Upper Riley Creek Corridor Ecological Enhancement Plan from Highway 5 to Lake Susan

Prepared for
Riley Purgatory Bluff Creek Watershed District and the City of Chanhassen

May 2021

Upper Riley Creek from Highway 5 to Lake Susan

Ecological Enhancement Plan

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Contents

List of Tables

List of Figures

List of Appendices

1.0 Context and Goals for this Ecological Enhancement Plan

This document was written to guide enhancement and stewardship efforts of ecological resources within Reach R4 of Upper Riley Creek (i.e. the Upper Riley Creek Stabilization Project, or Project) as shown in Figure 1-1. The project partners include the Riley Purgatory Bluff Creek Watershed District (RPBCWD), and city of Chanhassen (City). As noted in Section 8.0 of this plan, a cooperative agreement between the RPBCWD and City will be developed for activities related to construction and maintenance of a resulting project. This Ecological Enhancement Plan documents the goals of the partnership for the Upper Riley Creek Stabilization Project and establishes roles and responsibilities of Project partners for the estimated 20-year life of the agreement.

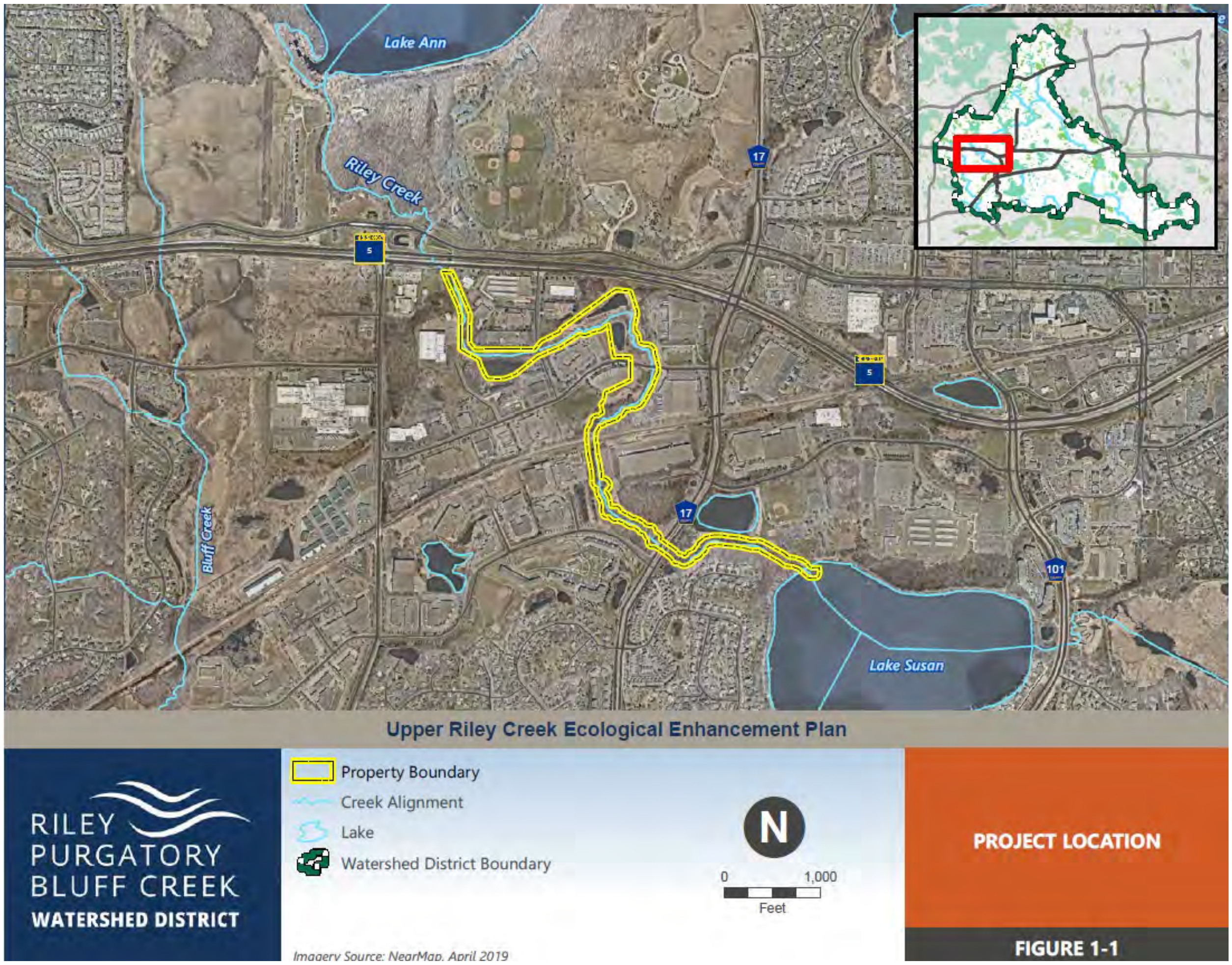


Figure 1-1 Location of Upper Riley Creek Stabilization Project

The partners will work collaboratively to review this ecological enhancement plan and financial prospectus that collectively establish leadership by each organization in site management tasks. The financing plan in Section 9.0 includes outlines the partners responsible for leading and financing the major project tasks.

2.0 Vision, Goals, and Project Approach

The vision for this Project is to provide an ecologically diverse stream reach that significantly reduces streambank erosion, provides diverse habitat layers, improves the ecological functions, and enhances the public's access and their understanding of why stable stream systems are important while providing improved inspection and maintenance access. The portion of upper Riley Creek between Highway 5 and Lake Susan, known as Reach R4 in the District's 2015 Creek Restoration Action Strategy (CRAS) report, has a channel bed that is primarily sand and silt with limited riffle/pool variability. Agriculture was the dominant land use in the watershed until the 1980's and 1990's when industrial and residential development increased, resulting in introduction of increased amounts of impervious surfaces in the watershed. This increase in impervious surfaces associated with development has increased the amount of runoff in the watershed, which has caused increased erosion in Upper Riley Creek.

Restoring the Upper Riley Creek ecosystem by implementing stream restoration measures to improve habitat, reduce erosion, reconnect the floodplain, and provide watershed improvements to counteract development-driven hydrologic watershed changes are estimated to reduce pollutant loads reaching Lake Susan by an estimated 470,000 pounds per year for total suspended solids and 250 pounds per year for phosphorus.

The Project will enhance the ecology of Upper Riley Creek by providing greater stream depth variability, more channel bed substructure types, and varied channel velocities. The proposed Project will remove accumulated debris from within the channel, reduce erosion and improve water quality while also improving natural stream habitat for aquatic organisms. Providing better floodplain connectivity for Upper Riley Creek also enhances surrounding riparian habitat and improves the ecological function through the corridor. By establishing a stable stream corridor, the Project will also help address the Minnesota Pollution Control Agency's (MPCA's) identified nutrient impairment in Lake Susan (which this reach of Riley Creek directly discharges into), Rice Marsh Lake, and Lake Riley. The lower portion of the Project's location in Lake Susan Park provides opportunities for interpretive signage and future programming to educate the public on the importance of diverse stream corridors.

As part of the Project partners planning processes, each have established goals intended to protect, restore, and enhance water resources. Table 2-1 provides a summary of how the Project aligns with these goals.

Table 2-1 Summary of Partner Goals and Project

Partner	Goals	How Project Aligns with Goal
RPBCWD	Design, maintain, and implement Education and Outreach programs to educate the community and engage them in the work of protecting, managing, and restoring water resources. (EO 1)	The project will educate the community that is near and recreational users on the project itself but also stewardship ideas that they can implement.
	Include sustainability and the impacts of climate change in District projects, programs, and planning.	The District will use sustainable materials to the extent practicable as part of the project.
	Protect, manage, and restore water quality of District lakes and creeks to maintain designated uses. (WQual 1)	The project is restoring the Reach R4 of Riley Creek.
	Preserve and enhance habitat important to fish, waterfowl, and other wildlife. (WQual 3)	The project will enhance the creek corridor which includes both terrestrial and aquatic habitats. The project will enhance the aquatic habitats by stabilizing eroding streambanks. Furthermore, the project will reduce habitat fragmentation by reconnecting the creek with the terrestrial uplands.
	Protect and enhance the ecological function of District floodplains to minimize adverse impacts. (WQuan 1)	The project will reconnect the creek to the floodplain which will also help increase of pollutant removal, promote infiltration and enhancing the ecological habitat.

Partner	Goals	How Project Aligns with Goal
	Limit the impact of stormwater runoff on receiving waterbodies. (WQuan 2)	The project will dissipate the energy of stormwater runoff entering the creek at several culvert outfalls within the creek reach.
City of Chanhassen	Achieve water quality standards in lakes, streams, and wetlands consistent with their designated uses and established classifications.	The project is restoring the Reach R4 of Riley Creek.
	Protect and rehabilitate wetlands to maintain or improve their function and value.	Wetland impacts will be avoided and any wetland impacts are anticipated to be temporary. Creek restoration will result in a net benefit to surrounding wetlands.
	Improve access to public infrastructure for future maintenance needs	Design considerations may be implemented to provide improved access to public infrastructure for maintenance purposes.
	Maintain primary responsibility for managing water resources at the local level and continue coordination and cooperation with other agencies and organizations.	The City will, in coordination with the District, be responsible for post-construction monitoring and inspections. Additionally, the City will be responsible for the long-term inspections and routine maintenance.
	Cultivate an environmentally literate public to promote an active community role.	The project will educate the community that is near and recreational users on the project itself but also stewardship ideas that they can implement.

This plan intends to adopt an adaptive management approach to restoring this reach of Upper Riley Creek. An adaptive management approach evaluates the project performance following implementation and then determine if further actions are necessary to maintain the restoration.

This project looks to enhance the creek's ecological values and functions, mitigate and prevent additional erosion of streambanks, and foster the use of natural materials and bioengineering principals for the restoration and maintenance of stream segments whenever feasible. Technical stakeholders, including the USACE and MNDNR, have expressed a preference for bioengineering over hard armoring for stream stabilization where possible. Bioengineering techniques maintain more of a stream's natural function and provide better habitat and a more natural appearance than hard armoring.

3.0 Location

Upper Riley Creek, approximately 9,000 feet long, includes those portions of Riley Creek between Lake Ann and Lake Susan in the city of Chanhassen, Minnesota. The Project reach encompassed in this Ecological Enhancement plan includes roughly 8,600 feet of Upper Riley Creek between MN Trunk Highway 5 and Lake Susan (see Figure 3-1). The watershed tributary to this reach is about 1,994 acres with roughly 35% of the area covered by impervious surfaces.

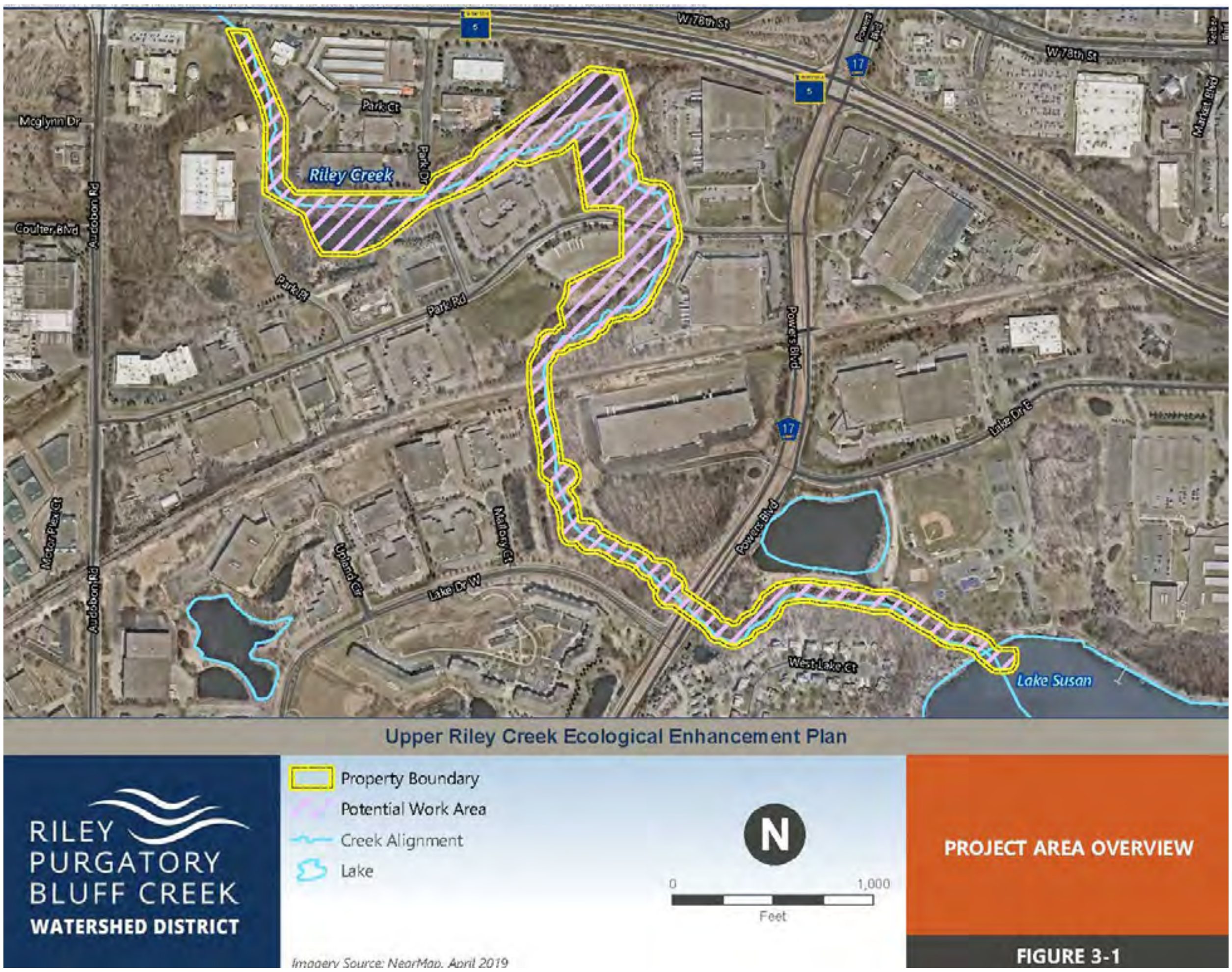


Figure 3-1 Project Area Overview

4.0 Land Use History

Prior to European settlement, the entire Riley Creek watershed was located in an ecoregion known as the Big Woods, where oak woodland and maple-basswood forests were the dominant vegetation types. As settlement occurred, much of the landscape was initially converted to farmland. Between the early 1900's and 1950's, the contributing watershed to Upper Riley Creek was primarily agricultural. As urban development spread outwards from the Minneapolis core, areas of farmland then became converted to urban and suburban landscapes. This conversion is ongoing in some of the undeveloped areas of Riley Creek watershed.

In the 1960's and 1970's, homes were constructed on nearby larger lakes; however, the Upper Riley Creek watershed was still predominantly agricultural. The city of Chanhassen grew slightly in this time, and some industrial facilities adjacent to the city of Chanhassen were constructed. By 1979, a few developments appeared within the watershed, but agriculture remained the dominant land use.

Much of the development in the Upper Riley Creek watershed occurred in the 1980's and 1990's. Between 1979 and 1991, approximately 75% of the current development occurred. Between 1991 and 2002 a belt of industrial development with significant impervious area was developed in the central portion of the watershed, resulting in developed conditions similar to present day. The only changes since 2002 have included occasional in-fill projects on undeveloped parcels.

The Project area begins south of Highway 5 and extends to Lake Susan. Three different zoning classifications are found in the vicinity and adjacent to the Project area, including public (municipal), commercial, and industrial. Several utility corridors are located in the Project area, including an active railroad track, a Metropolitan Council sanitary sewer main, and several municipal utilities (sanitary, water, etc.).

The watershed still has a large area of undeveloped land located between Highway 5 and Lake Ann, north of the Project boundary. This area is anticipated to eventually be developed as residential, which would result in additional impervious surface and runoff to Upper Riley Creek. A stabilization project on Upper Riley Creek will need to consider these eventual conditions, as well as future climate conditions, in its design.

5.0 Existing Conditions

Through the Project area, Riley Creek is generally is composed of a sand and silt channel bottom with areas of exposed gravel in the uppermost portions of the reach, downstream of Highway 5. The creek exhibits moderate to low development of distinct riffle, run, and pool features. The channel varies from approximately 1 to 4 feet in depth and ranges from 4 to 10 feet wide with narrower areas tending to be deeper. Based on monitoring data collected by the District in May through October of 2017 and 2018, flows through this portion of the creek range from less to one to approximately 13 cubic feet per second (cfs) with lower flows occurring during summer months (late July, August) and higher flows occurring during late spring/early summer (early June) rain events.

Within the Project area, portions of Riley Creek exhibit natural meandering patterns, while portions of the creek near the Chanhassen Public Works Building and adjacent to residential developments upstream of Lake Susan are straighter. The banks adjacent to the creek are quite steep near Highway 5 and in the vicinity of the railroad bridge with slopes ranging from 40 to 60 percent however, bank slopes flatten to approximately 10 percent near the stormwater ponds and Lake Susan.

