatives.

Alternative 10C—Raise channel bed with vanes/riffles

Alternative summary: Raise the channel bed elevation with boulder cross vanes or constructed riffles to act as localized grade control and improve connectivity of flood flows with the floodplain.

Advantages: The installation of cross vanes would facilitate sedimentation upstream of the cross vanes and naturally raise the stream bed without construction of an entirely new channel. If properly designed and constructed, cross vanes could also help direct flow away from existing eroding banks. This alternative will have reduced wetland impacts compared to Alternative 10B.

Disadvantages: Similar to Alternative 10B, raising the bed elevation could affect the upstream flood profile. Hydraulic modeling will be required during final design, and impacts could be offset by lowering the floodplain as described in Alternative 10D. In addition, this alternative will not alter the stream cross section if it is found to be overly wide in areas away from the installed vanes or riffles.

Feasibility: Providing that the design of the vanes or riffles can maintain existing flood elevations, this alternative is feasible.

Alternative 10D—Lower floodplain

Alternative summary: Lower portions of the floodplain adjacent to the stream channel to improve connectivity of flood flows with the floodplain and maintain the existing flood profile. This alternative may be used alone or in combination with Alternative 10B or 10C.

Advantages: Improved access to the floodplain creates fertile overbank areas for vegetation associated with the stream buffer and improves habitat in the buffer. Additionally, a lowered floodplain will produce increased flood storage and could lower the design flood profile.

Disadvantages: Lowering the floodplain within this reach will impact a delineated wetland. Additional permitting may be required to ensure the wetland impacts are mitigated or are determined to be self-mitigating. Due to the volume of soil to be removed, this alternative may be more costly than alternatives addressing the stream channel alone. Any grading work within the floodplain must not disturb the existing sanitary manholes and should provide vehicle access to the manholes.

Feasibility: This alternative is feasible and may allow for feasible construction of Alternative 10B or 10C. Based on feedback from the technical stakeholder meeting, permitting of the wetland impacts is not anticipated to be a significant obstacle.

Infeasible alternatives

Due to the relatively recent replacement of the culvert under Fernbrook Lane North by the City, any further replacement of the culvert or addition of culverts on the floodplain are considered infeasible.

Site 10 recommendations

Re-meandering the stream channel through Site 10 would require significant excavation, both for the new channel and to maintain flood flow capacity by lowering the floodplain. It may also conflict with the existing sanitary manhole in the area. Alternative 10C is recommended for this site because it provides many of the same benefits at a lower cost; in addition, fewer boulder vanes may be needed if the design is coordinated with stabilization of Sites 11 through 13. Alternative 10D is also recommended because some degree of increased flood flow capacity will likely be needed to offset the raised channel bed elevation.

G.7 Sites 11 through 13

Eroding banks are present in several locations in Reach 2. Sites 11 through 13 are located within the section of Plymouth Creek addressed in Site 10 (see Figure G-3). Stabilization of these sites could be performed instead of or in conjunction with one of the alternatives described for Site 10. The eroding banks at these sites are shown in Photo 10 through Photo 12 of Appendix A.

Alternatives 11A through 13A—Stabilize with hard armor/riprap

Alternative summary: Install riprap along the outer banks to reduce the sediment loading and loss of bank.

Advantages: Riprap is relatively inexpensive, effective in reducing bank erosion, and if properly designed can be resilient to large flood events.

Disadvantages: Hard armoring does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the riprap, maintenance costs tend to be higher than for bioengineering techniques.

Feasibility: This alternative is feasible if bioengineering techniques are not possible.

Alternatives 11B through 13B—Stabilize with root wads

Alternative summary: Install root wads around eroding bends to direct flow to the center of the stream.

Advantages: Root wads will reduce the erosive stress on the outer banks, reduce bank erosion, and allow vegetation to become established. Root wads also create scour pools and cover that can increase habitat diversity within the stream. Trees will likely need to be removed to gain access to these banks, providing a source for the root wads.

Disadvantages: Root wads will require removing trees; however, bank access is likely to require tree removal regardless of the technique. Adding root wads to the outer banks will add complexity and require more detailed design and construction oversight to achieve the desired flow patterns.

Feasibility: This alternative is feasible provided root wads would not require unnecessary tree removal.

Sites 11 through 13 recommendations

Given the expressed preference of the BCWMC and permitting agencies for bioengineering solutions, Alternatives 11B through 13B are recommended. As discussed in Section G.6 for Site 10, the required number of root wad may be reduced during final design if selected vane locations for Alternative 10C can meet the objectives of both raising the channel bed elevation and stabilizing meander bends.

G.8 Site 14

Site 14 includes the outfall from a 12-inch-diameter PVC pipe draining from the Plymouth Creek Park parking area to Plymouth Creek (see Figure G-3). The outfall of this pipe has limited stabilization and is causing sediment to erode into the creek (see Photo 13 in Appendix A).

Alternative 14A—Stabilize with hard armor/riprap

Alternative summary: Install riprap from the pipe outlet to the stream.

Advantages: Riprap is relatively inexpensive, effective in reducing erosion, and if properly designed can be resilient to large flood events. Riprap is the primary stabilization technique for pipe outlets due to its effectiveness at protecting against the high anticipated velocities and associated shear stresses from the outlet.

Disadvantages: Hard armoring does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the riprap, maintenance costs tend to be higher than for bioengineering techniques.

Feasibility: This alternative is feasible.

Alternative 14B—Stabilize with reinforced concrete swale

Alternative summary: Install a reinforced concrete swale from the pipe outlet to the stream.

Advantages: A concrete swale is highly effective in eliminating erosion at pipe outlets. If designed correctly, the swale can have a long life expectancy.

Disadvantages: A concrete swale does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the swale, maintenance costs tend to be higher than for bioengineering techniques.

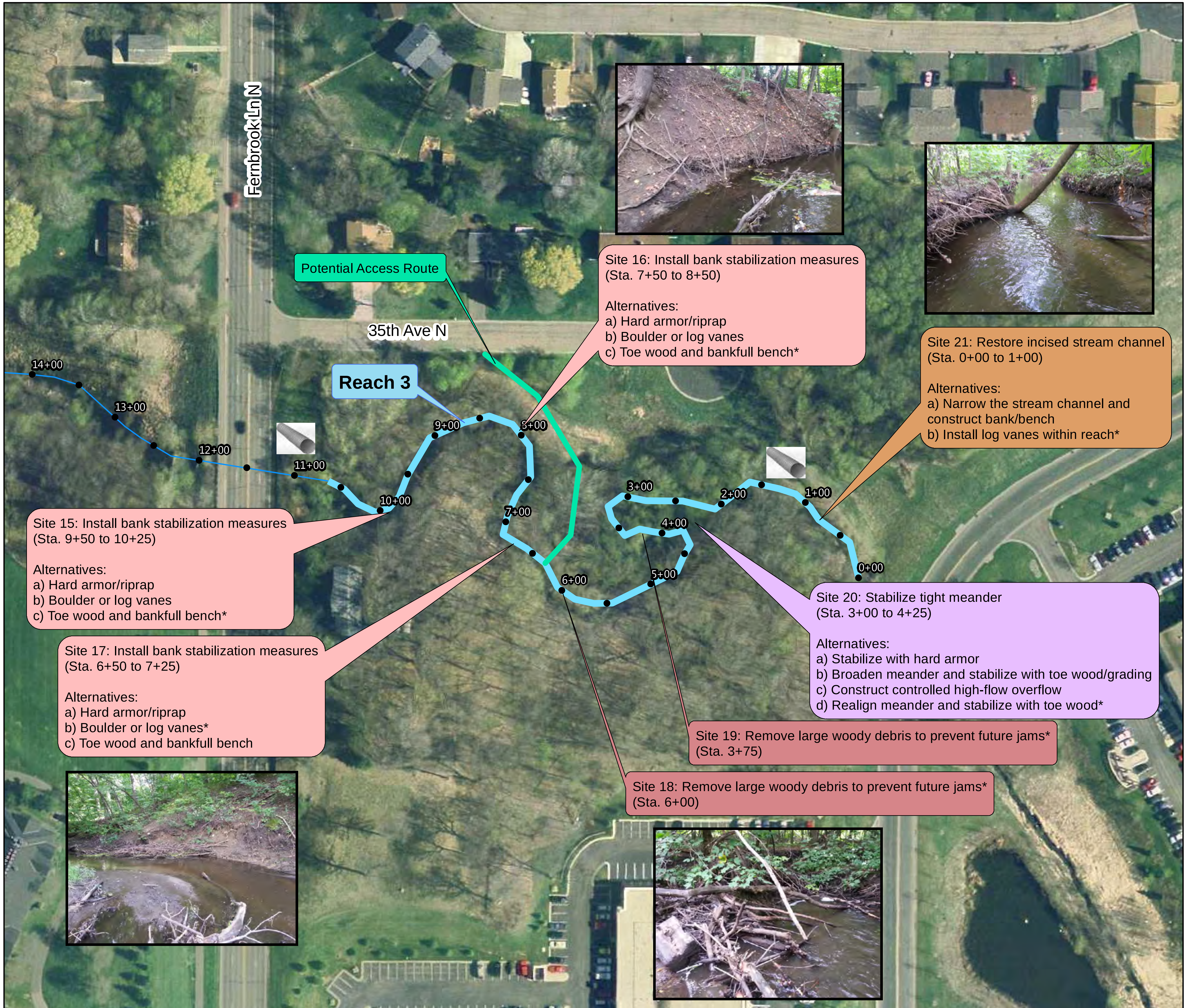
Feasibility: This alternative is feasible.

Infeasible alternatives

Due to the high anticipated velocities associated with the pipe outfall and the expense of replacing a failed pipe, bioengineering techniques are not typically used at sites like this.

Site 14 recommendations

Alternative 14A is recommended to maintain consistency with techniques used elsewhere within the project area (riprap rather than concrete armoring).



Reach 3

Issues: Several large eroding outer banks. Significant woody debris causing jams that redirect flow at banks. Unstable tight meander in downstream third in the process of being cut off.

Constraints: Narrow valley and low slope limit meandering potential, Deep shade limits vegetation options. Meander cutoff and loss of stream length could be permitting issue. Some existing trees may need preservation, inhibiting work access in their vicinity.

Legend

- Pedestrian Bridge
- Culvert Outfall

Note: Individual alternatives are defined as a, b, or c for many of the sites. One or more alternatives will be chosen for each site.

***Indicates recommended alternative**

N

Feet: 100 0 100 200

Meters: 30 0 30 60

Figure G-4

PLYMOUTH CREEK REACH 3 ALTERNATIVES
Plymouth Creek Feasibility Study
Bassett Creek Watershed
Management Commission

G.9 Sites 15, 16, and 17

Steep eroding banks are present in three locations within Reach 3, as shown on Figure G-4. In these locations, the bend radius is not overly tight, but the stream channel is cutting into high valley walls, causing bank failures, and undercutting trees (see Photo 14 through Photo 16 in Appendix A).

Alternatives 15A through 17A—Stabilize with hard armor

Alternative summary: Install riprap along the outer banks to reduce the sediment loading and loss of bank.

Advantages: Riprap is relatively inexpensive, effective in reducing bank erosion, and if properly designed can be resilient to large flood events.

Disadvantages: Hard armoring does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the riprap, maintenance costs tend to be higher than for bioengineering techniques. High erosive stress will continue to act at the toe of the steep banks, especially in high flows.

Feasibility: This alternative is feasible if suitable bioengineering alternatives are not identified.

Alternatives 15B through 17B—Stabilize with boulder or log vanes

Alternative summary: Install boulder or log vanes around eroding bends to direct flow to the center of the stream.

Advantages: Boulder or log vanes will reduce the erosive stress on the outer banks, reduce bank erosion, and allow for establishment of vegetation. Vanes also create mid-channel scour pools that can increase habitat diversity within the stream.

Disadvantages: Depending on their design, vanes can increase the upstream flood profile; hydraulic modeling will be required during final design to ensure that flood impacts are acceptable. Adding vanes to the outer banks will add complexity and require more detailed design and construction oversight to achieve the desired flow patterns. High erosive stress will continue to act at the toe of the steep banks during high flows.

Feasibility: This alternative is feasible.

Alternatives 15C through 17C—Stabilize with toe wood

Alternative summary: Install toe wood (root wads and large woody debris) around eroding bends to increase roughness of the lower banks and establish a vegetated bench at the toe of the high, eroding banks.

Advantages: Toe wood, constructed from natural materials at the project site, is effective in reducing stream bank erosion. Select trees can be removed within this reach to thin the cover and facilitate understory growth and provide material for the toe wood. The in-stream root wads create habitat complexity, while the vegetated bench separates the area of high erosive stress from the steep outer banks.

Disadvantages: Toe wood installation is more challenging than hard armoring and will require additional construction oversight to achieve the desired flow patterns. The longevity of toe wood depends on the woody material being consistently submerged (less potential for rotting) and successful establishment of vegetation along the bench. Toe wood becomes less cost effective if sufficient material is not available onsite.

Feasibility: This alternative is feasible, provided that sufficient woody material can be harvested from within the reach without excessive tree removal.

Infeasible alternatives

Stabilizing the high eroding banks with grading or VRSS is considered infeasible due to the number of trees that would need to be removed to grade the banks to a stable slope. Due to the shady conditions, establishing stabilizing vegetation for VRSS would be difficult.

Sites 15 through 17 recommendations

Although Sites 15 through 17 share many characteristics, the meander bends do not need to be stabilized using identical techniques. Hard armoring methods are not preferred, but there may not be sufficient woody material available to stabilize all three bends with toe wood; the optimal solution may require a combination of toe wood and vane techniques. Accordingly, Alternatives 15C, 16C, and 17B are recommended. Site 17 has the largest meander radius, making it the best candidate for stabilization with boulder or log vanes.

G.10 Sites 18 and 19

Large woody debris is present in two primary locations within the stream (see Figure G-4 and Photos 18 and 19 in Appendix A). The debris causes jams within the stream—redirecting flow towards the banks, which causes bank erosion.

Alternatives 18A and 19A—Remove large woody debris

Alternative summary: Remove existing large woody debris from the stream.

