Grant

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Cascade Creek Nine Key Element Plan

Federal Clean Water Act Section 319 Small Watershed Focus Grant Workplan

MINNESOTA POLLUTION CONTROL AGENCY

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Executive summary

The Cascade Creek Nine Key Elements Plan (Plan) was developed to fulfill the requirements set forth by the U.S. Environmental Protection Agency (EPA) for recipients of grants appropriated by Congress under Section 319 of the Clean Water Act (EPA 2013). The requirements emphasize the use of watershed-based plans that contain the nine minimum elements documented in the guidelines and EPA's Handbook for Developing Watershed Plans to Restore and Protect our Waters (EPA 2008).

This Plan builds on the foundation of many levels of planning efforts, water quality conditions, implementation goals and activities and an evaluation approach for the watershed. With the EPA approval of the Plan, the Plan will set the stage to further the previous and current restoration activities and continue efforts to achieve the water quality goals in the watershed.

Two reaches of Cascade Creek have been identified as impaired by excess turbidity or suspended sediment and fish and macroinvertebrate populations are stressed beyond state standards. Agricultural drainage in the headwaters of the watershed in rural Dodge and Olmsted counties combined with rapid urbanization in some areas within the City of Rochester have produced higher runoff volumes and peak flows which have increased streambank erosion and sediment deposition along and within Cascade Creek. These impacts have degraded water quality and aquatic habitat and have increased infrastructure maintenance costs and property damage to downstream residents.

A primary goal for the Cascade Creek Small Watershed is to meet the TSS water quality standard for the stream and have the two impaired reaches delisted. The TSS standard is for TSS concentrations to exceed 65 mg/L less than 10% of the time between April 1 and September 30. A load reduction goal of 11,262 tons/year will achieve the TMDLs for the two reaches. This reduction will be achieved with the implementation of the management measured discussed in this plan. Additional goals for this plan are to reduce nitrogen loading to groundwater & Cascade Creek through the implementation of field practices and reduction of fertilization rates/increased nitrogen use efficiency, increase water storage in the watershed corresponding to 0.25 inches of runoff (approximately 22,000 acre-ft), prioritizing headwater, high yield watersheds, and/or wetland storage areas, and reduce flood risks to structures and major infrastructure. These goals are drawn from the Zumbro River Watershed TMDL report, the Zumbro River Watershed Restoration and Protection Strategy report, and the Greater Zumbro Comprehensive Watershed Management Plan.

Priority will be given to practices that address TSS impairments, followed by those to address biota impairments. Additionally, practices will be prioritized through community engagement efforts to determine which practices are most desirable by residents and other stakeholders in the watershed. Implementation will be targeted to the critical areas identified in the plan. Results from evaluation and effectiveness monitoring will be used to adapt the practices and approaches to attain water quality standards.

Watershed characteristics of Cascade Creek

Cascade Creek is a warm water stream in Olmsted County and flows to the South Fork Zumbro River. The Cascade Creek watershed (Figure 1) is comprised of a single hydrologic unit code (HUC) 12 watershed (Table 1).

Figure 1. Cascade Creek Watershed (WHAF, 2023)

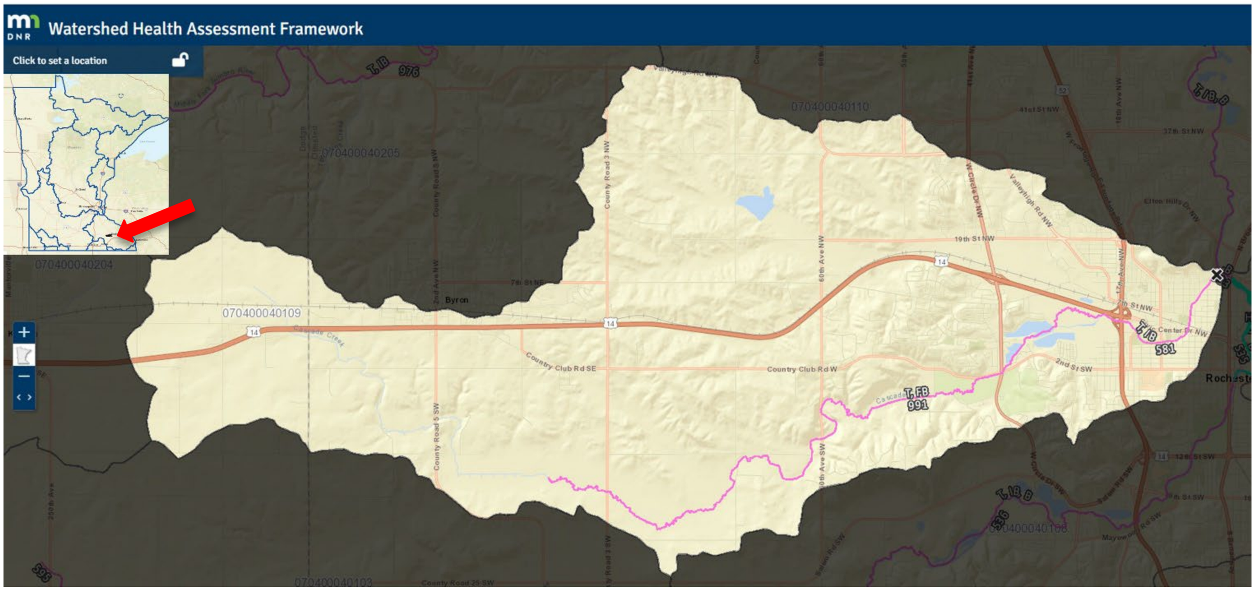


Table 1. HUC12 identification for Cascade Creek watershed

Watershed	HUC12 #
Cascade Creek	070400040109

The stream reaches and ponds in the watershed are listed in Table 2.

Table 2. Stream reaches and ponds in the Cascade Creek Watershed

Waterbody ID	Description	Length/Size	Use Class
07040004-640	Unnamed Creek, Headwaters to Cascade Creek	2.44 miles	2Bg
07040004-990	Cascade Creek	7.46 miles	2Bg
07040004-991	Cascade Creek	10.26 miles	2Bg
07040004-581	Cascade Creek	3.00 miles	2Bg
55-0025-00	Manor Woods Pond	45.53 acres	2B
55-0024-00	Cascade Ponds	75.32 acres	

The subwatershed drains a total of 24,326 acres, 64% of which is in agricultural use and 17% is developed (MPCA, 2016b). The area draining to Cascade Creek begins in Dodge County and expands as it flows through several townships in Olmsted County and eventually to the South Fork Zumbro River. The lower stretch of this stream flows through the city of Rochester before it reaches the Zumbro River. Many sections of the lower stretch have been altered or protected while many parts of the upper watershed remain unaltered/unmodified. This watershed sees quick runoff from altered landscapes causing flooding. Flooding in the watershed has proven to be a hot topic due to its effect on agricultural land and the downstream effects seen in the City of Rochester.

The drainage area of Cascade Creek exists mainly within the Rochester Plateau and to a lesser extent within the Blufflands agroecoregions, with minor areas classified as Level Plains, Undulating Plaines, Alluvium & Outwash, and steeper Alluvium. Most of the land area draining to this impaired reach is within Olmsted County, except for the far western portion which is in Dodge County (Zumbro River Watershed Turbidity TMDL).

Environmental justice

The Cascade Creek flows through areas of EJ concern in the city of Rochester. It is primarily the Kutzky Park Neighborhood. About half of the Kutzky Park Neighborhood residents have annual household incomes below $50,000/yr, over 75% are renters, and about 44% speak a language other than English at home (EPA EJ Screen, ACS summary report). The City of Rochester has put forward significant efforts to reach out to the various communities and ask what their concerns, thoughts, and needs are. This effort was carried out in preparation for the city's Sustainability and Resiliency Community Work Plan.

City of Rochester Sustainability and Resiliency Community Work Plan listening sessions were held with members the following communities and organizations:

- Cambodian community
- Hmong community
- Sudanese community
- Latinx/Hispanic community
- BIPOC communities
- Indian community
- Chinese American community
- Somali community
- Senior community
- Young adults & high school students
- Low-income populations
- Various neighborhood groups
- Mayo Clinic
- Rochester Public Schools
- The Elder Network
- Family Service Rochester
- Diversity Council
- Rochester Area Builders
- Families First of Minnesota
- Workforce Development

- Rochester Community Initiative
- University of Minnesota Rochester
- Indian Cultural Association of MN
- Olmsted County Environmental Commission
- Rochester Olmsted Youth Commission
- Zumbro Valley Health Center
- Interfaith Hospitality Network
- Compassion Rochester MN
- SE MN Alliance for Legal Defense for Immigrants
- The Village Agricultural Cooperative & Learning Community
- Youth Sports organizations

Additionally, because of the environmental justice, public safety, and a variety of other concerns, the City of Rochester is having hydrologic and hydraulic modeling done on Cascade Creek to help address the flooding concerns. This information will be incorporated into this living document as it becomes available. The City of Rochester's Comprehensive Surface water management plan has been developed with the co-design framework, which is a planning process that develops a true participatory process between members and avoids performative engagement.

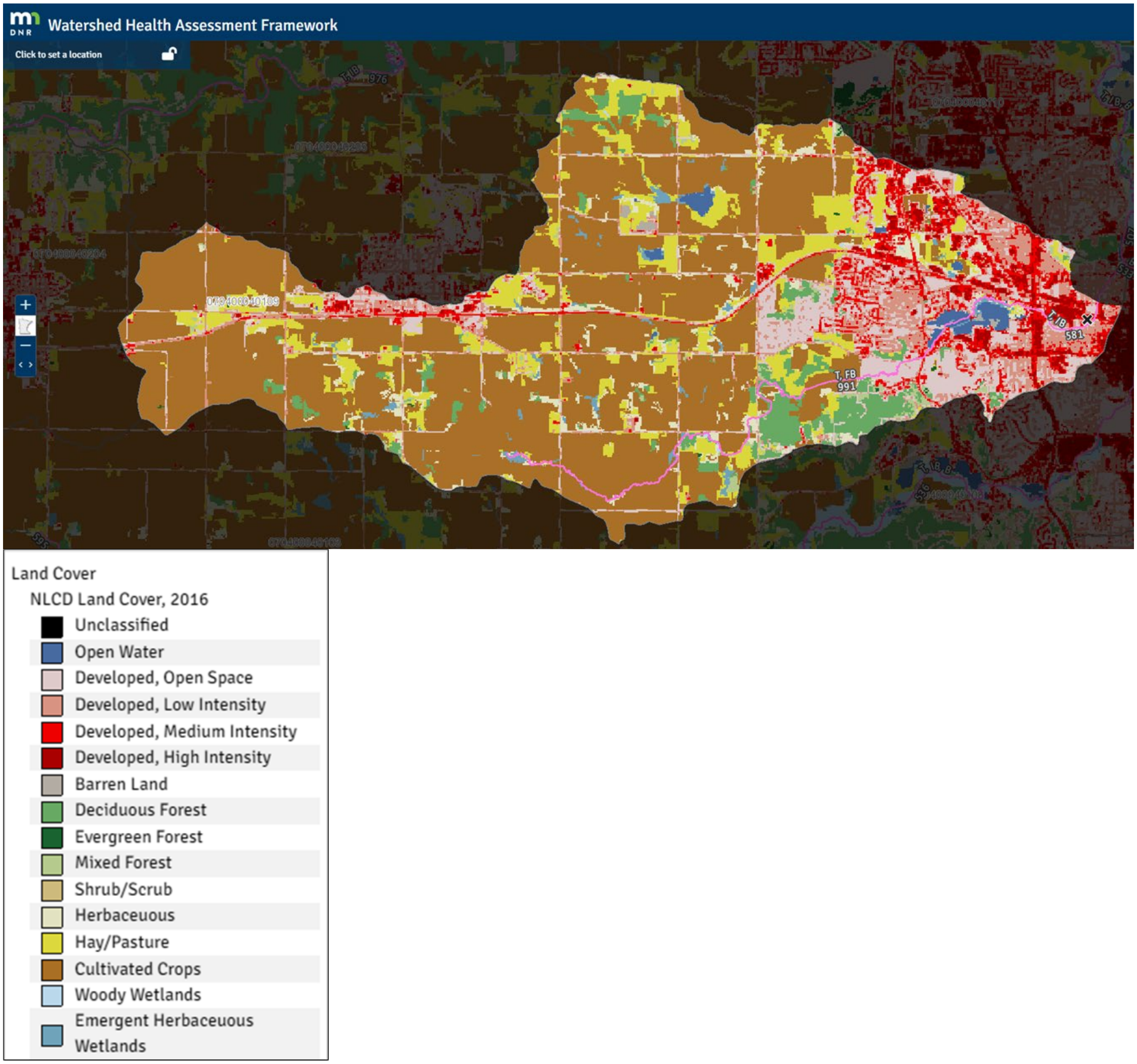
Land use

The land use in the Cascade Creek Watershed is primarily agriculture (crops, animal, and feedlots) and is summarized in Table 3 and illustrated in Figure 2.

