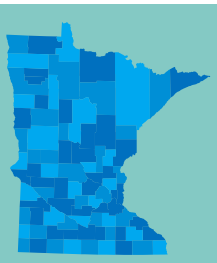
Grant

August 2022

Brown's Creek Watershed Nine Key Element Bridge Document

MINNESOTA POLLUTION CONTROL AGENCY



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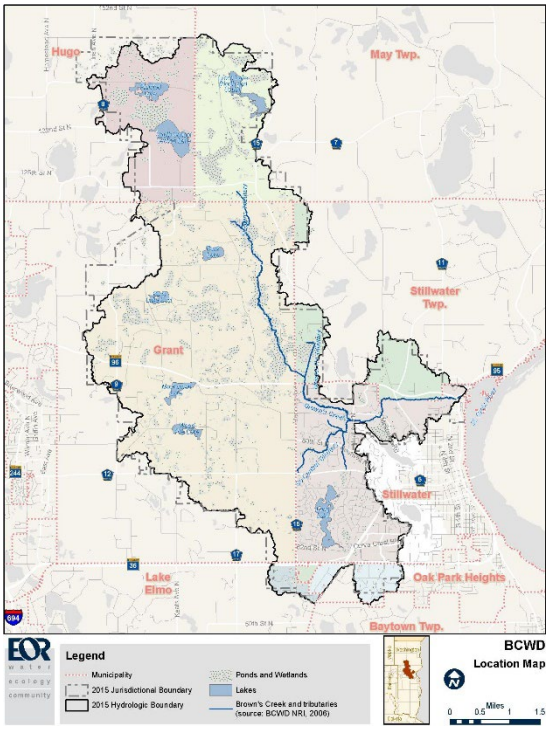
Executive summary

The Brown's Creek Watershed District (BCWD) is made up of communities interlaced with natural corridors. These natural corridors improve the function and value of the District's water resources and support a diverse population of plants, wildlife, and fish. The District brings people and the environment together to accommodate development that preserves the connection between surface water and groundwater and enhances the quality of these resources (https://bcwd.org/). The BCWD's work has recently been recognized with two national awards. The BCWD 2017-2026 Watershed Management Plan (The Plan) provides the direction for getting water resource improvement projects on the ground (website).

Historically the BCWD's focus has been on protecting the trout stream from the impacts of development by adopting stormwater management rules and retrofitting those portions of the watershed that were developed before stormwater management rules were in place. "Over the course of the last 15 years, the BCWD has transitioned from being an organization focused on the protection of a single species to one that is focused on the ecological health of the entire Brown's Creek corridor and the lakes, ponds and wetlands that support the constant source of groundwater to this cold water fishery. In addition, the BCWD recognizes the contributions it has on the St. Croix River, which is designated as a National Scenic Riverway" (BCWD, 2019, p. xvii).

This nine key element (NKE) document addresses the impairments in Brown's Creek and Long Lake in the BCWD, including an unnamed creek between Brown's Creek and Long Lake.

Figure 1. Brown's Creek Watershed (BCWD Plan, 2019)



Development of a NKE plan in conjunction with the existing Plan presented a complex challenge to mesh all of the varied programmatic requirements. Water and watershed plans in Minnesota are generally developed on a 10-year timeline with specific activities and projects that will be reasonably achieved

within the current funding and capacity of the watersheds. The EPA NKE plan requires that the 10-year timeline identify and adaptively work to implement activities and projects that will be required to meet the reductions needed to meet water quality standards. Part of the NKE plan is to work to identify and adaptively implement means to achieve these goals.

The Plan, along with the Long Lake management plan (LMP), uses an adaptive management approach. The Plan and LMP combined with the documentation described in this bridge document, fully provide the NKEs identified by EPA as critical in a watershed plan for achieving improvements in water quality for the waterbodies. This NKE document summarizes the details required to meet the NKEs and the BCWD planning processes.

Funding of projects proposed in this plan may be restricted to funding source. Only projects and practices that are allowable by EPA's 2014 program guidelines and Minnesota's Nonpoint Source Program Management Plan (except where noted in the MPCA's NPSMPP) will be funded by the Federal Clean Water Act Section 319 funds. Match funds and activities must also be eligible under the guidelines and plan.

Water quality conditions

The BCWD uses an extensive monitoring program to understand the watershed, evaluate issues, and determine appropriate watershed management approaches within the watershed. The water quality data was used in identifying Brown's Creek, Long Lake, and an unnamed creek between Brown's Creek and Long Lake as impaired for one or more designated use per the Clean Water Act and state water quality standards (Table 1).

Table 1. Summary of listed impairments of the Brown's Creek Subwatershed

Water body name	Water body description (AUID)	Water body type	Year added to List	Use lclass	Affected designated use	Pollutant or stressor	TMDL approved/ target completion year
Long Lake	Lake or Reservoir (82-0021)	Lake	2002	2B, 3C	Aquatic Recreation	Nutrients	2023
Brown's Creek	T30 R21W S12, north line to T30 R21W S13, east line (07030005-587)	Stream	2004 2010 2002 2012	1B, 2Bdg, 3B	Aquatic Life Aquatic Recreation	Benthic macroinvertebrates bioassessments Dissolved oxygen Lack of cold water assemblage *E.coli*	2023
Brown's Creek	T30 R20W S18, west line to St Croix R (07030005-520)	Stream	2010 2008 2010	1B, 2Ag, 3B	Aquatic Life	Dissolved oxygen Lack of cold water assemblage Turbidity *E. coli*	2023 2010 2010 2023
Unnamed creek	T30 R20W S19, south line to underground diversion (07030005-767)	Stream	2012	1B, 2Bdg, 3B	Aquatic Recreation	*E. coli*	2023

Long Lake

Long Lake was listed as impaired for eutrophication in 2002 due to elevated levels of total phosphorus (TP) and chlorophyll-*a* (Chl-*a*). The lake received a lake grade of F in 2002 and has a C+ in 2020, using the Metropolitan Council's lake grade system. The lake has been a priority resource for the BCWD and has been the target of extensive study and implementation. As a result of the activities, the lake TP and Chl-a concentrations have decreased and the lake now meets the shallow lakes nutrient criteria at site 201 in the north basin (Figure 2). However, the criteria are not met at the other stations. TP concentrations are highest at the south station (Figure 3), which is in a very shallow area that at times supports dense vegetation. The June – September average water quality conditions are shown in **Error! Reference source not found.**, along with the North Central Hardwood Forest ecoregion shallow lake eutrophication standard criteria.

Table 2. Long Lake Monitoring data summary (pre-2004-2020)

		Growing season average (June-Sept)		
		Total Phosphorus	**Chlorophyll-a**	**Secchi Depth**
	Period	**(µg/L)**	**(µg/L)**	**(ft)**
North Central Hardwood Forest – Shallow Lake Standard		<60	<20	>3.3
Baseline	**1989-2004**	**115**	**81.5**	**2**
2015 Progress to goals report	2004-2013	75	26	4.3
Progress to 2020	2011-2020	55	30	4.9

The TP and Secchi-depth transparency criteria of the standard are being met, but the Chl-*a* criterion is not being met. The MPCA assessed the lake for delisting as impaired for aquatic recreation use in 2021 and made an inconclusive determination, such that the nutrient impairment will remain.

Implementation activities will continue in lieu of completing a TMDL given that the standard is currently being met and the water quality will be reassessed. The trend analysis of the TP, Chl-a, and Secchi-depth transparency shows statistically significant improving trends on Long Lake. If water quality continues to improve, a TMDL will not be needed and attention can be given to protecting the water quality of the lake.

Figure 2. Long Lake growing season means of TP, Chl-*a*, and Secchi, site 201

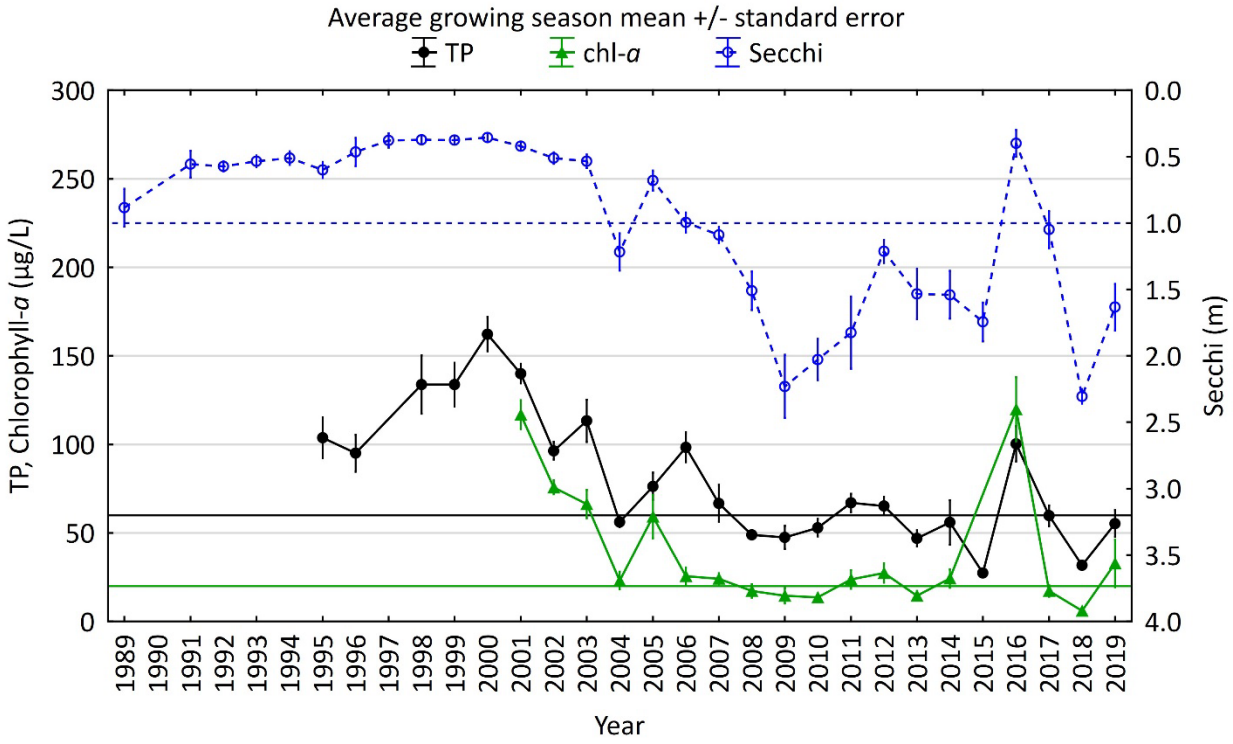
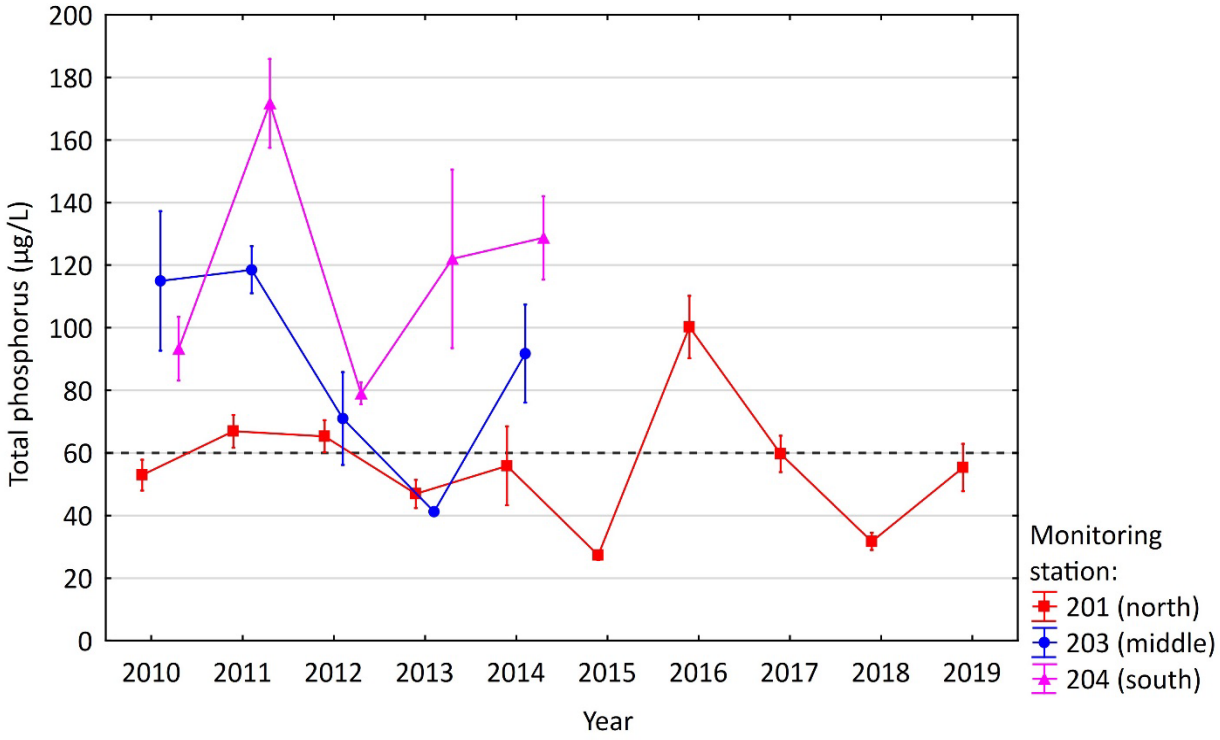