Advantages: Removal of the debris will allow the stream to flow naturally and reduce the stream bank erosion. It will also reduce flooding potential by removing the flow blockages.

Disadvantages: Woody debris removal will decrease the effective roughness of the stream channel and may cause increased flow velocities. Increased flow velocities in the absence of other restoration or stabilization measures could increase bank erosion.

Feasibility: This alternative is feasible and may provide a source of woody material for Alternatives 15C through 17C (toe wood), but it should not be pursued apart from other stabilization measures within Reach 3.

Sites 18 and 19 recommendations

Alternatives 18A and 19A are recommended.

G.11 Site 20

A tight meander is present within the downstream half of Reach 3 (Station 3+00 to 3+50 on Figure G-4). The meander radius is overly small, making the bend unstable and contributing to significant erosion of the outer bank. In addition, the meander is being cut off at the upstream bend (Station 4+25). Photo 19 in Appendix A shows the developing cutoff.

Alternative 20A—Stabilize with hard armor

Alternative summary: Install riprap along the outer banks of both the tight meander (Station 3+00 to 3+50) and the upstream meander (Station 4+00 to 4+50) to reduce sediment loading and loss of bank and prevent meander cutoff.

Advantages: Riprap is relatively inexpensive, effective in reducing bank erosion, and if properly designed can be resilient to large flood events.

Disadvantages: Hard armoring does not encourage vegetative growth and does not appear natural or provide quality in-stream habitat. If erosion occurs around or behind the riprap, maintenance costs tend to be higher than for bioengineering techniques. High erosive stress will continue to act at the toe of the steep bank, especially in high flows, and the tendency for the stream to cutoff the meander will remain.

Feasibility: This alternative is feasible if bioengineering methods are not possible.

Alternative 20B—Stabilize with toe wood and grading to broaden meander

Alternative summary: Install toe wood (root wads and large woody debris) around the eroding bends (Station 3+00 to 3+50 and 4+00 to 4+50) to increase roughness of the lower banks and establish a vegetated bench at the toe of the high, eroding banks. Use the toe wood bench to increase the meander radius by excavating a new channel, as necessary. Depending on the final channel alignment, boulder or log vanes may be used to decrease the length of toe wood required.

Advantages: This alternative retains the general meander pattern of the stream and can be designed to have minimal impact on the overall stream length. Toe wood is effective in reducing stream bank erosion, using natural sources of materials at the project site. Select trees can be removed within this reach to thin the cover, facilitate understory growth, and provide material for the toe wood. The in-stream root wads create habitat complexity, while the vegetated bench separates the area of high erosive stress from the steep outer banks.

Disadvantages: Due to the tight project limits in this area, the stream will still have relatively tight bends. This may, eventually, result in a cutoff loop regardless of stabilization efforts. Hydraulic modeling will be required during final design to ensure that flood impacts are acceptable. Toe wood installation is more challenging than hard armoring and will require additional construction oversight to achieve the desired flow patterns. The longevity of toe wood depends on the woody material being consistently submerged (less potential for rotting) and successful establishment of vegetation along the bench. A significant number of trees would need to be removed for grading and to ensure that enough material is available for toe wood.

Feasibility: This alternative is feasible, provided that sufficient woody material is available and that design of the adjusted meander pattern can maintain existing flood elevations.

Alternative 20C—Create controlled high-flow overflow

Alternative summary: Stabilize the area forming a natural cutoff (from approximately Station 2+25 to 4+25) with an armored overflow channel that could be used during flood events to prevent the stream from completing the meander cutoff. A grade-control structure made of fieldstone could direct flow through the area during flood events. This alternative could be combined with Alternative 20A or 20B to stabilize the remaining tight meander, which would continue to convey flow during low- to average-flow conditions.

Advantages: Stabilizing the natural overflow while retaining the existing low-flow channel will maintain the existing stream length and habitat while preventing uncontrolled stream migration and corresponding erosion. Installation of riprap or logs in this area would be relatively inexpensive and could be designed for stability during high flows.

Disadvantages: Hydraulic modeling will be required during final design to ensure that flood impacts are acceptable. If stabilization measures are not taken on the surrounding meander bends (Alternative 20A or 20B), the high-flow overflow could be flanked by erosion and the stream could experience an abrupt avulsion or change of course. This option will need to be approved by the MDNR. Monitoring information may need to be provided to address their concern that the design might result in the loss of habitat.

Feasibility: This alternative is feasible, provided that design of the high-flow overflow and any additional meander stabilization measures can maintain existing flood elevations.

Alternative 20D—Realign channel to stabilize and broaden meander

Alternative summary: Change the stream channel alignment upstream of the cutoff and the tight meanders (from approximately Station 3+00 to 6+25) to create meanders with stable curvature. Install toe wood and boulder or log vanes around both meander bends to stabilize the outer banks and create a bankfull bench.

Advantages: Creating a stable channel pattern will ensure long-term stability and reduce the risk of meander cutoff or avulsion. Toe wood and vanes are effective in reducing stream bank erosion, using natural sources of materials at the project site. Select trees can be removed within this reach to thin the cover, facilitate understory growth, and provide material for the toe wood. The in-stream root wads create habitat complexity, while the vegetated bench separates the area of high erosive stress from the steep outer banks.

Disadvantages: Changing the stream alignment will result in a reduction in overall stream length by approximately 100 feet, which will increase the stream slope. Hydraulic modeling will be required during final design to ensure that flood impacts are acceptable. Toe wood installation is more challenging than hard armoring and will require additional construction oversight to achieve the desired flow patterns. The longevity of toe wood depends on the woody material being consistently submerged (less potential for rotting) and successful establishment of vegetation along the bench. A significant number of trees would need to be removed for grading and to ensure that enough material is available for toe wood.

Feasibility: Based on feedback from MDNR that reductions in stream length may be acceptable in order to increase stability and long-term habitat value of the stream, this alternative is feasible. Final design will need to verify that sufficient woody material is available and that design of the adjusted meander pattern can maintain existing flood elevations.

Infeasible alternatives

Stabilizing this meander with boulder or log vanes alone is not considered feasible due to the low meander radius. In conditions with very tight meander bends, installation of vanes to redirect flow is sensitive to minor error and unexpected outcomes, and this alternative would not address the tendency of the stream to cutoff the meander.

Site 20 recommendations

Alternative 20D is recommended to prevent uncontrolled stream avulsion, reduce erosion from the tight meander banks, and increase the long-term habitat value of the stream. This alternative will be significantly more expensive than stabilizing the meander with hard armoring, but will provide long-term benefits to the channel stability, stream habitat, and natural character of Plymouth Creek in Reach 3. Coordination with MDNR and other permitting agencies will be required throughout the final design process to ensure that the reduction in stream length is acceptable.

G.12 Site 21

Similar to Site 3 in Reach 1, Site 21 consists of an over-widened stream channel without an active floodplain (see Figure G-4 and Photo 20 in Appendix A).

Alternative 21A—Narrow stream channel and construct floodplain bench

Alternative summary: Narrow the stream channel by grading to establish a vegetated floodplain bench within the existing channel alignment; offset the decreased channel cross section by cutting back the existing high banks.

Advantages: Narrowing the channel will provide improved habitat by deepening the channel during low flows and create an active (if narrow) floodplain and vibrant stream buffer soon after construction.

Disadvantages: Creating a floodplain without decreasing the overall conveyance of the narrowed channel will require significant grading and excavation from the existing upper banks. Tree removals will likely be required in some locations to achieve the desired channel shape. Hydraulic modeling will be required during final design to ensure the flood profile is not impacted.

Feasibility: Providing that the design of the narrowed channel can maintain existing flood elevations, this alternative is feasible, although it will require significant and costly grading.

Alternative 21B—Install log vanes

Alternative summary: Install log vanes and reshape the channel bottom to narrow the low-flow channel while maintaining the overall channel cross section.

Advantages: Narrowing the low-flow channel with log vanes will provide improved habitat by deepening the channel during low flows and reduce the stress on the upper banks during high flows. Natural materials available onsite could be used for much of the log vane construction.

Disadvantages: The bench created by the log vanes will remain below the bankfull flow elevation and periodic inundation will prevent establishment of vegetation. The exposed soil creek bottom may be less aesthetically pleasing than a vegetated floodplain.

Feasibility: Providing that the design of the narrowed channel can maintain existing flood elevations, this alternative is feasible.

Infeasible alternatives

Narrowing the stream channel by importing soil or rock and without excavating the high banks is not considered feasible due to the inevitable increase in the flood profile, which is not permitted by BCWMC policies.

The preference of stakeholders to maintain a natural stream channel makes lining Plymouth Creek with riprap infeasible.

Site 21 recommendations

Alternative 21B is recommended for stabilizing the stream bed and lower banks of Site 21 because it will require minimal tree removal and grading and utilize natural materials available onsite. Alternative 21C is recommended for stabilizing the upper banks and providing long-term natural aesthetics to the stream corridor.

Table G-1 Plymouth Creek feasibility study alternatives summary

Reach	Site	Alternative	Alternative Description	Advantages	Disadvantages	Rec.?
Reach 1	Site 1	Alternative A	Remeander into historic channels	Adds habitat by adding stream length, improves aesthetics and water quality.	Decreases already shallow slope, requires tree removals.	N
Reach 1	Site 1	Alternative B	Stabilize erosion areas with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not use historic channels, does not provide natural habitat, less aesthetically pleasing.	N
Reach 1	Site 1	Alternative C	Stabilize erosion areas with root wads, log vanes, and vegetation	Contributes to habitat, provides grade control, and utilizes materials generated on site.	Does not use historic channels, vegetation limited to shade-tolerant species.	Y
Reach 1	Site 2	Alternative A	Remeander into historic channels	Adds habitat by adding stream length, improves aesthetics and water quality.	Decreases already shallow slope, requires tree removals.	N
Reach 1	Site 2	Alternative B	Stabilize erosion areas with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not use historic channels, does not provide natural habitat, less aesthetically pleasing.	N
Reach 1	Site 2	Alternative C	Stabilize erosion areas with root wads, log vanes, and vegetation	Contributes to habitat, provides grade control, and utilizes materials generated on site.	Does not use historic channels, vegetation limited to shade-tolerant species.	Y
Reach 1	Site 3	Alternative A	Narrow channel for approx. 800'	Improves habitat by deepening channel, improves access to floodplain.	Requires significant grading and tree removals.	N
Reach 1	Site 3	Alternative B	Install log vanes within reach	Improves habitat by deepening channel, provides grade control, reduces upper bank stress.	Does not create vegetated floodplain.	Y
Reach 1	Site 3	Alternative C	Upper bank vegetation	Improves aesthetics of stream bank, reduces erosion.	Requires careful coordination with disc golf users, vegetation limited to shade-tolerant species.	Y
Reach 1	Site 4	Alternative A	Establish vegetated buffer	Improves aesthetics of riparian area, reduces erosion.	Requires careful coordination with disc golf users, vegetation limited to shade-tolerant species.	Y
Reach 1	Site 4	Alternative B	Realign disc golf course	Reduces or removes foot traffic pressure on banks.	May decrease natural amenities of course, may require clearing.	N
Reach 1	Site 5	Alternative A	Stabilize steep, eroding bank with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing.	N
Reach 1	Site 5	Alternative B	Vegetate steep, eroding bank with VRSS	Contributes to habitat, improves aesthetics.	More costly to install, vegetation limited to shade-tolerant species.	Y
Reach 1	Site 6	Alternative A	Stabilize bridge abutments with riprap and log vanes	Reduces erosion, reduces erosive pressure on abutments for added protection.	Riprap does not provide natural habitat, more complex design.	Y
Reach 1	Site 6	Alternative B	Stabilize bridge abutments with riprap only	Reduces erosion, less complex design.	Riprap does not provide natural habitat, requires more riprap.	N
Reach 1	Site 7	Alternative A	Stabilize bridge abutments with riprap and log vanes	Reduces erosion, reduces erosive pressure on abutments for added protection.	Riprap does not provide natural habitat, more complex design.	Y
Reach 1	Site 7	Alternative B	Stabilize bridge abutments with riprap only	Reduces erosion, less complex design.	Riprap does not provide natural habitat, requires more riprap.	N
Reach 2	Site 8	Alternative A	Stabilize bridge abutments with riprap and log vanes	Reduces erosion, reduces erosive pressure on abutments for added protection.	Riprap does not provide natural habitat, more complex design.	Y
Reach 2	Site 8	Alternative B	Stabilize bridge abutments with riprap only	Reduces erosion, less complex design.	Riprap does not provide natural habitat, requires more riprap.	N
Reach 2	Site 9	Alternative A	Stabilize bridge abutments with riprap and log vanes	Reduces erosion, reduces erosive pressure on abutments for added protection.	Riprap does not provide natural habitat, more complex design.	Y
Reach 2	Site 9	Alternative B	Stabilize bridge abutments with riprap only	Reduces erosion, less complex design.	Riprap does not provide natural habitat, requires more riprap.	N
Reach 2	Site 10	Alternative A	Raise stream bed in Fernbrook Lane North culvert	Low cost, improves stream access to floodplain.	Reduces culvert conveyance and may affect flood elevations.	N
Reach 2	Site 10	Alternative B	Create meanders in open area to add 70' of stream length	Improves habitat by adding stream length, improves stream access to floodplain, creates stable cross-section.	Decreases already shallow slope, increases wetland impacts, requires coordination with sanitary manholes.	N