Table 3. Land use breakdown in acres per PLET's internal server connections

	Urban	Cropland	Pastureland	Forest	Feedlots	Total*
Cascade Creek	6,721	12,749.7	3,713.3	1,236.96	4.4	24,425.4

Figure 2. Land use map of Cascade Creek Watershed



Streamflow and water quality summary

Dodge County Soil and Water Conservation District (SWCD), Olmsted County SWCD, Minnesota Department of Natural Resources (DNR) and Minnesota Pollution Control Agency (MPCA) have completed various monitoring activities in the watershed. The summary of data below is taken from various reports that characterize the impairments for the Cascade Creek Watershed.

In 2011, Olmsted County, the City of Rochester and Minnesota Department of Natural Resources (DNR) developed an MOU outlining a cooperative effort to obtain grants funds, implement projects and monitor the efficacy of the methods, all focused on Cascade Creek. The five-component framework for riverine processes was used as a guide to assure all aspects of watershed function were covered (Figure 3).

Figure 3. Instream Flow-Council's five-component framework for riverine processes

Stream flow is monitored at two sites on Cascade Creek (Table 4). The sites are operated throughout the year. The site web pages provide a data viewer, site descriptions, year-end summaries, and data for download.

Table 4. Stream flow monitoring sites on Cascade Creek

Gage site	Gage site ID	DNR Cooperative Stream Gaging web page	Period series record
Cascade Creek at Rochester, 7th St NW	41064001	https://www.dnr.state.mn.us/waters/csg/site.html?id=41064001	2007 – 2010, 2018 - 2022
Cascade Creek at Rochester, 45th Ave SW	41065002	https://www.dnr.state.mn.us/waters/csg/site.html?id=41065002	2013 - 2022

Stage and discharge data from 45th Avenue S.W. have been evaluated to determine bankfull flow conditions, defined as the flow that fills the stream channel up to the top of the stream banks prior to flooding. Bankfull conditions at the 45th Avenue site are calculated at 110 cubic feet per second (cfs). Larger rain events often produce bankfull flows, higher stream discharge and channel forming flows.

Cascade Creek has, on average, approximately 3.5 bankfull events each year (Figure 4). Since 2013, the largest number of these events occurring in one year was in 2019, when the annual precipitation total was also highest at 47 inches, 13 inches more than the annual average. Bankfull events tend to occur mostly during the spring and early summer months, March-June (Figure 5).

Figure 4. Number of bankfull events each year in Cascade Creek determined by using DNR's geomorphology survey information and corresponding discharge at 45th Ave.

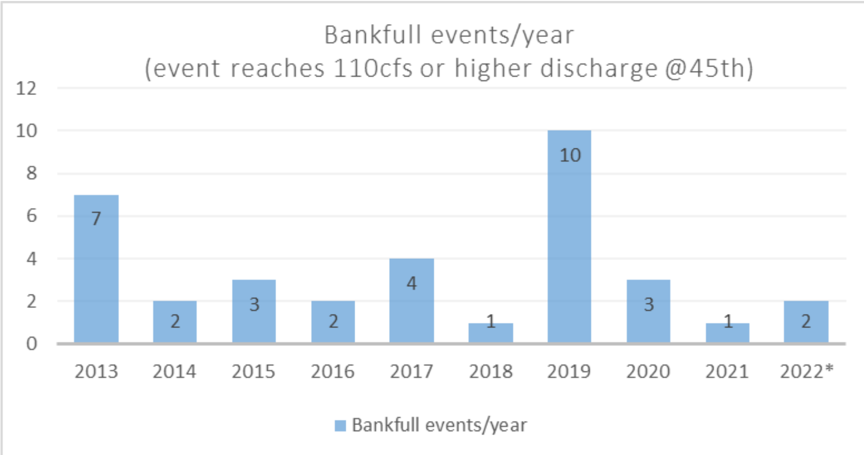
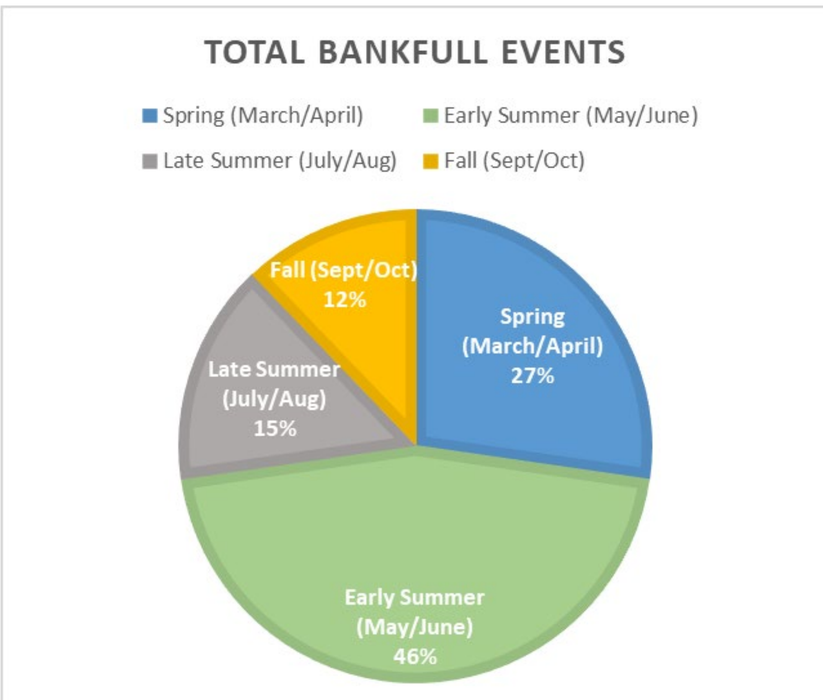


Figure 5. Bankfull events by season in Cascade Creek 20, using 45 Ave gage. (33 total events from 2013-2021)



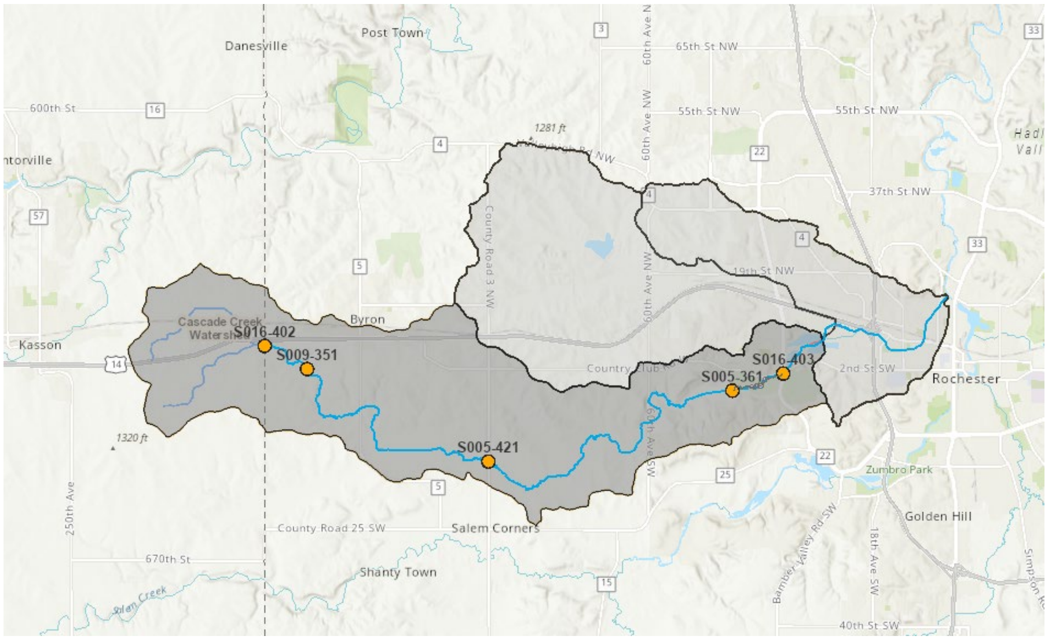
Water quality data is present in the MPCA database, EQuIS, for 12 sites along Cascade Creek. Eight sites are volunteer monitoring sites where Secchi transparency measurements are made. Three sites have water quality data from laboratory analyses. Five of the sampling sites have continuous turbidity and temperature monitoring. The period of record for each data type is summarized in Table 5. The location of the continuous turbidity and temperature sensors is shown in Figure 6.

Table 5. Summary of Secchi, chemistry, and continuous turbidity, temperature, and streamflow period of record

EQuIS site ID	Secchi period of record	Water chemistry period of record	Continuous turbidity & temperature	Streamflow	Location
S016-402	2020-2021		2012-current	2013-current	Cascade Creek near 19th Ave SW
S009-351	2016-2018		2012-current		Cascade Creek near Frontier Rd
S005-465	2008-2014				Cascade Creek near 10th St SW
S005-421	2008-2018	2014	2012-2016		Cascade Creek near CSAH 3
S001-573	2000-2020				Cascade Creek near 60th Ave SW
S005-361	2008, 2014-2020	2014, (2018, 2020 DO)	2012-current	2013-current (DNR gage 41065002)	Cascade Creek near 45th Ave SW
S016-403			2012-current		Cascade Creek near Hwy 22
S004-798	2007-2020				Cascade Creek near 17th Ave NW
S001-353	1999-2020				Cascade Creek near 11th Ave NW
S001-364	1999, 2007, 2013				Cascade Creek near 9th Ave NW
S001-354	1999-2008, 2013-2014	2007-2008, 2014		1998-2010, 2018-current (DNR gage 41065001)	Cascade Creek near 7th St NW
S008-839	2015-2019				Cascade Creek near mouth (near 4th Ave NW)

The MPCA has operated continuous turbidity sensors at five sites in Cascade Creek since 2012. The sensors measure turbidity and temperature continuously at 15-minute intervals and have been deployed each year during the open water season. As shown in Table 5, data collection began in 2012 at all five sites, however one site (CSAH 3) is no longer in operation. The CSAH 3 site was discontinued due to excess sediment burying the equipment and no longer providing reliable data. Two of the four remaining sites also have continuous flow data collection to help understand the relationship between flow and turbidity.

Figure 6. North and South Cascade Creek watersheds and long-term monitoring site locations



The turbidity sensors are robust and provide high resolution information regarding various turbidity events in-stream. Multiple sites located across the watershed of Cascade Creek help understand the dynamic nature of sediment movement in the stream, along with the magnitude and duration of turbidity events. The large turbidity datasets for these sites demonstrate the variability of the results depending on time of year, sediment sources, rainfall intensity/duration, and hydrologic conditions. As such, it takes a lot of data over a long period of time to begin to understand patterns and trends.

Turbidity has an obvious visual component as shown in Figure 7. Often, sediment in the stream will look like chocolate milk by the time it reaches 200 FNU (Formazin Nephelometric Unit; a measure of scattered light). During some conditions and flows, turbidity can have a similar appearance on the surface. Larger flows will often produce higher turbidities, however that is not always consistent, and results can vary. The causes for this inconsistency will be discussed in the following subsections.

Some small events can produce just as high turbidities, due to other sediment sources present. Since there are highly variable and unpredictable conditions, having a sensor recording turbidity every 15 minutes provides the optimum resolution of information possible to understand sediment dynamics for each site and storm event. This information is important in understanding and quantifying changes in turbidity and sediment movement resulting from changes in the watershed.

Figure 7. Photo comparison of various turbidity values at 45th Ave. Top left: clear baseflow conditions. Top right: small storm event, cloudy conditions. Bottom left: moderate storm event and turbidity. Bottom right: large storm event and turbidity.

Preliminary results of continuous turbidity data collection

Turbidity peaks

Depending on the storm event and time of year, different sites in Cascade Creek show varying results in turbidity. The patterns upstream to downstream can also be highly variable and are not always consistent. However, most events produce increasing turbidity moving downstream in the watershed. The site that has often shown the highest turbidity peaks in response to rain events comparatively is 45th Ave, followed by CR22. This could be due to several factors, including the large area of channelized stream just above this site (45th Ave). Channelization or stream alterations have been shown to increase bank erosion and sediment inputs. Also, the specific nature of the stream at this site may also be producing larger turbidity spikes from events due to higher flow velocity and its proximity to a culvert that could be disrupting sediment.

Turbidity duration

The duration of high turbidity is highly variable, but often the sites do not remain turbid for long periods of time and recover to normal conditions within 1-3 days. The two sites farthest downstream stay turbid longer compared to the upper sites, which tend to clear up much faster. This is expected given the additional sources of sediment that enter the system moving downstream and the longer duration of high flow in these locations.

Turbidity timing

Overall, the seasons that produces the highest turbidity events in Cascade Creek are late spring and early summer. Higher amounts of precipitation coupled with reduced crop canopy and growth, leave soils more susceptible to erosion and streams prone to higher flow increases, which result in higher in-stream turbidities. This is consistent with results from other studies on runoff and sediment losses in the region (MDA, Root River Field to Stream Partnership, 2020). This study, among others (Minnesota Discover Farms and Watershed Pollutant Load Monitoring Network), have shown nearly 80% of yearly sediment losses in watersheds occur in May and June. However, even though most of the higher turbidity events occur in late spring/early summer, all seasons have produced some significant turbidity events in Cascade Creek.