Figure 3. Long Lake total phosphorus concentrations (mean +/- standard error) by site



Recently, Long Lake was shown to be impaired for high chloride concentrations. Elevated chloride concentrations have been measured in the tributary to Long Lake and contribute to the chloride impairment in Long Lake. Chloride concentrations in Long Lake appear to be increasing comparing sample results from 2013 and 2019. The average concentration of three samples in 2013 was 85 mg/L and the average concentration in 2019 of four samples was 173 and 299 mg/L for surface and bottom samples, respectively (Trend report citation).

Brown's Creek

Resource Status (from 2020 Trend Analysis) –

- Mean daily flow (cfs) increases as we move downstream: from 4.6 cfs at Manning Avenue to almost double the flow (8.5 cfs) at the WOMP station.
- Flow volume (AF) fluctuates as we move downstream due to groundwater contributions and losses along the stream.
- Flow depth (in) from the contributing drainage area appears to be increasing over the last several years.
- 80 to 90% of the flow in Brown's Creek is baseflow, which is the portion of streamflow that persists throughout the year and typically corresponds to groundwater levels in the watershed.
- Stream flow in Brown's Creek is increasing over the period of record. Trends in baseflow and runoff volumes have similar statistically significant increasing trend as streamflow for all monitoring stations except for the WOMP monitoring station.

Monitoring the biological communities in a waterbody is the most direct way of assessing how well the waterbody is supporting aquatic life. The health of the macroinvertebrate community is measured using an index of biological integrity (M-IBI), which is based on the number and species of fish and macroinvertebrates present in a stream compared to what the stream is expected to support. The M-IBI scores in Brown's Creek are improving at all three monitoring locations.

The main water quality concerns for Brown's Creek and its tributaries are total suspended solids (TSS), TP, *E. coli* bacteria, and thermal loads. TSS concentrations at various sites along the creek prior to the completion of the 2017-2026 watershed district management plan exceeded the applicable water quality standard (10 mg/L for class 2A stream reaches) in 27% to 79% of water quality samples taken. TP concentrations at the sites were above the water quality standard (0.1 mg/L) in 19% to 59% of the samples. *E. coli* concentrations at the sites were above the water quality standard (126 org/100 mL) in 60% to 90% of the samples. Temperatures exceeded the daily maximum threat temperature for trout (18.3 deg. C) 2 to 38 times per year from 2007 through 2014. Temperatures also exceeded the daily maximum critical temperature for trout (23.9 deg. C) three to five times in 2011 and 2012.

The impaired biota TMDL completed for Brown's Creek includes two TMDLs—one for TSS and one for water temperature (EOR, 2010). The TMDL tables for the two parameters are shown in Table 2 and Table 5. The TMDLs were completed for these parameters following a stressor identification process that identified them as primary stressors to the cold water fishery. Elevated levels of copper were also identified as a stressor, but a TMDL was not completed due to uncertainties in the copper data. The TSS TMDL was written with TSS as a surrogate measure for the turbidity water quality standard in place at the time. The temperature TMDL was written for thermal load, which addresses the temperature stressor.

Table 3. TSS TMDL summary of Brown's Creek

Source		Permit number	% Allocation	TMDL (lbs/day)				
				High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
				81.3 - 17.5 cfs	17.5 - 9.7 cfs	9.7 - 7.6 cfs	7.6-5.9 cfs	5.9 - 0.0 cfs
LA			90.2%	2,800	1,313	946	757	617
WLA – Permitted stormwater	**Lake Elmo**	**MS400098**	0.035%	1.1	0.5	0.4	0.3	0.2
	Oak Park Heights	**Future [a]**	0.22%	7.0	3.3	2.4	1.9	1.5
	Stillwater	**MS400259**	9.5%	296	139	100	80	65
	Construction stormwater	**Various**	0.01%	0.3	0.1	0.1	0.1	0.1
	Industrial stormwater	**No current permitted sources**	0.01%	0.3	0.1	0.1	0.1	0.1
	Total		100%	3,105	1,456	1,049	839	684

a. The City of Oak Park Heights was not under MS4 permit coverage at the time of the TMDL report, but has since come under permit coverage (permit number MS400290).

The average annual TSS values from the TMDL for Brown's Creek are summarized in Table 3. The TSS concentration goal for the TMDL was determined to be 23 mg/L based on the water quality standard present for turbidity for cold water streams at the time of 10 NTU and a regression relationship between TSS and turbidity data for Brown's Creek. The existing and goal loads were computed using the average measured TSS and goal concentrations. An annual reduction of 547 t/yr of TSS is needed to meet the TMDL (Table 3).

Table 4. Annual average TSS values from the TMDL

	Average concentration (mg/L)	Loading rate (lbs/ac-yr)	Annual load (lbs/yr)	Annual load (tons/yr)
Existing (2000-2007)	142	285	1,475,000	737.5
Goal	23	74	381,809	190.9
Reduction needed		**211**	**1,093,191**	**546.6**
% load reduction needed			74%	

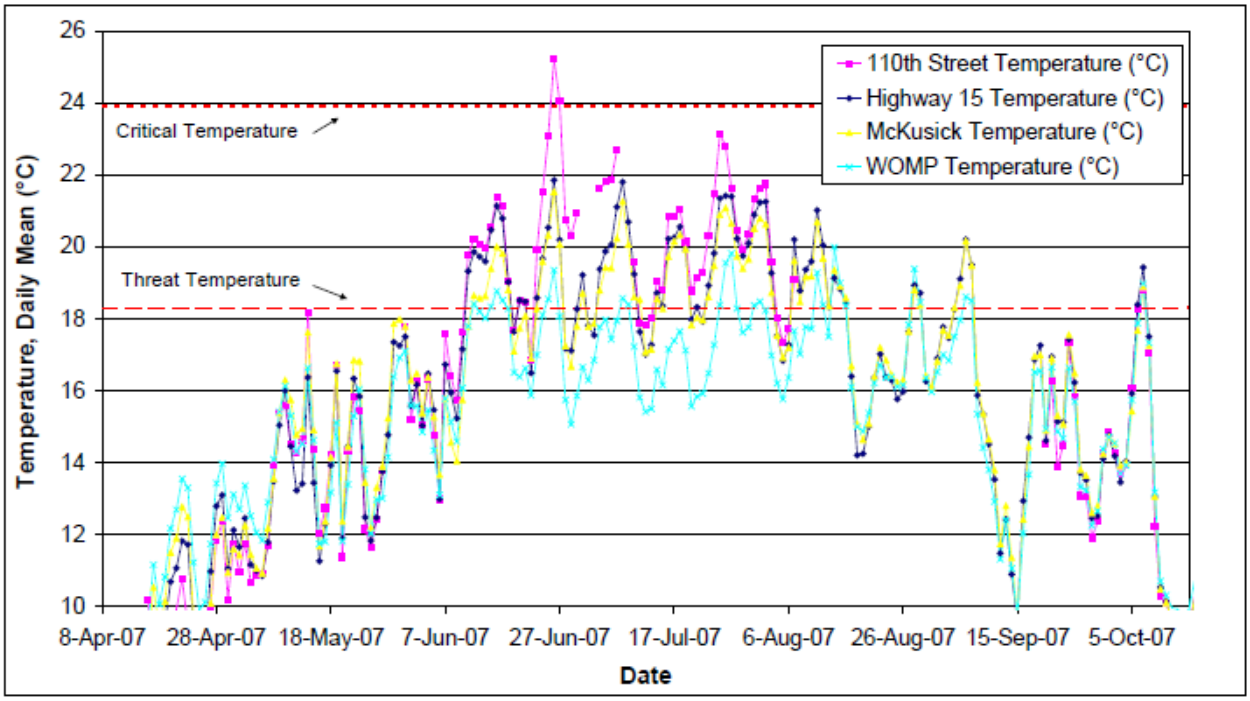
Annual TSS load calculations were made after the TMDL was completed through the Metropolitan Council's Watershed Outlet Monitoring Program (WOMP). The observed loads allow the evaluation of changes in TSS load over time. The modeled loads are different than the observed loads because of the different methodologies used. The observed loads were equated to the TMDL loads for the purposes of this plan. The average annual TSS load have decreased from the periods 2000 - 2007 to 2015 – 2020 (Table 4), indicating that BMP implementation has resulted in load reductions. The remaining load reduction for this plan to achieve the TMDL is 183 tons/year.

Table 5. Load reductions observed in monitoring and remaining reduction needed to meet TMDL

	TSS annual load adapted to TMDL (tons/yr)	TMDL Goal	Reduction needed (tons/yr)
Baseline (2000-2007) and TMDL	738	191	547
Current (2015-2020)	374	191	**183**

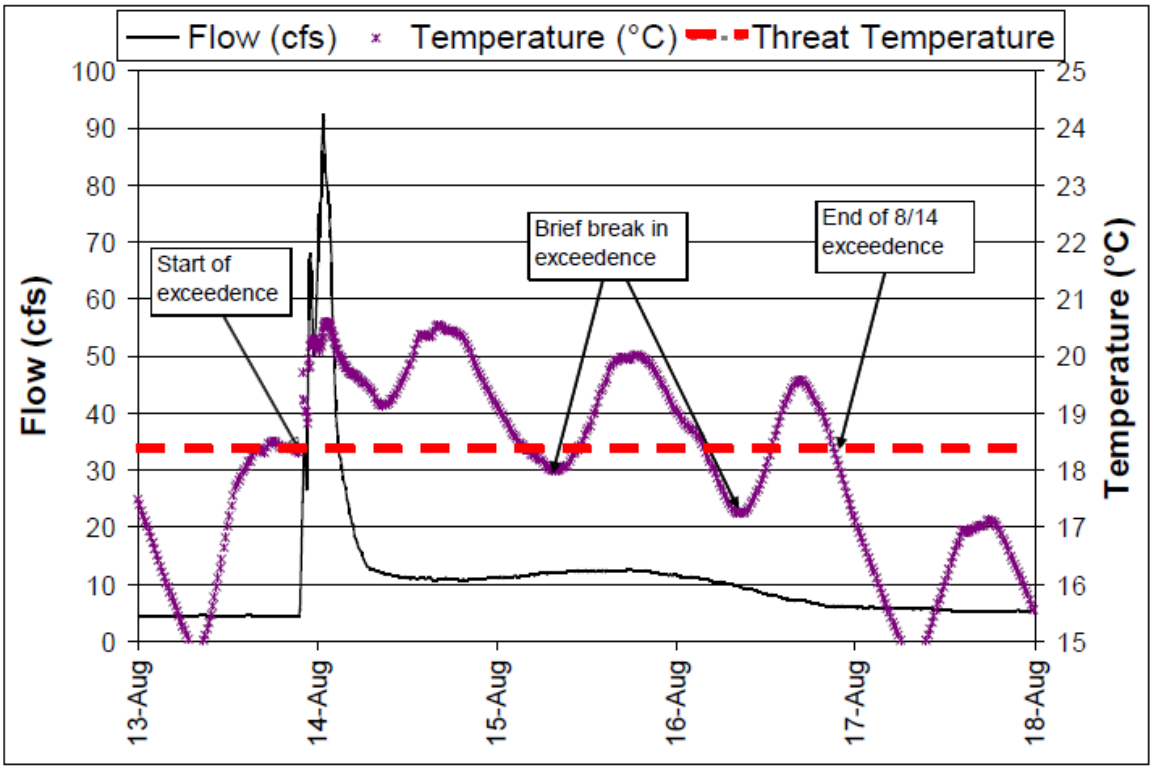
Stream water temperatures often exceeded the chronic or threat temperature (18.3 °C or 65 °F) identified for brown trout. Water temperatures during the summer are generally warmer at upstream sites and cooler at the downstream monitoring site (Figure 4).