Table G-1 Plymouth Creek feasibility study alternatives summary

Reach	Site	Alternative	Alternative Description	Advantages	Disadvantages	Rec.?
Reach 2	Site 10	Alternative C	Raise channel bed using cross vanes/constructed riffles	Reduces bed and bank erosion, improves stream access to floodplain.	Decreases already shallow slope, does not address stream cross-section in other locations.	Y
Reach 2	Site 10	Alternative D	Lower adjacent floodplain	Improves stream access to floodplain, improves buffer habitat, reduces flood elevation.	Significant disturbance of wetland, may require significant grading, requires coordination with sanitary manholes.	Y
Reach 2	Site 11	Alternative A	Stabilize eroding banks with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing.	N
Reach 2	Site 11	Alternative B	Stabilize banks with root wads	Reduces bank erosion, improves in-stream habitat, utilizes materials generated on site.	Requires tree removals, more complex design.	Y
Reach 2	Site 12	Alternative A	Stabilize eroding banks with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing.	N
Reach 2	Site 12	Alternative B	Stabilize banks with root wads	Reduces bank erosion, improves in-stream habitat, utilizes materials generated on site.	Requires tree removals, more complex design.	Y
Reach 2	Site 13	Alternative A	Stabilize eroding banks with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing.	N
Reach 2	Site 13	Alternative B	Stabilize banks with root wads	Reduces bank erosion, improves in-stream habitat, utilizes materials generated on site.	Requires tree removals, more complex design.	Y
Reach 2	Site 14	Alternative A	Stabilize culvert outfall with hard armor	Inexpensive, effectively stabilizes outfall from erosion.	Does not provide natural habitat, not aesthetically pleasing.	Y
Reach 2	Site 14	Alternative B	Stabilize culvert outfall with concrete swale	Effectively stabilizes outfall from erosion, long life expectancy.	Does not provide natural habitat, not aesthetically pleasing.	N
Reach 3	Site 15	Alternative A	Install bank stabilization measures at eroding banks using hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing, does not reduce erosive stress.	N
Reach 3	Site 15	Alternative B	Install 4 rock vanes for bank protection	Reduces erosive stress and bank erosion, improves in-stream habitat.	Can result in increases in flood elevations, less effective at high flows.	N
Reach 3	Site 15	Alternative C	Install bank stabilization measures at eroding banks using toe wood	Stabilizes bank and reduces stress and erosion, provides habitat, utilizes materials generated on site.	Installation can be challenging, useful life is less than other options, requires significant woody debris.	Y
Reach 3	Site 16	Alternative A	Install bank stabilization measures at eroding banks using hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing, does not reduce erosive stress.	N
Reach 3	Site 16	Alternative B	Install 4 rock vanes for bank protection	Reduces erosive stress and bank erosion, improves in-stream habitat.	Can result in increases in flood elevations, less effective at high flows.	N
Reach 3	Site 16	Alternative C	Install bank stabilization measures at eroding banks using toe wood	Stabilizes bank and reduces stress and erosion, provides habitat, utilizes materials generated on site.	Installation can be challenging, useful life is less than other options, requires significant woody debris.	Y
Reach 3	Site 17	Alternative A	Install bank stabilization measures at eroding banks using hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing, does not reduce erosive stress.	N
Reach 3	Site 17	Alternative B	Install 4 rock vanes for bank protection	Reduces erosive stress and bank erosion, improves in-stream habitat.	Can result in increases in flood elevations, less effective at high flows.	Y
Reach 3	Site 17	Alternative C	Install bank stabilization measures at eroding banks using toe wood	Stabilizes bank and reduces stress and erosion, provides habitat, utilizes materials generated on site.	Installation can be challenging, useful life is less than other options, requires significant woody debris.	N
Reach 3	Site 18	Alternative A	Remove large woody debris	Reduces flooding potential and bank erosion.	Decreases stream roughness and may increase flow velocity.	Y
Reach 3	Site 19	Alternative A	Remove large woody debris	Reduces flooding potential and bank erosion.	Decreases stream roughness and may increase flow velocity.	Y
Reach 3	Site 20	Alternative A	Stabilize with hard armor	Inexpensive, effective at reducing bank erosion, resilient to large flood events.	Does not provide natural habitat, less aesthetically pleasing, does not reduce erosive stress.	N

Table G-1 Plymouth Creek feasibility study alternatives summary

Reach	Site	Alternative	Alternative Description	Advantages	Disadvantages	Rec.?
Reach 3	Site 20	Alternative B	Stabilize with toe wood and grading to broaden meander	Stabilizes bank and reduces stress and erosion, provides habitat, utilizes materials generated on site, maintains existing stream length.	Installation can be challenging, useful life is less than other options, requires significant woody debris.	N
Reach 3	Site 20	Alternative C	Controlled overflow, install grade control structure downstream	Stabilizes active meander cutoff, maintains existing stream length.	Can be flanked by erosion and stream avulsion.	N
Reach 3	Site 20	Alternative D	Realign channel and stabilize meanders with vanes and toe wood	Stabilizes bank and reduces stress and erosion, provides habitat, utilizes materials generated on site, improves cross section stability.	Reduces stream length and increases stream slope, installation can be challenging, useful life is less than other options, requires significant woody debris.	Y
Reach 3	Site 21	Alternative A	Narrow channel for approx. 80'	Improves habitat by deepening channel, improves access to floodplain.	Requires significant grading and tree removals.	N
Reach 3	Site 21	Alternative B	Install log vanes within reach	Improves habitat by deepening channel, provides grade control, reduces upper bank stress.	Does not create vegetated floodplain.	Y

Appendix H

Detailed Alternative Cost Estimates

Table H-1 Plymouth Creek feasibility study alternatives cost estimates

Reach	Site	Alternative	Alternative Description	Construction Cost Estimate [1]	Construction Contingency [2]	Engineering [3]	Capital Cost Estimate [4][5]	Estimated Life Span [6] (years)	Annual Maint. Est. [7]	Major Maint. Est. [8]	30-Year Future Worth Estimate [9][10]	Annualized Cost [10][11]	TP Loading: Load Reduction (lb/yr)	TP Loading: Cost/lb Reduced [12]	TSS Loading: Load Reduction (lb/yr)	TSS Loading: Cost/lb Reduced [12]	Rec.?
Reach 1	Site 1	Alternative A	Remeander into historic channels	$ 93,600	$ 28,080	$ 28,080	$ 149,800	30	$ 440	$ 14,980	$ 411,600	$ 8,700	0.20	$ 44,260	340	$ 25.59	N
Reach 1	Site 1	Alternative B	Stabilize erosion areas with hard armor	$ 17,420	$ 5,230	$ 5,230	$ 27,900	30	$ 210	$ 13,950	$ 102,900	$ 2,200	0.20	$ 11,190	340	$ 6.47	N
Reach 1	Site 1	Alternative C	Stabilize erosion areas with root wads, log vanes, and vegetation	$ 16,080	$ 4,820	$ 4,820	$ 25,700	20	$ 190	$ 6,430	$ 83,100	$ 1,700	0.20	$ 8,650	340	$ 5.00	Y
Reach 1	Site 2	Alternative A	Remeander into historic channels	$ 37,420	$ 11,230	$ 11,230	$ 59,900	30	$ 180	$ 5,990	$ 164,800	$ 3,500	0.23	$ 15,420	390	$ 8.97	N
Reach 1	Site 2	Alternative B	Stabilize erosion areas with hard armor	$ 21,770	$ 6,530	$ 6,530	$ 34,800	30	$ 260	$ 17,400	$ 128,300	$ 2,700	0.23	$ 11,890	390	$ 6.92	N
Reach 1	Site 2	Alternative C	Stabilize erosion areas with root wads, log vanes, and vegetation	$ 10,810	$ 3,240	$ 3,240	$ 17,300	20	$ 130	$ 4,330	$ 56,000	$ 1,200	0.23	$ 5,290	390	$ 3.08	Y
Reach 1	Site 3	Alternative A	Narrow channel for approx. 800'	$ 35,270	$ 10,580	$ 10,580	$ 56,400	30	$ 170	$ 5,640	$ 155,200	$ 3,300	1.7	$ 1,990	2,890	$ 1.14	N
Reach 1	Site 3	Alternative B	Install log vanes within reach	$ 31,450	$ 9,440	$ 9,440	$ 50,300	20	$ 370	$ 12,580	$ 162,400	$ 3,400	1.7	$ 2,050	2,890	$ 1.18	Y
Reach 1	Site 3	Alternative C	Upper bank vegetation	$ 14,150	$ 4,250	$ 4,250	$ 22,700	10	$ 350	$ 5,680	$ 103,400	$ 2,200	1.7	$ 1,320	2,890	$ 0.76	Y
Reach 1	Site 4	Alternative A	Establish vegetated buffer	$ 14,840	$ 4,450	$ 4,450	$ 23,700	10	$ 320	$ 5,930	$ 105,800	$ 2,200	2.2	$ 990	3,850	$ 0.57	Y
Reach 1	Site 4	Alternative B	Realign disc golf course	$ 50,510	$ 15,150	$ 15,150	$ 80,800	30	$ 250	$ 8,080	$ 222,600	$ 4,700	2.2	$ 2,120	3,850	$ 1.22	N
Reach 1	Site 5	Alternative A	Stabilize steep, eroding bank with hard armor	$ 9,280	$ 2,780	$ 2,780	$ 14,800	30	$ 110	$ 7,400	$ 54,500	$ 1,100	1.9	$ 590	3,240	$ 0.34	N
Reach 1	Site 5	Alternative B	Vegetate steep, eroding bank with VRSS	$ 20,480	$ 6,140	$ 6,140	$ 32,800	20	$ 570	$ 8,200	$ 121,500	$ 2,600	1.9	$ 1,400	3,240	$ 0.80	Y
Reach 1	Site 6	Alternative A	Stabilize bridge abutments with riprap and log vanes	$ 7,940	$ 2,380	$ 2,380	$ 12,700	30	$ 100	$ 6,350	$ 47,000	$ 1,000	0.13	$ 7,530	230	$ 4.35	Y
Reach 1	Site 6	Alternative B	Stabilize bridge abutments with riprap only	$ 7,550	$ 2,270	$ 2,270	$ 12,100	30	$ 90	$ 6,050	$ 44,600	$ 900	0.13	$ 6,770	230	$ 3.91	N
Reach 1	Site 7	Alternative A	Stabilize bridge abutments with riprap and log vanes	$ 7,940	$ 2,380	$ 2,380	$ 12,700	30	$ 100	$ 6,350	$ 47,000	$ 1,000	0.13	$ 7,530	230	$ 4.35	Y
Reach 1	Site 7	Alternative B	Stabilize bridge abutments with riprap only	$ 7,550	$ 2,270	$ 2,270	$ 12,100	30	$ 90	$ 6,050	$ 44,600	$ 900	0.13	$ 6,770	230	$ 3.91	N
Reach 2	Site 8	Alternative A	Stabilize bridge abutments with riprap and log vanes	$ 7,940	$ 2,380	$ 2,380	$ 12,700	30	$ 100	$ 6,350	$ 47,000	$ 1,000	0.13	$ 7,530	230	$ 4.35	Y
Reach 2	Site 8	Alternative B	Stabilize bridge abutments with riprap only	$ 7,550	$ 2,270	$ 2,270	$ 12,100	30	$ 90	$ 6,050	$ 44,600	$ 900	0.13	$ 6,770	230	$ 3.91	N
Reach 2	Site 9	Alternative A	Stabilize bridge abutments with riprap and log vanes	$ 7,940	$ 2,380	$ 2,380	$ 12,700	30	$ 100	$ 6,350	$ 47,000	$ 1,000	0.13	$ 7,530	230	$ 4.35	Y
Reach 2	Site 9	Alternative B	Stabilize bridge abutments with riprap only	$ 7,550	$ 2,270	$ 2,270	$ 12,100	30	$ 90	$ 6,050	$ 44,600	$ 900	0.13	$ 6,770	230	$ 3.91	N
Reach 2	Site 10	Alternative A	Raise stream bed in Fernbrook Lane North culvert	$ 6,700	$ 2,010	$ 2,010	$ 10,700	15	$ 20	$ 5,350	$ 48,300	$ 1,000	1.7	$ 590	2,970	$ 0.34	N
Reach 2	Site 10	Alternative B	Create meanders in open area to add 70' of stream length	$ 81,590	$ 24,480	$ 24,480	$ 130,600	30	$ 380	$ 13,060	$ 358,700	$ 7,500	1.7	$ 4,400	2,970	$ 2.53	N
Reach 2	Site 10	Alternative C	Raise channel bed using cross vanes/constructed riffles	$ 20,970	$ 6,290	$ 6,290	$ 33,600	20	$ 250	$ 16,800	$ 123,800	$ 2,600	1.7	$ 1,520	2,970	$ 0.88	Y
Reach 2	Site 10	Alternative D	Lower adjacent floodplain	$ 35,230	$ 10,570	$ 10,570	$ 56,400	30	$ 170	$ 5,640	$ 155,200	$ 3,300	1.7	$ 1,940	2,970	$ 1.11	Y
Reach 2	Site 11	Alternative A	Stabilize eroding banks with hard armor	$ 11,280	$ 3,380	$ 3,380	$ 18,000	30	$ 130	$ 9,000	$ 66,100	$ 1,400	1.9	$ 730	3,340	$ 0.42	N
Reach 2	Site 11	Alternative B	Stabilize banks with root wads	$ 11,750	$ 3,530	$ 3,530	$ 18,800	20	$ 140	$ 4,700	$ 60,800	$ 1,300	1.9	$ 680	3,340	$ 0.39	Y
Reach 2	Site 12	Alternative A	Stabilize eroding banks with hard armor	$ 11,280	$ 3,380	$ 3,380	$ 18,000	30	$ 130	$ 9,000	$ 66,100	$ 1,400	1.9	$ 730	3,340	$ 0.42	N
Reach 2	Site 12	Alternative B	Stabilize banks with root wads	$ 11,750	$ 3,530	$ 3,530	$ 18,800	20	$ 140	$ 4,700	$ 60,800	$ 1,300	1.9	$ 680	3,340	$ 0.39	Y
Reach 2	Site 13	Alternative A	Stabilize eroding banks with hard armor	$ 11,280	$ 3,380	$ 3,380	$ 18,000	30	$ 130	$ 9,000	$ 66,100	$ 1,400	1.9	$ 730	3,340	$ 0.42	N
Reach 2	Site 13	Alternative B	Stabilize banks with root wads	$ 11,750	$ 3,530	$ 3,530	$ 18,800	20	$ 140	$ 4,700	$ 60,800	$ 1,300	1.9	$ 680	3,340	$ 0.39	Y
Reach 2	Site 14	Alternative A	Stabilize culvert outfall with hard armor	$ 6,710	$ 2,010	$ 2,010	$ 10,700	30	$ 80	$ 5,350	$ 39,500	$ 800	1.1	$ 730	1,910	$ 0.42	Y