While turbidity events in Cascade Creek can be highly variable, a few things show some consistency. One consistency is that the lower two sites almost always take longer to clear up (**Error! Reference source not found.** and **Error! Reference source not found.**). This is shown by the long lagging tail on the turbidity graph (MPCA time-series monitoring data, 2023). Since there are more sediment sources moving downstream throughout a watershed, this is fairly expected. The lower two sites usually also have higher turbidity peaks for any given event compared to the upper two sites. However, this isn't always the case. **Error! Reference source not found.** Figure 9 provides an example that may be an indication of an event that produced a lot of turbidity due to overland runoff, since the two upper sites peaked at higher turbidity compared to the lower sites. Multiple sediment sources were likely at play during this event, and it also indicates that sediment was probably stored somewhere in the watershed as it did not make it to the downstream sites. DNR WARSSS, which is not finalized, indicates this. This plan will be updated to clarify upon its finalization.

Figure 8. Small turbidity event showing the response from all sites in Cascade Creek, 5/11/2018. The two upper sites peak at lower levels and recover much faster than the lower two sites. (Missing data from CSAH 3)

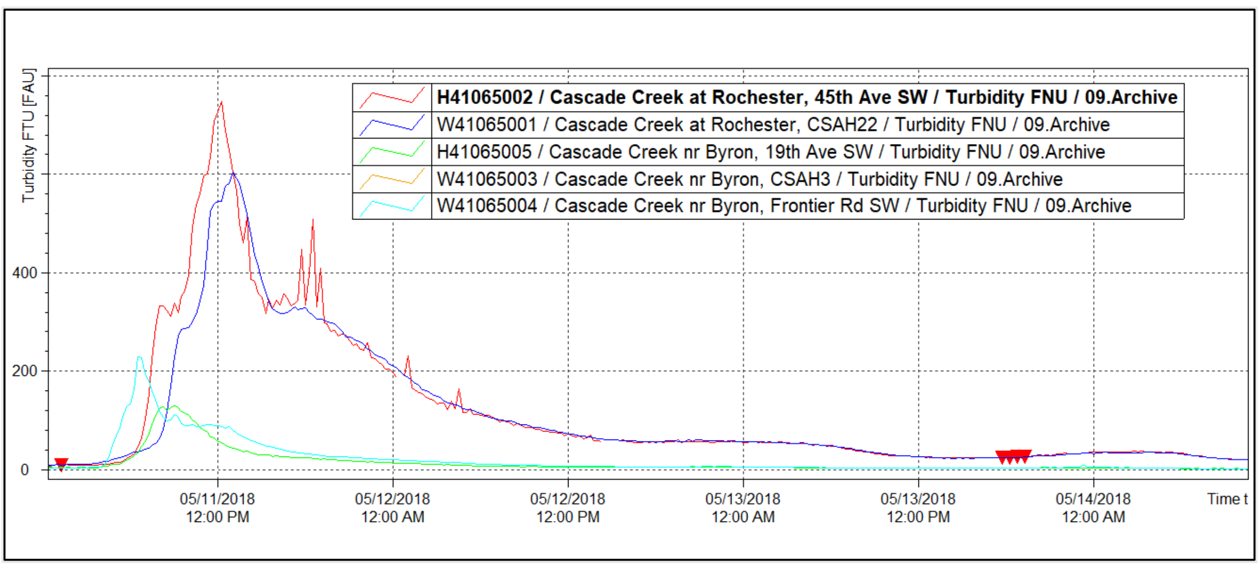
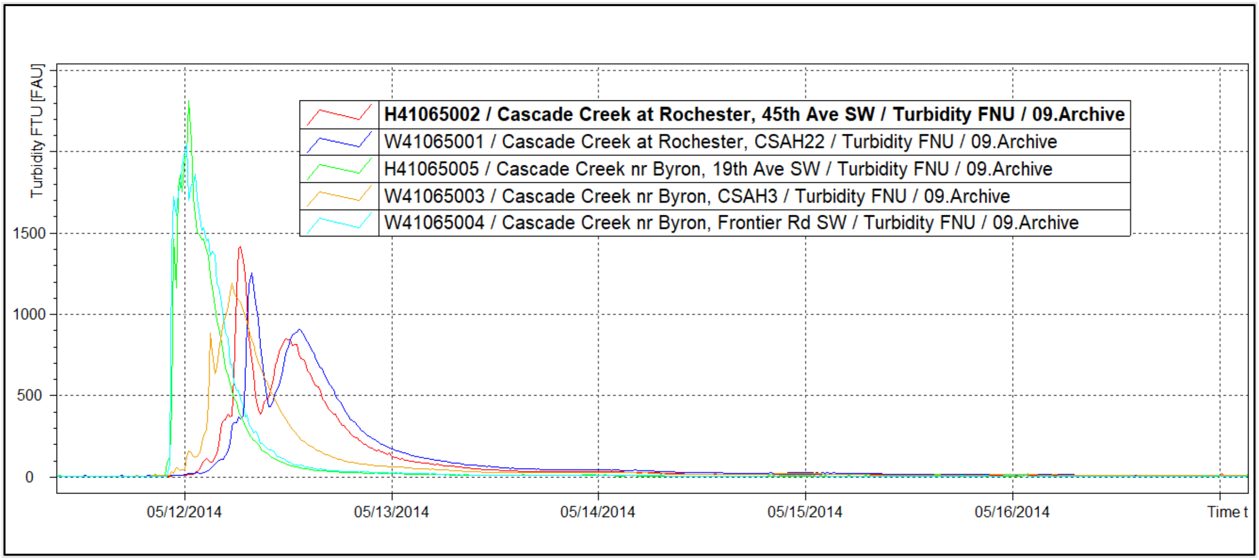


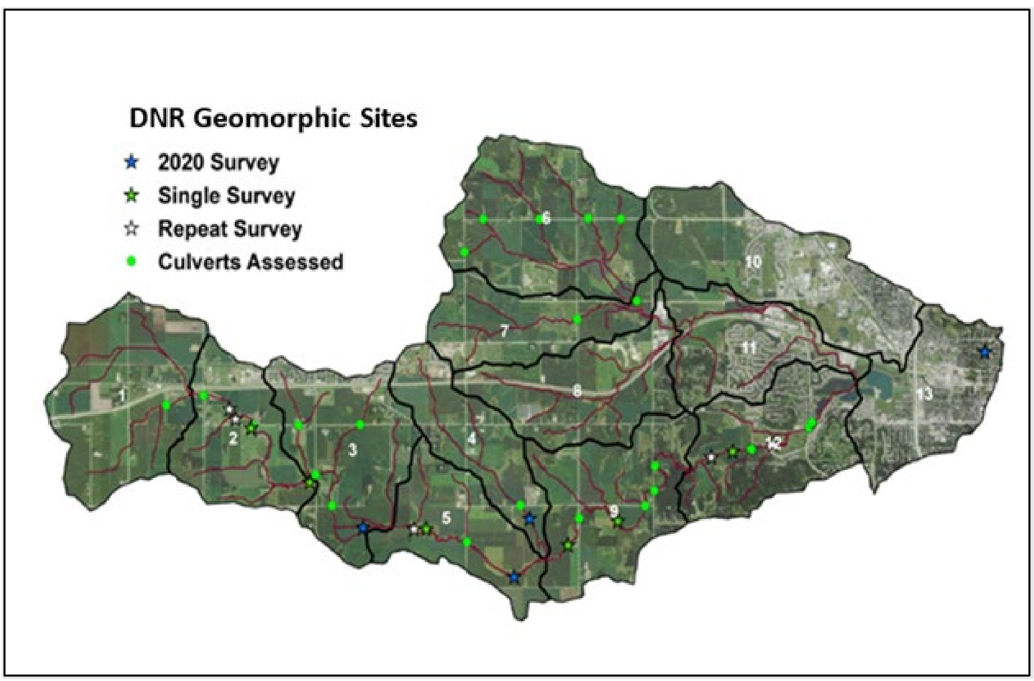
Figure 9. Larger bankfull turbidity event showing responses from all sites in Cascade Creek, 5/12/2013. The two upper sites peaked at much higher levels, compared to the mid-lower sites.



Suspended sediment and bedload have also been sampled by the USGS for the Cascade Creek restoration project with sampling conducted before and after project construction and upstream and downstream of the project. The data provide a more robust look at sediment dynamics and have helped develop sediment curves for Cascade Creek, which will be used to assist implementation.

Geomorphic surveys have been completed by DNR annually at the Cascade Creek restoration project since 2018 in addition to prior to construction in 2011 and 2014. Watershed-wide, 11 geomorphic surveys were completed within the watershed between 2012 -2013, five of the original sites were repeated in 2020 with an additional four new sites. Road crossing inventories were completed in 2011 with Olmsted County protocols and 2019 with DNR protocols (DNR, 2019) (Figure 10).

Figure 10. Geomorphic surveys and crossing inventory locations.



Bankfull events

Larger rain events often produce bankfull flows, higher stream discharge and channel forming flows. In these instances, the sediment source to the stream is potentially driven by the channel itself, especially in the lower reaches. However, during bankfull flows the stream may also be able to dissipate its energy and spread out into the floodplain (in places it has access to floodplain) which may also influence sediment storage and in-stream concentrations in a positive way.

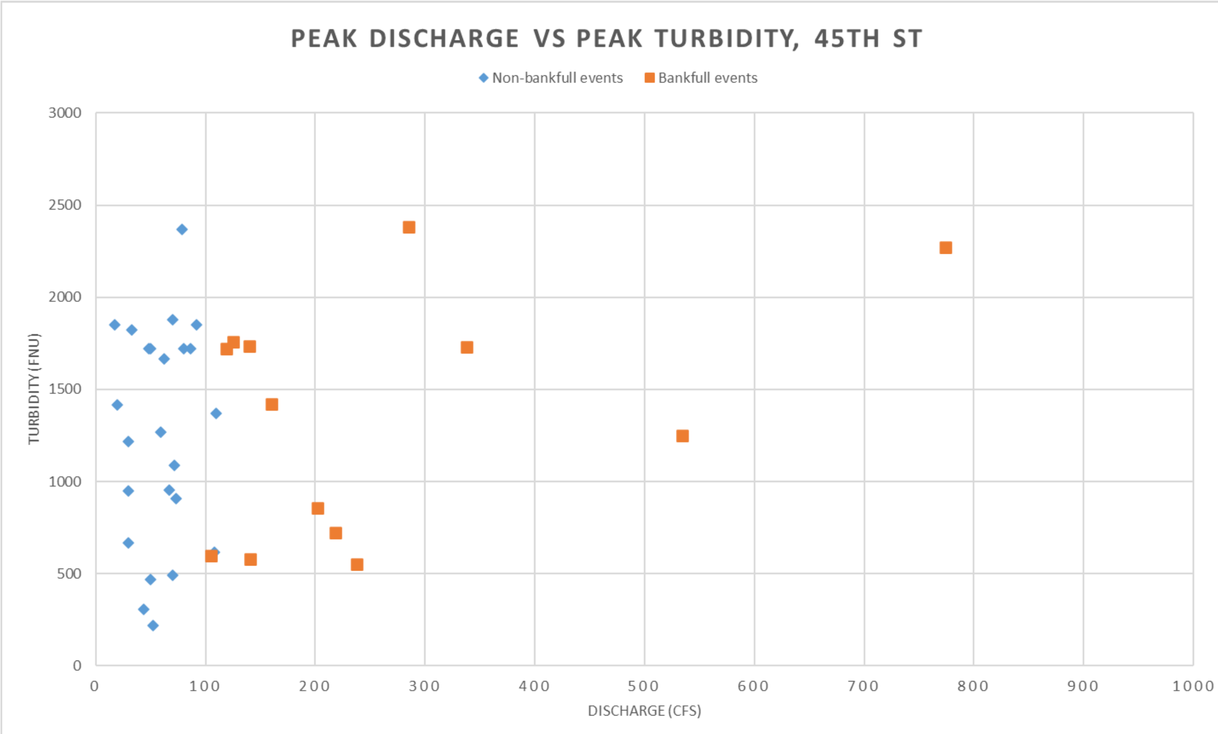
Looking at 17 different bankfull events during the period of record, the peak turbidities are highly variable, but are consistently high, on average between 800-1300 FNU (Figure 11).

The area receives between 3.8 and 4 inches more precipitation per year than the average of the entire climate record, going back to 1895. This increase in rainfall increases the volume of water entering the system that it cannot handle, due to extensive landscape change. This concept will be elaborated upon as the Watershed Assessment of River Stability and Sediment Supply (WARSSS) and will be incorporated into this plan as it becomes available. A similar study conducted in the Wells Creek Watershed (Mississippi River- Pepin) stated, "Large rain events were assessed by the DNR using available daily precipitation data from a nearby long-term monitoring station in Red Wing, MN. These data show the occurrence of 24-hour storm events of one inch and greater, over 30-year time periods, going back to the beginning of the 20th century. The largest shift appears to be in the period of 1960-1990, where large increases in the 1-2 inch and 2–3-inch events occurred. The following period, from 1990-2020 had the most occurrences of events above 3 inches of all the periods. Both storm intensity and total annual precipitation volumes have been increasing in the watershed (DNR 2021)". These large events have implications for erosion and sediment supply.