There are three stormwater ponds adjacent to the creek in upper portions of the Project area. Culverts convey Riley Creek beneath the following features in the Project area: Highway 5, Park Drive, Park Road, a railroad embankment, and Powers Boulevard. Approximately 4,100 linear feet of sanitary sewer main is located adjacent to the creek. There are currently no trails or other public access points to experience the creek, aside from the downstream portions of the Project area in Lake Susan Park.

5.1 Creek Restoration Action Strategy Scores

In 2015, the RPBCWD published a Creek Restoration Action Strategy (CRAS) report. The purpose of this report was to develop a series of scored categories to prioritize creek restoration and stabilization projects within the District. Each category was assigned a score of 1, 3, 5, or 7 such that a score of 1 was best (i.e. no degradation) and a score of 7 was worst (i.e. significant degradation). In many cases, scores were assigned based on a review of site photos rather than by field data assessment. Each category was assigned a "tier", with Tier I categories designated as those factors that affect public health and safety, align with goals in the District's Plan, and represent the key reasons why stream restoration projects are undertaken. The sum of Tier I scores was used to assign a priority rating from low (no restoration efforts needed) to severe (highest priority reach, immediate stabilization and/or restoration project needed). Tier I CRAS scores for the project reach are summarized in Table 5-1.

Table 5-1 2015 CRAS Scores

Reach	Description	Infra-structure	Erosion/Channel Stability	Ecological Benefits	Water Quality Summary	Tier I Score	Tier I priority
R4A	Hwy 5 to Park Dr.	3	5	5	3	16	Moderate
R4B	Park Dr. to Park Rd.	1	5	5	3	14	Moderate
R4C	Park Rd. to Railroad Br.	5	7	5	3	20	High
R4D	Railroad Br. to Powers Blvd.	5	7	5	3	20	High
R4E	Powers Blvd. to Lake Susan	5	7	5	3	20	High

Although the 2015 CRAS identified Upper Riley Creek as a degraded stream segment, the scope of the CRAS did not evaluate stream degradation causes or identify viable restoration alternatives. Upper Riley Creek was walked again in 2016 to further evaluate surface erosion, channel processes, and habitat. The updated field assessments yielded updated CRAS scores for Upper Riley Creek, which are listed in Table 5-2. The updated scores indicate that nearly all portions of Upper Riley Creek from Highway 5 to Lake Susan continue to be high priority for restoration or stabilization.

Table 5-2 Updated Tier I CRAS Scores based on 2016 Assessments

Reach	Description	Infra-structure	Erosion/Channel Stability	Ecological Benefits	Water Quality Summary	Updated Tier I Score	Updated Tier I priority
R4A	Hwy 5 to Park Dr.	5	5	5	3	18	High
R4B	Park Dr. to Park Rd.	3	3	5	3	14	Low
R4C	Park Rd. to Railroad Br.	5	5	5	3	18	High
R4D	Railroad Br. to Powers Blvd.	3	7	5	3	18	High
R4E	Powers Blvd. to Lake Susan	3	7	5	3	18	High

5.2 Vegetation

A vegetation assessment was completed in June 2020 to determine vegetation composition of the riparian portions of the Project area. The plant community surrounding the upper and middle portions of the Project reach are hardwood forest of marginal quality due to prevalence of non-native, invasive species, with a nearly continuous canopy cover (90-100%). The riparian area is dominated by green ash, boxelder, cottonwood, and silver maple. Sandbar willow becomes prevalent where the creek outlets to Lake Susan. European buckthorn, an invasive species, is prevalent throughout forested portions of the Project area, accounting for up to 75 percent of the canopy cover in some locations and comprising a portion of the understory. In general, the understory of forested sections is sparsely vegetated due to the high level of canopy cover (Figure 5-1).

Figure 5-1 European Buckthorn and Native Hardwood Forest Community with Sparse Understory

Unforested portions of the Project area reflect marsh and wet-meadow type settings dominated by river bulrush, and invasive reed canary grass and narrow-leaved cattail. Stinging nettle, smartweed, and goldenrod were also observed in the marsh and wet-meadow settings, though not as dominant species. In some portions of the Project area, reed canary grass accounts for nearly 100 percent of the vegetation cover (Figure 5-2).

Figure 5-2 Reed Canary Grass Dominated Plant Community in Project Area

5.3 Wetlands

A field wetland delineation was completed in May and June 2020. The wetland delineation was performed according to the Routine On-Site Determination Method specified in the U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual (1987 Edition) and the 2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual for the Midwest Region.

Delineated wetland boundaries and sample points were mapped in the field using a Trible GeoXH 700 Global positioning System unit capable of recording positions with sub-foot horizontal accuracy. Vegetation, soils, and hydrology data were collected at sample points within and around wetland areas. Soil samples were examined for hydric indicators according to the Natural Resources Conservation Service Field Indicators of Hydric Soils in the United States. Soil colors were determined using a Munsell® soil color chart. Plant species were identified, and percent aerial cover was estimated at each sample point using methods described within the USACE Midwest Regional Supplement to the 1987 manual. The corresponding wetland indicator status of each plant species was recorded using the current National Wetland Plant List.

Hydrologic conditions were also evaluated and recorded for each sample point. Delineated wetland areas were classified using the U.S. Fish and Wildlife Service (USFWS) Cowardin System, the USFWS Circular 39 system and the Eggers and Reed Wetland Classification System.

Five wetlands totaling 6.64 acres were delineated within the study area, as summarized in Table 5-3 and shown on Figure 5-3. Mapped communities for each wetland are shown on figures included in Appendix A. As part of RPBCWD's wetland management program, District staff completed assessments of several wetlands in the study area using the Minnesota Routine Assessment Method (MnRAM), as also noted in Table 5-3. The functional assessment categories in the MnRAM assessment were translated into the RPBCWD wetland value using the wetland definitions defined in Appendix D1 of RPBCWD's Wetland and Creek Buffers Rule (Rule D). The assessed wetlands are assigned a wetland rating in one of four categories: exceptional, high, medium, and low. Exceptional value wetlands are highly functional wetlands, while the low wetland ratings reflect wetlands that have been substantially disturbed. All of the classified wetlands in the study area fall within high or medium rating categories.

Table 5-3 Delineated Wetlands within Study Area

Wetland ID	Cowardin Wetland Type	Circular 39 Type	Wetland Community Type (Eggers & Reed)	RPBCWD Wetland Rating	Delineated Wetland Size
A1	PFO1A (palustrine, forested, broad-leaved deciduous, temporarily flooded)	1	Floodplain forest	Medium	0.50
B1	PFO1A (palustrine, forested, broad-leaved deciduous, temporarily flooded)	1	Floodplain forest	High	0.24
	PEMB (palustrine, emergent, saturated)	2	Wet meadow		2.89
	PEMC (palustrine, emergent, seasonally flooded)	3	Shallow marsh		0.51
	PUBHx (palustrine, unconsolidated bottom, permanently flooded, excavated)	4	Deep marsh; constructed stormwater pond		1.04
B2	PEMB (palustrine, emergent, saturated)	2	Sedge meadow	Medium	0.05
	PEMC (palustrine, emergent, seasonally flooded)	3	Shallow marsh		0.17
	PUBHx (palustrine, unconsolidated bottom, permanently flooded, excavated)	4	Deep marsh; constructed stormwater pond		0.97
C1	PEMAx (palustrine, emergency, temporarily flooded, excavated)	1	Seasonally flooded basin	Medium	0.07
E1	PSS1B (palustrine, scrub-shrub, broad-leaved deciduous, saturated)	6	Shrub-carr	Assumed to be High (Not yet rated)	0.20

Figure 5-3 Delineated Wetlands

The wetland delineation report was submitted to the city of Chanhassen for review and approval under the Wetland Conservation Act (WCA) in early September 2020. A site visit to confirm wetland boundaries was held on September 30, 2020 and attended by representatives from the City of Chanhassen, Minnesota Board of Soil and Water Resources, Carver County Soil and Water District, and Barr Engineering Co. Adjustments were made to the wetland boundaries based on the site visit, and the wetland delineation was approved by the Technical Evaluation Panel on November 4, 2020.

5.4 Soils and Hydrology

Nine different soil types are found in the Project area, as described in Table 5-4. Although soils in the Project area generally have a moderate susceptibility to erosion, most of these soils are generally found on steep slopes.

Table 5-4 Summary of Soils Conditions within the Project Area

Soil Type	Typical Soil Slopes	Erosion Susceptibility	Hydric Status
Essexville sandy loam	None listed	Low	Hydric
Hamel loam	0 to 2 percent	Moderate	Predominantly Hydric
Kilkenny-Lester loams	2 to 6 percent	Moderate	Not Hydric
Lester loam	10 to16 percent	Moderate	Not Hydric
Lester-Kilkenny complex	6 to 10 percent	Moderate	Predominantly Not Hydric
Lester-Kilkenny complex	10 to 16 percent	Moderate	Predominantly Not Hydric
Lester-Kilkenny loams	12 to 18 percent	Moderate	Not Hydric
Lester-Kilkenny complex	16 to 22 percent	Moderate	Predominantly Not Hydric
Muskego and Houghton soils	0 to 1 percent	None listed	Hydric

Riley Creek is the primary hydrologic resource in the Project area. It travels through a relatively wide valley before reaching Lake Susan. Riley Creek ultimately flows out of Lake Susan, thought Rice Marsh Lake and Lake Riley before discharging into the Minnesota River. This reach of Riley Creek has a moderately incised channel with little connection to its floodplain. The incised nature of the channel limits the ability of high flows to spread into a floodplain (where flows could be slowed to promote sedimentation), thereby keeping high flows concentrated in and near the main channel, exacerbating existing bank erosion.

5.5 Water Quality Impairments

States must develop a list of impaired waters that require total maximum daily load (TMDL) studies and routinely coordinate with the U.S. Environmental Protection Agency (EPA) for study approval. A TMDL study identifies the maximum amount of a certain pollutant that a body of water can receive without violating water quality standards and allocates that amount to the pollutant's sources. The MPCA maintains a list of impaired waters for the state of Minnesota. A creek is considered impaired if it fails to meet one or more of the state's water quality standards presented in Table 5-5.

Table 5-5 MPCA Water Quality Standards for Creeks

Water Quality Parameter	MPCA Water Quality Standard
Total Phosphorus (summer average, µg/L)	100
Chlorophyll *a* (summer average, µg/L)	18
Secchi Disc Transparency (summer average, m)	NA
Total Suspended Solids (mg/L)[1]	30
Daily Dissolved Oxygen Flux (mg/L)	3.5
Biological Oxygen Demand (5 day) (mg/L)	2
Escherichia coli (# per 100 mL)	126
Chloride (mg/L)	230

[1]To achieve the MPCA total suspended solids (TSS) stream water quality standard, a stream may not exceed 30mg/L TSS more than 10% of the time.

Lower Riley Creek, from Lake Riley to the Minnesota River, is included on the MPCA's 2020 Inventory of Impaired Waters; however, Upper Riley Creek has not yet been assessed by the MPCA. Because the MPCA has not yet completed a TMDL study for Upper Riley Creek, RPBCWD placed an automated water-sampling unit on Riley Creek at the culvert passing under Powers Boulevard, just upstream of Lake Susan, to better quantify rain event nutrient loading from upstream sources. The following water quality parameters were collected at this location from 2017 through 2019:

- Total phosphorus (TP; mg/L),
- Total dissolved phosphorus (TDP; mg/L),
- Chlorophyll-a (Chl-a; ug/L), and
- Total suspended solids (TSS; mg/L).

Based on the results of the district's recent monitoring efforts, as described below, Upper Riley Creek does not achieve the MPCA water quality standards in Table 5-5. As such, the creek discharges water with excess nutrient and suspended solids to Lake Susan, which also does not meet MPCA water quality standards for shallow lakes.

The TDP and TP concentrations measured at the Riley Creek/Powers Boulevard crossing from 2018 and 2019 are shown in Figure 5-4. The dashed line represents the MPCA's TP standard in class 2B creeks (≤ 0.1mg/L). The average TP across the 12 samples collected in 2019 was 0.497mg/L. This level is about four times the MPCA eutrophication water quality standard for class 2B creeks (≤ 0.1mg/L). As shown in Figure 5-4, none of the TP samples achieved the standard, and Upper Riley Creek is considered to be in poor health.

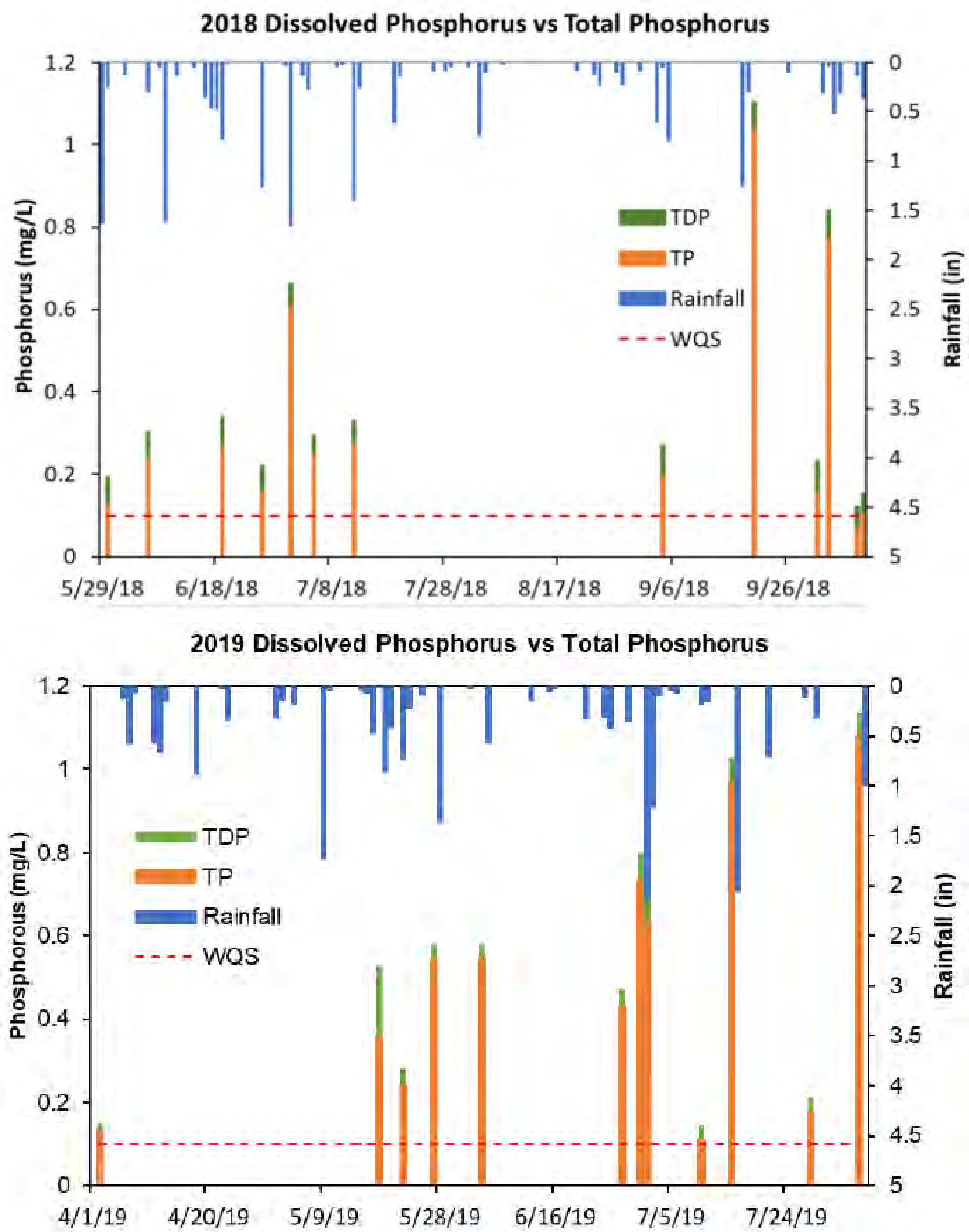


Figure 5-4 Upper Riley Creek TP and TDP Measurement at Powers Boulevard

TSS concentrations measured at the Riley Creek/Powers Boulevard crossing from 2018 and 2019 are summarized in Figure 5-5. The dashed line represents the MPCA's standard for TSS in class 2B creeks (≤30mg/L TSS no more than 10% of the time). Only two of the 2018 samples and none of the 12 samples taken in 2019 fell below the 30mg/L TSS standard, thus confirming this creek reach is in poor health. The high TSS and TP measured at the Riley Creek/Powers Boulevard crossing confirm the potential for significant pollutant loading directly to Lake Susan.