Table H-1 Plymouth Creek feasibility study alternatives cost estimates

Reach	Site	Alternative	Alternative Description	Construction Cost Estimate (1)	Construction Contingency (2)	Engineering (3)	Capital Cost Estimate (4)(5)	Estimated Life Span(6) (years)	Annual Maint. Est. (7)	Major Maint. Est. (8)	30-Year Future Worth Estimate(9)(10)	Annualized Cost(10)(11)	TP Loading		TSS Loading		Rec.?
													Load Reduction (lb/yr)	Cost/lb Reduced(12)	Load Reduction (lb/yr)	Cost/lb Reduced(12)	
Reach 2	Site 14	Alternative B	Stabilize culvert outfall with concrete swale	$ 7,730	$ 2,320	$ 2,320	$ 12,400	30	$ 100	$ 6,200	$ 46,100	$ 1,000	1.1	$ 910	1,910	$ 0.52	N
Reach 3	Site 15	Alternative A	Install bank stabilization measures at eroding banks using hard armor	$ 20,970	$ 6,290	$ 6,290	$ 33,600	30	$ 250	$ 16,800	$ 123,800	$ 2,600	7.0	$ 370	12,130	$ 0.21	N
Reach 3	Site 15	Alternative B	Install 4 rock vanes for bank protection	$ 23,010	$ 6,900	$ 6,900	$ 36,800	20	$ 220	$ 18,400	$ 133,000	$ 2,800	7.0	$ 400	12,130	$ 0.23	N
Reach 3	Site 15	Alternative C	Install bank stabilization measures at eroding banks using toe wood	$ 48,740	$ 14,620	$ 14,620	$ 78,000	20	$ 570	$ 19,500	$ 251,600	$ 5,300	7.0	$ 760	12,130	$ 0.44	Y
Reach 3	Site 16	Alternative A	Install bank stabilization measures at eroding banks using hard armor	$ 20,970	$ 6,290	$ 6,290	$ 33,600	30	$ 250	$ 16,800	$ 123,800	$ 2,600	7.0	$ 370	12,130	$ 0.21	N
Reach 3	Site 16	Alternative B	Install 4 rock vanes for bank protection	$ 23,010	$ 6,900	$ 6,900	$ 36,800	20	$ 220	$ 18,400	$ 133,000	$ 2,800	7.0	$ 400	12,130	$ 0.23	N
Reach 3	Site 16	Alternative C	Install bank stabilization measures at eroding banks using toe wood	$ 48,740	$ 14,620	$ 14,620	$ 78,000	20	$ 570	$ 19,500	$ 251,600	$ 5,300	7.0	$ 760	12,130	$ 0.44	Y
Reach 3	Site 17	Alternative A	Install bank stabilization measures at eroding banks using hard armor	$ 20,970	$ 6,290	$ 6,290	$ 33,600	30	$ 250	$ 16,800	$ 123,800	$ 2,600	7.0	$ 370	12,130	$ 0.21	N
Reach 3	Site 17	Alternative B	Install 4 rock vanes for bank protection	$ 23,010	$ 6,900	$ 6,900	$ 36,800	20	$ 220	$ 18,400	$ 133,000	$ 2,800	7.0	$ 400	12,130	$ 0.23	Y
Reach 3	Site 17	Alternative C	Install bank stabilization measures at eroding banks using toe wood	$ 48,740	$ 14,620	$ 14,620	$ 78,000	20	$ 570	$ 19,500	$ 251,600	$ 5,300	7.0	$ 760	12,130	$ 0.44	N
Reach 3	Site 18	Alternative A	Remove large woody debris	$ 3,670	$ 1,100	$ 1,100	$ 5,900	20	$ -	$ 1,480	$ 17,000	$ 400	0.09	$ 4,520	150	$ 2.67	Y
Reach 3	Site 19	Alternative A	Remove large woody debris	$ 3,670	$ 1,100	$ 1,100	$ 5,900	20	$ -	$ 1,480	$ 17,000	$ 400	0.09	$ 4,520	150	$ 2.67	Y
Reach 3	Site 20	Alternative A	Stabilize with hard armor	$ 29,880	$ 8,960	$ 8,960	$ 47,800	30	$ 350	$ 23,900	$ 175,800	$ 3,700	12.0	$ 310	20,800	$ 0.18	N
Reach 3	Site 20	Alternative B	Stabilize with toe wood and grading to broaden meander	$ 68,710	$ 20,610	$ 20,610	$ 109,900	20	$ 810	$ 27,480	$ 355,000	$ 7,500	12.0	$ 630	20,800	$ 0.36	N
Reach 3	Site 20	Alternative C	Controlled overflow, install grade control structure downstream	$ 31,240	$ 9,370	$ 9,370	$ 50,000	20	$ 370	$ 25,000	$ 184,200	$ 3,900	12.0	$ 330	20,800	$ 0.19	N
Reach 3	Site 20	Alternative D	Realign channel and stabilize meanders with vanes and toe wood	$ 92,380	$ 27,710	$ 27,710	$ 147,800	30	$ 440	$ 14,780	$ 406,300	$ 8,500	12.0	$ 710	20,800	$ 0.41	Y
Reach 3	Site 21	Alternative A	Narrow channel for approx. 80'	$ 16,650	$ 5,000	$ 5,000	$ 26,700	30	$ 80	$ 2,670	$ 73,400	$ 1,500	3.9	$ 380	6,780	$ 0.22	N
Reach 3	Site 21	Alternative B	Install log vanes within reach	$ 13,430	$ 4,030	$ 4,030	$ 21,500	20	$ 160	$ 5,380	$ 69,500	$ 1,500	3.9	$ 380	6,780	$ 0.22	Y
Project-wide			Educational signage	$ 2,500	$ 750	$ 750	$ 4,000	–	–	–	–	–	–	–	–	–	Y
Project-wide			Foot traffic management (temp. fencing and wood chip paths)	$ 5,000	$ 1,500	$ 1,500	$ 8,000	–	–	–	–	–	–	–	–	–	Y

Cost Summaries*

	Construction Cost Estimate	Construction Contingency	Engineering	Capital Cost Estimate	Estimated Life Span	Annual Maint. Est.	Major Maint. Est.	30-Year Future Worth Estimate	Annualized Cost	TP Load Reduction (lb/yr)	TP Cost/lb Reduced	TSS Load Reduction (lb/yr)	TSS Cost/lb Reduced
Lowest-cost feasible alternative at each site:	$ 316,000	$ 95,000	$ 95,000	$ 506,000		$ 3,400		$ 1,730,000	$ 36,300	52.2	$ 700	90,800	$ 0.40
Recommended alternative at each site:	**$ 479,000**	**$ 144,000**	**$ 144,000**	**$ 766,000**		**$ 5,200**		**$ 2,470,000**	**$ 52,100**	**52.2**	**$ 1,000**	**90,800**	**$ 0.57**
Highest-cost feasible alternative at each site:	$ 721,000	$ 216,000	$ 216,000	$ 1,153,000		$ 6,400		$ 3,510,000	$ 74,300	52.2	$ 1,420	90,800	$ 0.82

* Costs may not sum due to rounding.

(1) A Class 4 screening-level opinion of probable cost, as defined by the American Association of Cost Engineers International (AACI International), has been prepared for these alternatives. The opinion of probable construction cost provided in this table is made based on Barr'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 Barr at this time and includes a conceptual-level design of the project.

(2) Assumed 30% contingency on construction costs.

(3) Assumed 30% of construction costs for design, permitting, and adminstration.

(4) Includes estimated initial construction cost (with 30% contingency) and design, permitting, and adminstration costs (30% of construction cost).

(5) Many of the alternatives in this table are mutually exclusive. The total project cost will not be a sum of each of these alternatives, rather a sum of a unique combination of a portion of these alternatives.

(6) Estimated life span until significant maintenance is required.

(7) Assumed 50% of the initial establishment period maintenance for vegetation-only alternatives, 25% for all other alternatives. 2016 dollars.

(8) Assumed 50% of the original construction cost for hard armoring alternatives and 25% of the original construction cost for bioengineering alternatives. 2016 dollars.

(9) Future value of initial capital cost, annual maintenance cost, and major maintenance cost at end of expected life span.

(10) Assumes 3% inflation rate.

(11) Annualized 30-year future worth.

(12) Annualized cost divided by estimated annual pollution load reduction.

Table H2: Preliminary Cost Estimate for Site 1, Alternative A

Remeander into historic channels

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$8,509	$8,510	10% of project cost
Control of Water	LS	1	$2,934	$2,930	4% of primary item cost
Erosion Control	LS	1	$4,402	$4,400	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$520	
Select Tree Removal (>4")	EACH	12	$200	$2,400	
Excavate/Salvage Soil	CY	477	$15	$7,160	
Grading	SY	358	$6	$2,150	
Topsoil Import	CY	60	$33	$1,970	
Root Wads	EACH	3	$750	$2,250	
Rock Vanes	EACH	2	$2,000	$4,000	
Plant Shrubs	EACH	25	$50	$1,250	
Replace Bridge	LS	1	$50,000	$50,000	
Seeding and Mulch	ACRE	0.1	$8,000	$590	
Erosion Control Blanket	SY	358	$3	$1,070	
Damage Repair	LS	1	$1,467	$1,470	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$2,934	$2,930	4% of primary item cost
			Total	**$ 93,600**	
			Contingency (30%)	$ 28,080	
			Subtotal	**$ 121,700**	
			Design, Permitting, and Administration (30%)	$ 28,080	
			Total w/ Contingency & Engineering	**$ 149,800**	

30-yr and Annualized Cost analysis

Category:	Remeander		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 440	10%	of damage repair and maintenance
End of life span maintenance	$ 14,980	10%	of original project cost
Future Capital Cost	$ 363,600		
Future annual maintenance	$ 20,930		
Future end of life span cost	$ 27,060		
Total Future Worth	**$ 411,600**		
Annualized Cost	**$ 8,700**		

Table H3: Preliminary Cost Estimate for Site 1, Alternative B

Stabilize erosion areas with hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,584	$1,580	10% of project cost
Control of Water	LS	1	$546	$550	4% of primary item cost
Erosion Control	LS	1	$819	$820	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$460	
Select Tree Removal (>4")	EACH	6	$200	$1,200	
Grading	SY	316	$6	$1,890	
Furnish and Install Fieldstone Riprap	TON	74	$100	$7,360	
Topsoil Import	CY	26	$33	$870	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.1	$8,000	$520	
Erosion Control Blanket	SY	284	$3	$850	
Damage Repair	LS	1	$273	$270	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$546	$550	4% of primary item cost
			Total	**$ 17,420**	
			Contingency (30%)	$ 5,230	
			Subtotal	**$ 22,700**	
			Design, Permitting, and Administration (30%)	$ 5,230	
			Total w/ Contingency & Engineering	**$ 27,900**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 210	25%	of damage repair and maintenance
End of life span maintenance	$ 13,950	50%	of original project cost
Future Capital Cost	$ 67,700		
Future annual maintenance	$ 9,990		
Future end of life span cost	$ 25,200		
Total Future Worth	**$ 102,900**		
Annualized Cost	**$ 2,200**		

Table H4: Preliminary Cost Estimate for Site 1, Alternative C

Stabilize erosion areas with root wads, log vanes, and vegetation

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,462	$1,460	10% of project cost
Control of Water	LS	1	$504	$500	4% of primary item cost
Erosion Control	LS	1	$757	$760	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$460	
Select Tree Removal (>4")	EACH	6	$200	$1,200	
Grading	SY	89	$6	$530	
Root Wads	EACH	3	$750	$2,250	
Log Vanes	EACH	4	$1,200	$4,800	
Plant Shrubs	EACH	40	$50	$2,000	
Seeding and Mulch	ACRE	0.1	$8,000	$520	
Erosion Control Blanket	SY	284	$3	$850	
Damage Repair	LS	1	$252	$250	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$504	$500	4% of primary item cost
			Total	**$ 16,080**	
			Contingency (30%)	$ 4,820	
			Subtotal	**$ 20,900**	
			Design, Permitting, and Administration (30%)	$ 4,820	
			Total w/ Contingency & Engineering	**$ 25,700**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 190	25%	of damage repair and maintenance
End of life span maintenance	$ 6,430	25%	of original project cost
Future Capital Cost	$ 62,400		
Future annual maintenance	$ 9,040		
Future end of life span cost	$ 11,610		
Total Future Worth	**$ 83,100**		
Annualized Cost	**$ 1,700**		

Table H5: Preliminary Cost Estimate for Site 2, Alternative A

Remeander into historic channels

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$3,402	$3,400	10% of project cost
Control of Water	LS	1	$1,173	$1,170	4% of primary item cost
Erosion Control	LS	1	$1,760	$1,760	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$670	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Excavate/Salvage Soil	CY	616	$15	$9,240	
Grading	SY	462	$6	$2,770	
Root Wads	EACH	4	$750	$3,000	
Rock Boulder Vane	EACH	3	$2,000	$6,000	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.1	$8,000	$760	
Erosion Control Blanket	SY	462	$3	$1,390	
Damage Repair	LS	1	$587	$590	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,173	$1,170	4% of primary item cost
			Total	**$ 37,420**	
			Contingency (30%)	$ 11,230	
			Subtotal	**$ 48,700**	
			Design, Permitting, and Administration (30%)	$ 11,230	
			Total w/ Contingency & Engineering	**$ 59,900**	

30-yr and Annualized Cost analysis

Category:	Remeander		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 180	10%	of damage repair and maintenance
End of life span maintenance	$ 5,990	10%	of original project cost
Future Capital Cost	$ 145,400		
Future annual maintenance	$ 8,560		
Future end of life span cost	$ 10,820		
Total Future Worth	**$ 164,800**		
Annualized Cost	**$ 3,500**		