Non-bankfull events

Non-bankfull events (less than 110 cfs) can also produce high turbidities (regularly greater than 500 FNU) in the stream (Figure 11). In other words, it does not require a high stream discharge to produce turbid water in Cascade Creek (Figure 11). It's possible the sources of sediment are more variable and represent more than just channel sources for these types of events, especially in early spring when soils are most vulnerable; the DNR WARSS study will provide clarity on sources of sediment. Channel sources or near channel sources of sediment remain likely contributors to both types of events but also likely vary. Each site has on average 2-3 additional non-bankfull turbidity events each year. The year that produced the highest number of non-bankfull events was 2017, with 8 non-bankfull events. This translates to 8 additional events that produced turbidities greater than 500 FNU in Cascade Creek that year.

Figure 11. Comparison of peak discharge to peak turbidity for multiple storm events in Cascade Creek (45th Ave site).



Impairments

The Clean Water Act, Section 303(d) requires TMDLs to be developed for surface waters that do not meet applicable water quality standards necessary to support their designated uses. A TMDL determines the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards and allocates allowable pollutant loads to various sources needed to meet water quality standards.

There are two impairments in the planning area described in Table 6.

Table 6. Impairments and stressors in Cascade Creek Watershed (2022, MPCA 303(d) list)

Resource of Concern	Description	Waterbody Identification (WID)	Use Class	Impairment	Year listed	TMDL status	Stressors
Cascade Creek	From Cascade Lake to South Fork Zumbro River	07040004-581	2Bg, 3C	Turbidity Aquatic Life: Invertebrates	2006 2016	Approved	TSS, habitat, flow alteration
Cascade Creek	Start west of County Road 3 SW to Cascade Lake	07040004-991	2Bg, 3C	Turbidity Aquatic Life: Fishes	2006 2016	Approved	Habitat, flow alteration

Fish and macroinvertebrates

The lower stream reach of Cascade Creek, 07040004-581, was added to the impaired waters list in 2016 due to impaired macroinvertebrate communities based on MPCA sampling results in 2004. In contrast, fish index of biotic integrity (MIBI) was above the impairment threshold. The situation is opposite for the middle stream reach, 07040004-991, where it was added to the impaired waters list in 2016 due to impaired fish communities based on MPCA sampling results in 2004 and 2012. Additional DNR data from 2011 confirmed that the fish community was below impairment thresholds (Figure 12). In contrast, macroinvertebrate index of biotic integrity (MIBI) results were above the impairment threshold.

Figure 12. DNR Fisheries fish and invertebrate IBI survey locations

The impaired macroinvertebrate community of lower reach of Cascade Creek (-581) is stressed by elevated TSS, poor habitat conditions and flow alteration (Table 7). This reach also has an existing turbidity impairment. The sediment issues in this reach have a direct impact on the available habitat as well. Lack of riparian buffer and the surrounding urban land use can also be contributors to the suspended sediment and bedded sediment issues in this location in addition to the entire upstream watershed contributions. In addition, the fact that this entire reach is 100% modified and located in a highly developed area of the city of Rochester contributes to the habitat issues observed (MPCA, 2016c).

Table 7. Summary of stressor determinations in Cascade Creek (07040004-581)

Stream Name	AUID	Stressors:					
		Temperature	Dissolved Oxygen /Eutrophication	Nitrate	Suspended Sediment	Habitat	Flow Alteration/Connectivity
Cascade Creek (City of Rochester)	07040004-581	---	o	---	●	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

The impaired fish community in the upper reach of Cascade Creek (-991) is stressed by poor habitat conditions and flow alteration/connectivity (Table 8). Even though macroinvertebrates are not currently impaired in this location, they are showing signs of habitat related stress due to the poor substrate and surrounding land use. A geomorphic assessment by MNDNR revealed that Cascade Creek (flowing through old Meadow Lakes Golf Club) was actively incising and eroding the stream banks. This reach was contributing approximately three times more sediment per foot of stream than any other reach surveyed in Cascade Creek. In terms of connectivity, a perched culvert on CR22 and Cascade Lake completely blocks fish from migrating during certain flow regimes. In 2012, there were observed periods where the stream bed was completely dry. DNR intensive surveys on Cascade Creek also document habitat and flow alteration/connectivity as contributing issues to the impaired fish community. Reductions in phosphorus may be needed to ensure DO levels stay adequate (MPCA, 2016b).

Table 8. Summary of stressor determinations in Cascade Creek

		Stressors					
Stream Name	**AUID**	**Temperature**	**Dissolved Oxygen /Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Flow Alteration/Connectivity**
Cascade Creek (Upstream of City)	07040004-991	---	---	o	o	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

TMDLs

TMDLs for the impairments in Cascade Creek were developed and can be found in the Zumbro River Watershed Turbidity TMDL (Barr Engineering 2012) and the Zumbro River Watershed TMDL (Limnotech 2017). The water quality duration curve for the available turbidity dataset indicates exceedance of the target during high flow and moist conditions. The allowable TSS load is exceeded by approximately 75% at high flows and during moist conditions. (MPCA Zumbro River Watershed Turbidity TMDL). The TMDLs are shown in Table 9 and Table 10.

Table 9. Cascade Creek; Headwaters to Unnamed Cr, 07040004-639 TMDL

	Flow Zone				
	High	**Moist**	**Mid**	**Dry**	**Low**
	Tons/day				
TOTAL DAILY LOADING CAPACITY	7.93	4.17	1.95	0.81	0.33
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	NA	NA	NA	NA	NA
Communities Subject to MS4 NPDES Requirements	0.58	0.30	0.14	0.06	0.02
Construction and Industrial Stormwater	0.01	0.004	0.002	0.001	0.0003
Load Allocation	6.55	3.44	1.61	0.67	0.27
Margin of Safety	0.79	0.42	0.20	0.08	0.03

Table 10. Cascade Creek; Unnamed Cr to S Fk Zumbro R., 07040004-581 TMDL

	Flow Zone				
	High	Moist	Mid	Dry	Low
	Tons/day				
TOTAL DAILY LOADING CAPACITY	15.19	7.99	3.74	1.55	0.63
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	0.005	0.005	0.005	0.005	0.005
Communities Subject to MS4 NPDES Requirements	3.29	1.73	0.81	0.33	0.14
Construction and Industrial Stormwater	0.01	0.01	0.003	0.001	0.001
Load Allocation	10.37	5.45	2.55	1.05	0.43
Margin of Safety	1.52	0.80	0.37	0.15	0.06

The estimated annual TSS load for the Cascade Creek watershed using the PLET model is 15,016 tons per year (Table 11). The assumption for the NKE plan is that a load reduction of 75% of the estimated annual TSS load will achieve the reductions needed to meet the TMDL and achieve the annual load reduction needed to achieve the water quality standard for TSS. The 75% reduction equals 11,262 tons per year.

Table 11. PLET load estimations for the Cascade Creek Watershed

Watershed	N Load (lbs/year)	P Load (lbs/year)	TSS (tons/year)
Cascade Creek Watershed	120,205	28,767	15,016

Implementation strategies

The applicable land use, eligibility, BMPs, activities, implementation schedule, milestones, assessment criteria, costs, and by practice reduction estimates are described in Table 12 and are estimated to yield the reductions needed to reach water quality standards within 10 years. The estimated reductions were calculated by practice using the PLET tool. The total reductions for the plan are described in Element b. Estimated reductions and are calculated using the combined efficiencies calculator in PLET.

Section 319 funding eligibility will be determined at the time of grant awarding and project evaluation. Eligibility will be determined using the most up-to-date EPA guidelines and the Minnesota Nonpoint Source Program Management Plan (2019). No NPS funding streams will be used to address any NPDES permit requirements.

Assessment criteria will be used to determine the progression and implementation of this plan. They are expected to be leading indicators of watershed change. The monitoring described here and in Element i. Monitoring will be used to verify the success of the BMPs and planned activities. The water quality response will lag the implementation of activities.

Table 12. Applicable land use, eligibility, BMPs, activities, implementation schedule, milestones, assessment criteria, costs, and by practice reduction estimates (PLET, 2023).

Land use	319 eligible	Treatment type	WAGZ Item ID	Milestones					Assessment	Costs	Reductions		
				2-year	4-year	6-year	8-year	10-year			N lbs/yr	P lbs/yr	TSS t/yr
Streambank	Y	Stabilize or restore 18,750 linear feet of degraded streambank areas.	SWQ-1, ESC-3, ESC-5		1 mile			1 mile	# of stream miles restored	$2,000,000	2280	878	1425
	Y	Provide assistance for implementing natural channel design at 2 sites.											
Cropland	Y	Increase grassed waterways on 50 acres	SWQ-1	10 acres	10 acres	10 acres	10 acres	10 acres	# of acres treated	$50,000	250	83	38
	Y	Develop site-specific nutrient and fertilizer management plans covering 12,500 acres	SWQ-1	2,500 acres (5 plans)	2,500 acres (5 plans)	2,500 acres (5 plans)	2,500 acres (5 plans)	2,500 acres (5 plans)	# of acres treated and # of producers engaged to develop plans	$87,500	15842	8261	0
	Y	Increase Residue and Conservation Tillage (reduced and no till) on 5,000 cropland acres	SWQ-1	1,000 acres	1,000 acres	1,000 acres	1,000 acres	1,000 acres	# of acres treated	$110,000	18154	8574	3668
	Y	Increase Conservation crop rotation by 125 acres	SWQ-1	25 acres	25 acres	25 acres	25 acres	25 acres	# of acres treated	$5,000	207	51	24
	Y	Increase water storage by installing 10 Water and Sediment Control Basins	SWQ-1, FLD-1	2 WASCOBs, 20 acres	2 WASCOBs, 20 acres	2 WASCOBs, 20 acres	2 WASCOBs, 20 acres	2 WASCOBs, 20 acres	# of acres treated	$200,000	125	41	19
	Y	Land retirement of 200 acres to Conservation Cover, transitioning privately held ag lands to conservation	SWQ-1	40 acres	40 acres	40 acres	40 acres	40 acres	# of acres retired	$60,000	332	82	38
	Y	Add vegetative cover (Cover Crops) on 650 corn/soybean acres	SWQ-1	130 acres	130 acres	130 acres	130 acres	130 acres	# of acres treated	$35,750	852	130	62
	Y	Increase vegetative cover (cereal rye cover crop) on 5200 short season cropland acres (corn silage, small grains, peas, sweet corn, dry edible beans)	SWQ-1	1,040 acres	1,040 acres	1,040 acres	1,040 acres	1,040 acres	# of acres treated	$286,000	8616	2142	991
	Y	Implement 200 acres of field borders, vegetative barriers, forest edge buffers, or filter strips at edge of field	SWQ-1	40 acres	40 acres	40 acres	40 acres	40 acres	# of acres implemented	$60,000	10071	3332	1524
	Y	Install 2 saturated buffers treating 100 acres	WRAPS			1		1	# of acres treated	$20,000	334	113	50
	Y	Install 2 tile line bioreactors treating 100 acres	WRAPS			1		1	# of acres treated	$30,000	231	0	0

Land use	319 eligible	Treatment type	WAGZ Item ID	Milestones					Assessment	Costs	Reductions		
				2-year	4-year	6-year	8-year	10-year			N lbs/yr	P lbs/yr	TSS t/yr
	Y	Increase enrollment of lands in RIM, CRP, and similar programs by 200 acres	SWQ-1, FLD-8	40 acres	40 acres	40 acres	40 acres	40 acres	# of acres enrolled	$60,000	332	82	38
	Y	Restore 200 acres of riparian lands to perennials.	SWQ-1	40 acres	40 acres	40 acres	40 acres	40 acres	# of acres implemented	$60,000	3358	1139	508
	Y	Increase and restore wetlands by 40 acres	SWQ-1	0 acres	10 acres	10 acres	10 acres	10 acres	# of acres implemented	$200,000	1502	414	181
	Y	Convert 1,655 acres of marginal row crop farmland to perennial cover (marginal lands as determined by <60 on crop productivity index)	WRAPS	330 acres	330 acres	330 acres	330 acres	330 acres	# of acres converted	$496,500	12421	3424	1498
	Y	Technical & Admin Assistance staff time shared between SWCDs, joint powers boards, city staff	SWQ-1, SWQ-6	0.25 FTE	0.25 FTE	0.25 FTE	0.25 FTE	0.25 FTE		$250,000	--	--	--
	Y	Retire 100 acres of cropland to pasture		20 acres	20 acres	20 acres	20 acres	20 acres	# of acres retired	$15,000	165	41	121
Pastureland	Y	Implement rotational grazing land management on 250 acres of pastureland		50 acres	50 acres	50 acres	50 acres	50 acres	# of acres treated	$25,000	336	33	17
	Y	Implement alternative water Supply/livestock Pipeline on 250 acres		50 acres	50 acres	50 acres	50 acres	50 acres	# of acres treated	$25,000	122	18	9
	Y	Implement heavy use area protection on 500 acres of pastureland.		100 acres	100 acres	100 acres	100 acres	100 acres	# of acres treated	$50,000	369	63	34
	Y	Planting pasture & hayland on 250 acres.		50 acres	50 acres	50 acres	50 acres	50 acres	# of acres treated	$25,000	125	8	0
	Y	Implement livestock exclusion fencing on 100 acres.		20 acres	20 acres	20 acres	20 acres	20 acres	# of acres treated	$10,000	96	22	13
	Y	SWCD Technical & Admin Assistance		0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE		$100,000	--	--	--
Feedlots	Y	Provide financial assistance to producers to promote injection/incorporating manure on 600 acres	WRAPS	120 acres	120 acres	120 acres	120 acres	120 acres	acres of adoption	$18,000	475	319	0.03
	Y*	Work with agricultural producers to develop 5 manure management plans	GWQ-16	1 plan	1 plan	1 plan	1 plan	1 plan	# of plans developed	$10,000			
	Y*	Provide financial assistance for 3 animal waste management systems to reduce waste loading to streams including	SWQ-1, SWQ-3		1 project		1 project	1 project	# of animal waste management systems installed	$225,000	3563	437	0