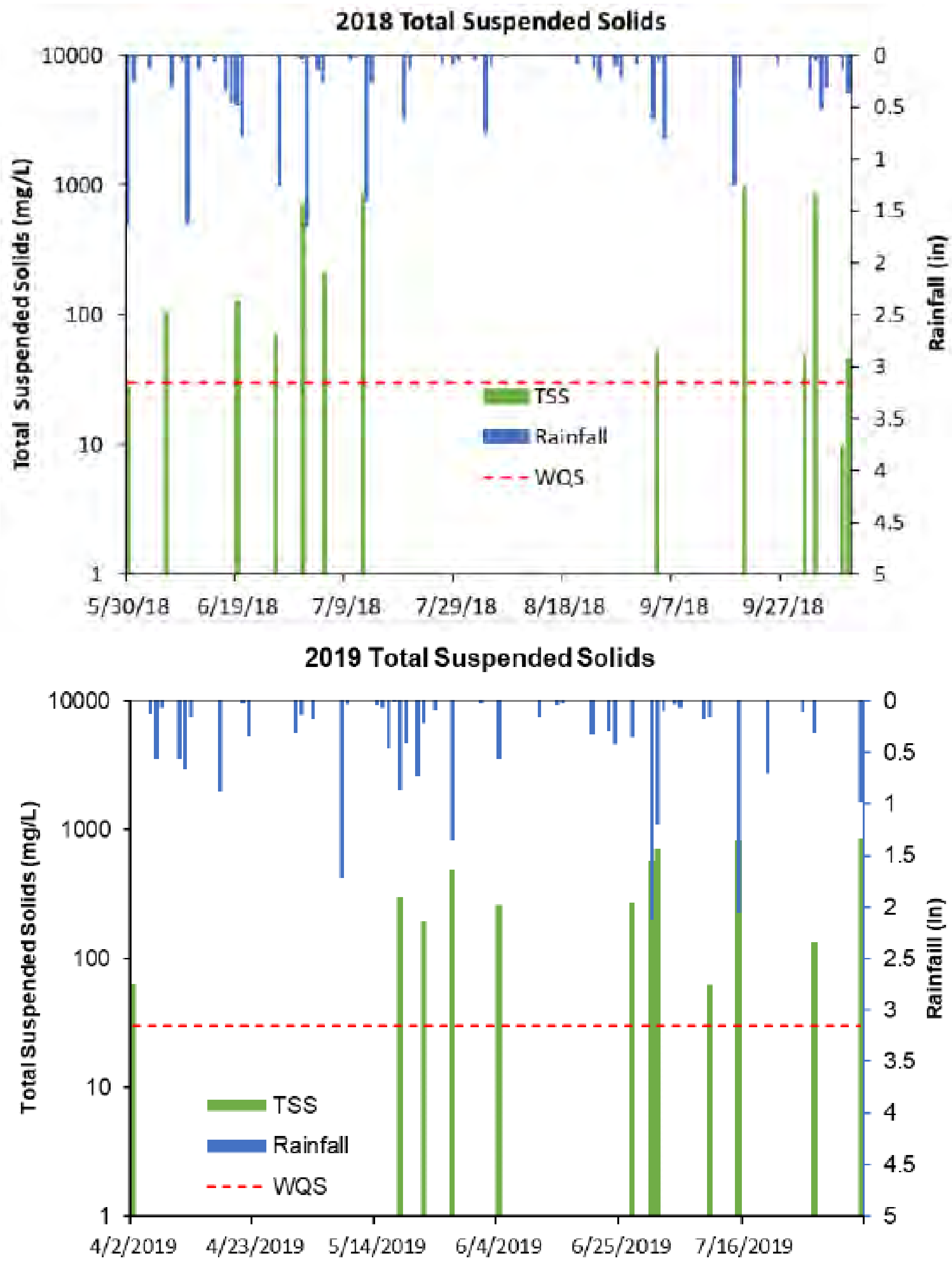


Figure 5-5 Upper Riley Creek TSS Measurements at Powers Boulevard

Lake Susan's position within the Riley chain of lakes makes lake water quality management important. Because water leaving Upper Riley Creek discharges directly to Lake Susan which in turn discharges downstream to Rice Marsh Lake and Lake Riley, it is important to keep phosphorus concentrations as low as possible entering Lake Susan. To that end, the RPBCWD and city of Chanhassen recently partnered to implement the Lake Susan Spent Lime Project and the Lake Susan Park Pond Reuse and Water Quality Project as efforts to improve Lake Susan water quality.

While these measures, along with a carp management initiative (discussed in Section 5.7) helped reduce phosphorus and chlorophyll-a concentrations and improve water clarity in the Lake Susan, the lake still does not achieve the MPCA's health standards. Water quality data collected in Lake Susan during 2020 indicate the summer average TP concentration (67 μg/L) was higher than the MPCA's shallow lake standard (60 μg/L). In February 2020, the MPCA released the *Lower Minnesota River Watershed TMDL Part II* to further identify the pollutant sources leading to Lake Susan's excess nutrient impairment. The TMDL also split the total phosphorus loads into a waste load allocation (WLA), load allocation (LA), and margin of safety (MOS) as summarized in Table 5-6. The table includes the existing annual loading rate, the allocated annual and daily loading rates, as well as the percent reductions required to meet the allocations for the impaired lake. According to the MPCA's TMDL:

- WLA represents the portion of the TP load associated with permitted sources (i.e. watershed loading).
- LA represents pollutant sources such as internal loading, groundwater, atmospheric deposition, and/or streambank erosion.
- The purpose of the MOS in the TMDL is to provide capacity to allow for uncertainty, which the TMDL assumed to be 5%.

RPBCWD worked collaboratively with the City to implement two water quality improvement projects, the Lake Susan spent lime facility and Lake Susan Park pond reuse and iron enhance sand filter, within the Lake Susan subwatershed to address the City's required wasteload reduction.

Table 5-6 Total Phosphorus Wasteload Allocations, Load Allocations, and Existing Conditions for Lake Susan, 2015 Water Year

		Existing TP Load		Allowable TP Load		Estimated Allowable Load Reduction	
		lbs/yr	lbs/day	lbs/yr	lbs/day	lbs/yr	%
Total Load		1,261	3.455	995	2.726	316	25
Wasteload	**Total WLA**	279	0.764	229	0.627	50	18
	MnDOT (MS400170)	27	0.074	27	0.074	0	0
	Carver County (MS400070)	9	0.025	9	0.025	0	0
	Chanhassen (MS400079)	241	0.660	191	0.523	50	21
	Construction/Industrial SW	2	0.005	2	0.05	0	0
Load	**Total LA**	**982**	**2,690**	**716**	**1.962**	**266**	**27**
	Atmospheric Deposition	33	0.090	33	0.090	0	0
	Internal Load	496	1.359	496	1.359	0	0
	Upstream Lakes	20	0.055	20	0.055	0	0
	Erosion Sources	400	1.096	134	0.367	266	67
	Groundwater	33	0.090	33	0.090	0	0
MOS (5%)				**50**	**0.137**		

Table 5-6 also shows that a considerable amount of TP entering Lake Susan is generated from erosion and internal sources. The TMDL indicates a 67% reduction in the erosion source loading is needed to achieve and maintain the long-term water quality goals in Lake Susan. Therefore, it is necessary to stabilize the streambank erosion sources in Upper Riley Creek to help achieve the water quality goals in Lake Susan.

5.6 Stream Geomorphic Assessment

Sediment delivery from the watershed to a stream is a natural process that occurs in all watersheds (Figure 5-6); however changes to the watershed change the dynamics of sediment delivery to and through the stream system. The basic sediment delivery to a stream can be broken down into three categories: surface erosion processes, hydrologic processes, and channel processes. Each of these processes is summarized in this section.

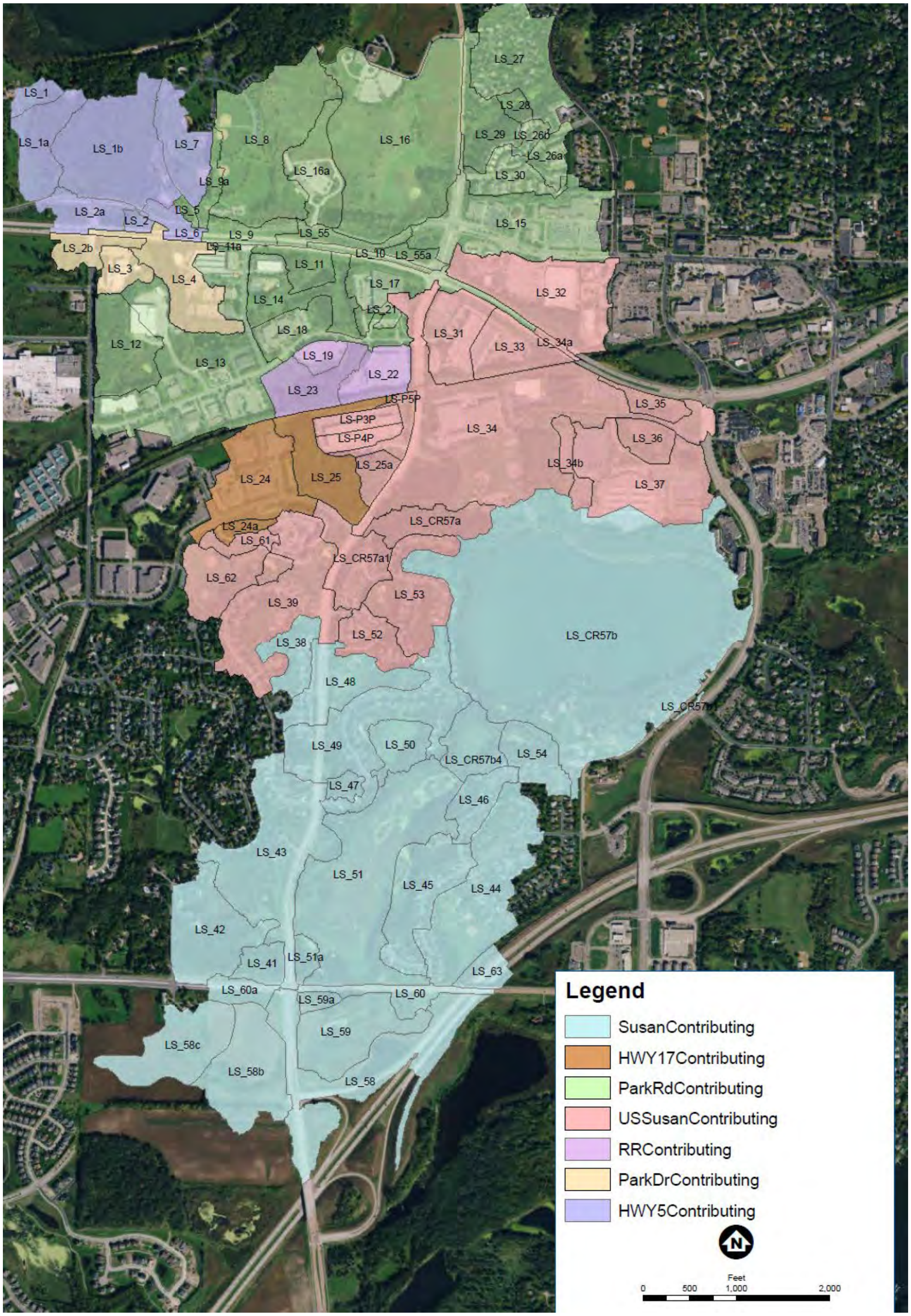


Figure 5-6 Contributing Watershed Summary Map

5.6.1 Surface Erosion

Surface erosion comes directly from the land surface and includes sediment that comes from both natural and impervious surfaces. It also includes mass wasting of hillslopes that contribute a significant amount of sediment directly into a drainage way or stream. While there is streambank erosion along Upper Riley Creek, the nature of the erosion is consistent with channel processes (Section 5.6.3) rather than mass wasting of a slope. Creek walks by District and Barr staff have not identified areas of mass wasting or other unusual sediment sources.

Surface erosion on natural surfaces is dependent on the watershed slope and the vegetation. Areas of a watershed that are unvegetated or poorly vegetated (e.g. fallow fields, development sites) will erode more and contribute more sediment than areas that are well vegetated. The Upper Riley Creek watershed is relatively flat and well vegetated, with seemingly minimal natural erosion from hillslopes.

The contributing watershed can play both a direct and indirect role in sediment delivery from surface erosion to the channel. Direct sediment delivery primarily includes sediment carried in runoff from impervious surfaces or eroded from land surfaces (usually unvegetated or poorly vegetated slopes) in the watershed. Direct sediment delivery can also include other sources, such as construction activities or agricultural land uses. Parking lots which are sanded in the winter can also contribute large quantities of sediment to the stream if they are not appropriately treated with best management practices (BMP). Indirect influences of sediment delivery involve hydrologic processes and are covered in Section 5.6.2.4.

5.6.1.1 Total Suspended Solids

Total suspended solids (TSS) originating from the watersheds reaching Lake Susan were quantified by a P8 model, originally developed by Wenck Associates, Inc. for RPBCWD and modified by for the MPCA's TMDL analysis. The P8 model indicates a total of 138,600 pounds of sediment leave the watersheds contributing to Lake Susan each year while 83,000 pounds reach Lake Susan from the contributing watersheds each year (excluding loading from the streambank erosion). Modeling indicates the existing detention basins and natural wetlands are removing approximately 67% of the sediment originating in the watershed. Implementing ecological enhancements of Upper Riley

Creek and the adjacent ponds could provide additional opportunities to detain TSS before it reaches Lake Susan.

5.6.2 Hydrologic Processes

Indirect influences of sediment delivery include increases in the volume and/or rate of runoff reaching the stream. As described in more detail in the following sections, there are multiple ways runoff volume and/or rates can increase, including:

- Changes in land use – natural → agricultural → urban/suburban development
- Increased impervious surface within the watershed;
- Modified watershed boundaries due to grading during development and installation of storm sewer systems;
- Increased efficiency of runoff delivery to streams due to the use of storm sewers;
- Climatological shifts that results in changes in the precipitation depth and intensity of storms.

Increases in the volume and/or rate of runoff contributing to a stream results in degradation of the stream bed and banks with transport of the eroded sediment downstream.

5.6.2.1 Flood Frequency and Magnitude Primer

Prior to the introduction of agriculture and grazing practices, Upper Riley Creek was likely in dynamic equilibrium with its watershed and was able to convey storm runoff without significant change in its shape, pattern, or profile. Transforming the landscape to one dominated by agriculture likely made fundamental changes to the hydrology by changing the dominant vegetation (both in the watersheds and adjacent to the creek), improving the rate of drainage from fields, and altering the sediment load to the creek. Relatively rapid fundamental changes to the hydrology can disrupt the dynamic equilibrium and result in erosion as the creek gradually moves toward a new balance with the hydrology and sediment supply to the creek in a process that can take years or decades to play out. When the watershed began to urbanize, a similar process likely began again as sediment supply, drainage patterns, and runoff rates and volumes changed again.

The most significant change associated with urbanization within the creek corridor is an increase in runoff from the watershed. With urbanization, the rate and volume of runoff generally increases, as shown in Figure 5-7 assuming mitigating measures are not implemented.

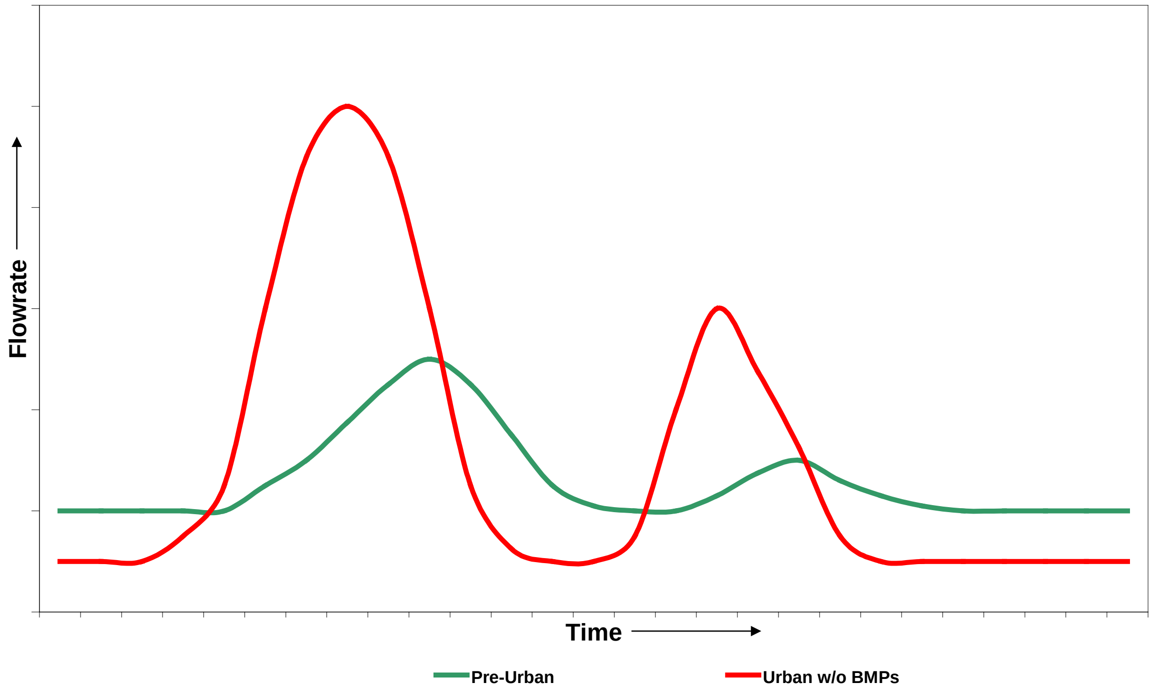


Figure 5-7 Change in Streamflow Due to Urbanization

The shape, pattern, and profile of the creek channel are closely related to the bankfull discharge. When the creek is in equilibrium with its environment, the shape, pattern, and profile are such that the creek can consistently convey the bankfull discharge without significant erosion. With urbanization, an increase in watershed imperviousness typically leads to an increase in the frequency of bankfull discharge as illustrated in Figure 5-8.