Table H6: Preliminary Cost Estimate for Site 2, Alternative B

Stabilize erosion areas with hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,979	$1,980	10% of project cost
Control of Water	LS	1	$683	$680	4% of primary item cost
Erosion Control	LS	1	$1,024	$1,020	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$530	
Select Tree Removal (>4")	EACH	16	$200	$3,200	
Grading	SY	364	$6	$2,190	
Furnish and Install Fieldstone Riprap	TON	85	$100	$8,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.1	$8,000	$600	
Erosion Control Blanket	SY	182	$3	$550	
Damage Repair	LS	1	$341	$340	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$683	$680	4% of primary item cost
			Total	**$ 21,770**	
			Contingency (30%)	$ 6,530	
			Subtotal	**$ 28,300**	
			Design, Permitting, and Administration (30%)	$ 6,530	
			Total w/ Contingency & Engineering	**$ 34,800**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 260	25%	of damage repair and maintenance
End of life span maintenance	$ 17,400	50%	of original project cost
Future Capital Cost	$ 84,500		
Future annual maintenance	$ 12,370		
Future end of life span cost	$ 31,430		
Total Future Worth	**$ 128,300**		
Annualized Cost	**$ 2,700**		

Table H7: Preliminary Cost Estimate for Site 2, Alternative C

Stabilize erosion areas with root wads, log vanes, and vegetation

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$983	$980	10% of project cost
Control of Water	LS	1	$339	$340	4% of primary item cost
Erosion Control	LS	1	$508	$510	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$530	
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Grading	SY	44	$6	$270	
Root Wads	EACH	3	$750	$2,250	
Log Vanes	EACH	2	$1,200	$2,400	
Plant Shrubs	EACH	15	$50	$750	
Seeding and Mulch	ACRE	0.1	$8,000	$600	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$169	$170	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$339	$340	4% of primary item cost
			Total	**$ 10,810**	
			Contingency (30%)	$ 3,240	
			Subtotal	**$ 14,050**	
			Design, Permitting, and Administration (30%)	$ 3,240	
			Total w/ Contingency & Engineering	**$ 17,300**	

30-yr and Annualized Cost analysis

Category:	Bioengineering	
Estimated life span (year)	20	1 number of major maint. events
Expected annual maintenance	$ 130	25% of damage repair and maintenance
End of life span maintenance	$ 4,330	25% of original project cost
Future Capital Cost	$ 42,000	
Future annual maintenance	$ 6,180	
Future end of life span cost	$ 7,820	
Total Future Worth	**$ 56,000**	
Annualized Cost	**$ 1,200**	

Table H8: Preliminary Cost Estimate for Site 3, Alternative A

Narrow channel for approx. 800'

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$3,206	$3,210	10% of project cost
Control of Water	LS	1	$1,105	$1,110	4% of primary item cost
Erosion Control	LS	1	$1,658	$1,660	6% of primary item cost
Clearing and Grubbing	ACRE	0.3	$7,000	$1,930	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Excavate/Salvage Soil	CY	667	$15	$10,000	
Grading	SY	667	$6	$4,000	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.3	$8,000	$2,200	
Erosion Control Blanket	SY	1333	$3	$4,000	
Damage Repair	LS	1	$553	$550	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,105	$1,110	4% of primary item cost
			Total	**$ 35,270**	
			Contingency (30%)	$ 10,580	
			Subtotal	**$ 45,900**	
			Design, Permitting, and Administration (30%)	$ 10,580	
			Total w/ Contingency & Engineering	**$ 56,400**	

30-yr and Annualized Cost analysis

Category:	General grading		
Estimated life span (year)	30	1	number of major maint. events
Expected annual maintenance	$ 170	10%	of damage repair and maintenance
End of life span maintenance	$ 5,640	10%	of original project cost
Future Capital Cost	$ 136,900		
Future annual maintenance	$ 8,090		
Future end of life span cost	$ 10,190		
Total Future Worth	**$ 155,200**		
Annualized Cost	**$ 3,300**		

Table H9: Preliminary Cost Estimate for Site 3, Alternative B

Install log vanes within reach

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$2,859	$2,860	10% of project cost
Control of Water	LS	1	$986	$990	4% of primary item cost
Erosion Control	LS	1	$1,478	$1,480	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Log Vanes	EACH	14	$1,200	$16,800	
Grading	SY	111	$6	$670	
Plant Shrubs	EACH	50	$50	$2,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	111	$3	$330	
Damage Repair	LS	1	$493	$490	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$986	$990	4% of primary item cost
			Total	**$ 31,450**	
			Contingency (30%)	$ 9,440	
			Subtotal	**$ 40,900**	
			Design, Permitting, and Administration (30%)	$ 9,440	
			Total w/ Contingency & Engineering	**$ 50,300**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 370	25%	of damage repair and maintenance
End of life span maintenance	$ 12,580	25%	of original project cost
Future Capital Cost	$ 122,100		
Future annual maintenance	$ 17,600		
Future end of life span cost	$ 22,720		
Total Future Worth	**$ 162,400**		
Annualized Cost	**$ 3,400**		

Table H10: Preliminary Cost Estimate for Site 3, Alternative C

Upper bank vegetation

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$1,286	$1,290	10% of project cost
Erosion Control	LS	1	$689	$690	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$960	
Topsoil Import	CY	73	$33	$2,420	
Plant Shrubs	EACH	100	$50	$5,000	
Seeding and Mulch	ACRE	0.1	$8,000	$1,100	
Erosion Control Blanket	SY	667	$3	$2,000	
Damage Repair	LS	1	$230	$230	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$459	$460	4% of primary item cost
			Total	**$ 14,150**	
			Contingency (30%)	$ 4,250	
			Subtotal	**$ 18,400**	
			Design, Permitting, and Administration (30%)	$ 4,250	
			Total w/ Contingency & Engineering	**$ 22,700**	

30-yr and Annualized Cost analysis

Category:	Veg. only		
Estimated life span (years)	10	3	number of major maint. events
Expected annual maintenance	$ 350	50%	of damage repair and maintenance
End of life span maintenance	$ 5,680	25%	of original project cost
Future Capital Cost	$ 55,100		
Future annual maintenance	$ 16,650		
Future end of life span cost	$ 31,680		
Total Future Worth	**$ 103,400**		
Annualized Cost	**$ 2,200**		

Table H11: Preliminary Cost Estimate for Site 4, Alternative A

Establish vegetated buffer

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,349	$1,350	10% of project cost
Erosion Control	LS	1	$637	$640	6% of primary item cost
Clearing and Grubbing	ACRE	0.2	$7,000	$1,290	
Topsoil Import	CY	49	$33	$1,610	
Plant Shrubs	EACH	125	$50	$6,250	
Seeding and Mulch	ACRE	0.2	$8,000	$1,470	
Temporary Fencing	LF	800	$2	$1,600	
Damage Repair	LS	1	$212	$210	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$425	$420	4% of primary item cost
Total				**$ 14,840**	
Contingency (30%)				$ 4,450	
Subtotal				**$ 19,300**	
Design, Permitting, and Administration (30%)				$ 4,450	
Total w/ Contingency & Engineering				**$ 23,700**	

30-yr and Annualized Cost analysis

Category:	Veg. only		
Estimated life span (years)	10	3	number of major maint. events
Expected annual maintenance	$ 320	50%	of damage repair and maintenance
End of life span maintenance	$ 5,930	25%	of original project cost
Future Capital Cost	$ 57,500		
Future annual maintenance	$ 15,220		
Future end of life span cost	$ 33,070		
Total Future Worth	**$ 105,800**		
Annualized Cost	**$ 2,200**		

Table H12: Preliminary Cost Estimate for Site 4, Alternative B

Realign disc golf course

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$4,592	$4,590	10% of project cost
Erosion Control	LS	1	$2,460	$2,460	6% of primary item cost
Clearing and Grubbing	ACRE	0.7	$7,000	$4,820	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Move Pin	EACH	4	$2,500	$10,000	
Move Tee Box	EACH	4	$500	$2,000	
Remove Old Tee Box	EACH	4	$500	$2,000	
Topsoil Import	CY	111	$33	$3,670	
Plant Trees	EACH	20	$250	$5,000	
Plant Shrubs	EACH	80	$50	$4,000	
Seeding and Mulch	ACRE	0.7	$8,000	$5,510	
Damage Repair	LS	1	$820	$820	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,640	$1,640	4% of primary item cost
			Total	**$ 50,510**	
			Contingency (30%)	$ 15,150	
			Subtotal	**$ 65,700**	
			Design, Permitting, and Administration (30%)	$ 15,150	
			Total w/ Contingency & Engineering	**$ 80,800**	

30-yr and Annualized Cost analysis

Category:	General grading		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 250	10%	of damage repair and maintenance
End of life span maintenance	$ 8,080	10%	of original project cost
Future Capital Cost	$ 196,100		
Future annual maintenance	$ 11,890		
Future end of life span cost	$ 14,590		
Total Future Worth	**$ 222,600**		
Annualized Cost	**$ 4,700**		

Table H13: Preliminary Cost Estimate for Site 5, Alternative A

Stabilize steep, eroding bank with hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$844	$840	10% of project cost
Control of Water	LS	1	$291	$290	4% of primary item cost
Erosion Control	LS	1	$436	$440	6% of primary item cost
Clearing and Grubbing	ACRE	0.01	$7,000	$80	
Select Tree Removal (>4")	EACH	6	$200	$1,200	
Grading	SY	56	$6	$330	
Furnish and Install Fieldstone Riprap	TON	26	$100	$2,590	
Topsoil Import	CY	9	$33	$310	
Plant Shrubs	EACH	50	$50	$2,500	
Seeding and Mulch	ACRE	0.01	$8,000	$90	
Erosion Control Blanket	SY	56	$3	$170	
Damage Repair	LS	1	$145	$150	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$291	$290	4% of primary item cost
			Total	**$ 9,280**	
			Contingency (30%)	$ 2,780	
			Subtotal	**$ 12,100**	
			Design, Permitting, and Administration (30%)	$ 2,780	
			Total w/ Contingency & Engineering	**$ 14,800**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 110	25%	of damage repair and maintenance
End of life span maintenance	$ 7,400	50%	of original project cost
Future Capital Cost	$ 35,900		
Future annual maintenance	$ 5,230		
Future end of life span cost	$ 13,370		
Total Future Worth	**$ 54,500**		
Annualized Cost	**$ 1,100**		

Table H14: Preliminary Cost Estimate for Site 5, Alternative B

Vegetate steep, eroding bank with VRSS

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,862	$1,860	10% of project cost
Control of Water	LS	1	$677	$680	4% of primary item cost
Erosion Control	LS	1	$1,015	$1,020	6% of primary item cost
Clearing and Grubbing	ACRE	0.01	$7,000	$80	
Select Tree Removal (>4")	EACH	6	$200	$1,200	
Grading	SY	56	$6	$330	
Furnish and Install Fieldstone Riprap	TON	26	$100	$2,590	
VRSS	SF	150	$45	$6,750	
Topsoil Import	CY	28	$33	$920	
Plant Shrubs	EACH	50	$50	$2,500	
Seeding and Mulch	ACRE	0.01	$8,000	$90	
Erosion Control Blanket	SY	56	$3	$170	
Damage Repair	LS	1	$293	$290	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$2,000	$2,000	
			Total	**$ 20,480**	
			Contingency (30%)	$ 6,140	
			Subtotal	**$ 26,600**	
			Design, Permitting, and Administration (30%)	$ 6,140	
			Total w/ Contingency & Engineering	**$ 32,800**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 570	25%	of damage repair and maintenance
End of life span maintenance	$ 8,200	25%	of original project cost
Future Capital Cost	$ 79,600		
Future annual maintenance	$ 27,120		
Future end of life span cost	$ 14,810		
Total Future Worth	**$ 121,500**		
Annualized Cost	**$ 2,600**		

Table H15: Preliminary Cost Estimate for Site 6, Alternative A

Stabilize bridge abutments with riprap and log vanes

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$630	$630	10% of project cost
Control of Water	LS	1	$252	$250	4% of primary item cost
Erosion Control	LS	1	$378	$380	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	4	$200	$800	
Grading	SY	44	$6	$270	
Furnish and Install Fieldstone Riprap	TON	21	$100	$2,070	
Log Vanes	EACH	2	$1,200	$2,400	
Topsoil Import	CY	4	$33	$120	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$126	$130	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$252	$250	4% of primary item cost
			Total	**$ 7,940**	
			Contingency (30%)	$ 2,380	
			Subtotal	**$ 10,300**	
			Design, Permitting, and Administration (30%)	$ 2,380	
			Total w/ Contingency & Engineering	**$ 12,700**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 100	25%	of damage repair and maintenance
End of life span maintenance	$ 6,350	50%	of original project cost
Future Capital Cost	$ 30,800		
Future annual maintenance	$ 4,760		
Future end of life span cost	$ 11,470		
Total Future Worth	**$ 47,000**		
Annualized Cost	**$ 1,000**		

Table H16: Preliminary Cost Estimate for Site 6, Alternative B

Stabilize bridge abutments with riprap only

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$599	$600	10% of project cost
Control of Water	LS	1	$240	$240	4% of primary item cost
Erosion Control	LS	1	$359	$360	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Grading	SY	67	$6	$400	
Furnish and Install Fieldstone Riprap	TON	31	$100	$3,110	
Topsoil Import	CY	7	$33	$240	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$120	$120	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$240	$240	4% of primary item cost
			Total	**$ 7,550**	
			Contingency (30%)	$ 2,270	
			Subtotal	**$ 9,800**	
			Design, Permitting, and Administration (30%)	$ 2,270	
			Total w/ Contingency & Engineering	**$ 12,100**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 90	25%	of damage repair and maintenance
End of life span maintenance	$ 6,050	50%	of original project cost
Future Capital Cost	$ 29,400		
Future annual maintenance	$ 4,280		
Future end of life span cost	$ 10,930		
Total Future Worth	**$ 44,600**		
Annualized Cost	**$ 900**		

Table H17: Preliminary Cost Estimate for Site 7, Alternative A

Stabilize bridge abutments with riprap and log vanes

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$630	$630	10% of project cost
Control of Water	LS	1	$252	$250	4% of primary item cost
Erosion Control	LS	1	$378	$380	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	4	$200	$800	
Grading	SY	44	$6	$270	
Furnish and Install Fieldstone Riprap	TON	21	$100	$2,070	
Log Vanes	EACH	2	$1,200	$2,400	
Topsoil Import	CY	4	$33	$120	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$126	$130	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$252	$250	4% of primary item cost
			Total	**$ 7,940**	
			Contingency (30%)	$ 2,380	
			Subtotal	**$ 10,300**	
			Design, Permitting, and Administration (30%)	$ 2,380	
			Total w/ Contingency & Engineering	**$ 12,700**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 100	25%	of damage repair and maintenance
End of life span maintenance	$ 6,350	50%	of original project cost
Future Capital Cost	$ 30,800		
Future annual maintenance	$ 4,760		
Future end of life span cost	$ 11,470		
Total Future Worth	**$ 47,000**		
Annualized Cost	**$ 1,000**		