Land use	319 eligible	Treatment type	WAGZ Item ID	Milestones					Assessment	Costs	Reductions		
				2-year	4-year	6-year	8-year	10-year			N lbs/yr	P lbs/yr	TSS t/yr
		installation of livestock waste storage facilities, waste treatment lagoons or manure waste treatment											
	Y*	Provide financial assistance for 3 small feedlot fixes/improvements such as watering, fence, filter strip, vegetated treatment area, stormwater runoff control and livestock shelter structures				2 projects		1 project	# of feedlots addressed	$90,000	3286	1022	0
	Y	SWCD Technical & Admin Assistance		0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE		$100,000			
Forest	Y	Provide financial and technical support to assist landowners in developing 5 forestry management plans		1 plan	1 plan	1 plan	1 plan	1 plan	# of plans developed	$10,000			
	Y	Work with private landowners to develop 5 invasive species management plans		1 plan	1 plan	1 plan	1 plan	1 plan	# of plans developed	$10,000			
Administration	Y*	Provide financial assistance for stormwater reuse projects to minimize urban stormwater runoff	FLD-1										
	N	Identify areas to target hydrologic modeling/analysis and develop hydrologic models/analyses using most current precipitation data		meeting to identify modeling needs		conduct modeling for cascade creek subwatershed			model completed	$75,000			
	N	Compile data on problem culverts from counties and road authorities based on existing inventories; meet with Partner public works departments annually to coordinate infrastructure improvements	FLD-4, FLD-3	2 meetings	2 meetings	2 meetings	2 meetings	2 meetings	# coordination meetings	$2,000			
Urban	Y*	Install 1 acre of residential rain gardens	LR-4	.2 acres	.2 acres	.2 acres	.2 acres	.2 acres	# of acres	$175,000	10	2	0
	Y*	Install 30 stormwater management practices (residential rain barrels and rain gardens) through financial assistance program	LR-4	6 residential BMPs	6 residential BMPs	6 residential BMPs	6 residential BMPs	6 residential BMPs	# of square feet treated	$50,000	309	61	9

Land use	319 eligible	Treatment type	WAGZ Item ID	Milestones					Assessment	Costs	Reductions		
				2-year	4-year	6-year	8-year	10-year			N lbs/yr	P lbs/yr	TSS t/yr
	Y	Invasive species and noxious weed removal along shoreline and restore with native plants	LR-4	7,000 feet	7,000 feet	7,000 feet	7,000 feet	7,000 feet	# of linear feet	$30,000	31	7	1
	Y	Manorwoods Ravine Stabilization (J6691)						stabilization completed	# of linear feet	$1,000,000	7	1	0
	Y	Cascade Creek Stabilization from HWY 52 to Civic Center Dr. (J4860) (5,728.17 ft)						stabilization completed	# of linear feet	$2,075,000	7	1	0
	Y	Technical and Admin Assistance		0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE		$100,000			
Monitoring	Y	Expand lysimeter and tile line monitoring network to determine what the observable reduction is for specific practices		Identify priority locations, begin monitoring baseline	Install lysimeters & begin monitoring baseline	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Assess effectiveness & implementation	1 report discussing effectiveness	$60,000			
	Y	Maintain existing DTS-12 continuous turbidity and temperature monitoring, alone with occasional grab samples											
	Y	Work with MDA, local SWCD and U of MN Extension to continue edge of field monitoring like discovery farms											
	Y	Work with DNR, USGS and others to continue monitoring sediment reduction at existing channel restoration and wetland bank restoration sites to better understand sediment movement and impacts of change											
	Y	Work with DNR, MGS and others on springshed mapping and monitoring of springs and shallow groundwater		Identify key springs to be monitored and springshed mapping needed	Install monitoring equipment, begin monitoring	Continue monitoring & review effectiveness	Continue monitoring & review effectiveness	Assess effectiveness & implementation	Completed springshed mapping for South Branch Cascade Creek	$70,000			
	Y	Promote citizen stream monitoring		engage at least 2 landowners in the watershed to collect monthly stream clarify, temp, and general ob.	maintain at least 2 landowners in the watershed to collect monthly stream clarify, temp, and general ob.	maintain at least 2 landowners in the watershed to collect monthly stream clarify, temp,	maintain at least 2 landowners in the watershed to collect monthly stream clarify, temp, and general ob.	maintain at least 2 landowners in the watershed to collect monthly stream clarify, temp, and general ob.	# of landowners engaged in citizen stream monitoring	$10,000			

Land use	319 eligible	Treatment type	WAGZ Item ID	Milestones					Assessment	Costs	Reductions		
				2-year	4-year	6-year	8-year	10-year			N lbs/yr	P lbs/yr	TSS t/yr
						and general ob.							
	Y	Technical and Admin Assistance for monitoring activities		0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE		$100,000			
Outreach	Y	Promote conservation tillage and the 5 soil health principles with field days and tours		2	2	2	2	2	# of events # of attendees	$10,000			
	Y	Distribute education materials to educate residents about local stormwater management, low impact design practices, and reuse		200 brochures	200 brochures	200 brochures	200 brochures	200 brochures	# of brochures	$1,000			
	Y	Host outreach events for agri-business to promote soil health practices		1	1	1	1	1	# of events # of attendees	$10,000			
	Y	Distribute education materials promoting the use of BMPs focused on soil health (e.g., cover crops, perennial vegetation, conservation tillage)		2	2	2	2	2	# of materials # of people reached with communications	$7,500			
	Y	Implement demonstration projects to show impact and implementation of soil health practices			1		1	1	# of projects # of attendees/visitors to demo	$15,000			
	Y	Targeted outreach to landowners with high priority wetland areas and channel restoration sites, including workshops and site visits		2	2	2	2	2	# of visits # of landowners engaged	$10,000			
	Y	Distribute education materials addressing protection of biologically significant elements in the watershed to adjacent landowners		2	2	2	2	2	# of materials # of landowners engaged	$7,500			
	Y	Organize and host volunteer events related to environmental stewardship (e.g., river cleanup)		2	2	2	2	2	# of events # of attendees	$10,000			
	Y	Targeted outreach to urban landowners on smart salting in the subwatershed		1	1	1	1	1	# of events # of attendees	$5,000			
	Y	Host workshops to educate residents about local stormwater management, low		2 workshops	2 workshops	2 workshops	2 workshops	2 workshops	# of attendees	$10,000			

Land use	319 eligible	Treatment type	WAGZ Item ID	Milestones					Assessment	Costs	Reductions		
				2-year	4-year	6-year	8-year	10-year			N lbs/yr	P lbs/yr	TSS t/yr
		impact design practices, and reuse											
	Y	Distribute education materials educate residents about local stormwater management, low impact design practices, and reuse		200 brochures	200 brochures	200 brochures	200 brochures	200 brochures	# of brochures	$1,000			
	Y	Technical and Admin Assistance		0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE	0.1 FTE		$100,000			
Total costs										**$6,657,750**			

* Eligibility for CAFO and stormwater activities will be evaluated on a case-by-case basis. Section 319 funding may not be used in fulfillment of any NPDES permit requirements.

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year	4-year	6-year	8-year	10-year			

Element a. Sources identified

An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

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Land use influences the rate of loading of sediment and nutrients. The pollutant yields (load per acre) for the land uses in the Cascade Creek watershed are shown in Table 13. The table also provides the percent contribution for each land use of the total estimated pollutant loads in the watershed.

Table 13. Percentage and per acre nitrogen, phosphorus, and sediment loading by land use (PLET, 2022)

Sources	N (lb/ac)	% N load	P (lb/ac)	% P load	TSS (t/ac)	% TSS load
Urban	3.9	24%	0.6	15%	0.09	4%
Cropland	5.0	59%	1.5	72%	0.95	81%
Pastureland	3.4	12%	0.5	7%	0.20	5%
Forest	0.1	0%	0.1	0%	0.02	0.1%
Feedlots	659	3%	66	1%		
% totals		97%		95%		90%

* Loads from septic and streambank sources omitted

In addition to direct land use loading, septic system and streambank erosion contribute pollutant loads to the stream. The contribution of these sources are shown in Table 14.

Table 14. Percentage of total loads from septic systems and streambank erosion (PLET, 2023)

Sources	% N load	% P load	% TSS load
Septic systems	1%	1%	
Streambank erosion	2%	4%	10%
% totals	3%	5%	10%

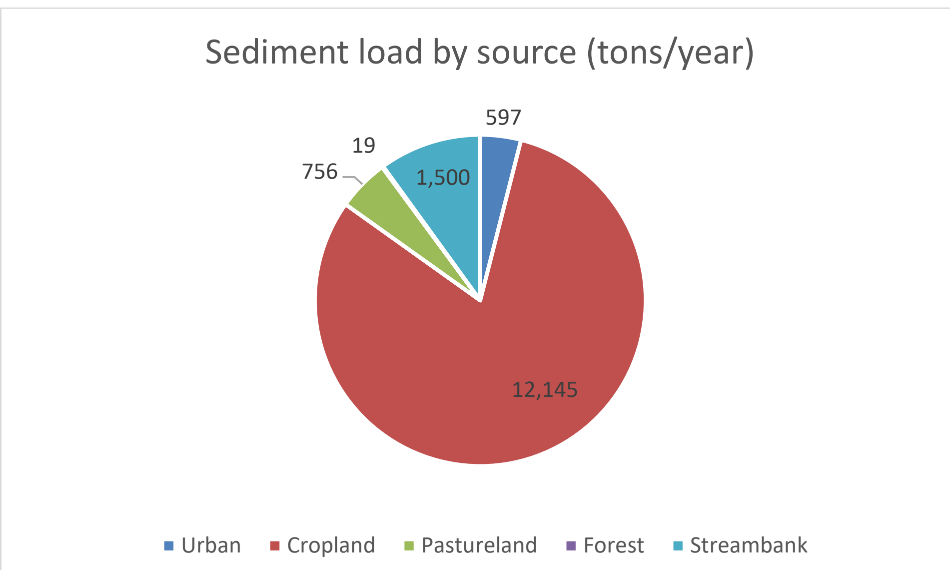
The main sediment sources to Cascade Creek include upland runoff from agricultural and urban land and channel and near channel stream processes. Factors influencing elevated sediment loads and high turbidity levels in the stream include altered hydrology, agricultural runoff, and legacy impacts of past disturbance. Increases in stream flow are not only a result of more intense storm events but also of increasing implementation of tile drainage on the landscape and urban stormwater runoff. This results in increased water levels within riverine systems resulting in greater levels of stream bank erosion and instream sedimentation, impacting water clarity, and diminishing the quality of aquatic habitat.

High turbidity and excess sediment come from multiple pathways in the watershed, including both point and nonpoint sources. Suspended sediment sources primarily include row crop agriculture, inadequate buffers near streams and intermittent waterways, and runoff from impervious surfaces. Stream channel and floodplain erosion and bank slumping are also sediment sources (MPCA, 2012). Cropland loss of sediment occurs with overland runoff and wind erosion. Sediment loss can also occur with tile drainage when open inlets are present. Erosion from cropland occurs when heavy rains fall on poorly vegetated fields, transporting soil via surface runoff and tile intakes into waterways.

Pollutant loading is exacerbated with drainage ditches and channelization that contribute to increased water velocities and peak flows. The potential for streambank erosion is increased with straightened channels as water flows tend to revert the channels to a meandering condition by eroding the channel banks. Drain tiling from agricultural settings into these ditch systems tends to exacerbate the condition. Streambank erosion occurs with the presence of unstable streambanks resulting from channel, watershed, and weather changes.

The estimated source contributions of sediment to Cascade Creek is shown in Figure 13.