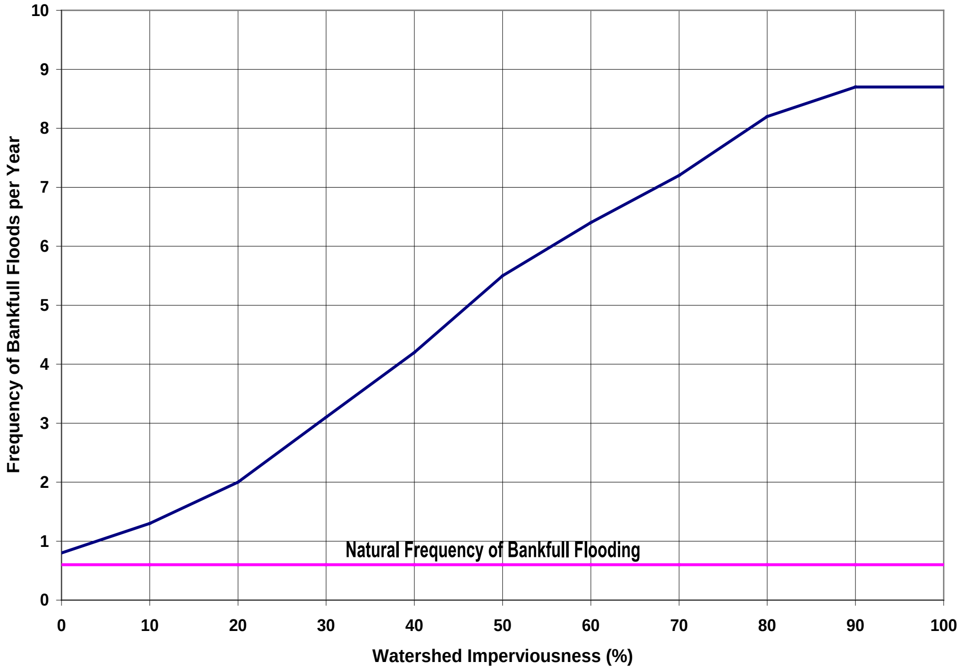


Figure 5-8 Conceptual Frequency of Bankfull Flooding as a Function of Imperviousness

The increase in the frequency of pre-development bankfull discharge means that there is a different, larger flow that occurs at the same frequency as the pre-development bankfull discharge frequency, and over time, the channel will adjust its dimensions to accommodate the larger flow that occurs at a frequency more consistent with a typical range of bankfull flow frequencies. The channel can adjust its dimensions through either deepening or widening by eroding and transporting the resulting sediment downstream. This is currently occurring in portions of Upper Riley Creek.

Detention ponds are often constructed to slow the rate of storm water flow to a creek, and thus attempt to maintain a more natural peak rate of flow to the creek and limit the impact to the magnitude of bankfull flows. By increasing storm water detention volume available, it may be possible to approach the pre-urbanized peak runoff rates to the creek.

Even if peak flows are sufficiently attenuated through stormwater detention, an increase in the total runoff volume may also impact stream geomorphology. The impacts are dependent on watershed characteristics and are less in watersheds with a lot of natural storage in lakes and wetlands, compared to those with little natural storage, because the channel is already adjusted to a longer hydrograph.

5.6.2.2 Upper Riley Creek Runoff Volume and Rate

Upper Riley Creek receives runoff from four distinct land use types: undeveloped parkland, industrial, and residential. The areas defined as residential and industrial have the potential to greatly increase runoff rates and volumes as compared to pre-development conditions due to increased imperviousness, leading to in-stream erosion.

The RPBCWD developed a detailed PCSWMM hydrologic and hydraulic model of Riley Creek in 2016. This model includes existing watersheds and land use to determine the rate and volume of runoff conveyed in Riley Creek. The PCSWMM model was used to analyze the impacts industrial and residential development in the watershed may have on the peak discharge and volume of water in this section of Riley Creek compared to pseudo pre-development conditions. Figure 5-9 and Figure 5-10 summarize the existing and pre-development conditions for 2-year cumulative runoff volume and percent increase in runoff volume (as compared to the immediate upstream segment) at several locations along the project reach.

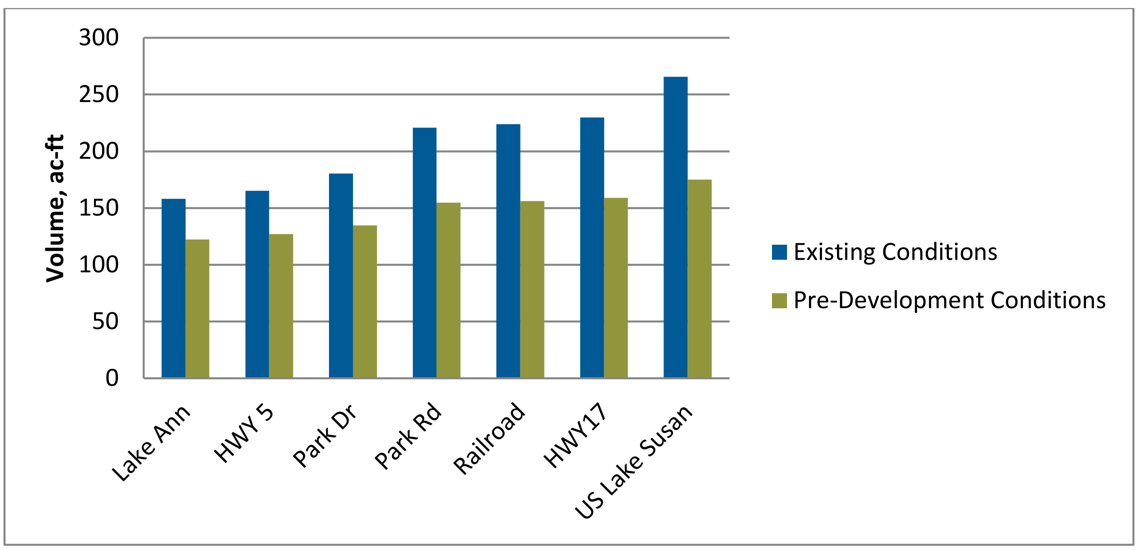


Figure 5-9 Cumulative Runoff Volume from the 2-year Design Storm from Lake Ann to Upstream of Lake Susan

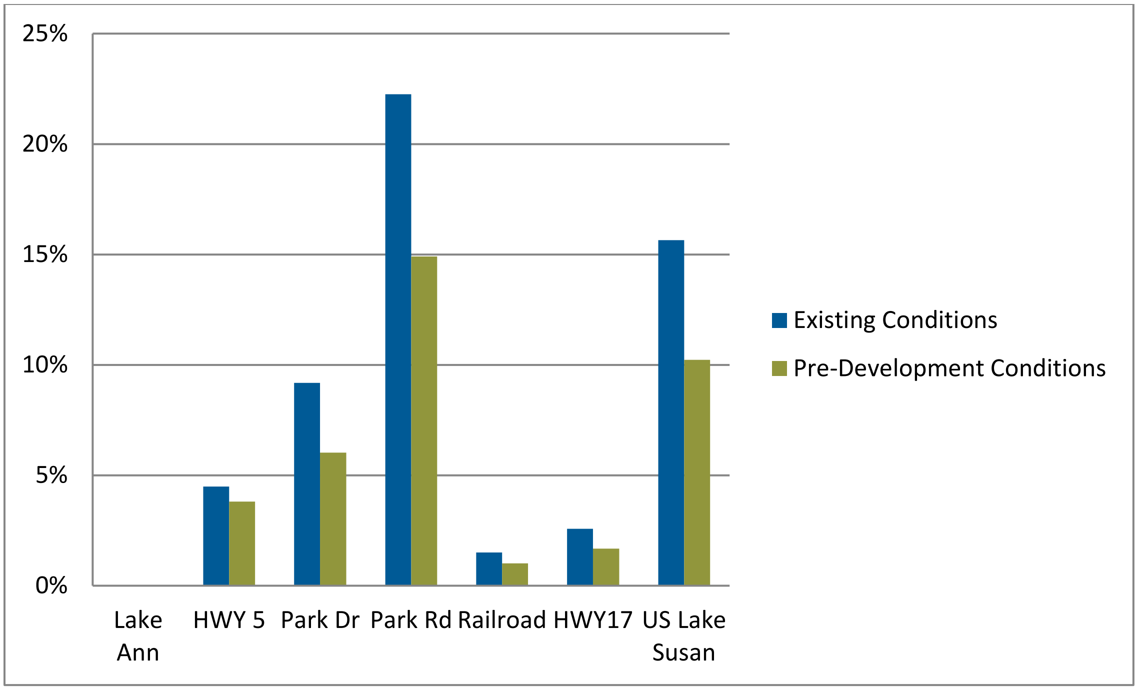


Figure 5-10 Percent Increase in Segment Runoff Volume from the 2-year Design Storm from Lake Ann to Upstream of Lake Susan

Compared to the pseudo pre-development condition, there is an estimated 52% increase in 2-year runoff volume entering Lake Susan under existing watershed conditions as shown in Figure 5-9. In addition, the true pre-development condition likely experienced less runoff volume and lower runoff rates than those approximated because of natural depressions and conveyances rather than the existing storm sewers. The segment immediately upstream of Lake Susan shows large increases in flow in Figure 5-10. The reach downstream of Park Road was also the creek section identified as having some of the most significant erosion.

While the PCSWMM model was also revised to approximate pre-development runoff peaks by assuming a fully pervious condition; the model still includes conveyance structures that are present today but were not present before development because pre-development flow patterns would have to be assumed. Since those conveyance structures were maintained for this analysis, the results defined as “Pre-development” should be considered proxies for actual pre-development modeling results and therefore the peaks should be analyzed for trends, not necessarily for their absolute value.

Figure 5-11 and Figure 5-12 provide the PCSWMM existing and pre-development 2-year and 10-year peak discharges. For the downstream section of the reach (HWY17), the 2-year peak discharge has increased by 125% as compared to pre-development conditions. The increase in the HWY17 reach is only 14% for the 10-year peak discharge. The 2-year event appears to have been impacted the most by watershed development and is critical when assessing stream erosion impacts.

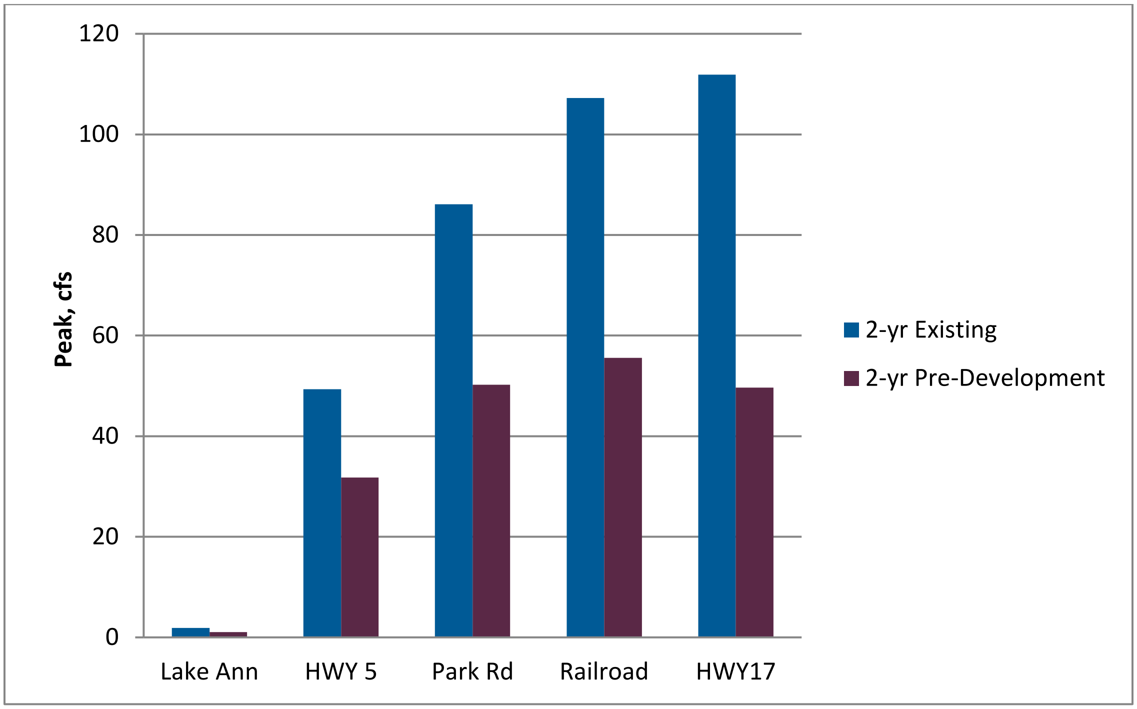


Figure 5-11 Peak 2-year Discharge in Riley Creek for Existing and Pre-Development Conditions

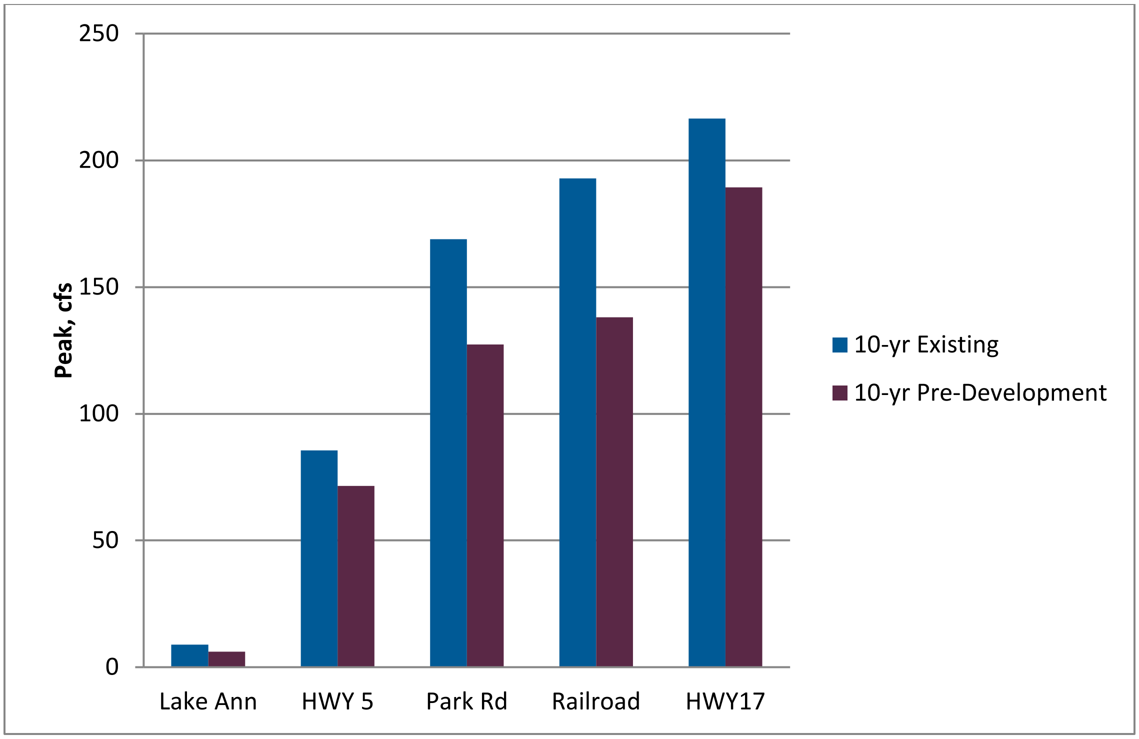


Figure 5-12 Peak 10-year Discharge in Riley Creek for Existing and Pre-Development Conditions

5.6.2.3 Climate Adaptation

Climate adaptation was the focus of a recent study by RPBCWD for the identification of future infrastructure impacts. Table 5-7 summarizes the key 100-year precipitation event rainfall depths associated with the vulnerability analysis.

Table 5-7 Vulnerability analysis rainfall depth summary

Precipitation Event Condition	100-yr, 24-hour Precipitation depth (inches)
Atlas 14	7.4
TP-40	6.0
Future Moderate	10.2
Future Optimistic	5.5
Future Pessimistic	17.6

The Atlas 14 rainfall depth is the current regulatory 100-yr precipitation depth typically based on rainfall data up to 2012. The TP-40 rainfall depth was determined based on data up to 1961 and was the regulatory 100-yr precipitation depth before the Atlas 14 update was issued.