Table H18: Preliminary Cost Estimate for Site 7, Alternative B

Stabilize bridge abutments with riprap only

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$599	$600	10% of project cost
Control of Water	LS	1	$240	$240	4% of primary item cost
Erosion Control	LS	1	$359	$360	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Grading	SY	67	$6	$400	
Furnish and Install Fieldstone Riprap	TON	31	$100	$3,110	
Topsoil Import	CY	7	$33	$240	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$120	$120	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$240	$240	4% of primary item cost
Total				**$ 7,550**	
Contingency (30%)				$ 2,270	
Subtotal				**$ 9,800**	
Design, Permitting, and Administration (30%)				$ 2,270	
Total w/ Contingency & Engineering				**$ 12,100**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 90	25%	of damage repair and maintenance
End of life span maintenance	$ 6,050	50%	of original project cost
Future Capital Cost	$ 29,400		
Future annual maintenance	$ 4,280		
Future end of life span cost	$ 10,930		
Total Future Worth	**$ 44,600**		
Annualized Cost	**$ 900**		

Table H19: Preliminary Cost Estimate for Site 8, Alternative A

Stabilize bridge abutments with riprap and log vanes

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$630	$630	10% of project cost
Control of Water	LS	1	$252	$250	4% of primary item cost
Erosion Control	LS	1	$378	$380	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	4	$200	$800	
Grading	SY	44	$6	$270	
Furnish and Install Fieldstone Riprap	TON	21	$100	$2,070	
Log Vanes	EACH	2	$1,200	$2,400	
Topsoil Import	CY	4	$33	$120	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$126	$130	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$252	$250	4% of primary item cost
			Total	**$ 7,940**	
			Contingency (30%)	$ 2,380	
			Subtotal	**$ 10,300**	
			Design, Permitting, and Administration (30%)	$ 2,380	
			Total w/ Contingency & Engineering	**$ 12,700**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 100	25%	of damage repair and maintenance
End of life span maintenance	$ 6,350	50%	of original project cost
Future Capital Cost	$ 30,800		
Future annual maintenance	$ 4,760		
Future end of life span cost	$ 11,470		
Total Future Worth	**$ 47,000**		
Annualized Cost	**$ 1,000**		

Table H20: Preliminary Cost Estimate for Site 8, Alternative B

Stabilize bridge abutments with riprap only

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$599	$600	10% of project cost
Control of Water	LS	1	$240	$240	4% of primary item cost
Erosion Control	LS	1	$359	$360	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Grading	SY	67	$6	$400	
Furnish and Install Fieldstone Riprap	TON	31	$100	$3,110	
Topsoil Import	CY	7	$33	$240	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$120	$120	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$240	$240	4% of primary item cost
Total				**$ 7,550**	
Contingency (30%)				$ 2,270	
Subtotal				**$ 9,800**	
Design, Permitting, and Administration (30%)				$ 2,270	
Total w/ Contingency & Engineering				**$ 12,100**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 90	25%	of damage repair and maintenance
End of life span maintenance	$ 6,050	50%	of original project cost
Future Capital Cost	$ 29,400		
Future annual maintenance	$ 4,280		
Future end of life span cost	$ 10,930		
Total Future Worth	**$ 44,600**		
Annualized Cost	**$ 900**		

Table H21: Preliminary Cost Estimate for Site 9, Alternative A

Stabilize bridge abutments with riprap and log vanes

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$630	$630	10% of project cost
Control of Water	LS	1	$252	$250	4% of primary item cost
Erosion Control	LS	1	$378	$380	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	4	$200	$800	
Grading	SY	44	$6	$270	
Furnish and Install Fieldstone Riprap	TON	21	$100	$2,070	
Log Vanes	EACH	2	$1,200	$2,400	
Topsoil Import	CY	4	$33	$120	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$126	$130	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$252	$250	4% of primary item cost
			Total	**$ 7,940**	
			Contingency (30%)	$ 2,380	
			Subtotal	**$ 10,300**	
			Design, Permitting, and Administration (30%)	$ 2,380	
			Total w/ Contingency & Engineering	**$ 12,700**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 100	25%	of damage repair and maintenance
End of life span maintenance	$ 6,350	50%	of original project cost
Future Capital Cost	$ 30,800		
Future annual maintenance	$ 4,760		
Future end of life span cost	$ 11,470		
Total Future Worth	**$ 47,000**		
Annualized Cost	**$ 1,000**		

Table H22: Preliminary Cost Estimate for Site 9, Alternative B

Stabilize bridge abutments with riprap only

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$599	$600	10% of project cost
Control of Water	LS	1	$240	$240	4% of primary item cost
Erosion Control	LS	1	$359	$360	6% of primary item cost
Clearing and Grubbing	ACRE	0.005	$7,000	$30	
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Grading	SY	67	$6	$400	
Furnish and Install Fieldstone Riprap	TON	31	$100	$3,110	
Topsoil Import	CY	7	$33	$240	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.005	$8,000	$40	
Erosion Control Blanket	SY	22	$3	$70	
Damage Repair	LS	1	$120	$120	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$240	$240	4% of primary item cost
			Total	**$ 7,550**	
			Contingency (30%)	$ 2,270	
			Subtotal	**$ 9,800**	
			Design, Permitting, and Administration (30%)	$ 2,270	
			Total w/ Contingency & Engineering	**$ 12,100**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 90	25%	of damage repair and maintenance
End of life span maintenance	$ 6,050	50%	of original project cost
Future Capital Cost	$ 29,400		
Future annual maintenance	$ 4,280		
Future end of life span cost	$ 10,930		
Total Future Worth	**$ 44,600**		
Annualized Cost	**$ 900**		

Table H23: Preliminary Cost Estimate for Site 10, Alternative A

Raise stream bed in Fernbrook Lane North culvert

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$593	$590	10% of project cost
Control of Water	LS	1	$1,000	$1,000	
Erosion Control	LS	1	$274	$270	6% of primary item cost
Raise Stream Bed in Culvert	TON	26	$136	$3,530	
Seeding and Mulch	ACRE	0.05	$8,000	$370	
Erosion Control Blanket	SY	222	$3	$670	
Damage Repair	LS	1	$91	$90	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$183	$180	4% of primary item cost
			Total	**$ 6,700**	
			Contingency (30%)	$ 2,010	
			Subtotal	**$ 8,700**	
			Design, Permitting, and Administration (30%)	$ 2,010	
			Total w/ Contingency & Engineering	**$ 10,700**	

30-yr and Annualized Cost analysis

Category:	Culvert bed		
Estimated life span (years)	15	2	number of major maint. events
Expected annual maintenance	$ 20	25%	of damage repair and maintenance
End of life span maintenance	$ 5,350	50%	of original project cost
Future Capital Cost	$ 26,000		
Future annual maintenance	$ 950		
Future end of life span cost	$ 21,320		
Total Future Worth	**$ 48,300**		
Annualized Cost	**$ 1,000**		

Table H24: Preliminary Cost Estimate for Site 10, Alternative B

Create meanders in open area to add 70' of stream length

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$7,417	$7,420	10% of project cost
Control of Water	LS	1	$2,557	$2,560	4% of primary item cost
Erosion Control	LS	1	$3,836	$3,840	6% of primary item cost
Clearing and Grubbing	ACRE	0.2	$7,000	$1,290	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Excavate/Salvage Soil	CY	1185	$15	$17,780	
Grading	SY	889	$6	$5,330	
Topsoil Import	CY	148	$33	$4,890	
Root Wads	EACH	15	$750	$11,250	
Rock Boulder Vane	EACH	3	$2,000	$6,000	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	200	$50	$10,000	
Seeding and Mulch	ACRE	0.2	$8,000	$1,470	
Erosion Control Blanket	SY	889	$3	$2,670	
Damage Repair	LS	1	$1,279	$1,280	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$2,557	$2,560	4% of primary item cost
			Total	**$ 81,590**	
			Contingency (30%)	$ 24,480	
			Subtotal	**$ 106,100**	
			Design, Permitting, and Administration (30%)	$ 24,480	
			Total w/ Contingency & Engineering	**$ 130,600**	

30-yr and Annualized Cost analysis

Category:	Remeander		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 380	10%	of damage repair and maintenance
End of life span maintenance	$ 13,060	10%	of original project cost
Future Capital Cost	$ 317,000		
Future annual maintenance	$ 18,080		
Future end of life span cost	$ 23,590		
Total Future Worth	**$ 358,700**		
Annualized Cost	**$ 7,500**		

Table H25: Preliminary Cost Estimate for Site 10, Alternative C

Raise channel bed using cross vanes/constructed riffles

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,906	$1,910	10% of project cost
Control of Water	LS	1	$657	$660	4% of primary item cost
Erosion Control	LS	1	$985	$990	6% of primary item cost
Rock Boulder Cross-Vane	EACH	4	$4,000	$16,000	
Seeding and Mulch	ACRE	0.02	$8,000	$150	
Erosion Control Blanket	SY	89	$3	$270	
Damage Repair	LS	1	$328	$330	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$657	$660	4% of primary item cost
			Total	**$ 20,970**	
			Contingency (30%)	$ 6,290	
			Subtotal	**$ 27,300**	
			Design, Permitting, and Administration (30%)	$ 6,290	
			Total w/ Contingency & Engineering	**$ 33,600**	

30-yr and Annualized Cost analysis

Category:	Rock vanes		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 250	25%	of damage repair and maintenance
End of life span maintenance	$ 16,800	50%	of original project cost
Future Capital Cost	$ 81,600		
Future annual maintenance	$ 11,890		
Future end of life span cost	$ 30,340		
Total Future Worth	**$ 123,800**		
Annualized Cost	**$ 2,600**		

Table H26: Preliminary Cost Estimate for Site 10, Alternative D

Lower adjacent floodplain

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$3,203	$3,200	10% of project cost
Control of Water	LS	1	$1,105	$1,100	4% of primary item cost
Erosion Control	LS	1	$1,657	$1,660	6% of primary item cost
Clearing and Grubbing	ACRE	0.2	$7,000	$1,290	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Excavation/Dispose of Soil	CY	296	$30	$8,890	
Grading	SY	889	$6	$5,330	
Excavate/Salvage Soil	CY	148	$15	$2,220	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	50	$50	$2,500	
Seeding and Mulch	ACRE	0.2	$8,000	$1,470	
Erosion Control Blanket	SY	889	$3	$2,670	
Damage Repair	LS	1	$552	$550	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,105	$1,100	4% of primary item cost
			Total	**$ 35,230**	
			Contingency (30%)	$ 10,570	
			Subtotal	**$ 45,800**	
			Design, Permitting, and Administration (30%)	$ 10,570	
			Total w/ Contingency & Engineering	**$ 56,400**	

30-yr and Annualized Cost analysis

Category:	General grading		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 170	10%	of damage repair and maintenance
End of life span maintenance	$ 5,640	10%	of original project cost
Future Capital Cost	$ 136,900		
Future annual maintenance	$ 8,090		
Future end of life span cost	$ 10,190		
Total Future Worth	**$ 155,200**		
Annualized Cost	**$ 3,300**		

Table H27: Preliminary Cost Estimate for Site 11, Alternative A

Stabilize eroding banks with hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,025	$1,030	10% of project cost
Control of Water	LS	1	$354	$350	4% of primary item cost
Erosion Control	LS	1	$530	$530	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$140	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	100	$6	$600	
Furnish and Install Fieldstone Riprap	TON	23	$100	$2,330	
Topsoil Import	CY	17	$33	$550	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$170	
Erosion Control Blanket	SY	100	$3	$300	
Damage Repair	LS	1	$177	$180	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$354	$350	4% of primary item cost
			Total	**$ 11,280**	
			Contingency (30%)	$ 3,380	
			Subtotal	**$ 14,700**	
			Design, Permitting, and Administration (30%)	$ 3,380	
			Total w/ Contingency & Engineering	**$ 18,000**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 130	25%	of damage repair and maintenance
End of life span maintenance	$ 9,000	50%	of original project cost
Future Capital Cost	$ 43,700		
Future annual maintenance	$ 6,180		
Future end of life span cost	$ 16,260		
Total Future Worth	**$ 66,100**		
Annualized Cost	**$ 1,400**		

Table H28: Preliminary Cost Estimate for Site 11, Alternative B

Stabilize banks with root wads

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,068	$1,070	10% of project cost
Control of Water	LS	1	$368	$370	4% of primary item cost
Erosion Control	LS	1	$553	$550	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$140	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	50	$6	$300	
Root Wads	EACH	4	$750	$3,000	
Topsoil Import	CY	17	$33	$550	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$170	
Erosion Control Blanket	SY	100	$3	$300	
Damage Repair	LS	1	$184	$180	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$368	$370	4% of primary item cost
			Total	**$ 11,750**	
			Contingency (30%)	$ 3,530	
			Subtotal	**$ 15,300**	
			Design, Permitting, and Administration (30%)	$ 3,530	
			Total w/ Contingency & Engineering	**$ 18,800**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 140	25%	of damage repair and maintenance
End of life span maintenance	$ 4,700	25%	of original project cost
Future Capital Cost	$ 45,600		
Future annual maintenance	$ 6,660		
Future end of life span cost	$ 8,490		
Total Future Worth	**$ 60,800**		
Annualized Cost	**$ 1,300**		