Figure 13. Sediment loading by source (PLET, 2022)



The sources of nitrogen and phosphorus in the watershed are shown in Figure 14 and Figure 15. The largest contributors of both nitrogen and phosphorus are cropland, urban, and pasture. Overland runoff and tile drainage are the primary pathways of the nutrient runoff with tile drainage accounting much of the nitrogen loading and dissolved component of phosphorus loading. This is especially prevalent given that much of the poorly drained row cropland in the watershed has been pattern tiled to improve drainage (MPCA, 2012). The increased tiling also alters the hydrology of the watershed resulting in increased pollutant loads.

Figure 14. Nitrogen loading by source (PLET, 2022)

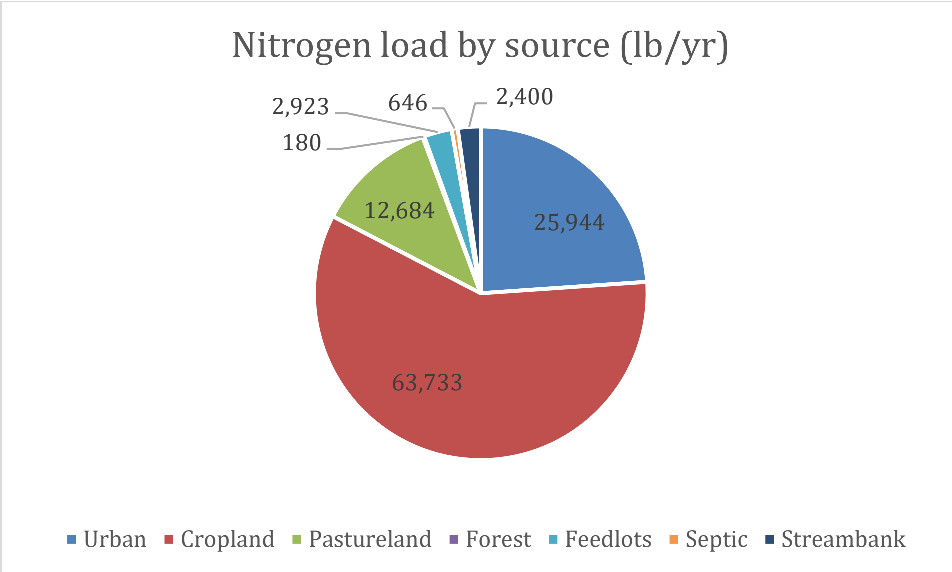
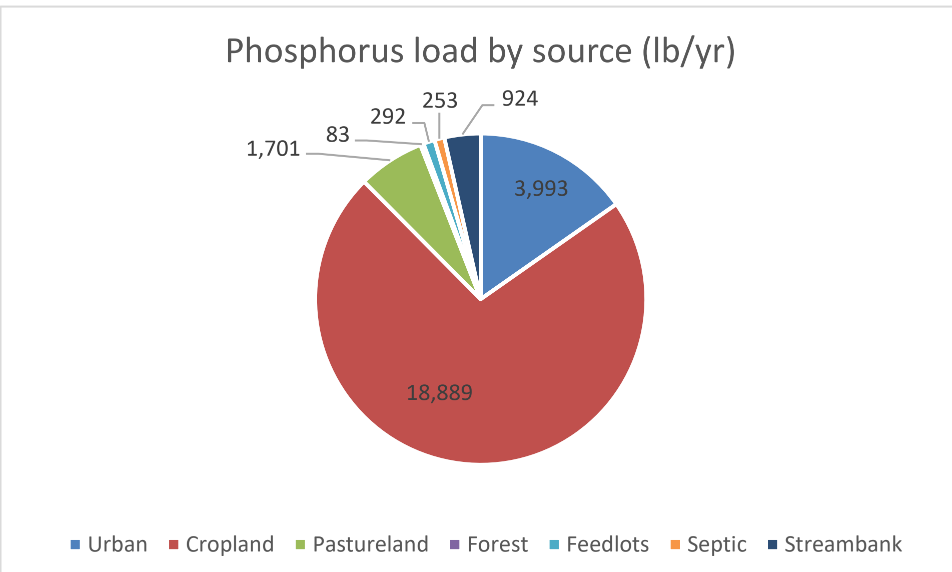


Figure 15. Phosphorus loading by source (PLET, 2022)



Impervious surfaces (roads, parking lots, roofs, etc.) contribute direct runoff, increasing the amount of water in the stream. The increased runoff subsequently leads to increased stream bed and bank erosion, adding more suspended sediment and nutrients to the stream. (MPCA, 2012). Approximately 6,800 acres or 32.2% of the watershed, comprising western Rochester and surrounding urbanized areas along the Highway 14 corridor, are subject to MS4 regulations (MPCA Zumbro River Watershed Turbidity TMDL). The default breakout of urban land uses from PLET are summarized in Table 15.

Table 15. Urban land use distribution (default values from PLET (2022)

Type	Percent	Acres
Commercial	15%	1,008
Industrial	10%	672
Institutional	10%	672
Transportation	10%	672
Multi-family residential	10%	672
Single family residential	30%	2,016
Urban cultivated	5%	336
Vacant	5%	336
Open space	5%	336
Total urban		6,721

Element b. Estimated reductions

> *An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded stream banks).*
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Load reductions were calculated using the Pollutant Loading Estimation Tool (PLET) for the practices outlined in this plan (Table 6). The estimated pollutant loads before and after BMP implementation are summarized in Table 16. The reductions from practices described in this plan and implementation already completed in this watershed are summarized in Table 17 and Table 18. The total estimated reductions for the past work completed and implementation in this plan will reduce sediment loading by 11,440 t/yr. This exceeds the TMDL reduction needed to meet the TMDL (11,262 t/yr).

Table 16. Estimated pollutant loads before and after BMPs, with estimated load reductions, in the Cascade Creek South Branch Watershed

	Starting loads			Post implementation		
Watershed	**N (lbs/yr)**	**P (lbs/yr)**	**Sediment (t/yr)**	**N (lbs/yr)**	**P (lbs/yr)**	**Sediment (t/yr)**
Cascade Creek	120,205	28,767	15,017	80,680	25,889	11,668

Table 17. Estimated pollution reduction by land use in the Cascade Creek South Branch Watershed (PLET, 2022)

Watershed	N Reduction (lbs/year)	P Reduction (lbs/year)	Sediment Reduction (tons/year)
Reductions from combined Cropland practices	39,396	13,034	8,944
Reductions from pasture practices	2,168	301	152
Reductions from combined Urban practices	601	149	19
Reductions from combined Feedlot practices	11,684	2,753	--
Streambank restoration practices	2,280	878	1,425
Totals Reductions	**76,344**	**24,521**	**10,540**

Table 18. Work completed in Cascade Creek Watershed 2012-2020 (Healthier Watersheds, 2022)

Watershed	N Reduction (lbs/year)	P Reduction (lbs/year)	Sediment Reduction (tons/year)
Reductions completed – combined Cropland	3,717	1147	765
Reductions completed - combined Urban practices	43	8	2
Completed streambank restoration practices	577	222	361
Totals Reductions	**4,337**	**1,377**	**1,128**

BMPs often function as a system, and the reductions summarized in Table 17 and Table 18 were modeled using the combined efficiencies of the practices using the PLET BMP calculator.

Element c. Best management practices

> *A description of the BMPs (NPS management measures) that are expected to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas (by pollutant or sector) in which those measures will be needed to implement this plan.*
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Various tools and models have been used to target and prioritize management activities in the Zumbro River Watershed. This plan used these tools to begin identifying the critical areas contributing the most sediment and nutrients in the Cascade Creek subwatershed. Further analysis using individual components of the tools provide the next level of critical area identification for use in targeting specific areas for implementation activities.

Restoration strategies provided in the Zumbro River WRAPS report are focused on core combinations of BMPs that were examined closely by technical practitioners and vetted with local stakeholders. The nutrient BMP spreadsheets for both nitrogen and phosphorus (developed by the University of Minnesota) were used to iteratively to examine the estimated reductions associated with combinations of practices (https://wlazarus.cfans.umn.edu/nbmp-xlsm-spreadsheet-downloads). HSPF model scenario simulations showed general agreement with the reduction estimates provided by the spreadsheets. The PLET model, used in this plan, show similar breakdowns of loading and estimated reductions.

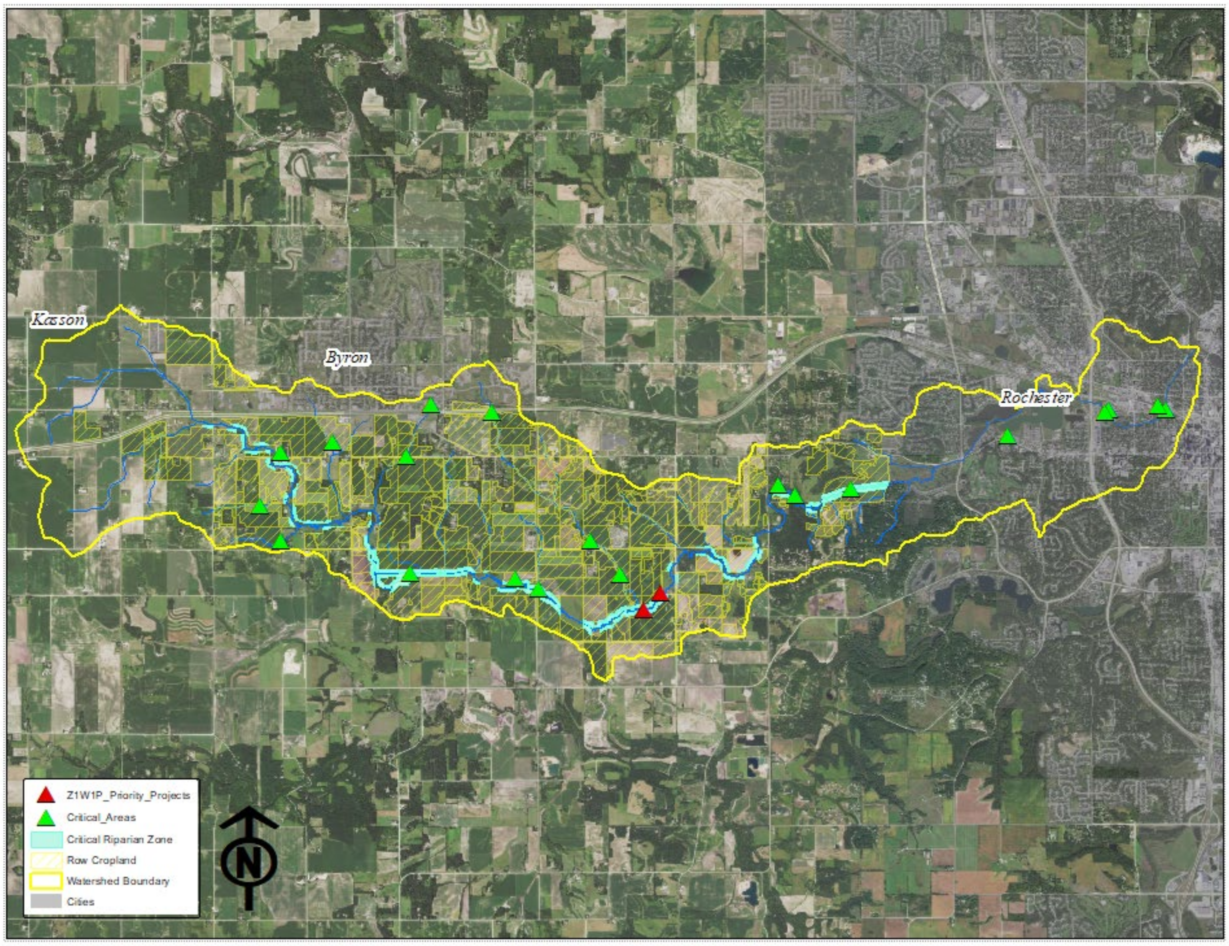
The planned BMP implementation and stream restoration activities are listed in Table 12.

Critical areas

The Zumbro River Watershed HSPF model simulated that upland sources contribute 42% of the sediment load for the entire watershed followed by bed and bank erosion (39%) and gully and ravine erosion (18%) (MPCA, 2017). The assessment described below, in the Cascade Creek watershed identified the most critical areas potentially contributing sediment from these sources. A map of critical areas is shown in Figure 16 with descriptions of the areas following the figure.

The critical areas and priority project locations were identified in a digital terrain analysis by Barr Engineering, Inc. in 2016 as part of a whole Zumbro River Watershed analysis. The analysis identified catchment outlet locations where beneficial field practices could be implemented. Of the top 50 priority locations in the Zumbro River Watershed based on pollutant loading and local geospatial characteristics, two locations are in the Cascade Creek watershed (red triangles in Figure 16).

Figure 16. Critical areas in Cascade Creek for implementing management measures.



Critical areas (green triangles in the figure) were identified as failing structural best management practices and the absence of critical best management practices that, if implemented, would provide substantial benefit to receiving waters. These have been identified based on staff knowledge of the landscape and historical information on previously implemented structural best management practices. Critical riparian zones are shown as a blue outline in Figure 16. Restoration and protection in these areas will trap pollutants from overland flow, provide important habitat corridors for plants and animals, and reconnect the floodplain during times of high flow**.** The channelized stream reaches shown in bold blue outline are also identified as areas where restoration efforts could be utilized to address bank erosion and channel stability.