Future site conditions could be subject to further rainfall increases. In 2014, the Climate Program Office sector of the National Oceanic and Atmospheric Administration published The *Long-term climate information and forecasts supporting stakeholder-driven adaptation decisions for urban water resources: Response to climate change and population growth. Final project report: Sectoral Applications Research Program FY2011*, which determined mid-century (year 2050) 100-year precipitation depths for moderate, optimistic, and pessimistic climate conditions. Inundation mapping for the existing 100-year and 90% confidence interval (similar depths to future moderate precipitation depths) are shown in Figure 5-13. The future moderate scenario would result in an approximate 38% increase in the precipitation, subsequent increases in peak discharge and volume in Riley Creek, and additional channel erosion.

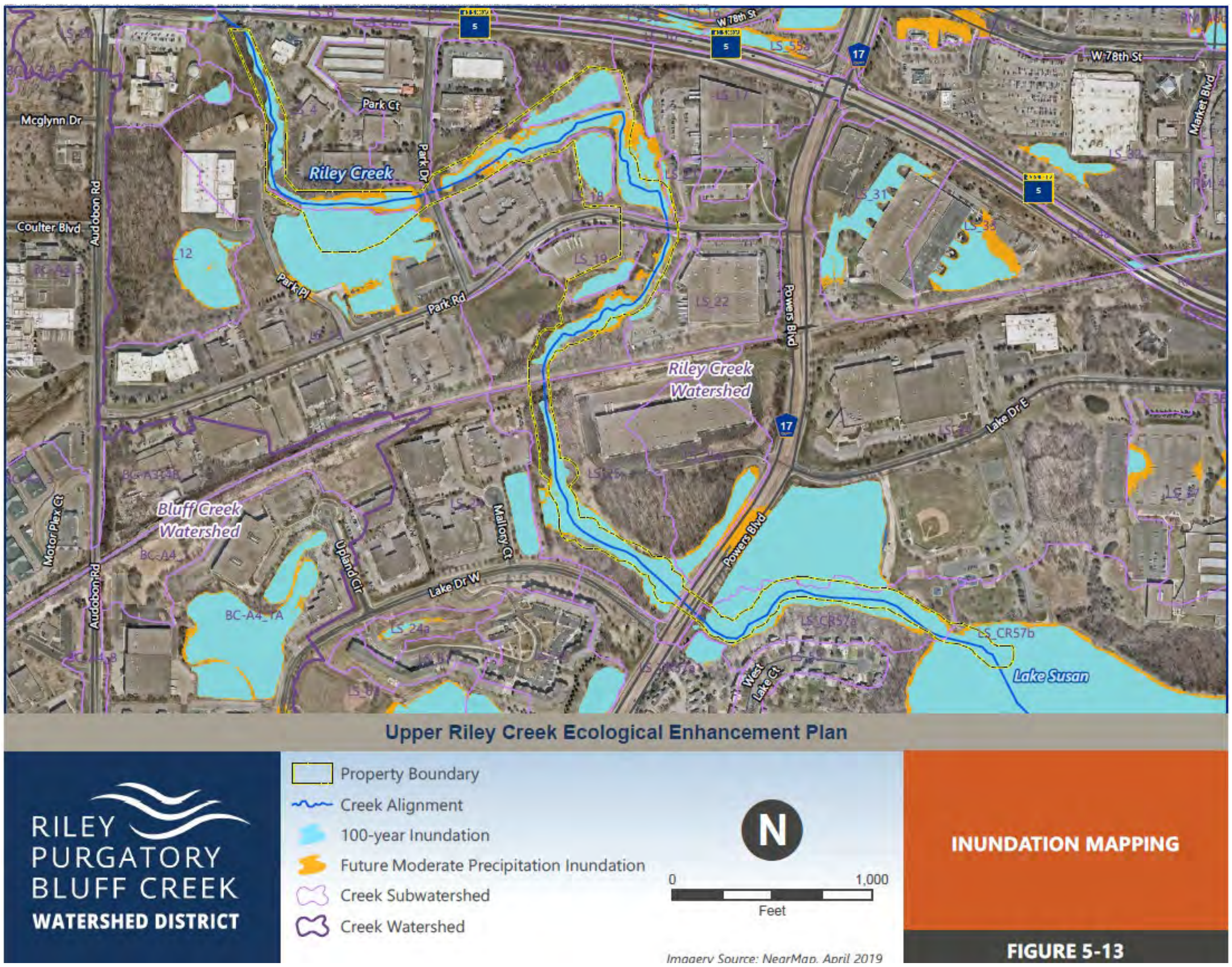


Figure 5-13 Existing 100-Year and Future Moderate Inundation along Upper Riley Creek

5.6.2.4 Hydrologic Analysis Summary

An evaluation of hydrologic processes reviewed available data associated with existing hydrologic and hydraulic models, watershed land use, climate studies, and the TMDL study with the intent of identifying contributing causes of streambank erosion in Riley Creek and sediment deposition in Lake Susan. The watershed analysis determined the following key items:

- The upstream third of the watershed remains largely pervious with some single-family homes, while the center of the watershed is industrial with significant impervious area. The downstream third of the watershed is a mix of industrial and single-family homes. The watershed is anticipated to continue to develop and add impervious surface in the future.
- The additional impervious area associated primarily with the central industrial area has resulted in increases in the 2-year design storm runoff volume and peak discharge of approximately 52% and 126%, respectively, for the reach immediately upstream of Lake Susan.
- Large increases in runoff volumes occur at Park Road and immediately upstream of Lake Susan. The increases in runoff volume can be attributed to the installation of storm sewer conveyance systems through the pre-development watershed divides and to the large amount of impervious surfaces without sufficient stormwater detention.
- Future increases in precipitation will result in increased runoff volumes and peak discharges over the next 50 years which should be considered in future regulations and designs.
- Streambank erosion can largely be attributed to the increase in impervious area in the watershed and to the revisions of drainage divides/conveyance features causing increased runoff volumes and rates.
- Watersheds with little or no runoff detention and subsequent low TSS removal were identified in this analysis. These watersheds could be locations for improvements to existing BMPs or construction of new BMPs as part of an ecological enhancement program with the goal of reducing the runoff peaks reaching Riley Creek.

5.6.3 Channel Processes

Erosion and mass wasting due to natural channel processes result in the direct loss of soil from the streambanks and bed. Erosion and migration of the channel banks and bed are natural processes of all stream systems, however changes to the stream hydrology can result in increases in the stream erosion and migration rates. Activities such as roads crossing the creek, channel straightening, and concentration of flow at culvert crossings can also have negative impacts on the creek by altering the stable pattern and profile of the channel. Areas of disturbed natural vegetation along the creek banks and within the floodplain also result in greater erosion potential. Increases in streambank erosion can cause damage to nearby infrastructure and can result in downstream sedimentation and pollution of lakes or other waterbodies. This section evaluates the in-stream stability/erosion rates of Upper Riley Creek primary through field data collection.

5.6.3.1 Streambank Erosion Potential

The initial instability within Upper Riley Creek is likely caused by the gradual increase in runoff volume and increased peak runoff rates generated by a developing watershed. In addition, this reach of Upper Riley Creek has several perched culverts, with evidence of scour at the unprotected outfalls also contributing to localized erosion. Streambanks within this reach are 4 to 6 or more feet tall, with vertical side slopes that are largely bare of vegetation. Due to its incised nature, flood flows are confined to the channel rather the expanding into a floodplain, thereby generating more erosive pressure on the stream bed and banks, especially during larger storm flows. Based on MnDNR regional curves and USGS regression equations, Upper Riley Creek should have a mean bankfull depth of 1.5 to 2.5 feet instead of the current 4 to 6 feet.

Bank erosion hazard index (BEHI), near bank stress, and modified Pfankuch channel stability rating worksheets were completed for six segments along Upper Riley Creek based on site photographs. A formal survey of the Upper Riley Creek segment was not completed.

Modified Pfankuch Channel Stability Ratings

The Pfankuch method assigns channel stability rating based on a series of qualitative questions to predict creek stability. The method evaluates mass wasting potential adjacent to the channel, detachability of bank and bed materials, channel capacity, and evidence of excessive erosion and/or deposition. A higher rating score indicates greater channel instability. The final score is adjusted based on the Rosgen stream classification. The resulting scores are summarized in Table 5-8. In general, the condition of the creek degrades from Lake Ann to Lake Susan. The channel is in worse condition downstream of Park Road, which is the location where the contributing drainage area increases significantly.

Table 5-8 Modified Pfankuch Channel Stability Rating

Reach	Description	Pfankuch Rating	CRAS Score
R5	Lake Ann to Hwy 5	Good	3
R4A	Hwy 5 to Park Drive	Good / Fair	3 / 5
R4B	Park Drive to Park Road	Good	3
R4C	Park Road to Railroad Bridge	Fair	5
R4D	Railroad Bridge to Powers Blvd	Fair	5 / 7
R4E	Powers Blvd to Lake Susan	Fair / Poor	5 / 7

Bank Erosion Hazard Index Scores

The Bank Erosion Hazard Index (BEHI) was developed by Dave Rosgen and adopted by the U.S. Environmental Protection Agency (EPA) as a method for assessing streambank erosion condition and potential using variables that are known to affect bank erosion rates. The BEHI method assigns points (low scores being low susceptibility and higher scores being high susceptibility) to several aspects of streambank condition and considers bank height, bankfull height, bank angle, root depth, root density, and vegetated surface protection. Scores are then correlated to a streambank risk rating ranging from very low risk to extreme risk and are used to help estimate erosion rates. A summary of the BEHI rating is provided in Table 5-9.

Table 5-9 Summary of Average BEHI Ratings

Reach	Description	BEHI Rating
R5	Lake Ann to Hwy 5	Low
R4A	Hwy 5 to Park Drive	Moderate
R4B	Park Drive to Park Road	Low/Moderate
R4C	Park Road to Railroad Bridge	Moderate
R4D	Railroad Bridge to Powers Blvd	Moderate/High
R4E	Powers Blvd to Lake Susan	High

In general, the Upper Riley Creek reach is susceptible to streambank erosion, likely due to tall streambanks in combination with lower root densities and lower vegetated surface protection.

Near Bank Stress Ratings

Near bank stress (NBS) quantifies the amount of stress affecting a streambank using one of seven different calculation methods, and the use of this method requires an in-depth analysis with survey data to fully determine the severity of the near bank stress. The survey needed to complete a full NBS analysis was not completed for this phase of assessment. NBS ratings can change rapidly along a stream and the localized NBS near an actively eroding bank can significantly impact both actual and predicted erosion rates. Ratings on most banks are very low or low so a low average rating was assumed for all reaches in order to estimate erosion. For perspective, the range of erosion rates for a stream with a NBS rating of low is approximately 0.035 ft/yr, 0.15 ft/yr, and 0.25 ft/yr, for "low," "moderate," and "high" BEHI ratings, respectively.

Bank Erosion Rates

Based on the BEHI and NBS Ratings, the erosion rates and volumes for each reach were estimated and summarized in Table 5-10. Without restoration measures along Upper Riley Creek, it is anticipated that similar amounts of sediment will continue to be deposited into Lake Susan.

Table 5-10 Estimated Annual Erosion Volume for each Subreach

Reach	Description	Estimated Bank Erosion Rate[1] (feet per year)	Estimated Average Bank Height (ft)	Reach Length (ft)	Estimated Annual Erosion Volume (tons/yr)
R5	Lake Ann to Hwy 5	0.035	2	3,300	15
R4A	Hwy 5 to Park Drive	0.15	3	1,770	41
R4B	Park Drive to Park Road	0.09	4	1,820	34
R4C	Park Road to Railroad Bridge	0.15	3	1,200	28
R4D	Railroad Bridge to Powers Blvd	0.20	3	1,780	55
R4E	Powers Blvd to Lake Susan	0.25	3	1,960	76
			Total	**11,830**	**250**

1 – from Rosgen, Dave. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Fort Collins, CO: Wildland Hydrology, 2006

5.7 Habitat and Wildlife Assessment

This reach of Riley Creek provides potential habitat for a diversity of organisms, including fish, such as green sunfish, fathead minnow, and bluntnose minnow; amphibians, such as frogs, toads, and salamanders; birds such as bald eagles, hawks, heron, wood ducks, and perching birds; and mammals, such as fox, deer, squirrels, beaver, and muskrats. Wildlife found in the Project area are primarily expected to be habitat generalists due to the present lack of high-quality habitat through a majority of this reach.

The United States Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) database indicates that the Northern long-eared bat may be found within the Project area, although the database shows that no designated critical habitat for this species is present. The Minnesota Department of Natural Resources (MnDNR) National Heritage Information System (NHIS) data indicates that the closest record of the Northern long-eared bat is approximately eight miles southwest of the Project area.

The Minnesota Biological Survey (MBS) is a program that tracks sensitive plant and animal data across the state, as well as the ecology of native plant communities and functional landscapes. The MBS assign biodiversity significance rankings to surveyed sites (sites of biodiversity significance, SBS). There are no MBS sites in or near the Project area.

RPBCWD staff previously assessed the habitat conditions for this reach of Riley Creek based on the Minnesota Stream Habitat Assessment (MSHA) protocol developed by the MPCA, with ratings throughout the reach classified as “fair.” These reaches scored well on shade and cover in the channel, including large woody debris in the channel which creates excellent habitat; they scored poorly on bank erosion and bed substrate lacking a diverse mix of sizes of sediment. The sediment was dominated by clays, silts, and other fine materials which are not good for a diverse in-stream fauna population.

In addition, the RPBCWD undertook several years of research with the University of Minnesota to better understand the role that carp play in the Riley chain of lakes. Carp can be notable contributors of phosphorus in aquatic systems as their feeding habits resuspend sediment. Their ability to thrive in areas of poor water quality allow their populations to grow rapidly compared to native species, resulting in greater amounts of phosphorus generated through excrement. Due to these factors, it is difficult to implement an in-lake phosphorous management strategy until carp populations are controlled. This research effort revealed that Rice Marsh Lake acts as a nursery for carp young of year. In years where Rice Marsh Lake experiences a winter kill, panfish are killed, while carp are able to survive through the poor conditions. A strong panfish population is important to eat carp eggs before young of the year hatch. As such, preventing winter kill in Rice Marsh Lake is important in the phosphorous management strategy for the Riley chain of lakes. As a result of this study, RPBCWD implemented a carp management program including extensive carp netting and removal, as well as installing a winter aeration system in the Rice Marsh Lake to promote blue gill survival. By managing carp in the system the District is able to reduce the amount of sediment, an thus phosphorus, being contributed to the water columns as well as promote vegetation regeneration, all of which help improve the health of the aquatic ecosystem.

5.8 Cultural Resources

A Phase I Archaeological Survey for the Project was completed in May 2020. This included background research on the Project area, as well as a pedestrian survey. Background research identified one archaeological site located outside of the Project area, near Lake Susan. Subsurface testing in the vicinity of this site was completed during the pedestrian survey. Testing consisted of three transects placed on either side of the creek north and south of the identified site with three to six shovel tests excavated along each transect. All subsurface tests were negative for cultural resources, and no new archaeological sites were identified.

5.9 Phase I Environmental Site Assessment

A Phase I environmental site assessment was completed for the Project in July 2020 to identify recognized environmental conditions (i.e. sites of contamination from hazardous substances or petroleum) that may be present in the Project area. The assessment included a database review and coordination with the RPBCWD's Administrator and City of Chanhassen to complete a questionnaire on known land uses. No recognized environmental conditions were documented by the Phase I environmental site assessment.

5.10 Public Infrastructure

A number of public infrastructure elements are located in the Project area, as described below and shown in Figure 5-14.

5.10.1 Stormwater Ponds

Three constructed stormwater ponds exist in the northern portion of the Project area, one approximately 1.5 acres in size located adjacent to the city of Chanhassen public works building and two each approximately 0.9 acres in size located south of Highway 5. These ponds collect stormwater runoff from the surrounding developed areas.

5.10.2 Culverts

Upper Riley Creek passes beneath local infrastructure via culverts in several location within the Project area, including: Highway 5, Park Drive, Park Road, the railroad, and Powers Boulevard. The previously-deteriorated crossing at Park Road was recently replaced in 2017/2018. Erosion is visible on the downstream side of several of these crossings. In addition, there are several storm sewer outfall culverts adjacent to the creek. Many of these are perched above the channel elevation and protection measures to control erosion.

5.10.3 Sanitary Sewer

Metropolitan Council has a sanitary sewer main that parallels approximately 4,100 linear feet of Upper Riley Creek. The purpose of a sanitary sewer main is to collect and transport wastewater to a treatment facility.