Table H29: Preliminary Cost Estimate for Site 12, Alternative A

Stabilize eroding banks with hard armor

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$1,025	$1,030	10% of project cost
Control of Water	LS	1	$354	$350	4% of primary item cost
Erosion Control	LS	1	$530	$530	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$140	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	100	$6	$600	
Furnish and Install Fieldstone Riprap	TON	23	$100	$2,330	
Topsoil Import	CY	17	$33	$550	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$170	
Erosion Control Blanket	SY	100	$3	$300	
Damage Repair	LS	1	$177	$180	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$354	$350	4% of primary item cost
			Total	**$ 11,280**	
			Contingency (30%)	$ 3,380	
			Subtotal	**$ 14,700**	
			Design, Permitting, and Administration (30%)	$ 3,380	
			Total w/ Contingency & Engineering	**$ 18,000**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 130	25%	of damage repair and maintenance
End of life span maintenance	$ 9,000	50%	of original project cost
Future Capital Cost	$ 43,700		
Future annual maintenance	$ 6,180		
Future end of life span cost	$ 16,260		
Total Future Worth	**$ 66,100**		
Annualized Cost	**$ 1,400**		

Table H30: Preliminary Cost Estimate for Site 12, Alternative B

Stabilize banks with root wads

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,068	$1,070	10% of project cost
Control of Water	LS	1	$368	$370	4% of primary item cost
Erosion Control	LS	1	$553	$550	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$140	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	50	$6	$300	
Root Wads	EACH	4	$750	$3,000	
Topsoil Import	CY	17	$33	$550	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$170	
Erosion Control Blanket	SY	100	$3	$300	
Damage Repair	LS	1	$184	$180	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$368	$370	4% of primary item cost
			Total	**$ 11,750**	
			Contingency (30%)	$ 3,530	
			Subtotal	**$ 15,300**	
			Design, Permitting, and Administration (30%)	$ 3,530	
			Total w/ Contingency & Engineering	**$ 18,800**	

30-yr and Annualized Cost analysis

Category:	Bioengineering	
Estimated life span (years)	20	1 number of major maint. events
Expected annual maintenance	$ 140	25% of damage repair and maintenance
End of life span maintenance	$ 4,700	25% of original project cost
Future Capital Cost	$ 45,600	
Future annual maintenance	$ 6,660	
Future end of life span cost	$ 8,490	
Total Future Worth	**$ 60,800**	
Annualized Cost	**$ 1,300**	

Table H31: Preliminary Cost Estimate for Site 13, Alternative A

Stabilize eroding banks with hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,025	$1,030	10% of project cost
Control of Water	LS	1	$354	$350	4% of primary item cost
Erosion Control	LS	1	$530	$530	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$140	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	100	$6	$600	
Furnish and Install Fieldstone Riprap	TON	23	$100	$2,330	
Topsoil Import	CY	17	$33	$550	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$170	
Erosion Control Blanket	SY	100	$3	$300	
Damage Repair	LS	1	$177	$180	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$354	$350	4% of primary item cost
			Total	**$ 11,280**	
			Contingency (30%)	$ 3,380	
			Subtotal	**$ 14,700**	
			Design, Permitting, and Administration (30%)	$ 3,380	
			Total w/ Contingency & Engineering	**$ 18,000**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 130	25%	of damage repair and maintenance
End of life span maintenance	$ 9,000	50%	of original project cost
Future Capital Cost	$ 43,700		
Future annual maintenance	$ 6,180		
Future end of life span cost	$ 16,260		
Total Future Worth	**$ 66,100**		
Annualized Cost	**$ 1,400**		

Table H32: Preliminary Cost Estimate for Site 13, Alternative B

Stabilize banks with root wads

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,068	$1,070	10% of project cost
Control of Water	LS	1	$368	$370	4% of primary item cost
Erosion Control	LS	1	$553	$550	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$140	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	50	$6	$300	
Root Wads	EACH	4	$750	$3,000	
Topsoil Import	CY	17	$33	$550	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$170	
Erosion Control Blanket	SY	100	$3	$300	
Damage Repair	LS	1	$184	$180	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$368	$370	4% of primary item cost
			Total	**$ 11,750**	
			Contingency (30%)	$ 3,530	
			Subtotal	**$ 15,300**	
			Design, Permitting, and Administration (30%)	$ 3,530	
			Total w/ Contingency & Engineering	**$ 18,800**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 140	25%	of damage repair and maintenance
End of life span maintenance	$ 4,700	25%	of original project cost
Future Capital Cost	$ 45,600		
Future annual maintenance	$ 6,660		
Future end of life span cost	$ 8,490		
Total Future Worth	**$ 60,800**		
Annualized Cost	**$ 1,300**		

Table H33: Preliminary Cost Estimate for Site 14, Alternative A

Stabilize culvert outfall with hard armor

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$610	$610	10% of project cost
Control of Water	LS	1	$210	$210	4% of primary item cost
Erosion Control	LS	1	$315	$320	6% of primary item cost
Clearing and Grubbing	ACRE	0.01	$7,000	$100	
Select Tree Removal (>4")	EACH	4	$200	$800	
Grading	SY	67	$6	$400	
Furnish and Install Fieldstone Riprap	TON	31	$100	$3,110	
Topsoil Import	CY	6	$33	$180	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.01	$8,000	$60	
Erosion Control Blanket	SY	33	$3	$100	
Damage Repair	LS	1	$105	$110	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$210	$210	4% of primary item cost
			Total	**$ 6,710**	
			Contingency (30%)	$ 2,010	
			Subtotal	**$ 8,700**	
			Design, Permitting, and Administration (30%)	$ 2,010	
			Total w/ Contingency & Engineering	**$ 10,700**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 80	25%	of damage repair and maintenance
End of life span maintenance	$ 5,350	50%	of original project cost
Future Capital Cost	$ 26,000		
Future annual maintenance	$ 3,810		
Future end of life span cost	$ 9,660		
Total Future Worth	**$ 39,500**		
Annualized Cost	**$ 800**		

Table H34: Preliminary Cost Estimate for Site 14, Alternative B

Stabilize culvert outfall with concrete swale

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$773	$770	10% of project cost
Control of Water	LS	1	$266	$270	4% of primary item cost
Erosion Control	LS	1	$400	$400	6% of primary item cost
Clearing and Grubbing	ACRE	0.01	$7,000	$100	
Select Tree Removal (>4")	EACH	4	$200	$800	
Grading	SY	67	$6	$400	
Install Concrete Swale	CY	50	$80	$4,000	
Furnish and Install Fieldstone Riprap	TON	5	$100	$520	
Topsoil Import	CY	6	$33	$180	
Plant Shrubs	EACH	10	$50	$500	
Seeding and Mulch	ACRE	0.01	$8,000	$60	
Erosion Control Blanket	SY	33	$3	$100	
Damage Repair	LS	1	$133	$130	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$266	$270	4% of primary item cost
Total				**$ 7,730**	
Contingency (30%)				$ 2,320	
Subtotal				**$ 10,100**	
Design, Permitting, and Administration (30%)				$ 2,320	
Total w/ Contingency & Engineering				**$ 12,400**	

30-yr and Annualized Cost analysis

Category:	Hard armor	
Estimated life span (years)	30	1 number of major maint. events
Expected annual maintenance	$ 100	25% of damage repair and maintenance
End of life span maintenance	$ 6,200	50% of original project cost
Future Capital Cost	$ 30,100	
Future annual maintenance	$ 4,760	
Future end of life span cost	$ 11,200	
Total Future Worth	**$ 46,100**	
Annualized Cost	**$ 1,000**	

Table H35: Preliminary Cost Estimate for Site 15, Alternative A

Install bank stabilization measures at eroding banks using hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,906	$1,910	10% of project cost
Control of Water	LS	1	$657	$660	4% of primary item cost
Erosion Control	LS	1	$985	$990	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Grading	SY	111	$6	$670	
Furnish and Install Fieldstone Riprap	TON	65	$100	$6,480	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	108	$3	$320	
Damage Repair	LS	1	$328	$330	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$657	$660	4% of primary item cost
			Total	**$ 20,970**	
			Contingency (30%)	$ 6,290	
			Subtotal	**$ 27,300**	
			Design, Permitting, and Administration (30%)	$ 6,290	
			Total w/ Contingency & Engineering	**$ 33,600**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 250	25%	of damage repair and maintenance
End of life span maintenance	$ 16,800	50%	of original project cost
Future Capital Cost	$ 81,600		
Future annual maintenance	$ 11,890		
Future end of life span cost	$ 30,340		
Total Future Worth	**$ 123,800**		
Annualized Cost	**$ 2,600**		

Table H36: Preliminary Cost Estimate for Site 15, Alternative B

Install 4 rock vanes for bank protection

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$2,092	$2,090	10% of project cost
Control of Water	LS	1	$584	$580	4% of primary item cost
Erosion Control	LS	1	$875	$880	6% of primary item cost
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Rock Boulder Vane	EACH	4	$2,000	$8,000	
Seeding and Mulch	ACRE	0.1	$8,000	$920	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Erosion Control Blanket	SY	556	$3	$1,670	
Damage Repair	LS	1	$292	$290	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$584	$580	4% of primary item cost
			Total	**$ 23,010**	
			Contingency (30%)	$ 6,900	
			Subtotal	**$ 29,900**	
			Design, Permitting, and Administration (30%)	$ 6,900	
			Total w/ Contingency & Engineering	**$ 36,800**	

30-yr and Annualized Cost analysis

Category:	Rock vanes		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 220	25%	of damage repair and maintenance
End of life span maintenance	$ 18,400	50%	of original project cost
Future Capital Cost	$ 89,300		
Future annual maintenance	$ 10,470		
Future end of life span cost	$ 33,230		
Total Future Worth	**$ 133,000**		
Annualized Cost	**$ 2,800**		

Table H37: Preliminary Cost Estimate for Site 15, Alternative C

Install bank stabilization measures at eroding banks using toe wood

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$4,431	$4,430	10% of project cost
Control of Water	LS	1	$1,528	$1,530	4% of primary item cost
Erosion Control	LS	1	$2,292	$2,290	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	30	$200	$6,000	
Grading	SY	111	$6	$670	
Furnish and Install Toe Wood	LF	100	$250	$25,000	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	15	$250	$3,750	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	111	$3	$330	
Damage Repair	LS	1	$764	$760	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,528	$1,530	4% of primary item cost
			Total	**$ 48,740**	
			Contingency (30%)	$ 14,620	
			Subtotal	**$ 63,400**	
			Design, Permitting, and Administration (30%)	$ 14,620	
			Total w/ Contingency & Engineering	**$ 78,000**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 570	25%	of damage repair and maintenance
End of life span maintenance	$ 19,500	25%	of original project cost
Future Capital Cost	$ 189,300		
Future annual maintenance	$ 27,120		
Future end of life span cost	$ 35,220		
Total Future Worth	**$ 251,600**		
Annualized Cost	**$ 5,300**		

Table H38: Preliminary Cost Estimate for Site 16, Alternative A

Install bank stabilization measures at eroding banks using hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,906	$1,910	10% of project cost
Control of Water	LS	1	$657	$660	4% of primary item cost
Erosion Control	LS	1	$985	$990	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Grading	SY	111	$6	$670	
Furnish and Install Fieldstone Riprap	TON	65	$100	$6,480	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	108	$3	$320	
Damage Repair	LS	1	$328	$330	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$657	$660	4% of primary item cost
			Total	**$ 20,970**	
			Contingency (30%)	$ 6,290	
			Subtotal	**$ 27,300**	
			Design, Permitting, and Administration (30%)	$ 6,290	
			Total w/ Contingency & Engineering	**$ 33,600**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 250	25%	of damage repair and maintenance
End of life span maintenance	$ 16,800	50%	of original project cost
Future Capital Cost	$ 81,600		
Future annual maintenance	$ 11,890		
Future end of life span cost	$ 30,340		
Total Future Worth	**$ 123,800**		
Annualized Cost	**$ 2,600**		

Table H39: Preliminary Cost Estimate for Site 16, Alternative B

Install 4 rock vanes for bank protection

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$2,092	$2,090	10% of project cost
Control of Water	LS	1	$584	$580	4% of primary item cost
Erosion Control	LS	1	$875	$880	6% of primary item cost
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Rock Boulder Vane	EACH	4	$2,000	$8,000	
Seeding and Mulch	ACRE	0.1	$8,000	$920	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Erosion Control Blanket	SY	556	$3	$1,670	
Damage Repair	LS	1	$292	$290	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$584	$580	4% of primary item cost
			Total	**$ 23,010**	
			Contingency (30%)	$ 6,900	
			Subtotal	**$ 29,900**	
			Design, Permitting, and Administration (30%)	$ 6,900	
			Total w/ Contingency & Engineering	**$ 36,800**	

30-yr and Annualized Cost analysis

Category:	Rock vanes		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 220	25%	of damage repair and maintenance
End of life span maintenance	$ 18,400	50%	of original project cost
Future Capital Cost	$ 89,300		
Future annual maintenance	$ 10,470		
Future end of life span cost	$ 33,230		
Total Future Worth	**$ 133,000**		
Annualized Cost	**$ 2,800**		

Table H40: Preliminary Cost Estimate for Site 16, Alternative C

Install bank stabilization measures at eroding banks using toe wood

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$4,431	$4,430	10% of project cost
Control of Water	LS	1	$1,528	$1,530	4% of primary item cost
Erosion Control	LS	1	$2,292	$2,290	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	30	$200	$6,000	
Grading	SY	111	$6	$670	
Furnish and Install Toe Wood	LF	100	$250	$25,000	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	15	$250	$3,750	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	111	$3	$330	
Damage Repair	LS	1	$764	$760	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,528	$1,530	4% of primary item cost
			Total	**$ 48,740**	
			Contingency (30%)	$ 14,620	
			Subtotal	**$ 63,400**	
			Design, Permitting, and Administration (30%)	$ 14,620	
			Total w/ Contingency & Engineering	**$ 78,000**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 570	25%	of damage repair and maintenance
End of life span maintenance	$ 19,500	25%	of original project cost
Future Capital Cost	$ 189,300		
Future annual maintenance	$ 27,120		
Future end of life span cost	$ 35,220		
Total Future Worth	**$ 251,600**		
Annualized Cost	**$ 5,300**		