The DNR is developing a Watershed Assessment of River Stability and Sediment Supply (WARSSS) for Cascade Creek that will identify additional critical areas for implementation. The WARSSS framework is a systemic and repeatable way of understanding stream channel stability and sedimentation. When completed, it will provide smaller catchment scale estimates of excess sediment loads, including their underlying cause(s). This provides a foundation when developing prioritized restoration and protection management strategies. Recent sediment studies suggest in TSS impaired systems excess sediment coming from in-channel sources are a much higher percentage of the total load than overland sources. How the proportionality of these loads change from headwaters to the mouth is critical in allocating fiscal and staff resources. The WARSSS report is expected to help increase the specificity of the targeting of practices within the critical areas established in this plan. Information will be incorporated into this plan when the report is available. It is not expected to dramatically change the course of the activities and plans.

Figure 17 illustrates two stream reaches that are critical loading areas. The two streambank reaches are planned for restoration (Table 12). The reaches were identified in a 2014 assessment as having steep slopes and highly erodible soils causing bank instability. These conditions have the potential to create unsafe conditions for users of the adjacent parks and trails and raise flood levels by trees and banks encroaching into the channel. Restoration will require bank stabilization, potential flood control improvements, sediment removal, and channel improvements to remove restrictions as Cascade Creek flows through the city of Rochester (Yaggy Colby, 2014).

Figure 17. Stream reaches planned for streambank restoration in two phases.

Figure 18 shows streambank erosion along the creek in the old Meadow Lakes Golf Club. The location of the eroding reach is illustrated in Figure 19. The reach was actively incising and eroding the stream banks with an estimated 550 tons of sediment eroded per year (Table 19). The reach was contributing approximately three times more sediment per foot of stream than any other reach surveyed in the entire Cascade Creek Watershed (MPCA, 2016c). A rehabilitation project was completed from 2014 to 2019 and restored the former 40-acre golf course with a new channel and reconnected the floodplain (Figure 20). Five wetland basins were also built and planted with native vegetation. The project virtually eliminated the erosion problem that once fed 550 tons of sediment per year into Cascade Creek. The project successes are summarized https://www.dnr.state.mn.us/waters/csg/site.html?id=41065002.

Figure 18. Bank Erosion, South Branch Cascade Creek 2007

Figure 19. Location of Meadow Lakes Golf Course stream project

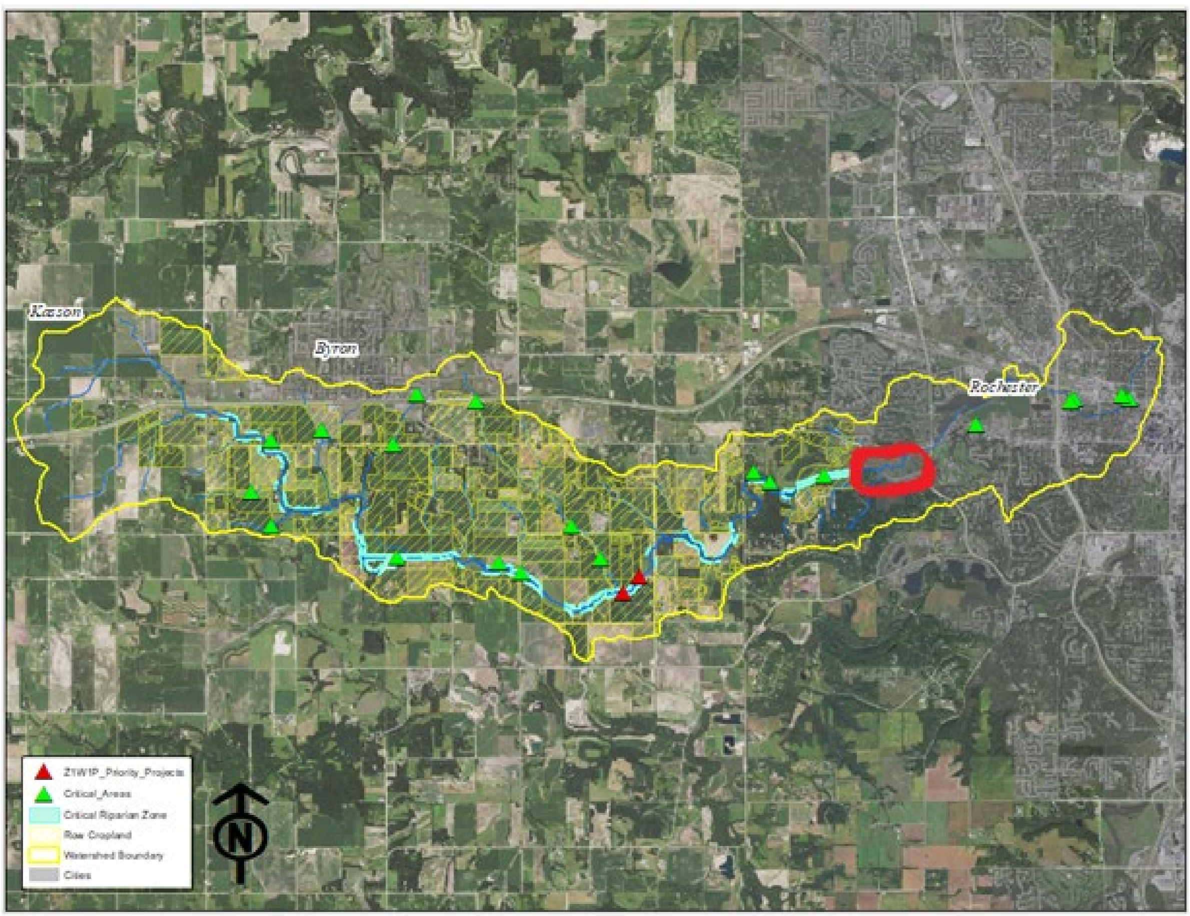


Table 19. Streambank erosion rates estimated for the South Branch Cascade Creek Stream Channel and Floodplain Restoration

Year	Streambank erosion rate/load (tons/year)
2011 (pre-restoration)	545
2014 (pre-restoration)	750
2019 (post-restoration)	160
2022 (post-restoration)	68

Figure 20. South Branch Cascade Creek Stream Channel and Floodplain Restoration Project

Element d. Expected costs and technical assistance

An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement the entire plan (include administrative, Information and Education, and monitoring costs). Expected sources of funding, States to be used Section 319, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds to assist in implementing this plan.

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The estimated costs of the activities in this plan are shown in Table 12. The total estimated cost to attain the sediment reductions needed to achieve the TSS water quality standard for Cascade Creek is $8,557,750.

The implementation strategies outlined in this plan will be achieved through an extensive partnership network that has a successful history of collaborating on watershed projects. Partner organizations in the Greater Zumbro Watershed recently formalized their partnership through the Watershed Alliance of the Greater Zumbro (WAGZ). Member organizations are:

- Dodge County
- Dodge Soil and Water Conservation District
- Goodhue County
- Goodhue Soil and Water Conservation District
- Olmsted County
- Olmsted Soil and Water Conservation District
- Rice County
- Rice Soil and Water Conservation District
- Wabasha County
- Wabasha Soil and Water Conservation District
- Steele Soil and Water Conservation District
- Bear Valley Watershed District
- City of Rochester, MN

The WAGZ organizations also partner with state and federal agencies including, but not limited to National Resource Conservation Services (NRCS)/Environmental Quality Incentives Program (EQIP), U.S. Farm Service Agency (FSA), U.S. Fish and Wildlife Services (USFWS), Minnesota Department of Natural Resources (DNR) (forestry, fisheries, wildlife, waters), Minnesota Department of Health (MDH), Minnesota Department of Agriculture (MDA), Minnesota Board of Soil and Water Resources (BWSR), and MPCA. These partners provide technical support, research data, field work, monitoring, and funding for implementation projects. Additionally, these partners interact with the community and provide education and outreach.

Through intentional relationship building efforts, reciprocal partnerships have also been established with local, non-profit organizations and community groups that all value healthy waters. Some of these organizations include:

- Rochester Art Center
- History Center of Olmsted County
- The Diversity Council
- Zumbro Valley Audubon Society
- EarthFest Rochester MN
- Mayo Clinic - Sustainability
- University of Minnesota Extension
    - Master Gardeners
    - Master Naturalists
- Rochester Community Education

These partners will be integral to helping to reach and educate the citizens and users of the Cascade Creek Watershed. In addition to outreach and education, the UMN Extension program can be a source of technical assistance and field work to both watershed professionals and the community. The City of Rochester has a robust and diverse population that requires purposeful interaction and outreach.

Potential funding sources will be obtained from city and county funding and support, NRCS-EQIP, DNR, BWSR implementation funding and grants, MPCA grants, stormwater grants, and other federal, state, and local grant opportunities. Private organizations and non-governmental organizations (NGOs) are also a source of support and funding. In-kind services and support will be sought from volunteers, citizens, and other interested parties.

Our implementation strategies will have a greater impact by working with our partners towards the common goals outlined in this plan.

Element e. Education and outreach

> *An information/education component that will be implemented to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, implementing, and maintaining the NPS management measures that will be implemented.*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

Public participation and education are necessary to successfully implement this Plan and achieve meaningful progress towards Plan goals. Our partners will utilize the International Association for Public Participation (IAP2) public participation spectrum (Figure 21) to determine the appropriate level of community engagement during each phase of the planning and implementation process. Our partners expect that financial, technical, and engineering studies will determine what is feasible in the watershed, and community engagement will determine what's desirable by stakeholders.

Figure 21. International Association for Public Participation (https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf)

INCREASING IMPACT ON THE DECISION

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Our public participation will focus on collaboration and involve levels during the planning and prioritization process and then move into consult and inform as project implementation occurs. Planned levels of engagement include.

- Collaborate:
    - Create a resident advisory committee that practices consensus building and participatory decision-making. Members of this committee will be:

        - Members of Community Advisory Committee from City of Rochester
        - Comprehensive Surface Water Management Plan
        - Members of Neighborhood Associations
        - Members of Byron Area Farmers group
        - Other residents and regional stakeholders that express interest
- Involve:
    - Site visits and site-specific technical assistance (e.g., structural BMP practices) nutrient management plans
    - Workshops (e.g., to promote implementation of soil health BMPs to agricultural producers, urban water stewardship practices)
    - Demonstration projects/research sites
    - Volunteer events
- Consult:
    - Surveys
    - Public Meetings
- Inform:
    - Websites
    - Social media posts
    - Targeted mailings
    - News articles/press releases (project- or initiative-specific)
    - Educational handouts (e.g., information about vegetated buffers, groundwater conservation)
    - Public presentations to community groups and school groups
    - Exhibitor events (county fair, EarthFest)

Our public engagement and education efforts will build upon existing relationships, project partnerships, and outreach efforts. The City of Rochester has an Environmental Education Specialist as a member of this team that will coordinate these efforts in collaboration with Olmsted and Dodge team members, as identified in Table 12.

The adoption of soil health practices amounts to a cultural change in this area. While reductions from implementing the practices are important, the Cascade Creek Watershed partners are also focusing on facilitating the cultural change to encourage the adoption of these practices. These activities include targeted education events, including field trials, events, and peer-to-peer learning. The WAGZ offer Cover Crops 101 classes to watershed landowners to help provide technical information and how-to information. Even more importantly, the partners are facilitating a “coach-the-coach” program to utilize the known peer effect on adoption.

Element f. Reasonably expeditious schedule

> *A schedule for implementing the activities and NPS management measures identified in this plan that is reasonably expeditious.*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

The schedule for this watershed plan is designated in 2-year increments described in Table 12. When implemented as planned, the activities and BMPs described will reach the estimated reductions needed to meet water quality standards in 10 years.

Element g. Milestones

> *A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

The planned milestones for this watershed are designated in 2-year increments and will take place over the next 10 years (2022-2032). Specific milestones for each activity are captured in Table 12. The accomplishment of these milestones will be used to evaluate the implementation of this plan.

Element h. Assessment criteria

> *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

The assessment criteria for this watershed are designated in 2-year increments and the unit of measure is described in Table 12. The assessment criteria and achievement of milestone goals will be used to measure the accomplishment of this NKE plan. It is difficult to anticipate the response of the stream to BMPs within a 10-year period. While water chemistry and other water quality monitoring is considered the gold standard, to encourage the continued adoption and support of these efforts, alternative and additional measures must be employed. The connection of BMPs on the landscape to the response in chemistry changes can be difficult to communicate to the public. The milestones described in Table 12. Applicable land use, eligibility, BMPs, activities, implementation schedule, milestones, assessment criteria offer an alternative means of measuring, and importantly, communicating the successes to support the forward momentum of implementation adoption. There are estimated reductions associated with these practices which will allow watershed professionals to have an approximate idea of the loading changes to be expected. These milestones are to ensure that the expected reductions are taking place. Traditional water quality monitoring (chemical, sediment, and biological) and the visual inspections of the watershed demonstrate success. Visual inventories of streambank erosion, gullies, and field runoff can be the leading indicator of the success of implementation.