Figure 4. Daily mean stream temperatures at Brown's Creek monitoring sites in 2007 (EOR 2010)



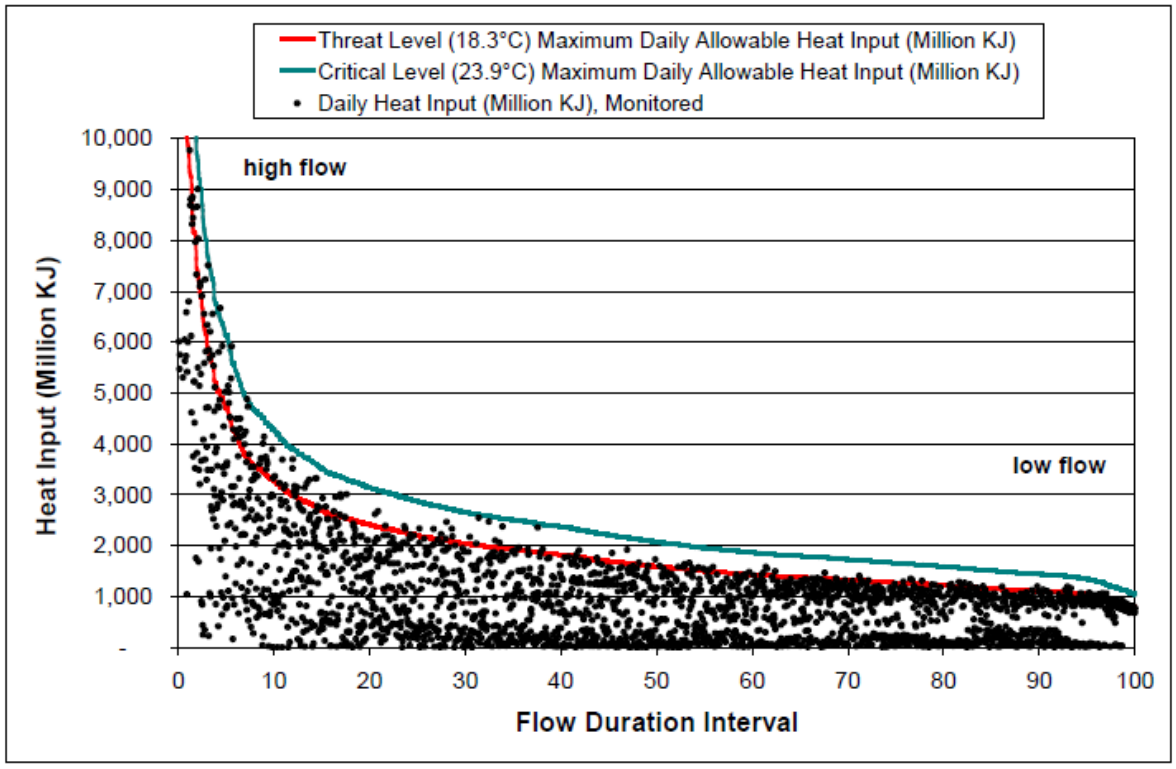
Stream temperatures vary diurnally with increases following increases in air temperature and solar radiation during the day (Figure 5). Stream temperatures decrease during precipitation events as a result of decreased air temperatures and solar radiation, but then increase as surface runoff dilutes the cooler baseflows from groundwater inputs.

Figure 5. Time-series temperature data at downstream monitoring site in August, 2007 (EOR 2010)



With the surface runoff connection to warmer water temperatures, temperature exceedances generally occur at higher stream flows as shown by the heat load duration curve shown in Figure 6.

Figure 6. Heat load duration curve for downstream monitoring site on Brown's Creek, 2000-2007 (EOR 2010)



The TMDL for temperature was established to provide allocations for decreasing the thermal load to Brown's Creek and thus decrease the amount of time stream water temperatures exceed the threat temperature of 18.3 °C (65 °F) for brown trout. Thermal load is a measure of the amount of energy in water expressed as kilojoules per kilogram and is used given that there is no direct measure of temperature load. The TMDL and allocations are presented in terms of the kilojoules per day (KJ/day) that the stream can assimilate and maintain water temperatures below the brown trout threat temperature. The TMDL determined that a 6% reduction in thermal load was required to meet the TMDL load capacity. To comply with the allocations, the entities that control heat loading into Brown's Creek will be required to either implement the actions in the implementation plan or implement substitute actions that will reduce thermal loadings to the same extent. An accounting of heat load sources and reductions based on energy units (KJ/day) is not required (EOR 2010).

Table 6. Summary of heat load TMDL for Brown's Creek Watershed

Source		Permit number	TMDL (Million KJ/day)				
			High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
			81.3 - 17.5 cfs	17.5 - 9.7 cfs	9.7 - 7.6 cfs	7.6-5.9 cfs	5.9 - 0.0 cfs
LA – Watershed			2,732	517	223	108	59
LA – Baseflow			1,668	1,630	1,342	1,150	970
WLA – Permitted stormwater	**Lake Elmo**	**MS400098**	1.1	0.20	0.09	0.04	0.023
	Oak Park Heights	**Future [a]**	6.8	1.3	0.55	0.27	0.15
	Stillwater	**MS400259**	289	55	23.6	11.4	6.2
	Construction stormwater	**Various**	0.3	0.05	0.02	0.01	0.006
	Industrial stormwater	**No current permitted sources**	0.3	0.05	0.02	0.01	0.006
	Total		4,697	2,203	1,589	1,270	1,036

a. The City of Oak Park Heights was not under MS4 permit coverage at the time of the TMDL report, but has since come under permit coverage (permit number MS400290).

In addition to the TSS and temperature issues for Brown's Creek and the nutrient issue for Long Lake, the Brown's Creek watershed is a part of the St. Croix River and Lake St. Croix watershed. Brown's Creek was assigned a phosphorus load reduction target of 1,954 lbs/yr in the Lake St. Croix Nutrient TMDL. This load reduction target was adjusted to 848 lb/yr phosphorus to reflect more recent monitoring data (BCWD 2019).

The primary water quality concern in the unnamed creek is *E. coli*; the reach was listed in 2012 with an aquatic recreation impairment due to high concentrations of *E. coli*. Monthly geometric means exceeded the monthly water quality criteria of 126 org / 100 mL in June, July, August, and September. Nine percent of samples exceeded the acute water quality criteria of 1,260 org / 100 mL in 2006–2016.

There is no specific TMDL for this waterbody. Under most conditions (up to the 10-year storm event), this tributary is diverted away from Brown's Creek and towards McKusick Lake. Retrofits to the existing iron-enhanced sand filter with biochar as the potential to address this impairment.

Implementation strategies

The implementation practices and strategies for this watershed are a list of best management practices (BMPs) that when implemented will yield the estimated reductions needed to meet water quality standards and improve habitat quality. The strategies listed are intended to provide the flexibility to the BCWD to choose the best practice with the available implementation opportunity. The BCWD must not only gain the trust and permission from landowners, but also must work and coordinate efforts with multiple entities that work within the watershed. For example, an opportunity may present itself to coordinate with a municipality or Minnesota Department of Transportation (MnDOT) during a road construction project. It is also difficult to pinpoint precisely when these opportunities will arise.

This plan and implementation are to address all aspects of pollutant loading in this watershed. Some of that loading comes from the stormwater conveyance system that is permitted through the MS4 permits held by individual entities in this watershed. All practices that address the stormwater conveyance system are not eligible for Section 319 funding. There are no specific practices or implementation detailed in the MS4 permits. Final eligibility of practices will be determined for specific projects at time of grant project work plan reviews.

The BCWD and its partners have implemented many of the BMPs identified in this NKE bridge document as part of its ongoing activities in completing the district's previous (2007-2016) and current (2017-2026) watershed management plans. The milestone-strategy table in Table 6 and includes the planned years for the activities and the completed years for the activities if the activities have been completed.

Table 7. Summary of planned management activities, schedule, assessment criteria, estimated reductions and costs for Brown's Creek Watershed (activities required by stormwater permit are not eligible for Section 319 funding)

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
	Sedimentation basins to capture agricultural runoff on one parcel (site not disclosed in plan)			Sediment basins installed			# sediment basins	$ 94,600	18.5				
Brown's Creek Bluff Stability: DNR pursuing funding and time for EOR to assist with project design and construction plan review	Bluff erosion identified in 4 areas within the gorge portion of Brown's Creek. Steep slopes and a bedrock valley expose soils to erosive stream forces. Bedrock protects steep slopes within the valley in many locations, but a bedrock valley occurs in the gorge along approximately 2,000' of channel starting roughly 900' upstream of the Highway 96 crossing.	DNR study completed	Feasibility of bluff stabilization determined				# study	$ 2,000					
	Stillwater Country Club Re-Use: local drainage opportunities local drainage plus a nearby Mud Pond, and included flow from local drainage, Mud Pond, and nearby wetland complex. Design and construction, this action is not required by a stormwater permit		Country club reuse designed	Country club reuse construction completed			# design # constructed	$ 292,000	6.5				
	11,500 ft^3 rock crib to capture 22.2 acres at Brown's Creek Trail and McKusick Road, this action is not required by a stormwater permit			Rock crib designed	Rock crib construction completed		# design # constructed	$ 100,000	0.4			15%	
Geomporphic and Stream Visual Assessments, these activities are not required by a stormwater permit	Reach 1 log jam removals, selective tree thinning, small bank repair	Reach 1					# feet thinned # jams removed # bank repair	$ 115,000	0.7	0.7	12		
	Reach 2 - Bank shaping & grading, selective tree thinning		Reach 2				# feet bank shaped # feet thinned	$ 135,000	10.3	10.3	200		
	Reach 3 - Bank shaping & grading, grade control structures, selective tree thinning			Reach 3			# feet bank shaped # grade control structures	$ 195,000	12.6	12.6	250		

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
							# feet thinned						
	Reach 4 - Selective tree thinning and small bank repair				Reach 4		# feet thinned # feet bank repair	$100,000	2.4	2.4	30		
Implement thermal improvement projects (stream channel and bank restoration, buffers and vegetation) , these activities are not required by a stormwater permit	450 feet on Brown's Creek Cove/Millbrook Development (Practice ID 9)					450 feet on Brown's Creek Cove/ Millbrook Development (Practice ID 9)	# feet	$10,000	5.2			X	
	325 ft upstream of county Road 5 (Practice ID 3)					325 ft upstream of county Road 5 (Practice ID 3)	# feet	$3,000	3.7			X	
	653 feet on Schubert properties (Practice ID 4)					653 feet on Schubert properties (Practice ID 4)	# feet	$15,000	7.5			X	
	653 feet on City of Stillwater Property (Brown's Creek Park) (Practice ID 8)					653 feet on City of Stillwater Property (Brown's Creek Park) (Practice ID 8)	# feet	$94,000	7.5			X	
	500 ft upstream of Wolf Marine (Practice ID 9)					500 ft upstream of Wolf Marine (Practice ID 9)	# feet	$10,000	5.8			X	
	Approximately 1,000 feet on Grogan property (Practice ID 14)					Approximately 1,000 feet on Grogan property	# feet	$13,000	11.5			X	