Table H41: Preliminary Cost Estimate for Site 17, Alternative A

Install bank stabilization measures at eroding banks using hard armor

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,906	$1,910	10% of project cost
Control of Water	LS	1	$657	$660	4% of primary item cost
Erosion Control	LS	1	$985	$990	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Grading	SY	111	$6	$670	
Furnish and Install Fieldstone Riprap	TON	65	$100	$6,480	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	108	$3	$320	
Damage Repair	LS	1	$328	$330	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$657	$660	4% of primary item cost
			Total	**$ 20,970**	
			Contingency (30%)	$ 6,290	
			Subtotal	**$ 27,300**	
			Design, Permitting, and Administration (30%)	$ 6,290	
			Total w/ Contingency & Engineering	**$ 33,600**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 250	25%	of damage repair and maintenance
End of life span maintenance	$ 16,800	50%	of original project cost
Future Capital Cost	$ 81,600		
Future annual maintenance	$ 11,890		
Future end of life span cost	$ 30,340		
Total Future Worth	**$ 123,800**		
Annualized Cost	**$ 2,600**		

Table H42: Preliminary Cost Estimate for Site 17, Alternative B

Install 4 rock vanes for bank protection

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$2,092	$2,090	10% of project cost
Control of Water	LS	1	$584	$580	4% of primary item cost
Erosion Control	LS	1	$875	$880	6% of primary item cost
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Rock Boulder Vane	EACH	4	$2,000	$8,000	
Seeding and Mulch	ACRE	0.1	$8,000	$920	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Erosion Control Blanket	SY	556	$3	$1,670	
Damage Repair	LS	1	$292	$290	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$584	$580	4% of primary item cost
			Total	**$ 23,010**	
			Contingency (30%)	$ 6,900	
			Subtotal	**$ 29,900**	
			Design, Permitting, and Administration (30%)	$ 6,900	
			Total w/ Contingency & Engineering	**$ 36,800**	

30-yr and Annualized Cost analysis

Category:	Rock vanes		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 220	25%	of damage repair and maintenance
End of life span maintenance	$ 18,400	50%	of original project cost
Future Capital Cost	$ 89,300		
Future annual maintenance	$ 10,470		
Future end of life span cost	$ 33,230		
Total Future Worth	**$ 133,000**		
Annualized Cost	**$ 2,800**		

Table H43: Preliminary Cost Estimate for Site 17, Alternative C

Install bank stabilization measures at eroding banks using toe wood

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$4,431	$4,430	10% of project cost
Control of Water	LS	1	$1,528	$1,530	4% of primary item cost
Erosion Control	LS	1	$2,292	$2,290	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	30	$200	$6,000	
Grading	SY	111	$6	$670	
Furnish and Install Toe Wood	LF	100	$250	$25,000	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	15	$250	$3,750	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	111	$3	$330	
Damage Repair	LS	1	$764	$760	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$1,528	$1,530	4% of primary item cost
			Total	**$ 48,740**	
			Contingency (30%)	$ 14,620	
			Subtotal	**$ 63,400**	
			Design, Permitting, and Administration (30%)	$ 14,620	
			Total w/ Contingency & Engineering	**$ 78,000**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 570	25%	of damage repair and maintenance
End of life span maintenance	$ 19,500	25%	of original project cost
Future Capital Cost	$ 189,300		
Future annual maintenance	$ 27,120		
Future end of life span cost	$ 35,220		
Total Future Worth	**$ 251,600**		
Annualized Cost	**$ 5,300**		

Table H44: Preliminary Cost Estimate for Site 18, Alternative A

Remove large woody debris

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$334	$330	10% of project cost
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Seeding and Mulch	ACRE	0.1	$8,000	$550	
Erosion Control Blanket	SY	333	$3	$1,000	
Damage Repair	LS	1	$63	$60	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$126	$130	4% of primary item cost
			Total	**$ 3,670**	
			Contingency (30%)	$ 1,100	
			Subtotal	**$ 4,800**	
			Design, Permitting, and Administration (30%)	$ 1,100	
			Total w/ Contingency & Engineering	**$ 5,900**	

30-yr and Annualized Cost analysis

Category:	Debris Removal		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ -	0%	of damage repair and maintenance
End of life span maintenance	$ 1,480	25%	of original project cost
Future Capital Cost	$ 14,300		
Future annual maintenance	$ -		
Future end of life span cost	$ 2,670		
Total Future Worth	**$ 17,000**		
Annualized Cost	**$ 400**		

Table H45: Preliminary Cost Estimate for Site 19, Alternative A

Remove large woody debris

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$334	$330	10% of project cost
Select Tree Removal (>4")	EACH	8	$200	$1,600	
Seeding and Mulch	ACRE	0.1	$8,000	$550	
Erosion Control Blanket	SY	333	$3	$1,000	
Damage Repair	LS	1	$63	$60	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$126	$130	4% of primary item cost
			Total	**$ 3,670**	
			Contingency (30%)	$ 1,100	
			Subtotal	**$ 4,800**	
			Design, Permitting, and Administration (30%)	$ 1,100	
			Total w/ Contingency & Engineering	**$ 5,900**	

30-yr and Annualized Cost analysis

Category:	Debris Removal		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ -	0%	of damage repair and maintenance
End of life span maintenance	$ 1,480	25%	of original project cost
Future Capital Cost	$ 14,300		
Future annual maintenance	$ -		
Future end of life span cost	$ 2,670		
Total Future Worth	**$ 17,000**		
Annualized Cost	**$ 400**		

Table H46: Preliminary Cost Estimate for Site 20, Alternative A

Stabilize with hard armor

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$2,716	$2,720	10% of project cost
Control of Water	LS	1	$936	$940	4% of primary item cost
Erosion Control	LS	1	$1,405	$1,400	6% of primary item cost
Clearing and Grubbing	ACRE	0.05	$7,000	$320	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	222	$6	$1,330	
Furnish and Install Fieldstone Riprap	TON	162	$100	$16,200	
Topsoil Import	CY	19	$33	$610	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	20	$50	$1,000	
Seeding and Mulch	ACRE	0.05	$8,000	$370	
Erosion Control Blanket	SY	111	$3	$330	
Damage Repair	LS	1	$468	$470	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$936	$940	4% of primary item cost
			Total	**$ 29,880**	
			Contingency (30%)	$ 8,960	
			Subtotal	**$ 38,800**	
			Design, Permitting, and Administration (30%)	$ 8,960	
			Total w/ Contingency & Engineering	**$ 47,800**	

30-yr and Annualized Cost analysis

Category:	Hard armor		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 350	25%	of damage repair and maintenance
End of life span maintenance	$ 23,900	50%	of original project cost
Future Capital Cost	$ 116,000		
Future annual maintenance	$ 16,650		
Future end of life span cost	$ 43,170		
Total Future Worth	**$ 175,800**		
Annualized Cost	**$ 3,700**		

Table H47: Preliminary Cost Estimate for Site 20, Alternative B

Stabilize with toe wood and grading to broaden meander

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$6,246	$6,250	10% of project cost
Control of Water	LS	1	$2,154	$2,150	4% of primary item cost
Erosion Control	LS	1	$3,231	$3,230	6% of primary item cost
Clearing and Grubbing	ACRE	0.05	$7,000	$320	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Excavate/Salvage Soil	CY	296	$15	$4,440	
Grading	SY	222	$6	$1,330	
Topsoil Import	CY	37	$33	$1,220	
Furnish and Install Toe Wood	LF	150	$250	$37,500	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.0	$8,000	$370	
Erosion Control Blanket	SY	222	$3	$670	
Damage Repair	LS	1	$1,077	$1,080	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$2,154	$2,150	4% of primary item cost
			Total	**$ 68,710**	
			Contingency (30%)	$ 20,610	
			Subtotal	**$ 89,300**	
			Design, Permitting, and Administration (30%)	$ 20,610	
			Total w/ Contingency & Engineering	**$ 109,900**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 810	25%	of damage repair and maintenance
End of life span maintenance	$ 27,480	25%	of original project cost
Future Capital Cost	$ 266,800		
Future annual maintenance	$ 38,540		
Future end of life span cost	$ 49,630		
Total Future Worth	**$ 355,000**		
Annualized Cost	**$ 7,500**		

Table H48: Preliminary Cost Estimate for Site 20, Alternative C

Controlled overflow, install grade control structure downstream

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$2,840	$2,840	10% of project cost
Control of Water	LS	1	$979	$980	4% of primary item cost
Erosion Control	LS	1	$1,469	$1,470	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$160	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Grading	SY	333	$6	$2,000	
Furnish and Install Fieldstone Riprap	TON	156	$100	$15,560	
Plant Trees	EACH	5	$250	$1,250	
Plant Shrubs	EACH	20	$50	$1,000	
Rock Boulder Vane	EACH	1	$2,000	$2,000	
Seeding and Mulch	ACRE	0.02	$8,000	$180	
Erosion Control Blanket	SY	111	$3	$330	
Damage Repair	LS	1	$490	$490	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$979	$980	4% of primary item cost
			Total	**$ 31,240**	
			Contingency (30%)	$ 9,370	
			Subtotal	**$ 40,600**	
			Design, Permitting, and Administration (30%)	$ 9,370	
			Total w/ Contingency & Engineering	**$ 50,000**	

30-yr and Annualized Cost analysis

Category:	Rock vanes		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 370	25%	of damage repair and maintenance
End of life span maintenance	$ 25,000	50%	of original project cost
Future Capital Cost	$ 121,400		
Future annual maintenance	$ 17,600		
Future end of life span cost	$ 45,150		
Total Future Worth	**$ 184,200**		
Annualized Cost	**$ 3,900**		

Table H49: Preliminary Cost Estimate for Site 20, Alternative D

Realign channel and stabilize meanders with vanes and toe wood

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$8,398	$8,400	10% of project cost
Control of Water	LS	1	$2,896	$2,900	4% of primary item cost
Erosion Control	LS	1	$4,343	$4,340	6% of primary item cost
Clearing and Grubbing	ACRE	0.1	$7,000	$710	
Select Tree Removal (>4")	EACH	30	$200	$6,000	
Excavate/Salvage Soil	CY	652	$15	$9,780	
Grading	SY	489	$6	$2,930	
Topsoil Import	CY	81	$33	$2,690	
Furnish and Install Toe Wood	LF	150	$250	$37,500	
Rock Boulder Vane	EACH	2	$2,000	$4,000	
Plant Trees	EACH	20	$250	$5,000	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.1	$8,000	$810	
Erosion Control Blanket	SY	489	$3	$1,470	
Damage Repair	LS	1	$1,448	$1,450	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$2,896	$2,900	4% of primary item cost
			Total	**$ 92,380**	
			Contingency (30%)	$ 27,710	
			Subtotal	**$ 120,100**	
			Design, Permitting, and Administration (30%)	$ 27,710	
			Total w/ Contingency & Engineering	**$ 147,800**	

30-yr and Annualized Cost analysis

Category:	Remeander		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 440	10%	of damage repair and maintenance
End of life span maintenance	$ 14,780	10%	of original project cost
Future Capital Cost	$ 358,700		
Future annual maintenance	$ 20,930		
Future end of life span cost	$ 26,690		
Total Future Worth	**$ 406,300**		
Annualized Cost	**$ 8,500**		

Table H50: Preliminary Cost Estimate for Site 21, Alternative A

Narrow channel for approx. 80'

Item Description	Unit	Estimated Quantity	Unit Price	Extension	Notes
Mobilization	LS	1	$1,514	$1,510	10% of project cost
Control of Water	LS	1	$522	$520	4% of primary item cost
Erosion Control	LS	1	$784	$780	6% of primary item cost
Clearing and Grubbing	ACRE	0.04	$7,000	$260	
Select Tree Removal (>4")	EACH	20	$200	$4,000	
Common Fill Import	CY	119	$25	$2,960	
Grading	SY	89	$6	$530	
Topsoil Import	CY	15	$33	$490	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.04	$8,000	$290	
Erosion Control Blanket	SY	178	$3	$530	
Damage Repair	LS	1	$261	$260	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$522	$520	4% of primary item cost
			Total	**$ 16,650**	
			Contingency (30%)	$ 5,000	
			Subtotal	**$ 21,700**	
			Design, Permitting, and Administration (30%)	$ 5,000	
			Total w/ Contingency & Engineering	**$ 26,700**	

30-yr and Annualized Cost analysis

Category:	General grading		
Estimated life span (years)	30	1	number of major maint. events
Expected annual maintenance	$ 80	10%	of damage repair and maintenance
End of life span maintenance	$ 2,670	10%	of original project cost
Future Capital Cost	$ 64,800		
Future annual maintenance	$ 3,810		
Future end of life span cost	$ 4,820		
Total Future Worth	**$ 73,400**		
Annualized Cost	**$ 1,500**		

Table H51: Preliminary Cost Estimate for Site 21, Alternative B

Install log vanes within reach

Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Extension**	**Notes**
Mobilization	LS	1	$1,221	$1,220	10% of project cost
Control of Water	LS	1	$421	$420	4% of primary item cost
Erosion Control	LS	1	$632	$630	6% of primary item cost
Clearing and Grubbing	ACRE	0.02	$7,000	$130	
Select Tree Removal (>4")	EACH	10	$200	$2,000	
Log Vanes	EACH	3	$1,200	$3,600	
Grading	SY	33	$6	$200	
Topsoil Import	CY	6	$33	$180	
Plant Trees	EACH	10	$250	$2,500	
Plant Shrubs	EACH	30	$50	$1,500	
Seeding and Mulch	ACRE	0.02	$8,000	$150	
Erosion Control Blanket	SY	89	$3	$270	
Damage Repair	LS	1	$211	$210	2% of primary item cost
One-Year Establishment Maintenance Period	LS	1	$421	$420	4% of primary item cost
			Total	**$ 13,430**	
			Contingency (30%)	$ 4,030	
			Subtotal	**$ 17,460**	
			Design, Permitting, and Administration (30%)	$ 4,030	
			Total w/ Contingency & Engineering	**$ 21,500**	

30-yr and Annualized Cost analysis

Category:	Bioengineering		
Estimated life span (years)	20	1	number of major maint. events
Expected annual maintenance	$ 160	25%	of damage repair and maintenance
End of life span maintenance	$ 5,380	25%	of original project cost
Future Capital Cost	$ 52,200		
Future annual maintenance	$ 7,610		
Future end of life span cost	$ 9,720		
Total Future Worth	**$ 69,500**		
Annualized Cost	**$ 1,500**		