Adaptive management

Adaptive management is an approach to water quality restoration efforts where BMP implementation efforts are combined with an on-going evaluation of the water quality issues. Effects of implemented BMPs are reflected by adjustments to the resource goals, implementation plan and/or implementation efforts when needed. Adjustments are made to incorporate the knowledge gained through the combined efforts. Adaptive management¬—sometimes referred to as adaptive implementation—is critical when various uncertainties are significant in a watershed (Shabman et al., 2007). This approach is essentially a “learning while doing” approach. It means that uncertainty is not forgotten once implementation begins. Rather, a focus is placed on reducing the uncertainty present through implementation, monitoring and evaluation, research, and experimentation. The knowledge gained through these efforts is then focused on reducing the uncertainties in the TMDL, the implementation approaches and/or water uses and criteria. The approach goes beyond just asking “when” in implementation, to include “where, what, how and why” (Shabman et al., 2007).

Uncertainties related to the water quality criteria, TMDL numbers, sediment sources and aquatic life stressors are present in the Cascade Creek TMDL report, even though much was learned through the TMDL study. Through an adaptive management approach, this initial implementation plan has been developed to begin implementation activities, continue survey and inventory efforts and evaluate the progress toward meeting the aquatic life goals for the river. As this work is completed, the TMDL implementation goals, priorities and BMPs will be examined and revised, as needed.

The Cascade Creek 319 workgroup anticipates a biennial review process including an assessment of partnership operations and self-assessment of workload and delivery of implementation actions. The biennial assessment will consider the pace of progress toward the plan goals and will provide additional data that may impact plan priorities and help define future implementation activities. A more thorough evaluation of plan progress will take place toward the end of the first grant. Over the life of the nine-key element plan, information may arise that warrant revisions to the plan. New priority issues may emerge, or strategies may need to be adjusted. The relative importance of existing issues may change based on monitoring data, modeling results, or shifting priorities of the partners.

At the time of writing the plan, the partnership developed the following prompts and associated responses to help guide the adaptive management approach:

- Are the most significant sediment sources being addressed?
    - If not: re-evaluate the sources, determine whether different funding sources are needed to target sources.
- Is voluntary BMP adoption meeting the targets in the plan?
    - If not: Consider putting additional funds toward field walk overs and outreach staff for making one on one connections with producers, find ways to leverage more watershed-based implementation funding or increasing cost-share on projects, increase development of outreach materials to targeted areas to better communicate the issues and the need to work collaboratively to meet our water quality goals.
- Are the installed BMPs performing as intended?
    - If not: Consider an assessment of what other BMPs would have a larger impact for this area such as water storage practices and find additional funding sources, consider is more monitoring is needed to assess upstream sources, consider if additional modeling is needed to assess increased precipitation or hydrology changes.
- Are risks to under-represented populations being mitigated?
    - If not: Consider putting additional funding into outreach staffing and development of materials for communicating risks and working together on solutions with other agencies and partners.

Element i. Monitoring

> *The monitoring & evaluation component to track progress and evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.*
>
> *EPA Handbook for Restoring and Protecting Our Waters*

The State of Minnesota agencies and local partners, including the Dodge County SWCD, Olmsted County SWCD and the City of Rochester, have identified Cascade Creek as a priority stream. This is evident from the long term biological and chemical monitoring completed by the DNR and MPCA in Cascade Creek since 2000. Regular biological and chemical monitoring will continue with the DNR and MPCA through the duration of this project.

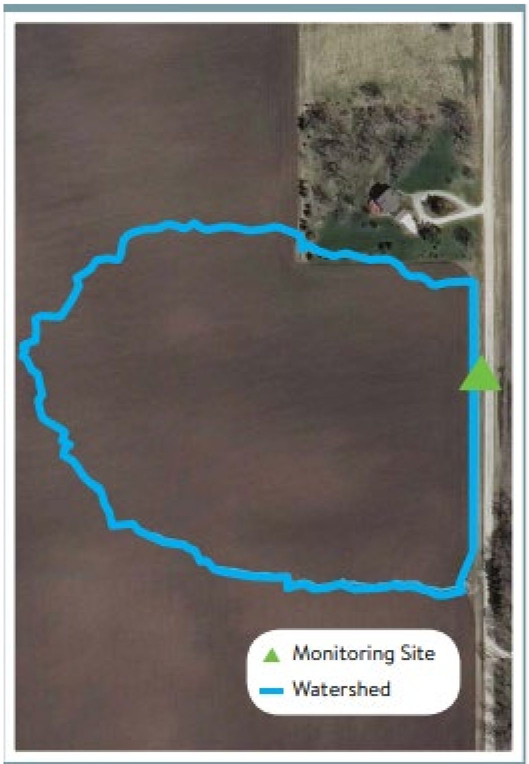
Streamflow monitoring will continue at the two sites currently being monitored. Volunteer monitoring (MPCA Citizen Volunteer Monitoring Program) of Secchi transparency will continue. Eight sites have been monitored by volunteers in the past with five sites with recent monitoring. The implementation workgroup will promote continued monitoring at these sites and other critical sites in the watershed. The MPCA plans to continue the continuous turbidity and temperature monitoring at the four current sites in partnership with the Olmsted SWCD. These sites are listed in Table 5.

The second cycle of Intensive Watershed Monitoring (IWM) by MPCA will occur in 2024 followed by use assessments in 2025. Water quality assessments have historically included dissolved oxygen, phosphorus, nitrate, *E. coli*, fish, and macroinvertebrates. The IWM monitoring will include two to three sites, using the MPCA's state and local needs process to determine the sites.

To determine the effectiveness of best management practice implementation proposed in this plan, additional monitoring will be required. Additional discharge and pollutant monitoring downstream, near the confluence with the Zumbro River will help isolate effectiveness of implementation and other changes in the different areas of the watershed, as well as the overall pollutant load being delivered from Cascade Creek to the Zumbro River and any reductions thereof. There is regular monitoring of TSS at five prior and existing MPCA sites located at: Frontier, County Line Road, County Road 3, 45^{th}St, and County Road 22.

A Discovery Farm site on the Ralph and Donna Herbst farm located in Dodge County, near the headwaters of Cascade Creek was monitored from 2012-2019. Their farm was selected as a site because it was representative of typical landscape and crop production practices in the region. Figure 22 shows the field watershed and location of the monitoring site. The implementation workgroup will work with MDA and Discovery Farms staff to continue a similar monitoring approach using edge of field data collection at sites near the headwaters of Cascade Creek to help inform how well BMPs and beneficial soil health practices are performing to provide better estimates of the effectiveness and investment to continue those practices. Current lysimeter, tile, and spring monitoring networks will be expanded to monitor effectiveness of practices and to determine what the observable reduction is for specific practices.

Figure 22. Watershed delineation to Herbst Farm Monitoring Site



The Discovery Farms Minnesota site was designed to provide information to better understand how farm management practices can impact sediment and nutrient movement through surface runoff and tile lines in the region. Additionally, the study provided necessary “edge of field data'' to help analyze how agricultural practices impact local water quality data (Herbst Farm (discoveryfarmsmn.org)).

Connecting localized and broader changes in the water quality with land use changes and implementation of BMPs within Cascade Creek and sharing this information and feedback with local partners will keep them invested in the process and will help inform how well the BMPs are performing. The collected information can also be used in watershed predictive models to provide better estimates of effectiveness of BMPs especially in the unique landscape of southeastern Minnesota.

References

Barr Engineering, Inc. 2021. Comprehensive Watershed Management Plan: 2022-2031. Prepared through the One Watershed One Plan Program on behalf of the Watershed Alliance for the Greater Zumbro. November 2021

Bonestroo, 2005. Cascade Lake Master Plan. Prepared for the City of Rochester. January 2005.

Bonestroo, 2008. Peak Flow Reduction Opportunities in the Cascade Creek Tributaries. Prepared for Olmsted County. November 2008.

City of Rochester, 2021. Sustainability and Resiliency Community Work Plan. [Sustainability & Resiliency Community Work Plan | Topic List | Rochester, MN (rochestermn.gov)]

Dodge County Technical Water Planning Committee. May 2016. Approved Sept 12,2006, Amended Plan Approved by BWSR 12-14-2011. Dodge County Water Management Plan 2006-2016 (including 2017-2021 Amendment. https://www.co.dodge.mn.us/EnvironmentalServices/Final%20Dodge%20County%20Amended%20Comprehensive%20Water%20Plan.pdf

LimnoTech. September 21, 2015 (Revised October 19, 2015. Task 3: Technical Memorandum to Document Tasks 1 and 2—Refinement of the ZRWHSPF Watershed Model and Application to Management Scenarios. Memorandum

LimnoTech. 2017. Zumbro River Watershed Restoration and Protection Strategies Report, Minnesota Pollution Control Agency. Prepared for the Minnesota Pollution Control Agency. Prepared by LimnoTech. November, 2017.

Lenhart, C. et al. 2017. The Agricultural BMP Handbook for Minnesota, Second Edition. Minnesota Department of Agriculture. 2017.

Minnesota Department of Health (MDH). July 2019 (GRAPS Report #10). Draft Zumbro River Watershed Groundwater Restoration and Protection Strategies (GRAPS) Report

Minnesota Pollution Control Agency (MPCA). 2012. Zumbro River Watershed Total Maximum Daily Loads for Turbidity Impairments. Prepared for US Environmental Protection Agency, Region 5. January, 2012.

MPCA. Minnesota Stormwater Manual Wiki. Minnesota Stormwater Manual (state.mn.us) Accessed September 2022.

MPCA. 2014. Minnesota Nutrient Reduction Strategy

MPCA. 2016a. Development of Biological Criteria for Tiered Aquatic Life Uses: Fish and macroinvertebrate thresholds for attainment of aquatic life use goals in Minnesota streams and rivers.

MPCA. 2016b. Zumbro River Watershed Monitoring and Assessment Report.

MPCA. 2016c. Zumbro River Watershed Stressor Identification Report.

MPCA. 2017. Zumbro River Watershed Restoration and Protection Strategy Report (Zumbro WRAPS)

Rochester, City of. 2013. Water Primer.

Rochester, City of. 1999 (updated in 2004). 1999 Stormwater Management Plan.

Rochester-Olmsted Planning Department. 2013-2023 Olmsted County Water Management Plan. https://www.olmstedcounty.gov/sites/default/files/2020-11/County%20Water%20Management%20Plan%20%281%29.pdf

SEH. 2007. Cascade Creek Flood Modeling and Corridor Planning. Prepared for City of Rochester, MN. November 2007.

Shabman, L., K. Reckhow, M.B. Beck, J. Benaman, S. Chapra, P. Freedman, M. Nellor, J. Rudek, D. Schwer, T. Stiles and C. Stow. 2007. Adaptive Implementation of Water Quality Implementation Plans: Opportunities and Challenges. Nicholas School of the Environment and Earth Sciences, Nicholas Institute, Duke University. NI R 07-03. 98 pp.

Yaggy Colby. 2014. Stabilization Feasibility Study for Cascade Creek (Highway 52 to 7th Street NW). Prepared for City of Rochester, MN. April 2014.

Zumbro Watershed Partnership (ZWP). 2012. Zumbro Watershed Comprehensive Management Plan, Sediment Reduction Component. wq-iw9-13c. August 9, 2012.

Zumbro River Watershed Partnership (ZWP). 2014. Zumbro River Watershed Restoration Prioritization. June 30, 2014.

Appendix A: PLET output and assumptions

The practices described in this plan were calculated for estimated reductions using the U.S. EPA PLET model. The following assumptions and practices were used to estimate reductions associated with the plan.

The PLET model has a component to calculate estimated reductions and loading from streambank erosion. The inputs and reductions are summarized in Table 20.

Table 20. Streambank restoration assumptions, loads, and reductions (PLET, 2023).

Length ft	Height ft	Lateral recession	Rate range ft/yr	Rate ft/yr	BMP efficiency %	Soil class	Soil weight t/ft^3	Annual load t/yr	Load reduction t/yr
18,748	4	Very Severe	0.5+	0.5	0.95	Silty clay loam, silty clay	0.04	1499.84	1424.848

Table 21. Combined efficiencies by land use (PLET, 2023)

Land use	BMP efficiency		
	N	P	TSS
Cropland	0.56	0.771	0.59
Pastureland	0.161	0.14	0.2
Feedlots	0.8	0.9425	0

Table 22. Estimated load reductions by land use and pollutant (PLET, 2023)

Sources	N load (lb/yr)	P load (lb/yr)	BOD load (lb/yr)	Sediment load (t/yr)
Urban	25343	3844	99040	578
Cropland	44730	9582	138545	4979
Pastureland	10548	1407	37232	605
Forest	180	83	421	19
Feedlots	2921	168	19473	0
Septic	646	253	2640	0
Streambank	2400	924	4799	1500
Total	**86768**	**16261**	**302151**	**7681**