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
						(Practice ID 14)							
	950 feet upstream of Hwy 96 (Practice ID 12)					950 feet upstream of Hwy 96 (Practice ID 12)	# feet	$120,000	10.9			X	
	1,045 ft on Costa Lorraine M Properties (Practice ID 13)					1,045 ft on Costa Lorraine M Properties (Practice ID 13)	# feet	$190,000	12.0			X	
	Update the CEQUAL-W2 (Thermal) Model – Update the CEQUAL Model to include improvements made to the system since 2016			Update the CEQUAL-W2 (Thermal) Model			# model	$ 20,000					
	Total Phosphorus Source Assessment - This assessment should include a sequential diagnostic monitoring approach for TP sources in the Brown's Creek	Total Phosphorus Source Assessment					# assessments	$ 10,000					
Total Phosphorous Source Reduction- Implement the total phosphorus assessment, these activities are not required by a stormwater permit	1 wetland restoration		1 wetland restoration				# wetlands restored	$ 150,000	8	X	667	L	
E. coli Reduction –Brown's Creek	Biochar Filtration (eligible when installed outside the MS4 conveyance system)			Biochar filtration (treating 50 acres)			# filters	$ 100,000			667		
E. coli Reduction –Diversion Drainage Retrofit	Retrofit the existing iron enhanced sand filter with Biochar Filtration (eligible when installed outside the MS4 conveyance system)		Retrofit sand filter with biochar				# Filters	$ 100,000			667		
Pond outlet configurations for modifications to further trap sediment within the ponds by addition of a filtration/infiltration	Oak Glen Golf Course Pond Retrofit - P1065			Oak Glen Golf Course Pond Retrofit - P1065			# retrofit	$ 18,725	0.67	6	25.3	L	5

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
ring around the perimeter, these activities are not required by a stormwater permit	Oak Glen Golf Course Pond Retrofit - P1045	Increased recharge and decreased thermal loading		Oak Glen Golf Course Pond Retrofit - P1045			# retrofit	$ 44,650	2.202	19	801	L	
	Oak Glen Golf Course Pond Retrofit - P1044			Oak Glen Golf Course Pond Retrofit - P1044			# retrofit	$ 38,275	0.44	4	16.9	L	
	Oak Glen Golf Course Pond Retrofit - P1043			Oak Glen Golf Course Pond Retrofit - P1043			# retrofit	$ 8,425	0.3	3	12.7	L	
	Oak Glen Golf Course Pond Retrofit - P1042			Oak Glen Golf Course Pond Retrofit - P1042			# retrofit	$ 128,888	1.16	11	46.4	H	
	Oak Glen Golf Course Pond Retrofit - P1184			Oak Glen Golf Course Pond Retrofit - P1184			# retrofit	$ 89,300	2.61	25	105.4	H	
	Oak Glen Golf Course Pond Retrofit - P1217			Oak Glen Golf Course Pond Retrofit - P1217			# retrofit	$ 50,375	0.58	5	21.1	M	1.6
	Oak Glen Golf Course Pond Retrofit - P1048			Oak Glen Golf Course Pond Retrofit - P1048			# retrofit	$ 23,225	0.25	2	8.4	H	
	Stonebridge Trail (CR 5) Stormwater Management Retrofits and Stabilization at Brown's Creek Crossing in collaboration with Washington County 2025 planned		Stonebridge Trail (CR 5) Retrofit				# retrofit	$ 7,460	1.54	15	650		
Stream Geomorphology + Thermal Buffer Improvements, these activities are not required by a stormwater permit	Increased stream vegetation and stream stabilization Reach 1				Increased stream vegetation and stream stabilization Reach 1		# feet buffer # feet restored	$ 6,400				L	

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
	Increased stream vegetation and stream stabilization Reach 3			Increased stream vegetation and stream stabilization Reach 3			# feet buffer # feet restored	$ 120,000	4.5	43		L	
	Increased stream vegetation and stream stabilization Reach 4					Increased stream vegetation and stream stabilization Reach 4	# feet buffer # feet restored	$ 38,400				L	
	Increased stream vegetation and stream stabilization Reach 6		Increased stream vegetation and stream stabilization Reach 6				# feet buffer # feet restored	$ 19,200	7.7			M	
	Increased stream vegetation and stream stabilization Reach 8			Increased stream vegetation and stream stabilization Reach 8			# feet buffer # feet restored	$ 93,600	4.3			L	
	Increased stream vegetation and stream stabilization Reach 9		Increased stream vegetation and stream stabilization Reach 9				# feet buffer # feet restored	$ 12,200	1.6	15		L	
	Increased stream vegetation and stream stabilization Reach 10	In progress					# feet buffer # feet restored	$ 162,720				L	
	Increased stream vegetation and stream stabilization Reach 11	In progress					# feet buffer # feet restored	$ 91,922	4.6	44		L	
	Increased stream vegetation and stream stabilization Reach 12		Increased stream vegetation and stream stabilization Reach 12				# feet buffer # feet restored	$ 175,274	3.4	53		L	
	Increased stream vegetation and stream stabilization Reach 13			Increased stream vegetation			# feet buffer # feet restored	$ 498,235	8.5			H	

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
				and stream stabilization Reach 13									
	Increased stream vegetation and stream stabilization Reach 14		Increased stream vegetation and stream stabilization Reach 14				# feet buffer # feet restored	$ 12,000				L	
Improved Street Sweeping (Addressing the conveyance system of curb and gutter in MS4 is ineligible for Section 319 funding)	Street sweeping frequency should be increased to 10 sweepings per year to prevent solids from reaching the stream	Street sweep 20 times	Street sweep 20 times	Street sweep 20 times	Street sweep 20 times	Street sweep 20 times	# street sweeping	$ -	10		19.4		
Road Sand Management (Addressing the conveyance system of curb and gutter in MS4 is ineligible for Section 319 funding)	Application of road sand within the watershed should be reviewed to verify that the recommended rates are being observed. Recommended sanding rates vary from 400 – 750 lbs/2 lane mile (LTAP et al. 2005) for particular road conditions.	Practice variable road sand application	Practice variable road sand application	Practice variable road sand application	Practice variable road sand application	Practice variable road sand application	# t/sand applied	$ -	20				
Pond Maintenance (MS4 permit activities are not eligible for Section 319 funding)	Municipalities regulated under the National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) Municipal Separate Storm Sewer System (MS4) Permit Program are required to annually inspect all structural pollution control devices and 20 percent of all stormwater ponds they operate. Pond design should incorporate maintenance requirements, allowing easy access for the removal of sediment that accumulates in the basin. Regular inspections will determine when it is necessary to dredge the pond and remove excess sediment accumulation, but generally ponds should be evaluated to determine the need for dredging every five years.	Conduct maintenance on 20% of ponds (annually)	Conduct maintenance on 20% of ponds (annually)	Conduct maintenance on 20% of ponds (annually)	Conduct maintenance on 20% of ponds (annually)	Conduct maintenance on 20% of ponds (annually)	% maintained	$ -	8				

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
Yard Waste (Not eligible for Section 319 funding)	The City of Stillwater allows residents to place ward waste curbside for collection on trash day from April 1 - November 1	Yard waste collections April 1 - November 1 annually	Yard waste collections April 1 - November 1 annually	Yard waste collections April 1 - November 1 annually	Yard waste collections April 1 - November 1 annually	Yard waste collections April 1 - November 1 annually	# months yard waste collected	$ -	2				
Pond Management: Golf Course	Pond management plans should be developed for Oak Glen Golf Course and Stillwater Country Club to ensure that irrigation operations are not inadvertently leading to an increase in sediment load or thermal load to the creek.		Pond management plan developed				# plans	$ 5,000	0.8				
Stormwater Management - Golf Course, these activities are not required by a stormwater permit	Develop management plan to promote water conservation, preserve or improve water quality and protect water resources. Environmental concern of golf courses is the degradation of water quality as a result of the use of high rates of fertilizers, pesticides and fungicides on managed turf that makes up the courses. Other practices that have the potential to produce stormwater pollutants to contribute to increased stormwater runoff include equipment and parts washing; fuel storage; irrigation of golf course grounds.	Stormwater plan developed	Stormwater practices implemented to yield 8 t/yr TSS reduction (rain gardens, infiltration basin, buffers)				# buffers # equipment practices # t/yr reduced	$ 5,000	8				

Project name	BMP/Practice/Activity	Milestones					Assessment	Cost	Estimated reductions				
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10-year			TSS t/yr	P reductions #/yr	*E. coli* Billion MPN/yr	Temp loading	Volume reduction
Stormwater Management – Homeowners, these activities are not required by a stormwater permit	Develop management plan to assist homeowners with proper use of fertilizer or pesticides on lawns, gardens, shrubs and trees. Improperly storing and applying these products may result in fertilizer or pesticides moving through the soil into the groundwater or washing off into surface waters. It is important for homeowners to know how to maintain their yard while still protecting surface water and groundwater. Proper application of fertilizers and pesticides, safe storage practices, and correct watering are all part of the overall protection plan.	Landowner lawn and garden management plans					# plans	$ 5,000					
Totals								**$ 3,522,874**	**216.8**	**271.0**	**4199.6**		6.6

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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Long Lake

Predominant land uses in the Long Lake Tributary Drainage Area include low to moderate density residential areas, old fields, row crops, and forests (Table 7). South of Long Lake, along the Highway 36 corridor, land use includes a mixture of light industrial and office space, along with retail business. The Highway 36 corridor has experienced the highest amount of urban growth in the Brown's Creek watershed (BCWD, 2019).

The sources for the Long Lake pollutant loading are described fully in the Long Lake Management Plan (EOR 2006). They are summarized in Table 8 as average annual pollutant loads for each subwatershed as modeled by P8. Although pollutant loads may have changed since 2006, because the land cover distribution has not changed substantially, the loading from the 2006 Long Lake Management Plan is assumed to describe current loadings.

Table 8. Land cover in Long Lake watershed (National Land Cover Dataset 2016)

Category	2006 percent area (%)	2016 percent area (%)
Developed	72%	73%
Pasture/hay	8%	10%
Crops	2%	1%
Natural [a]	11%	9%
Water and wetland	8%	7%

a. "Natural" is primarily forests, but also includes shrubland and grassland.

Table 9. Summary of P and TSS loading to the Long Lake by subwatershed (EOR 2006)

Major Subwatershed	Total Phosphorus Load lbs/year	Total Suspended Solids Load lbs/year
Bruers Pond	15.32	340.93
Central Legends	7.41	554.55
Direct Drainage	29.81	15723.65
Highway 36 North	49.99	9951.52

Major Subwatershed	Total Phosphorus Load lbs/year	Total Suspended Solids Load lbs/year
*Highway 36 South**	*28.83*	*7039.96*
Marine Circle Pond	14.89	1695.96
*Marketplace East**	*80.23*	*22624.89*
*Marketplace North**	*154.01*	*25581.41*
Marketplace West	340.67	33109.55
*Menards Pond**	*89.74*	*10441.8*
North Croixwood	23.30	4504.23
North Legends	0.93	14.8
North Liberty	3.92	632.3
South Legends	9.14	897.92
South Liberty	1.96	342.25

* Subwatershed contributes to a downstream subwatershed. Does NOT load directly to lake.

Point source loading

There are no permitted wastewater facilities that discharge to surface waters in the Long Lake watershed.

Regulated stormwater delivers and transports pollutants to surface waters and is generated in the watershed during precipitation events. Two types of regulated stormwater are permitted in the Long Lake watershed—municipal separate storm sewer system (MS4) and construction stormwater runoff. MS4s are defined by the MPCA as stormwater conveyance systems owned or operated by an entity such as a state, city, township, county, district, or other public body having jurisdiction over disposal of stormwater or other wastes. The following entities are permitted MS4 entities in the Long Lake watershed: the cities of Grant, Lake Elmo, Oak Park Heights, and Stillwater; Washington County; and MnDOT. The city of Grant is regulated solely within the U.S. Census-defined urbanized area (UA) and other platted areas outside the UA but within the jurisdiction, and Washington County and MnDOT are regulated solely within the UA.