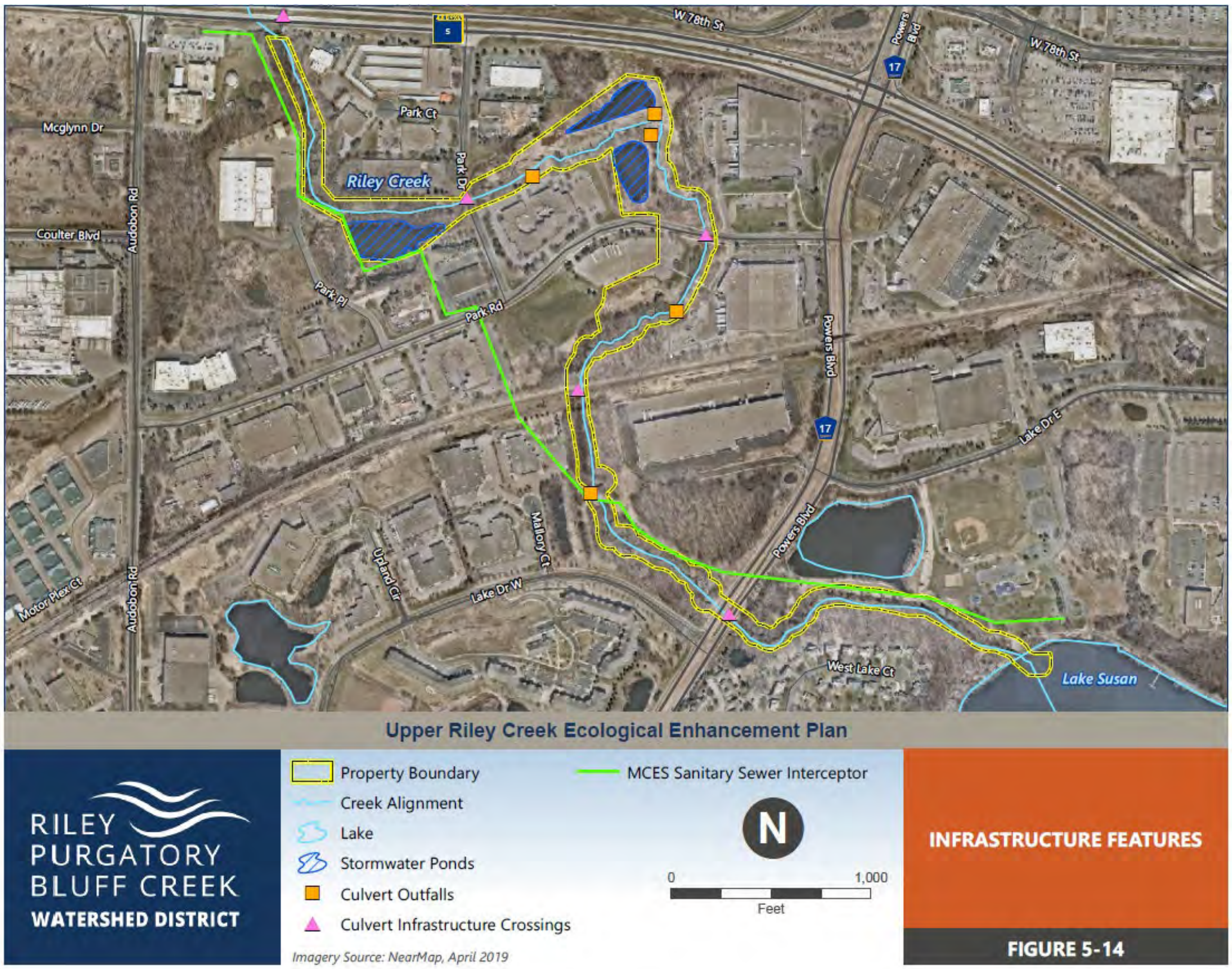


Figure 5-14 Infrastructure Features

5.11 Easements

Easements may be needed from both public and private properties for site access and/or project construction. Land ownership is shown on Figure 8-1 below. The specific needs for easements will be determined during Project design.

6.0 Desired Future Outcomes

The proposed ecological enhancement project will result in improved ecological functions along the Project reach and downstream Lake Susan by reducing stream bank erosion, reconnecting the creek to its floodplain, restoring habitat, and promoting diverse vegetation. Reducing the sediment and phosphorus loading to Upper Riley Creek will also help restore and protect all downstream water bodies, including Lake Susan, Rice Marsh Lake, Lake Riley and ultimately the Minnesota River. These elements will be planned and implemented in coordination with opportunities to preserve and enhance maintenance access to public infrastructure features.

The total reduction in pollutant loading as a result of stabilizing the Project reach is estimated as **470,000** pounds per year **TSS** and **250** pounds per year **TP**. These values are representative of an erosion rate of approximately 0.10 to 0.25 feet per year for the stream banks. This reduction in TSS and TP loading is a critical component for improving the ecological health of the aquatic ecosystems (Upper Riley Creek and Lake Susan) and essential to potentially removing the Lake Susan from the MPCA's impaired waters list.

The proposed Project design will focus on improving the ecosystem by stabilizing the creek while also improving degraded habitat conditions along the Project reach. The Project reach has a primarily sandy/silty channel bed with limited riffle/pool variability. The proposed Project would provide greater stream depth variability, more channel bed substructure types, and varied channel velocities. Each of these variabilities enhances in-stream habitat features, potentially allowing more opportunities for macroinvertebrates and fish to use this reach of Upper Riley Creek. Providing better floodplain connectivity for Upper Riley Creek also enhances surrounding riparian habitat.

In addition to the expected water quality improvement expect from restoring the stream, the Project will provide other benefits as summarized in Table 6-1.

Table 6-1 Project Benefit Summary

Benefits	Qualitative Discussion	Metric
Habitat (acres)	Create in-channel habitat for fish and macroinvertebrates providing pools, riffle and refuge area for aquatic life. Improve riparian habitat conditions through invasive species removal and better connection of riparian corridor to stream channel.	Up to 3.9 acres of in-channel habitat improvements; Up to 21.6 acres of riparian habitat improvements
Pollutants (e.g., TP, TSS, etc; lbs)	Restore stable streambanks and improve riparian buffer to reduce movement of eroded soil and nutrients to Riley Creek and Lake Susan. Provide additional stormwater detention by removing accumulated sediment in stormwater ponds to allow for additional pollutant settling.	Reduce TSS by 470,000 lbs/yr; Reduce TP by 250 lbs/yr
Abstraction (cubic ft)	Re-connecting Riley Creek channel to floodplain allows for greater infiltration due to sandy soils found in the floodplain. Vegetation found within the floodplain also improves infiltration.	Metric cannot be measured in the context of this Project.
Streambank Restored (feet)	Restore stable streambanks and improve riparian buffer is significant driver of the other benefits presented in this table.	8,627 feet of channel length
Groundwater Conserved (gal)	Benefit is not applicable.	
Community Reach	Location of a portion of the project in a public park allows for public accessibility; public hearing will be held prior to RPBCWD Board ordering project; will hold adjacent landowner meetings prior to construction; informational pamphlets explaining project will be placed at Lake Susan Park during construction; plans for future interpretive signage	
Flow Reduction (fps, cfs, psf, etc.)	Re-connect Riley Creek channel to floodplain, allowing high flows to extend into floodplain, reducing velocity of flows through the area.	
Flood Storage (acft)	Improve connectivity of creek to floodplain, providing for project resiliency and reducing flow velocities Provide additional stormwater detention by removing accumulated sediment in stormwater ponds and potential modifications to increase flood storage capacity.	
Wetland Management Class	Benefit is not applicable.	

[1] These values are representative of an erosion rate of approximately 0.10 to 0.25 feet per year for the stream banks.

7.0 Stakeholder Engagement

The RPBCWD and city of Chanhassen have facilitated opportunities for both agency and landowner input during development of this Plan.

An agency stakeholder meeting was held on August 20, 2020. The purpose of this meeting was to introduce the Project and its need, review field studies completed, identify key concerns, and to discuss preliminary concepts under consideration to address the concerns. Agency feedback was solicited regarding design considerations, infrastructure, and future permitting. Representatives from the U.S. Army Corps of Engineers, Minnesota Department of Natural Resources, Board of Water and Soil Resources, and Metropolitan Council attended. At this meeting, USACE indicated that any potential stream re-meandering would need to be evaluated for loss of stream length, and the Metropolitan Council noted a sanitary sewer main that parallels a considerable portion of the creek.

Adjacent landowners were invited by mailing to a virtual open house on February 4, 2021. The purpose of this meeting was to introduce the Project and allow participants to ask questions and express concerns. Five representatives from three adjacent properties attended the virtual open house. Landowner engagement will be ongoing through the design phase of the Project.

8.0 Strategies for Ecological Enhancement and Management

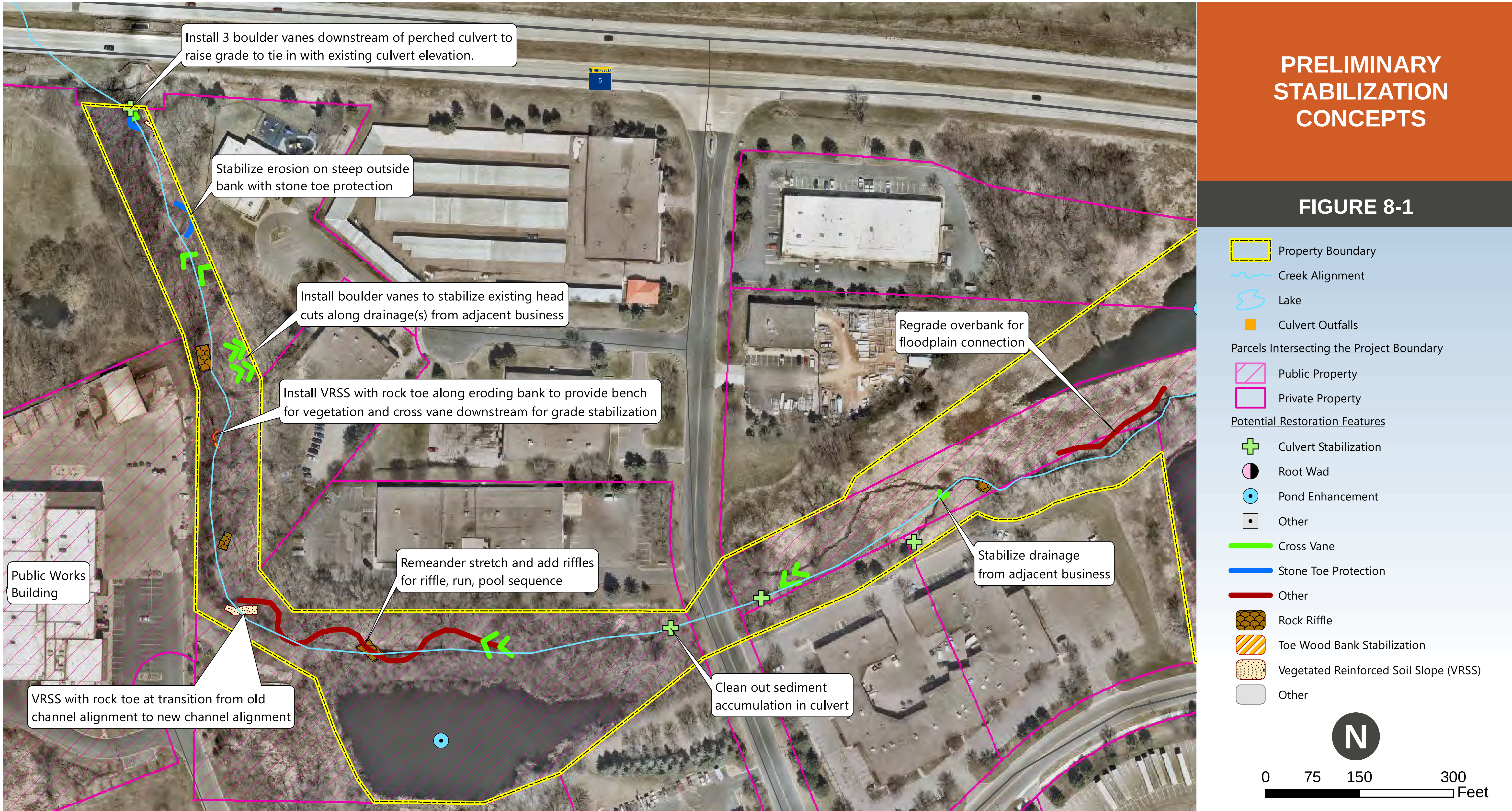
The RPBCWD is proposing to enhance approximately 8,600 feet of Upper Riley Creek, as summarized on Figure 3-1. All restoration projects require ongoing management to ensure their long-term success. This section describes the initially proposed restoration techniques and outlines a management program.

8.1 Restoration Activities

Improvements to this reach of Upper Riley Creek would be provided through several methods as summarized in Figure 8-1 and Table 8-1.

PRELIMINARY STABILIZATION CONCEPTS

FIGURE 8-1



RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

Upper Riley Creek Ecological Enhancement Plan


PRELIMINARY STABILIZATION CONCEPTS
FIGURE 8-2
Property Boundary
Creek Alignment
Lake
Culvert Outfalls
Parcels Intersecting the Project Boundary
Public Property
Private Property
Potential Restoration Features
Culvert Stabilization
Root Wad
Pond Enhancement
Other
Cross Vane
Stone Toe Protection
Other
Rock Riffle
Toe Wood Bank Stabilization
Vegetated Reinforced Soil Slope (VRSS)
Other
N
0 75 150 300 Feet
RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT
Regrade overbank for floodplain connection
Install cross vanes to raise channel grade for improved floodplain connection
Stabilize drainage from adjacent business
Install cross vanes to stabilize incoming drainage and prevent headcutting
Clean out sediment accumulation in culvert
Grade to create bankfull bench
Clear accumulated debris adjacent to pedestrian bridge
Regrade right overbank to increase floodplain connection
Stabilize perched culvert with riprap apron
The area upstream is more entrenched than the downstream area; Install boulder vanes to raise grade
17
Upper Riley Creek Ecological Enhancement Plan

PRELIMINARY STABILIZATION CONCEPTS

FIGURE 8-3

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

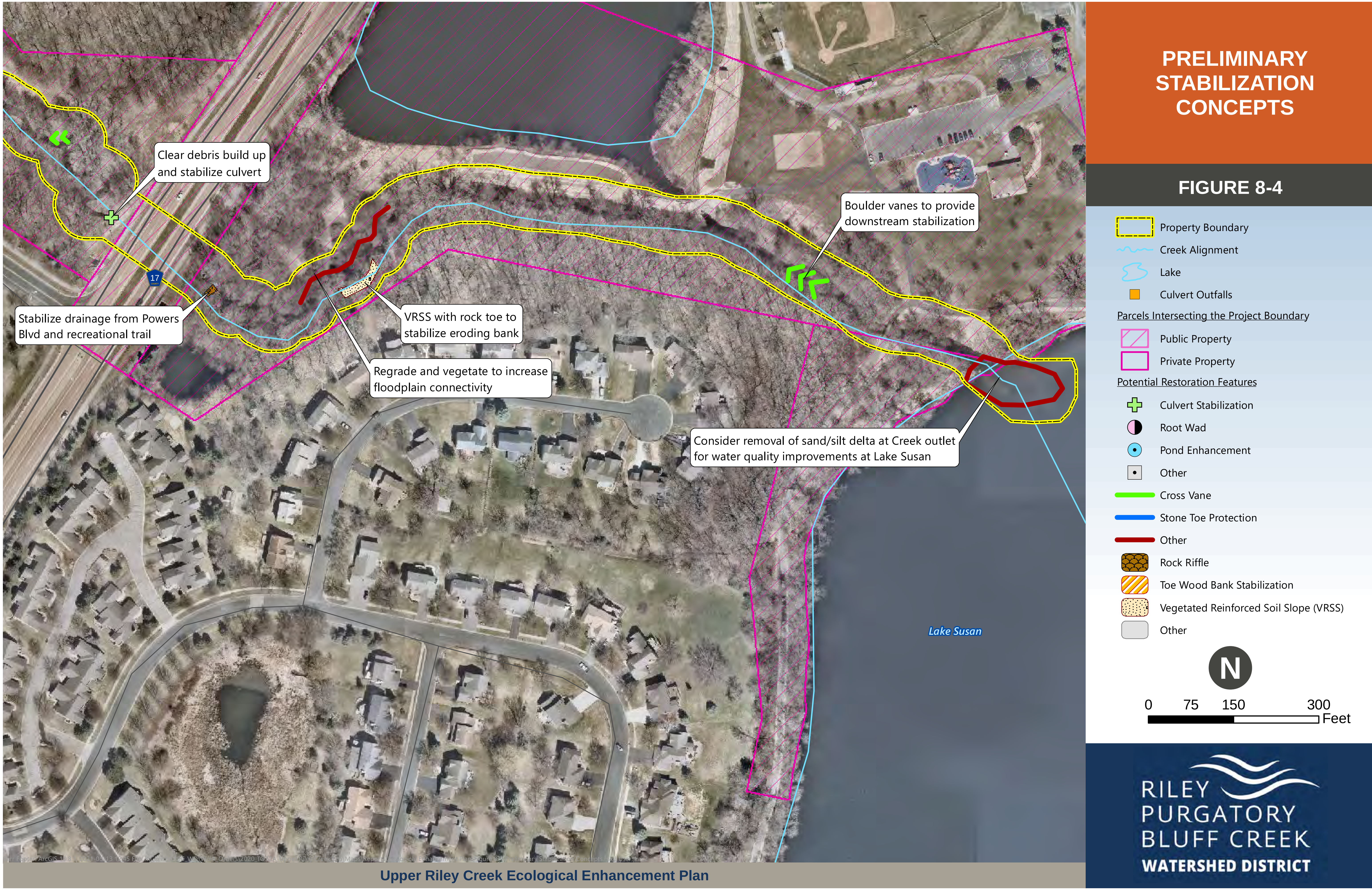
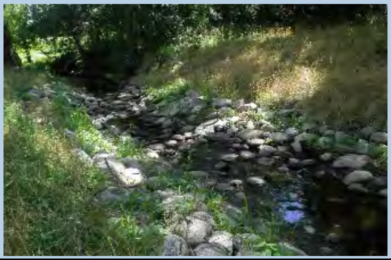