Construction stormwater is regulated through an NPDES permit (MNR100001). Untreated stormwater that runs off a construction site can carry sediment and phosphorus to surface water bodies. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities. There are currently 17 permitted construction stormwater sites in the Long Lake watershed. This represents a small area in the watershed, and construction stormwater is not considered a significant source of sediment or phosphorus to Long Lake.

Non-point source loading

In addition to localized sources of pollutants (commonly referred to as point sources), non-point source (NPS) pollution is a major contributor of pollutants. The NPS pollution cannot be traced to a single source or pipe. In this case, pollutants are carried from land to water in stormwater or snowmelt runoff, in seepage through the soil, and in atmospheric transport. Whereas, many point sources frequently discharge continuously throughout the year, NPS pollution often discharge in response to precipitation or snowmelt events. Some areas of the Brown's Creek watershed are served by subsurface sewage treatment systems (SSTS). Non-compliant SSTS is also considered a NPS of pollutant. The MPCA and

Washington County implement SSTS regulatory programs to manage the environmental and public health impacts related to SSTS (BCWD, 2019).

Internal phosphorus loading is another NPS of phosphorus to Long Lake. Shallow lakes often have a high level of internal phosphorus loading due to the amount of contact between low oxygen lake water and bottom sediments, in addition to bottom-feeding fish and wind energy in shallow depths.

Brown's Creek

Increased imperviousness (hydrology and ecology disruptions) leads to reduced baseflow, larger and more frequent stormwater discharges, increased water temperatures, and increased pollutant load, which in turn leads to changes in stream habitat, decreased aquatic diversity, and degradation of the resource (BCWD, 2019). Changes in flow conditions (e.g., urbanization near a stream) leads to bank erosion, undercutting, and stream widening (rates and volumes of runoff) (BCWD, 2019). This contributes to TP, thermal, and TSS loading.

Brown's Creek consists of several distinct reaches that have been grouped into the North Branch and Main Branch sections based on their character and function assessments. North Branch Brown's Creek is made up of eight reaches, which are defined by changes in geomorphology or disruption of the creek by roads or driveways. The section also contains three tributary reaches and extends from the headwaters of the creek to Highway 96 near Manning Avenue (Table 9). Main Branch Brown's Creek is made up of 12 mainstem reaches, extending from Highway 96 to the St. Croix River, and seven tributary reaches (Table 9).

Table 10. Summary of North Branch Brown's Creek and tributary reaches.

Reach name	Location description	Characteristics
North Branch Reach 1	Above 110th Street	generally runs through the center of a shrub carr/emergent wetland
North Branch Reach 2	Above 110th Street	runs through a dense, disturbed lowland hardwood forest and appears to be degraded, displaying moderate erosion
Goggins Tributary Reach 1	121st Street N to North Branch Brown's Creek	runs through a relatively steep wooded ravine and has intermittent flow
Goggins Tributary Reach 2	Above 121st Street N	similar in nature to North Branch Reach 1
North Branch Reach 3	Downstream 110th Street	moderate-gradient stream, flowing for about one quarter mile through a narrow floodplain of shrub swamp and mixed hardwood swamp
North Branch Reach 4	Downstream North Branch Reach 3 to Gateway Trail	large emergent marsh wetland complex
North Branch Reach 5	Downstream of Gateway Trail	mixed hardwood tamarack swamp
North Branch Reach 6	Downstream North Branch Reach 5	mixed hardwood tamarack swamp
North Branch Reach 7	Downstream North Branch Reach 6, one mile stretch above Manning Avenue	approximately seven feet wide and one and a half feet deep

Reach name	Location description	Characteristics
Manning Reach of the North Branch	Downstream Manning Avenue	Significant signs of human alteration. Woody vegetation has been removed from the stream banks and the creek bottom has been filled with fieldstone
Mendel Road Tributary	outlet for the large wetland complex east of Manning Avenue to North Branch Brown's Creek	excavated ditch constructed through a large wetland

Table 11. Summary of Main Branch Brown's Creek and tributary reaches.

Reach name	Location description	Characteristics
Main Branch - McKusick Reach	Highway 96 near Manning Avenue to McKusick Road	first reach of the Creek that runs extensively through upland
Main Branch - DNR Reach 9	McKusick Road to Neal Avenue	bordered by hardwood forest and riparian wetland
Main Branch - Neal Avenue Reach	Downstream Neal Avenue	bordered by hardwood forest
Main Branch - Golf Course Realignment Reach	Downstream Neal Avenue, below Neal Avenue Reach	reach was realigned by the MNDNR in 1999 to replace a reach of the creek running through the McKusick wetland to improve fisheries habitat and reduce thermal pollution
Main Branch - DNR Reaches 1 - 7	Downstream Golf Course Realignment Reach	bordered by hardwood forests and steeply sloped uplands, gorge reach runs parallel to the Brown's Creek State Trail through steep slopes with high erosion potential, areas of significant groundwater discharge as the gorge cuts through the Prairie Du Chien bedrock layer
Long Lake Tributary Reach 1	Highway 12 to Boutwell Road	barely discernible creek within the wetland
Long Lake Tributary Reach 2	Boutwell Road to the confluence with the South Central and Zephyr Tributaries	mixed hardwood tamarack swamp
South Central Tributary	intersection of Manning Avenue and County Road 12 to the confluence with the Zephyr tributary and Long Lake Tributary Reach 2	flow to the McKusick Lake Diversion Structure located at the former railroad bed
Zephyr Tributary	Northwest of confluence with South Central Tributary and Long Lake Tributary Reach 2	flow to the McKusick Lake Diversion Structure located at the former railroad bed
Long Lake Tributary Reach 3	Downstream of confluence of above tributary reaches to former railroad bed	flow to the McKusick Lake Diversion Structure located at the former railroad bed
Long Lake Tributary Reach 4	Former railroad bed to Brown's Creek, just upstream of Neal Avenue	

A Stream Visual Assessment was completed following the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS) Stream Visual Assessment Protocol Version 2 (SVAP) in 2016. The protocol provides an initial evaluation of the overall condition of wadeable streams, their riparian zones, and their instream habitats. The assessment determined that all 40 reaches that were assessed scored good to excellent, indicating no single area of severe erosion and source of sediment along the stream. The assessment provided individual measures of physical condition that qualitatively describe potential sediment sources and stream habitat and connectivity issues.

Primary sources of heat (or lack of cold water) were evaluated through the completion of a stream temperature model for Brown's Creek (Herb and Correll, 2016). Potential sources of heat to the stream included lack of riparian shading conditions, discharge of warm water from stormwater ponds, and beaver ponds. The absence of groundwater contributions to the stream supplying cool water and wetland dynamics affecting water temperatures are also potential issues. The modeling found that the stormwater ponds were not significant contributors of heat. Areas without riparian shading are important in increased stream water temperatures. The effects of baseflow contributions remain uncertain.

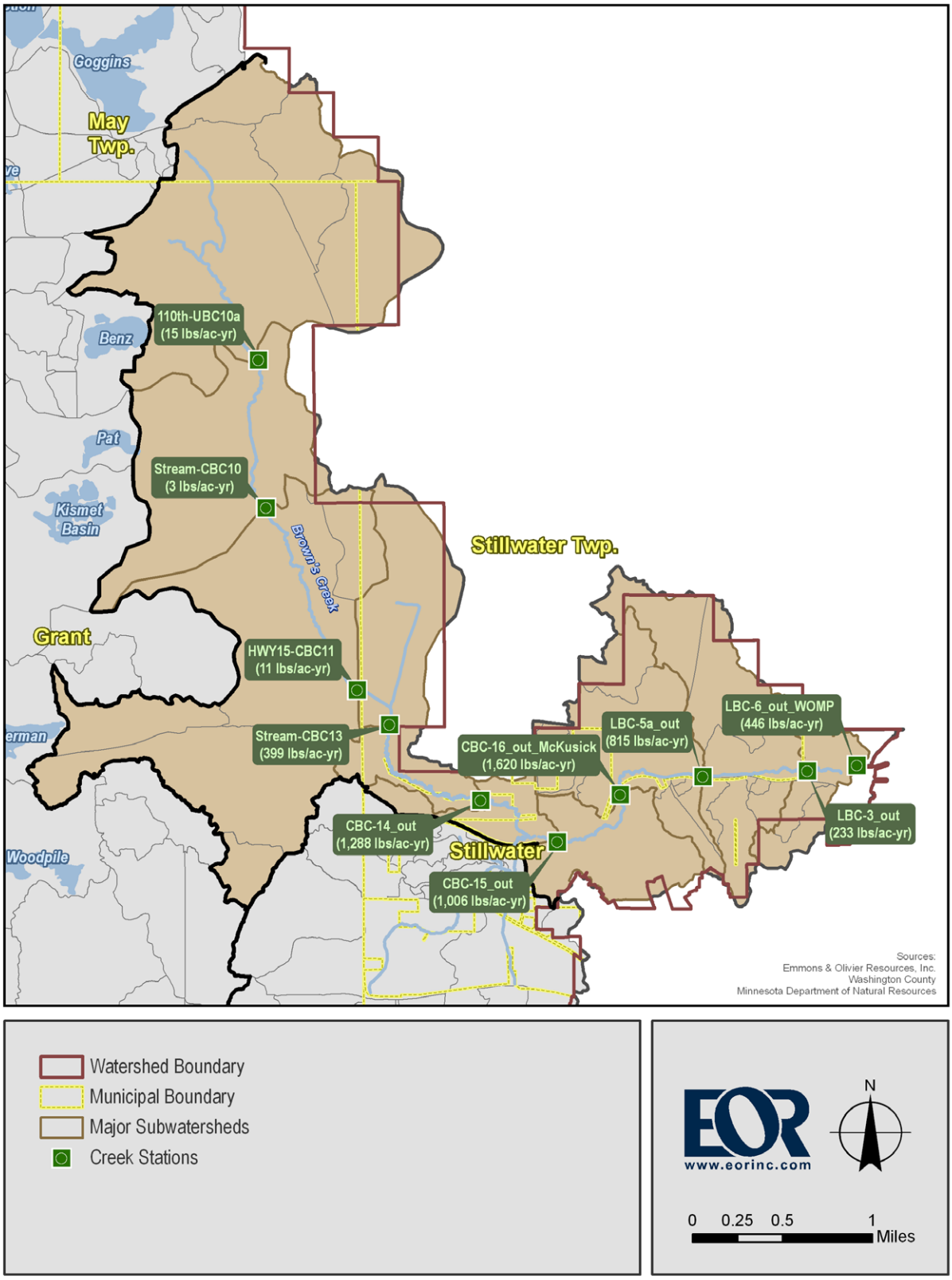
The Program for Predicting Pollution Particle Passage through Pits, Puddles, and Ponds (P8) model was used to estimate the subwatershed and catchment TSS loads to Brown's Creek for the development of the TSS TMDL. The model for the TSS loading was developed for the contributing drainage area to Brown's Creek. The contributing area comprises about 72% of the BWCD with the remaining 28% being landlocked areas with no overland flow to Brown's Creek. The model was calibrated and verified using monitoring data collected near the mouth of the stream through the Metropolitan Council's Watershed Outlet Monitoring Program (WOMP).

The surface water contributing area of the watershed was divided into 10 subwatersheds. Nearly all were estimated to exceed the loading rate goal of 74 lbs/ac-yr determined for the TMDL. The highest subwatershed loading rates per acre occurred in the subwatersheds between P8 model locations CBC13 and LBC-5a (Table 11 and Figure 7), which represent the mid- to lower-watershed areas. The total loads in the upper subwatersheds were relatively large, but the areal rate was lower given the larger size of the subwatersheds. These two areas represent the initial breakout of critical areas for sediment loading to the stream.

Table 12. Average TSS loads estimated by P8 model along Brown's Creek (Table 9 in EOR 2010)

Creek location (P8 model device name)	Area between devices (ac)	Device outflow (TSS lb/yr)	Device outflow (TSS lb/ac-yr)	TSS added between stations (lb/yr)	TSS added between stations (lb/ac-yr)
LBC-6_out_WOMP	160	1,474,892	285	71,253	446
LBC-3_out	491	1,403,639	280	114,604	233
LBC-5a_out	462	1,289,036	285	377,101	815
CBC-16_out_McKusick	267	911,935	224	433,191	1,620
CBC-15_out	126	478,743	126	126,649	1,006
CBC-14_out	141	352,094	96	181,784	1,288
Stream-CBC13	338	170,310	48	134,786	399
HWY15-CBC11	1,280	35,524	11	14,393	11
Stream-CBC10	628	21,130	11	1,614	3
110th-UBC10a	1,286	19,517	15	19,517	15
Total	*5,181*			*1,474,892*	

Figure 7. Estimated average annual TSS contributions added between P8 model locations (Figure 24 from EOR 2010)



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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Reductions for each of the waterbodies have been determined through the development of the TSS TMDL or through the expert judgement of the BCWD staff and consultants. The TMDLs developed for Brown's Creek were for TSS and water temperature. Detailed reductions by practice are included in the Implementation Strategies section, in Table 6. These reductions and the work that has been completed in Long Lake and Brown's Creek Watersheds, will meet the estimated reductions to meet water quality standards in 10 years when fully implemented.

Long Lake

The Long Lake Watershed is broken into multiple subwatersheds, as illustrated in Figure 8.

No TMDL has been developed for the lake. This work has reduced the TP in the lake to almost meeting water quality standards. Those and the reductions summarized in Table 6 are expected to meet the reductions needed to meet water quality standards for Long Lake when fully implemented.

Figure 8. Subwatersheds in the Long Lake Watershed (BCWD)

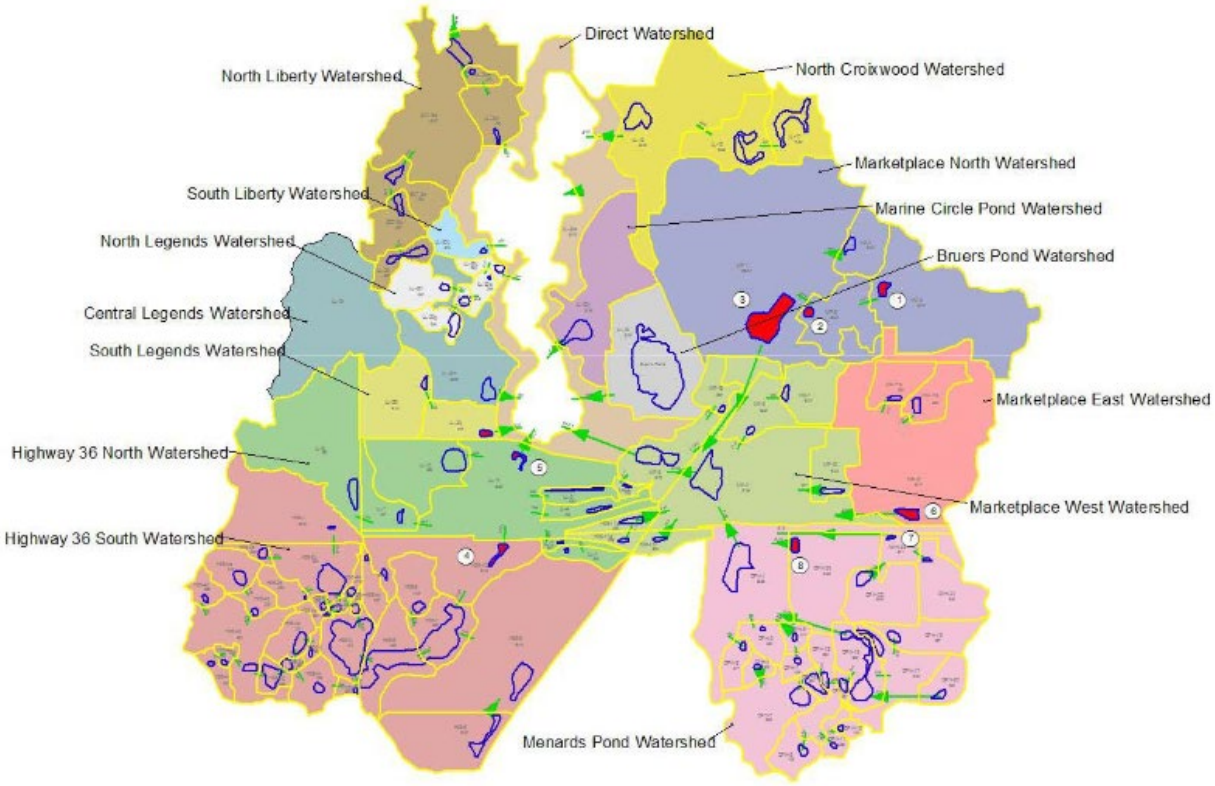
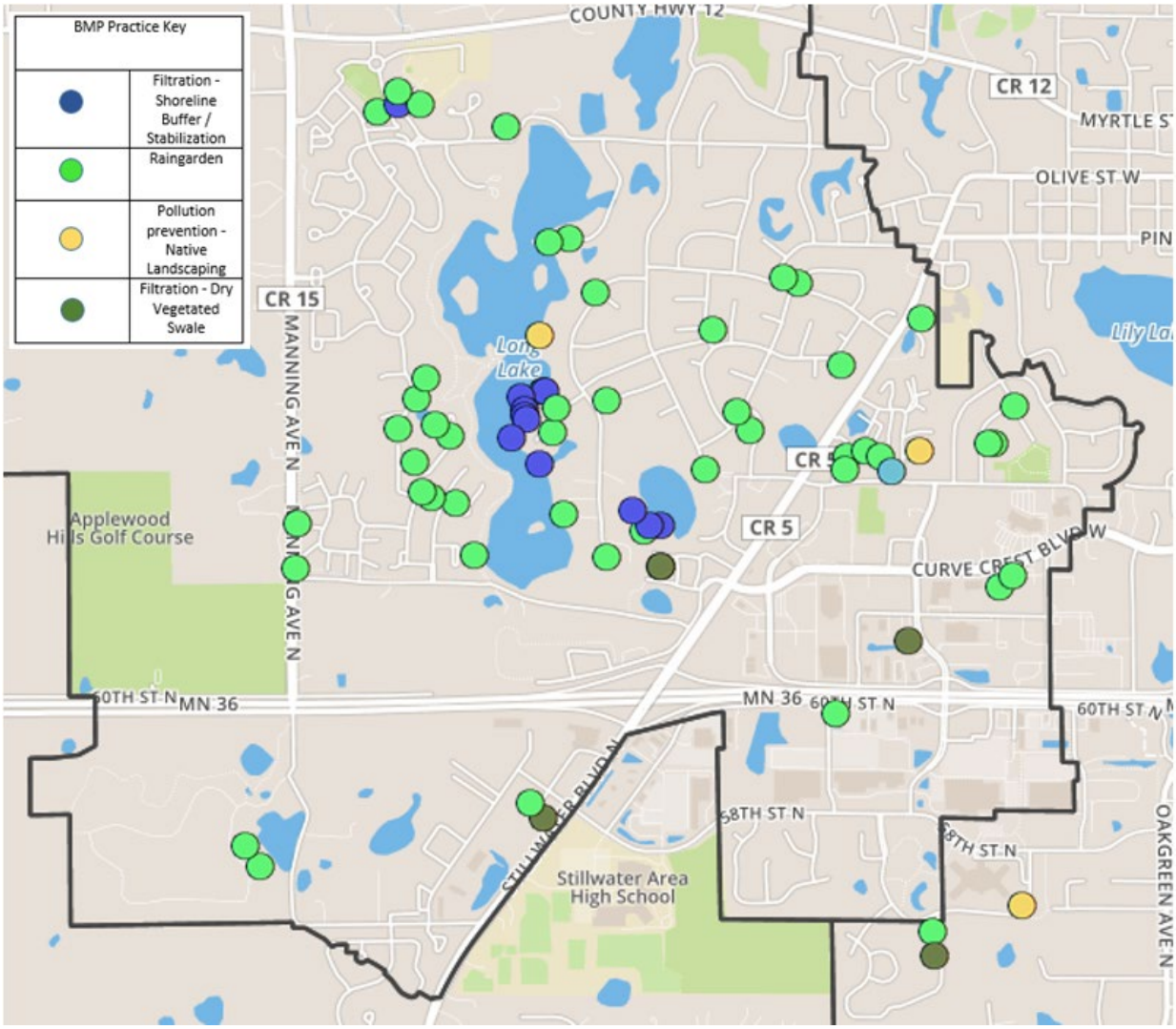


Figure 9. Some examples of completed BMPs in the Long Lake Watershed



Brown's Creek

Implementation of the BMPs and associated activities that reduce sediment erosion and transport will reduce the average annual TSS load by 217 tons/yr to meet the annual load capacity of 191 tons/yr identified in the TMDL. Attainment of this reduction will result in TSS no longer being a stressor to aquatic life as defined in the TMDL.

Implementation of the BMPs and associated activities that reduce the thermal load to the stream will address the lack of a cold water fish assemblage impairment by decreasing the amount of time stream temperatures exceed 18.3°C (65°F). Given uncertainties in the identification of pollutant loads and the quantification of improvements associated with implementation activities designed to address thermal loads, the goal will be to reduce the uncertainty over the course of the project by monitoring the system while implementing the recommended projects and assessing the need to implement additional projects in the future. The temperature TMDL does not require an accounting of heat load sources and reductions based on energy units. The TMDL states that the actions identified in the TMDL implementation plan (EOR 2012), or substitute actions, are required to comply with the TMDL (EOR 2010). Selection of thermal load reduction activities in the implementation plan was supported by a

literature review of BMPs used to address thermal loads to cold water fisheries and from stormwater management facilities.

There have been numerous practices implemented in the Brown's Creek Watershed. There are many other practices that have occurred in the watershed since the development of the TMDLs. Although these are not detailed out such as the practices implemented by BCWD, the water quality data shows an improvement in both TSS and temperature of Brown's Creek. It is expected that the reductions of past practices and those planned in will meet the thermal load and TSS reductions required by the TMDLs. There has not been a TMDL developed for the *E. coli* impairment; however, this plan will reduce *E. coli* by 6,337 Billion MPN/yr. It is expected that Brown's Creek will meet water quality standards for *E. coli* after the implementation of this plan.

In addition to reductions addressing the Brown's Creek impairments, the Brown's Creek watershed has been assigned a TP load reduction for the Lake St. Croix phosphorus TMDL of 848 lbs/yr of phosphorus. Reductions for practices planned and implemented (1,329 lbs/yr TP) have exceeded the target TP Reduction for Lake St. Croix.

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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The suite of best management practices and activities listed in Table 6 and are estimated to achieve the pollutant reductions and habitat improvements needed to reach water quality standards. There are certain challenges associated with addressing NPS pollution in watershed districts, particularly the challenge of timing projects and working with other entities' schedules and budgets. The timeline for implementation provided by the BCWD will achieve the estimated reductions needed to reach water quality standards within ten years. However, the order of implementation or precise years is subject to adaptation as the BCWD must coordinate with multiple entities' schedules and budgets. The implementation practices will be selected and prioritized by the criteria described below.

The implementation philosophy for each waterbody is described below.

Long Lake

The BCWD has implemented many BMPs since it was listed for impairment and the Long Lake Management plan was developed in 2006. It is expected that the Long Lake water quality improvements will lead to a delisting of this lake in the very near future. The BCWD intends to continue to implement to improve and maintain water quality in this lake.