PRELIMINARY STABILIZATION CONCEPTS
FIGURE 8-4
Clear debris build up and stabilize culvert
Stabilize drainage from Powers Blvd and recreational trail
17
VRSS with rock toe to stabilize eroding bank
Regrade and vegetate to increase floodplain connectivity
Boulder vanes to provide downstream stabilization
Consider removal of sand/silt delta at Creek outlet for water quality improvements at Lake Susan
Lake Susan
Property Boundary
Creek Alignment
Lake
Culvert Outfalls
Parcels Intersecting the Project Boundary
Public Property
Private Property
Potential Restoration Features
Culvert Stabilization
Root Wad
Pond Enhancement
Other
Cross Vane
Stone Toe Protection
Other
Rock Riffle
Toe Wood Bank Stabilization
Vegetated Reinforced Soil Slope (VRSS)
Other
N
0 75 150 300
Feet
RILEY PURGATORY BLUFF CREEK
WATERSHED DISTRICT
Upper Riley Creek Ecological Enhancement Plan

Table 8-1 Project Design Elements

Design Element	Purpose	Ecological Benefit
Rock Riffles 	Gravel or cobble-sized material installed in the stream bed to create natural flow patterns and to control stream bed elevations.	The variety in flow and channel substrate size provides habitat diversity for aquatic species. Approximately 9 rock riffles are proposed in preliminary stabilization concept.
Cross Vanes 	Boulders buried in the stream bed and extending partially ("vanes") or entirely across the stream ("cross vanes") to achieve one or more of the following goals: re-direct flows away from banks, encourage sediment deposition in selected areas, and control stream bed elevations.	Scour pools develop over time near the vane, which provide habitat diversity for species that prefer pools to faster flowing in-channel habitat. Approximately 35 cross vanes are proposed in preliminary stabilization concept.
Root Wads 	Tree trunks with the root ball attached, installed either singly (root wads) or in conjunction with additional large woody debris and toe wood to Increase bank roughness and resistance to erosion, re-direct flows away from banks, and provide a bench for establishment of riparian vegetation	Creates undercut/overhanging bank habitat features. The preliminary stabilization concept currently does not include use of root wads, but this feature may become incorporated as design progresses.
VRSS/Toe Wood Bank Stabilization 	Soil lifts created with a combination of root wads and long-lasting, biodegradable fabric and vegetated to stabilize steep slopes and encourage establishment of root systems for further stabilization.	Creates undercut/overhanging bank habitat features. Approximately 6 locations of VRSS and/or toe wood bank stabilization are proposed in preliminary stabilization concept.

Design Element	Purpose	Ecological Benefit
Outlet Adjustment and Stabilization 	Allows stormwater to outlet at an elevation more proximately to the channel elevation. This, along with placement of a material to dissipate flows, reduces potential for in-channel scour.	When flows are appropriately dissipated, there is less sedimentation and associated turbidity in the waterway. Up to 10 outlet adjustments and/or stabilizations are proposed in preliminary stabilization concept.
Floodplain Connectivity 	Active floodplain/vegetated bench—modifications made to the stream cross section to increase floodplain connectivity and decrease erosive stress during flood flows; for this project, constructed by raising the channel bed.	Provides a smooth transition between in-channel, riparian, and upland habitat. Approximately 5 locations of opportunity to improve floodplain connectivity are proposed in preliminary stabilization concept.
Vegetation/Buffer 	Established along a stream bank or overbank area to stabilize bare soils and increase resistance to fluvial erosion.	Using trees, shrubs, and a seed mix of grass and forbs provides a diverse array of vegetation strata and habitat types. Allows for more naturalized aesthetics, with emphasis on native species. Project would be designed to comply with District buffer rules.
Pond Enhancement 	Allows greater capacity for detention of flood flows and sediment removal.	Removal of sediments that have accumulated in ponds over times allows for a healthier aquatic ecosystem by removing pollutants and creates better opportunity for TSS to settle out of the water column.

The elevation of the Riley Creek channel would be raised three to five feet by constructing a series of rock riffles and natural boulder or log grade controls. These features will raise the elevation of the channel by providing areas of grade control, allowing higher flows to better extend outside of the creek channel and into the floodplain. Allowing higher flower to more easily move outside the creek channel reduces the potential of further downcutting and associated erosion.

In addition, a variety of bioengineering methods, including rock cross vanes, rock vanes, log vanes, root wads, and toe wood bank stabilization, will be incorporated across the proposed Project reach as needed to dissipate stream flows. Overbank areas would be graded to a stable, 2:1 or flatter slope and vegetated with native vegetation. In addition, the elevation of perched outlets and culverts would be adjusted as appropriate and the outfall areas stabilized to dissipate flow energies. Accumulated natural and foreign debris in the channel would be removed, allowing flows to pass through the channel unobstructed. The intent of the proposed Project is to be cut/fill neutral, meaning there will be no net gain or loss of soil materials from the Project site.

8.2 Management Activities

8.2.1 Inspections

The RPBCWD and/or City of Chanhassen will conduct an annual inspection of the Project during the growing season each year. All inspections will include the tasks listed below, along with any other visual observation necessary. In addition, stream bank erosion issues often develop following high flow events; therefore the inspection tasks listed below should also be performed following storm events exceeding a 10-year return period for storm events with durations of 12 hours or greater, as defined by Atlas 14 and as recorded at the National Weather Service station in Chanhassen.

- Inspect the condition of each of the stream bank protection locations throughout the Project Area. Criteria to note include but are not limited to the following:
    - For areas with riprap protection, should note:
        - The general condition of the riprap.
        - Observed displacement of riprap material.
    - For areas with rock vanes and cross vanes for bank protection, should note:
        - Displacement of boulders used to construct the vanes.
        - Potential undermining of the vanes due to scour immediately downstream of the vanes.
        - Flow patterns that appear to be eroding around the vane.
        - Any bank erosion within approximately 10 feet of the vane.
    - For areas with root wads for bank protection, should note:
        - The general condition of the root wads (moved, rotted, etc.).

        - Any bank erosion within approximately 10 feet of the root wad.
    - For areas with re-established vegetation, should note:
        - The general condition of seeded areas and vegetative plantings.
        - The survival rates of vegetative plantings.
        - The percent cover by grasses and forbs in seeded areas.
- Document significant bank erosion locations, as defined as areas with raw, unvegetated banks greater than approximately two feet tall and with bank angles steeper than approximately 45 degrees.
- Note any observed changes in the stream flow pattern or direction throughout the Project, and note other locations where bank protection may be required;
- Examine storm sewer outlets for undermining, blockage and scour at the outlet and erosion;
- Record location of accumulated debris, downed trees and branches that may adversely redirect the stream flow into the stream banks;
- Take photographs to document the inspection findings in the preceding inspection tasks.

The inspection results will be summarized in a brief inspection report as described in the ANNUAL REPORT section. Appendix B contains the inspection form to be used during field inspections. Over the life of the project, the inspection form may be periodically revised to improve inspection effectiveness, including but not limited to the implementation of a mobile data collection app. The assessment will be amended to this report (the Upper Riley Creek Corridor Enhancement Plan) and can be used to inform potential actions.

8.2.2 Maintenance

Routine maintenance activities may include removal of fallen trees that may impede the flow of water, revegetating exposed soils, replacement of boulders for cross vanes, repair of displaced riprap and maintenance of buffer areas as identified through the inspection report. Maintenance will consist of activities to ensure that the flow of water is not impeded. All maintenance activities will comply with RPBCWD’s standard buffer maintenance requirements as summarized below:

- Buffer vegetation must not be cultivated, cropped, pastured, mowed, fertilized, subject to the placement of mulch or yard waste, or otherwise disturbed, except for periodic cutting or burning that promotes the health of the buffer, actions to address disease or invasive species, mowing for purposes of public safety, temporary disturbance for placement or repair of buried utilities, or other actions to maintain or improve buffer quality and performance, each as approved by

RPBCWD in advance in writing or when implemented pursuant to a written maintenance plan approved by RPBCWD.

- Diseased, noxious, invasive or otherwise hazardous trees or vegetation may be selectively removed from buffer areas and trees may be selectively pruned to maintain health.
- Pesticides and herbicides may be used in accordance with Minnesota Department of Agriculture rules and guidelines.
- No fill, debris or other material will be placed within a buffer.
- No structure or impervious cover (hard surface) may be created within a buffer area.

Routine Maintenance of the Project is defined as activities that will not require equipment that would adversely impact the Project area, as follows:

- Removing fallen trees that are causing bank erosion;
- Vegetation maintenance, such as vegetation replacement that does not require the use of heavy equipment within the Project area;
- Replacement of cross vane boulders and repair of displaced riprap.

Routine Maintenance does not include reconstruction of failed toe and bank stabilization design elements requiring heavy equipment. The City may solicit the RPBCWD for funding to address these non-Routine Maintenance repairs collaboratively.

The City's maintenance responsibilities will be determined based on the annual inspection report in combination with maintenance priorities, funding availability, and potential for impacts to public infrastructure. Maintenance needs and funding availability will be collaboratively reviewed by the City and RPBCWD on an annual basis.

8.2.3 Annual report

A brief Project inspection and maintenance report will be developed on or before January 31 of each year. The report will contain the following information:

- A summary of the inspection, including the presence or absence of any and all items specifically mentioned in the Inspections section above.
- Describe any maintenance activities completed for the previous 12-month period ending December 31, including dates and actions.
- A record of the location and quantity of any debris or fallen trees removed from Riley Creek.
- List the type and quantities of materials used to repair bank protection at any repair locations stabilized.
- A tabulation of costs for all labor, materials, and equipment involved in any maintenance activities for the previous 12-month period ending December 31.

9.0 Agreements

Table 9-1 summarizes anticipated agreements required prior to construction of the Upper Riley Creek Restoration Project.

Table 9-1 Summary of Anticipated Agreements

Description	Notes	Period	Lead Organization
Cooperative agreement between RPBCWD and city of Chanhassen	Cooperative agreement between RPBCWD and city of Chanhassen for activities related to construction and maintenance of the restoration project. The agreement would establish procedures for performing specific tasks, and define responsibilities of each organization.	2021	RPBCWD and city of Chanhassen

10.0 Financing, Work Plan and Responsibilities

Table 10-1 identifies work plan, finances and responsibilities for the project. There are four main parts to the project: design, implementation, post-construction monitoring and long-term monitoring/maintenance.

For budgeting estimates, the level of design definition is less than 20 percent at this phase of project. Industry resources for cost estimating (AACE International Recommended Practice No. 18R-97, and ASTM E2516-06 Standard Classification for Cost Estimate Classification System) provide guidance on cost uncertainty, depending on the level of project design developed. The opinion of probable cost (i.e. budgeting estimate) for the proposed project generally corresponds to a Class 4 estimate characterized by completion of limited engineering and use of deterministic estimating methods. As the level of design detail increases, the level of uncertainty is reduced. Due to the project currently being in the planning-level phase, it is standard practice to place a broad accuracy range around the point cost estimate. The accuracy range is based on professional judgment considering the level of design completed, the complexity of the project, and the uncertainties in the project scope; the accuracy range does not include costs for future scope changes that are not part of the project as currently defined or risk contingency. The estimated accuracy range for this budgeting estimate is -30% to +60%.

Table 10-1 Financing and Work Plan Summary

	Activity	Budgetary Dollars	Year	Organization Lead
Design	Upper Riley Creek Stabilization	$200,000	2021	RPBCWD
Bidding and Award	Upper Riley Creek Stabilization	$10,000	2022	RPBCWD
Implementation	Upper Riley Creek Stabilization	$1,600,000	2022-2023	RPBCWD
	Storm sewer outfalls (4-6 locations)	$150,000 RPBCWD and City to split cost 50/50	2022-2023	RPBCWD
	Stormwater pond clean-out	$476,000	2022-2023	City of Chanhassen
Post-Construction monitoring and inspections	3-year Warranty	Staff will monitor	2023-2026	RPBCWD and city of Chanhassen
Long-term	Inspections	In-Kind	2023-2043	RPBCWD (most years) and city of Chanhassen (every 5 years)
	Routine maintenance	TBD	2023-2043	City of Chanhassen
	Non-routine maintenance	Determined as needed based on inspections	2023-2043	City of Chanhassen and RPBCWD
	Stormwater pond clean-out/maintenance	Determined as needed based on inspections	2023-2043	City of Chanhassen

The primary points of contact for this plan are presented in are presented in Table 10-2.

Table 10-2 Primary Points of Contact

Organization	Staff Member	Phone
RPBCWD	District Administrator	952-687-1348
City of Chanhassen	Water Resources Coordinator	952-227-1169

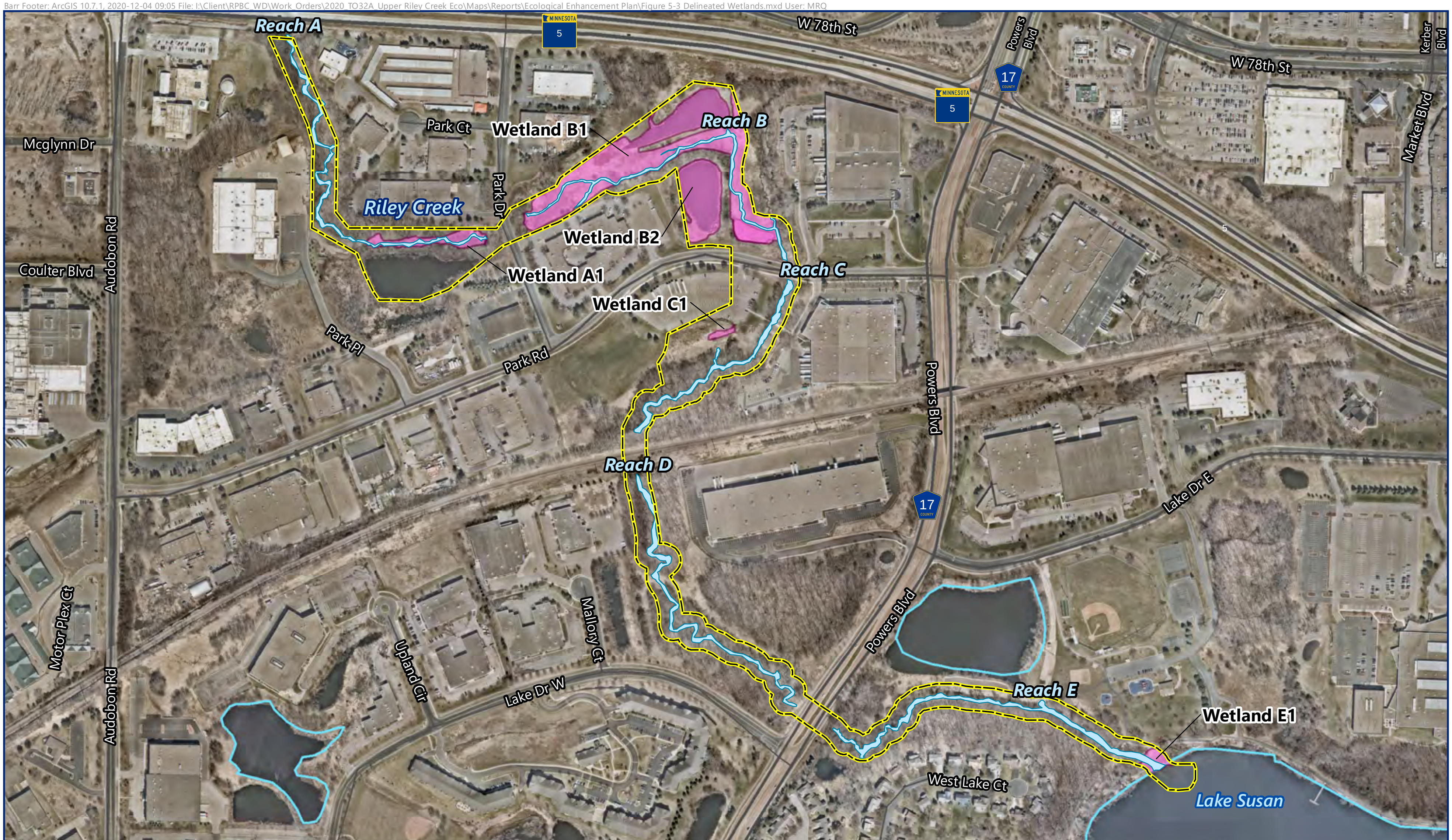
Anticipated financial participation of the parties involved is summarized in Table 10-3.