Brown's Creek

The BMPs prescribed for the stream are listed in Table 6. The BMPs address excess sediment loading and elevated water temperatures. Activities addressing TSS target riparian and streambank erosion along with stormwater sediment contributions. Many of these activities will also work to reduce P loading. The BMPs needed to mitigate stream temperatures will involve increase stream shading through vegetative plantings. The vegetation will often be coordinated with the riparian erosion control activities. Restoration activities will include addressing stream width, shading and over-hanging banks, and stream profile and alignment. Stormwater reuse practices will also be implemented to reduce the amount of warmer water discharges from stormwater ponds and conveyance systems. The BCWD will also continue to investigate improving cold water inputs to the stream from groundwater via wetland discharges and riparian inflows. Implementation activities to address the *E. coli* impairment will include fixing noncompliant SSTS, addressing pet waste management, and stormwater runoff controls. A partnership with Washington County will help to prioritize and address noncompliant SSTS.

The District's cost-share program will assist in the installation of erosion and sedimentation control by citizens of the District.

The Brown's Creek Watershed District Rules (May 1, 2007) contain stormwater management, erosion and sediment control, and buffer standards that will provide the controls needed to meet the no net

increase requirements of the TMDL (see Table 4 and Figure 6) for most new development and redevelopment activity. These standards include:

- No increase in annual phosphorus loading from pre-development conditions
- Volume control for the 2-year 24-hour rainfall event as compared to pre-settlement conditions
- Stormwater temperature discharge requirements for facilities proposed within the contributing drainage area to a groundwater-dependent natural resource (e.g., Brown's Creek)
- Buffer zone widths for Brown's Creek of 50 feet for the streamside zone, 100 feet for the middle zone and an outer zone corresponding to the upland edge of the idle zone to the structure setback line under the applicable shoreland ordinance.
- Erosion and sediment control standards. Construction stormwater BMPs will be an important component of the BCWD TSS implementation plan. Currently, the BCWD issues permits and conducts inspections on most construction sites (sites disturbing more than 5,000 sq ft. and/or 50 cu. Yds) . The District's permitting program ensures that erosion and sediment control BMPs are in place and functioning properly, thus reducing the potential for sediment loading to the creek.
- Stormwater management requirements apply to "land disturbance of 5,000 square feet or more within the surface water contributing area of a groundwater dependent natural resource".

Critical areas

Riparian area critical areas were identified with a terrain analysis and the Brown's Creek Visual Assessment also completed in 2016. The assessment identified areas of potential sources of erosion and sediment loading. However, no sites were identified as being more severe than others. Long term stabilization activities will occur following the list of priority erosion areas.

Riparian zone management

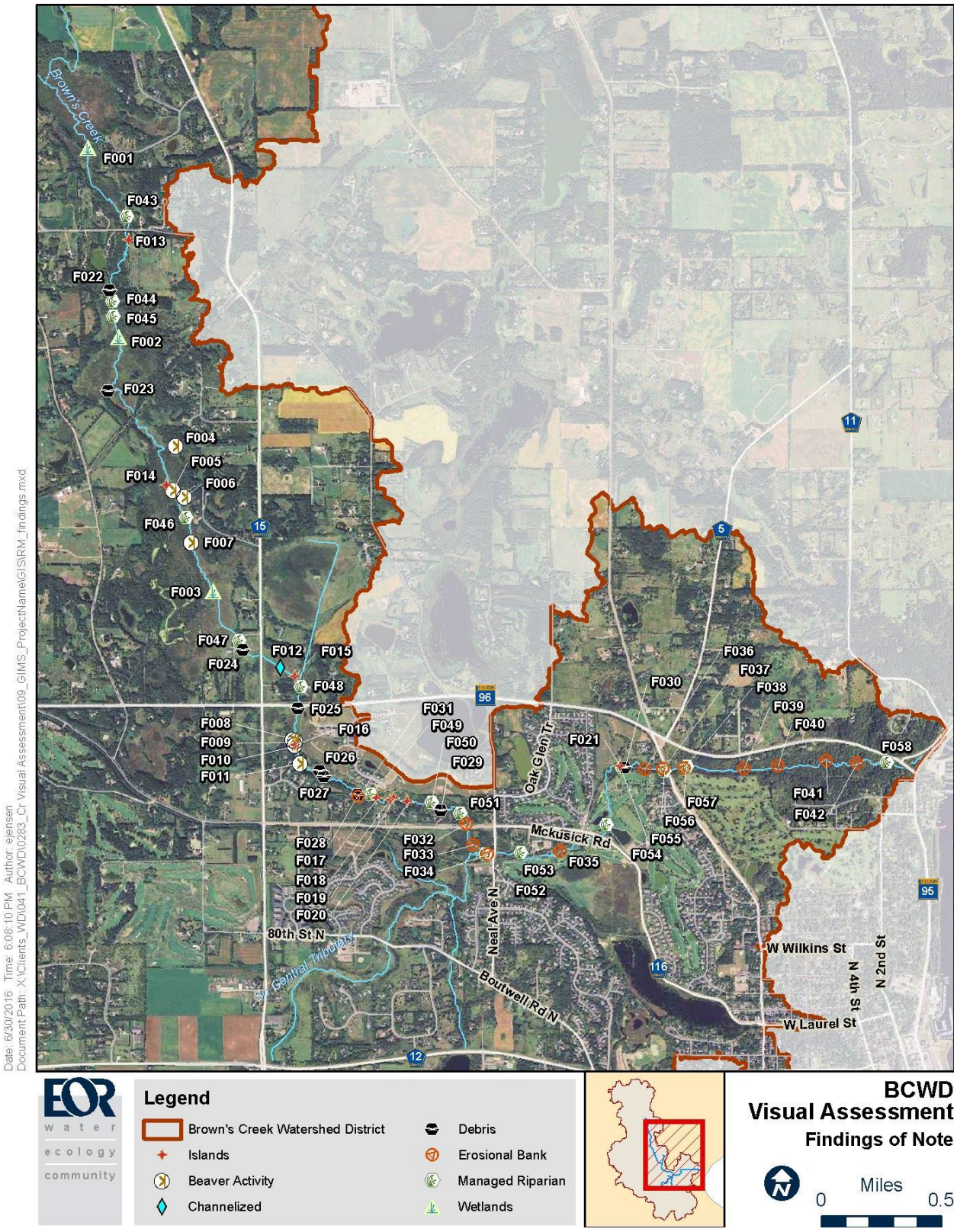
Table 13. Table 2 from the Visual Assessment Report 2016

Category	Unique ID	Reach Location	Description
Wetlands	F001	2016001	Headwater wetlands upstream of reach 1; largely undefined channel, majority cattails, soft silty bottom
	F002	2016011	Wetland upstream of Gateway trail: majority reed canary grass, inundated, undefined stream channel during bankfull flows
	F003	2016011	Open water wetland extends from Gateway Trl to near Manning Ave
Beaver Activity	F004	2016011	Frequent beaver activity with several abandoned lodges scattered throughout
	F005	2016011	Large beaver lodge embedded in bank
	F006	2016011	Several beaver created channels; several old dams reinforced, frequent beaver activity
	F007	2016011	Large abandoned beaver dam
	F008	2016019	Small willow/beaver dam creating meander cutoff
	F009	2016019	Frequent beaver activity
	F010	2016019	Abandoned beaver dam

Category	Unique ID	Reach Location	Description
	F011	2016020	Large abandoned beaver dam impoundment
Channelized	F012	2016015	Channelized section of stream presents restoration opportunity, homogenous habitat complexity, low shade, homogenous riparian species
Islands	F013	2016006	River left depositional island downstream of crossing ID C0032016
	F014	2016011	Depositional island upstream of frequent beaver activity and abandoned beaver channels
	F015	2016016	Meander cutoff upstream of debris jam caused by instream willow thicket
	F016	2016019	Meander cutoff adjacent to significant spring river right spring
	F017	2016021	River left meander cutoff
	F018	2016021	River left meander cutoff
	F019	2016021	River left meander cutoff
	F020	2016021	River left meander cutoff
	F021	2016033	Depositional island, channel braid downstream of cascade/weir
Debris	F022	2016007	Barbed wire spanning channel
	F023	2016011	Abandoned, partially submerged boat
	F024	2016012	Fenced chicken coop instream river right
	F025	2016017	Fence spanning stream
	F026	2016020	Abandoned fence river right
	F027	2016020	Failed foot bridge
	F028	2016021	Chain link fence spanning stream
	F029	2016023	Failed rip rap crossing
	F030	2016032	Barbed wire spanning channel
Erosion Banks	F031	2016021	River right rootball and large scour bank
	F032	2016025	Headcutting road drainage river left
	F032	2016026	Steep erosional cut bank, 5ft thalweg depth
	F033	2016027	River right steep 10ft bank
	F034	2016029	Long scour bank river left
	F035	2016032	80ft+ long scour bank river left
	F036	2016033	Steep river left scour bank
	F037	2016033	Steep river right scour bank
	F038	2016034	50 ft height bluff erosion
	F039	2016034	River left gully
	F040	2016036	30 ft height river left bluff erosion
	F041	2016037	Significant clay slide
Managed Riparian	F043	2016004	Constricted channel with landscape rock, mowed to edge of water, erosion potential within floodplain
	F044	2016007	Mowed path , riparian managed for buckthorn and other woody species
	F045	2016009	Cleared vegetation on along both banks

Category	Unique ID	Reach Location	Description
	F046	2016011	River left mowed to edge of water
	F047	2016012	River left has 0-20ft buffer, chicken coop installed instream on river right
	F048	2016017	Constricted channel with landscape rock, mowed to edge of water, erosion potential within floodplain
	F049	2016021	Mowed path, vegetation management for hunting
	F050	2016023	Mowed to edge of water river right
	F051	2016025	Mowed to edge of water river right
	F052	2016027	Mowed within riparian, 20 ft buffer
	F053	2016027	10 ft buffer, intensively mowed river left, gully formed and managed with landscaping materials
	F054	2016031	BCWD stream restoration project within golf course
	F055	2016032	River left grazing, historic cobble/rock weirs, midstream fences
	F056	2016033	Mowed to edge of water river left, revegetation/ prairie planting river right
	F057	2016033	Buckthorn and riparian vegetation clearing river left, mowed to edge of water
	F058	2016038	Historic DNR restoration project

Figure 10. Figure 7 from the Visual Assessment Report



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.

Total implementation of this plan, including district operations, education outreach, monitoring, and other functions is expected to exceed $10 million. Estimated costs, by practice are included in Table 6.

The BCWD works with the following to collaborate and address water quality concerns:

- Washington County
- City of Stillwater
- City of Bayport
- City of Lake Elmo
- City of Hugo
- City of Grant
- May Township
- Stillwater Township
- DNR

Additionally, the BCWD works with other entities, such as the MnDOT to capitalize on opportunities to install BMPs with the work being conducted. This opens additional opportunities to leverage funds and address multiple concerns. The BCWD works well with the business community and other commercial entities to address their concerns when developing or redeveloping their properties.

In addition to the partners listed, there are numerous others that the BCWD intends to reach out to during implementation of the Plan including homeowners associations, school district, Trout Unlimited, the St. Croix River Association, the Washington Conservation District, the Natural Resources Conservation Service, the Board of Water and Soil Resources and the Minnesota Pollution Control Agency. These partners may provide technical assistance in meeting load reductions, provide additional education and outreach, and/or provide sources of funding for implementation.

Each year the BCWD will invite all of the Implementation Partners to a TMDL Implementation meeting. It is expected that member communities, Washington County, and MnDOT will submit a summary of BMP projects/initiatives completed in the previous year and the anticipated TSS reductions to the creek. Using the Implementation Plan Table (Table 11), BMPs will be catalogued to track progress toward the individual wasteload and load reduction goals. These annual meetings will also be used to discuss progress towards achieving the goals of the TMDL Implementation Plan, discuss TSS and thermal load source evaluations, and discuss additional opportunities for load reductions that may not have been previously identified.

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.

Activities in the Implementations YTD Table identify specific outreach activities related to this plan. In addition, the BCWD has an extensive regime for involving the public.