Table 10-3 Financial Participation Summary

Organization	Amount
RPBCWD	$1,575,000 (includes 50/50 storm sewer outfall)
City of Chanhassen	$651,000 (includes 50/50 storm sewer outfall)

Appendix A

Mapped Wetland Communities



Upper Riley Creek Ecological Enhancement Plan

RILEY PURGATORY BLUFF CREEK WATERSHED DISTRICT

- Property Boundary
- Creek Alignment
- Lake
- Delineated Creek
- Delineated Wetland

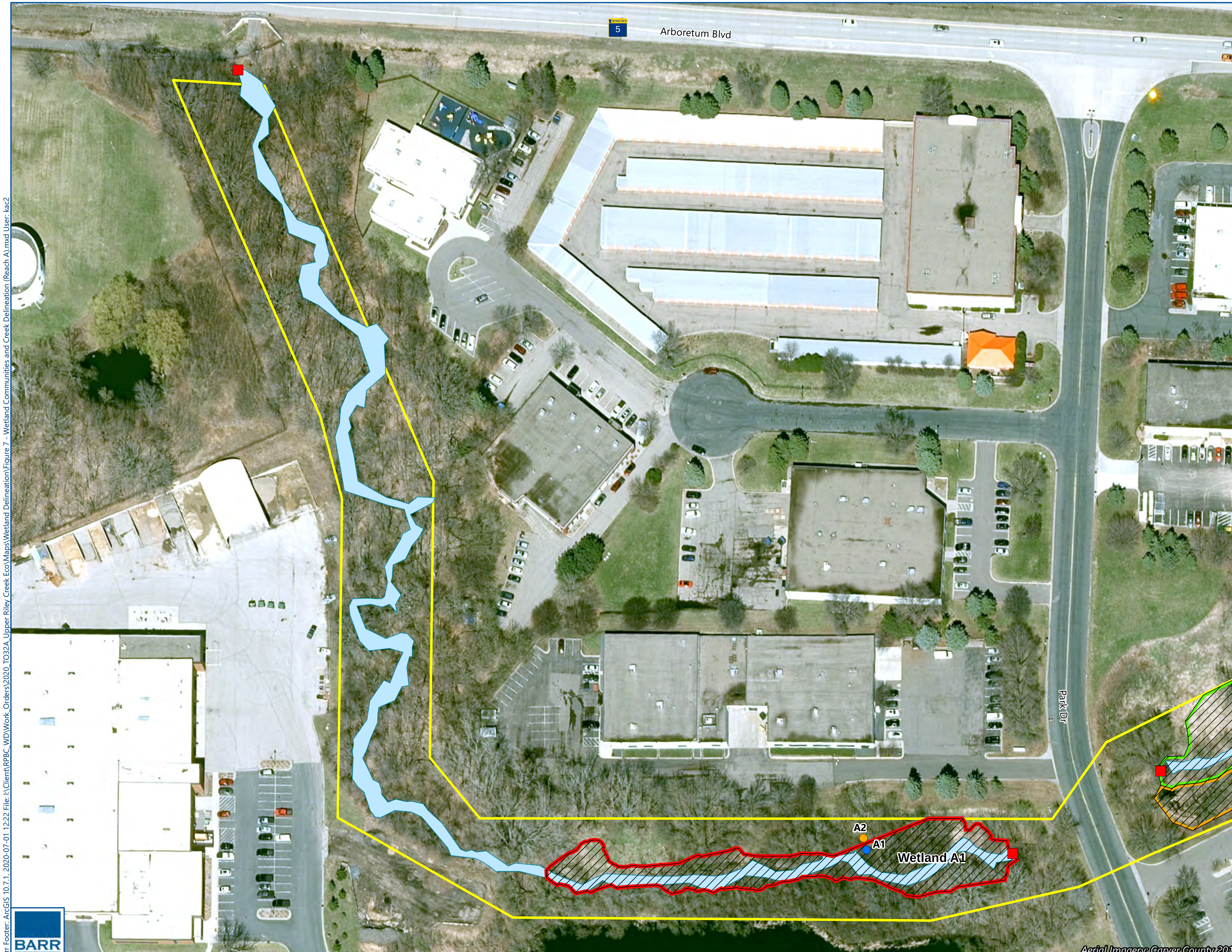
N

0 1,000
Feet

Imagery Source: NearMap, April 2019

DELINEATED WETLANDS

FIGURE A-1



Property Boundary
Delineated Wetland
Delineated Creek
Culvert

Wetland Communities

Floodplain Forest
Shallow Marsh
Wet Meadow

Sample Points

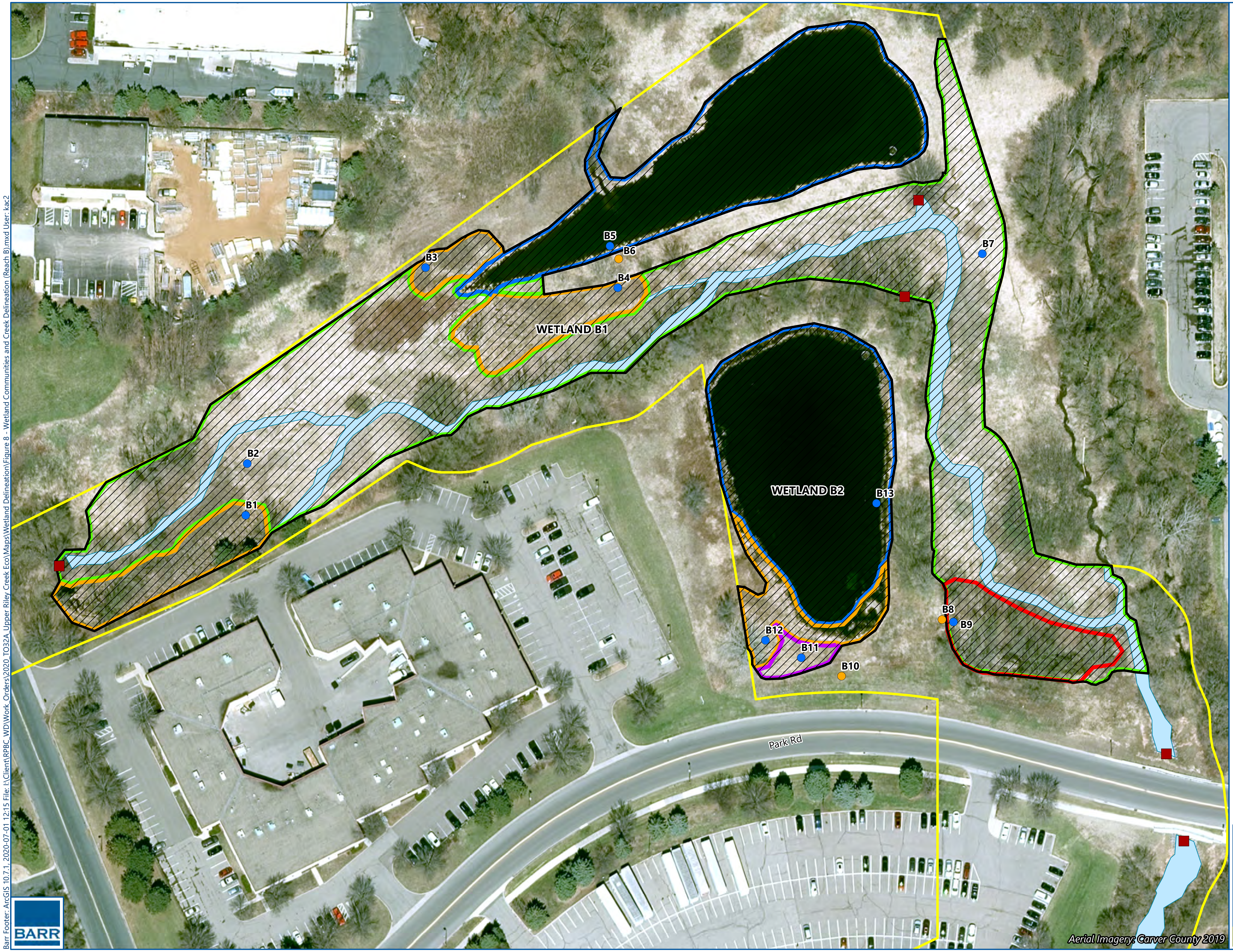
Upland
Wetland

N

0 100 200
Feet

WETLAND & CREEK DELINEATION (SECTION A)
Upper Riley Creek Ecological Enhancement
Chanhassen, Minnesota

FIGURE A-2



Property Boundary
Delineated Wetland
Delineated Creek
Culvert

Wetland Communities

Deep Marsh
Floodplain Forest
Sedge Meadow
Shallow Marsh
Wet Meadow

Sample Points

Upland
Wetland

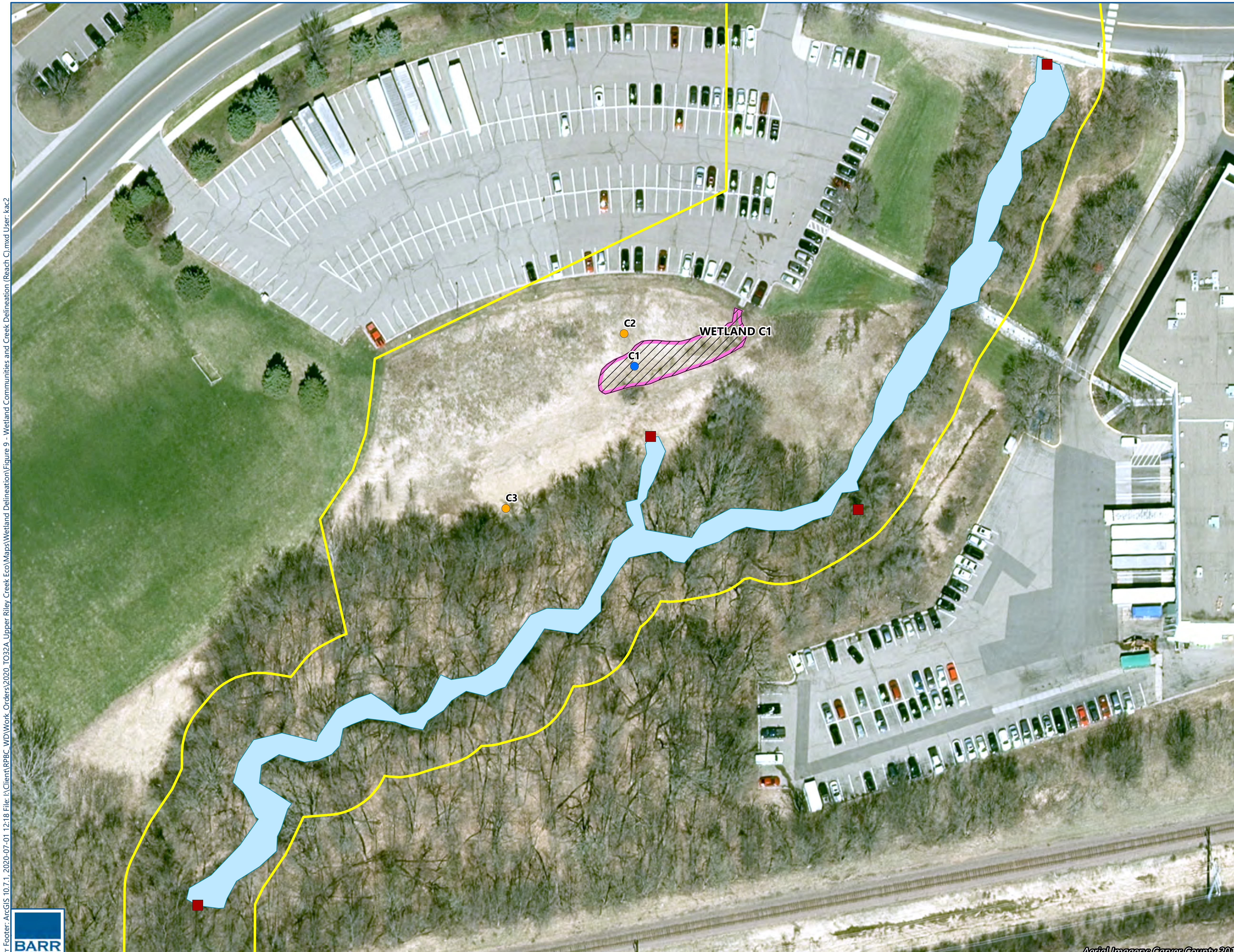
N

0 90 180
Feet

WETLAND & CREEK
DELINEATION (SECTION B)
Upper Riley Creek Ecological
Enhancement
Chanhassen, Minnesota

FIGURE A-3

BARR



Property Boundary

Delineated Wetland

Delineated Creek

Culvert

Wetland Communities

Seasonally Flooded Basin

Sample Points

Upland

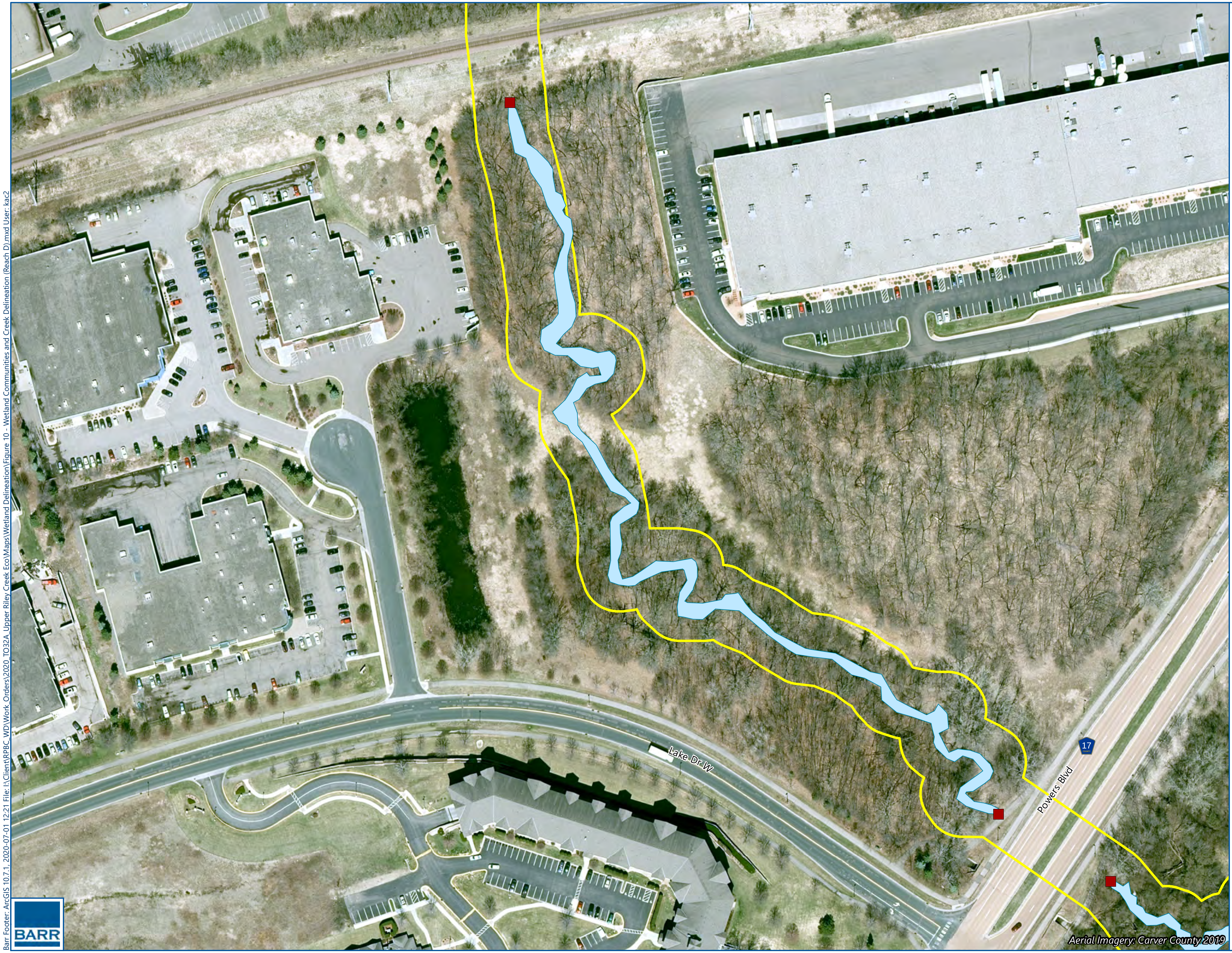
Wetland

0 70 140

Feet

WETLAND & CREEK DELINEATION (SECTION C)
Upper Riley Creek Ecological Enhancement
Chanhassen, Minnesota

FIGURE A-4



Property Boundary

Delineated Creek

Culvert

N

0 100 200

Feet

WETLAND COMMUNITIES AND CREEK DELINEATION (REACH D)
Upper Riley Creek Ecological Enhancement
Chanhassen, Minnesota

FIGURE A-5

BARR

Property Boundary
Delineated Wetland
Delineated Creek
Culvert

Wetland Communities

Shrub-Carr

Sample Points

Upland
Wetland

0 120 240
Feet

WETLAND & CREEK DELINEATION (SECTION E)
Upper Riley Creek Ecological Enhancement
Chanhassen, Minnesota

FIGURE A-6

BARR

Appendix B

Inspection Form: Upper Riley Creek Corridor Enhancement Plan

[Place Holder – will be developed pending final design and construction]