BCWD is one of 25 partners in the East Metro Water Resource Education Program (EMWREP). The program goal is to educate community residents, businesses, staff and decision-makers about issues affecting local lakes, rivers, streams, wetlands and groundwater resources and to engage people in projects, and to protect and improve the health of water resources. By partnering with other watershed districts, municipalities, county and other local government entities, the message is consistent and has a much larger impact. This program has won several awards and has been recently expanded to cover all of the Lower St. Croix One Watershed One Plan area.

In addition to and in collaboration with EMWREP, the BCWD works closely with the Citizen Advisory Committee to bring watershed events and messaging to residents and businesses to increase environmental awareness and stewardship action to protect and enhance the water resources.

Table 14. Education and outreach by goal for the BCWD (BCWD Plan, 2019, Table 47)

SUB- Municipality and Developer/Contractor Education and Outreach ISSUE:

POLICY: The BCWD is committed to providing education and outreach services to municipalities in the District to promote good stewardship of water and natural resources.

GOALS		IMPLEMENTATION ITEM	
A	Increase municipal official and staff capacity for and use of development techniques and regulatory strategies that protect natural resources and benefit water quality.	1	Coordinate BCWD education and outreach efforts with those of municipalities and other local watershed organizations by continuing to support the East Metro Water Resource Education Program (EMWREP).
		2	Encourage attendance at training sessions hosted by Stormwater U on ordinances, development planning strategies, and development techniques that protect natural resources and benefit water quality by providing stipends so that 2 people from each District community can attend once every three years.
		3	Promote the MPCA's tool called WMAt for winter maintenance professionals to promote chloride reduction activities in the Long lake subwatershed.
B	Increase municipal official and staff capacity to promote the benefits of regular maintenance of stormwater management and infiltration practices and increase the implementation of maintenance practices.	1	Encourage attendance at training sessions hosted by Stormwater U on stormwater management facility maintenance schedules and procedures and the relation to water quality improvement (e.g. best practices to reduce impacts to water resources from parks and road maintenance activities - road salt application, fertilizer use,

SUB- **Municipality and Developer/Contractor Education and Outreach ISSUE:**

POLICY: **The BCWD is committed to providing education and outreach services to municipalities in the District to promote good stewardship of water and natural resources.**

GOALS		IMPLEMENTATION ITEM	
			irrigation practices) by providing stipends so that 2 people from each District community can attend once every three years.
		2	Work with municipalities in the development of operation and maintenance plans for stormwater management facilities.
C	Increase municipal official and municipal staff awareness of the BCWD and the assistance it can provide to municipalities.	1	Develop demonstration projects to highlight BMPs and stewardship.
		2	Promote Friends of the Mississippi River's Blue Star Award program to recognize municipal programs or projects and/or developer and contractor programs or projects that exemplify water and natural resource stewardship.
		3	Educate municipalities about the District's Rules.

The BCWD promotes good stewardship of water and natural resources through education and POLICY: outreach opportunities for land owners and managers conducting work within the District in order to promote good stewardship of water and natural resources.

GOALS		IMPLEMENTATION ITEM	
A	Increase developers', contractors', homeowner's associations and property managers' awareness and use of development techniques that protect natural resources and benefit water quality.	1	Conduct workshops targeted to developers and realtors about marketing lakeshore properties based on BCWD analysis of lake functions and values.
		2	Provide training sessions on development planning strategies and development techniques that protect natural resources and benefit water quality.
B	Increase developers', contractors', homeowner's associations and property managers' awareness of the importance of construction, installation, and maintenance techniques on the long-term functionality of stormwater management practices and increase the implementation of these techniques.	1	Encourage attendance at training sessions hosted by Stormwater U on stormwater management practice construction and installation techniques and the relationship to the continued functionality of the practice by providing stipends to individuals involved in construction oversight once every three years.
		2	Encourage developers with active projects in the watershed to attend erosion control seminars held by EMWREP / MECA.
C	Increase developer, contractor, homeowner's associations and property managers' awareness of the BCWD and the assistance it can provide.	1	Educate developers and the local design community about the District's Rules.

POLICY: **The BCWD will leverage and highlight existing efforts of other organizations conducting environmental stewardship work in the area**

GOALS		IMPLEMENTATION ITEM	
A	Increase citizen awareness of surface water, groundwater, and natural resource protection, restoration, and stewardship.	1	Send an annual newsletter to all citizens of the District. The newsletter may contain information on topics such as groundwater recharge, wetland and lake aesthetics and natural condition, home and yard care practices, and shoreline and wetland stewardship as well as information on BCWD accomplishments.
		2	Include an educational component in all BCWD capital improvement projects.
		3	Provide targeted educational messages through local businesses and local organizations. Businesses and organizations may include fertilizer suppliers, lawn care and garden companies, lake associations and garden clubs.
		4	Host education seminars on Estate Planning to educate the public about tax incentives to property owners who create and donate a conservation easement.
		5	Provide education to residents of the District on groundwater conservation strategies.
B	Promote citizen-led efforts in water and natural resource restoration, protection, and stewardship.	1	Continue to administer the Annual Recognition Program to recognize citizen efforts in water resource and natural resource protection.
		2	Conduct BMP installation and implementation training workshops to provide citizens with the knowledge to install and implement BMPs on their properties. Programs could include workshops on topics such as rain barrels, rain gardens, shoreline restoration, and fertilizer use, and native vegetation buffer establishment and maintenance.
		3	Utilize the cost-share program to assist citizens in best management practice installation.
		4	Develop demonstration projects to highlight stormwater management practices natural resource protection methods and resource stewardship.

The BCWD desires to provide its citizens education and public involvement opportunities in POLICY: watershed management planning and implementation in order to promote good stewardship of water and natural resources.

GOALS		IMPLEMENTATION ITEM	
A	Increase citizen awareness of the BCWD, its role, and the functions and assistance it provides.	1	Update the District website and Facebook page to include easy-to-use information on resource protection and stewardship.
		2	Include an educational component in all BCWD capital improvement projects.
		3	Educate citizens about the District's permitting program

		4	Host annual ice cream social in different parts of the watershed to highlight local projects and to engage residents in scientific and recreational activities
B	Provide K – 12 educational opportunities to encourage stewardship and increase awareness of the interconnected nature of land, surface water, and groundwater.	1	Develop classroom educational program that provides grants to teachers planning water and natural resource education sessions for their classroom or assist with curriculum development (e.g. perform monitoring activities, monitor BMPs, design BMPs, and develop watershed educational materials for variety of audiences).
		2	Conduct classroom presentations (K-12) on watershed concepts and water and natural resource stewardship.
C	Stay informed on the topic of pollutants of emerging concern in lakes, streams, and groundwater by monitoring future studies completed by the MPCA and sharing information with the public.	1	Educate the public about pollutants of emerging concern including the widespread prevalence of pharmaceutical and cosmetic products in our lakes and streams, how these compounds can disrupt hormone regulation of aquatic organisms, such as fish, and how these chemicals enter lakes and streams.

Table 15. Estimated costs of annual education and outreach (BCWD, 2019, adapted from Table 48)

Implementation Activities	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Coordinate BCWD education and outreach efforts with those of municipalities and other local watershed organizations by continuing to support the EMWREP.	20.4	20.4	20.4	21.4	21.4	21.4	25	25	25	25
Encourage attendance at training sessions hosted by Stormwater U on ordinances, development planning strategies, and development techniques that protect natural resources & benefit water quality by providing stipend: 2 people from District communities can attend once every 3 years.	2	--	--	2	--		2			2
Encourage attendance at training sessions hosted by Stormwater U on stormwater management facility maintenance schedules and procedures and the relation to water quality improvement by providing stipends: 2 people from District communities can attend once every three years.	--	--	2	--	--	2			2	
Educate municipalities about the District's Rules.	--	--	0.5	1	1	1	1	1	1	1
Encourage attendance at training sessions hosted by Stormwater U on stormwater management practice construction and installation techniques and the relationship to the continued functionality of the practice by providing stipends to individuals involved in construction oversight once every 3 yrs.	2	--	--	2	--	--	2	--	--	2
Educate developers & the local design community about the District's Rules.	--	--	--	--	--	--	--	--	--	-
Send annual newsletter to all citizens of the District.	5	5	5	5	5	5	5	5	5	5
Include an educational component in all BCWD capital improvement projects.	6.5	--	6.5	--	6.5	--	6.5	--	6.5	--

Implementation Activities	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Host education seminars on Estate Planning to educate the public about tax incentives to property owners who create and donate a conservation easement.	--	0.25	--	0.25	--	.25	--	.25	--	.25
Continue to administer the Annual Recognition Program to recognize citizen efforts in water resource and natural resource protection.	0.25	--	0.25	--	0.25	--	.25	--	.25	--
Update the District website and Facebook page to include easy-to-use information on resource protection and stewardship	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Host annual ice cream social in different parts of the watershed to highlight local projects and to engage residents in scientific and recreational activities	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Develop classroom educational program	5	5	5	5	5	5	5	5	5	5
Conduct classroom (K-12) presentations on watershed concepts and water and natural resource stewardship.	1	1	1	1	1	1	1	1	1	1

Table 16. Additional education and promotion (BCWD, 2019, Table 49 and 50)

Work with municipalities in the development of operation and maintenance plans for stormwater management facilities.
Promote Friends of the Mississippi River's Blue Star Award program to recognize municipal programs or projects and/or developer and contractor programs or projects that exemplify water and natural resource stewardship.
Encourage developers with active projects in the watershed to attend erosion control seminars held by EMWREP / MECA.
Educate citizens about the District's permitting program.
Promote the MPCA's tool called WMAt for winter maintenance professionals to promote chloride reduction activities in the Long lake subwatershed.
Conduct workshops targeted to developers and realtors about marketing lakeshore properties based on BCWD analysis of lake functions and values.
Provide training sessions on development planning strategies and development techniques that protect natural resources and benefit water quality.
Provide targeted educational messages through local businesses and local organizations. Businesses and organizations may include fertilizer suppliers, lawn care and garden companies, lake associations and garden clubs.
Provide education to residents of the District on groundwater conservation strategies.
Conduct BMP installation and implementation training workshops to provide citizens with the knowledge to install and implement BMPs on their properties. Programs could include workshops on topics such as rain barrels, rain gardens, shoreline restoration, and fertilizer use, and native vegetation buffer establishment and maintenance.
Educate the public about pollutants of emerging concern including the widespread prevalence of pharmaceutical and cosmetic products in our lakes and streams, how these compounds can disrupt hormone regulation of aquatic organisms, such as fish, and how these chemicals enter lakes and streams.

Element f. Reasonably expeditious schedule

A schedule for implementing the activities and NPS management measures identified in this plan that is reasonably expeditious.

Table 6 includes the schedule for the activities needed to reach the reductions required to meet water quality standards in Long Lake and Brown's Creek within 10 years, if implemented as planned.

Element g. Milestones

A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

A key element of the implementation of the Plan, though, is continuing to learn more about the stresses and challenges on watershed resources, and BCWD will remain open and willing to reassess its funding priorities in light of new data, additional analysis and the successes and setbacks that are necessarily a part of pursuing goals and priorities in a dynamic system. The milestones are included in the implementation tables found in Table 6.

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.

Assessment criteria is included in Table 6.

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.

The BCWD has a comprehensive monitoring program that includes flow and water quality measurements throughout Brown's Creek, its tributaries and in-lake sampling. Bimonthly sampling of Long Lake and flow, chemistry, and biological monitoring will continue for Brown's Creek. Long-term flow monitoring at the outlet of Brown's Creek is conducted year-round as part of the Metropolitan Council's Watershed Outlet Monitoring Program.

Table 17. Monitoring activities in BCWD (BCWD, 2019, adapted from Table 34)

SUB-ISSUE: Monitoring Needs ISSUE:

POLICY: The District prioritizes cost effective monitoring and research that measures the progress made towards achieving the District goals to conserve, protect, and restore natural resources	
GOALS	**IMPLEMENTATION ITEM**
Collect and analyze valuable information about the District's water resources and natural resources	Continue to implement baseline monitoring program including the collection of local climatology data and thermal monitoring in Brown's Creek (includes costs for equipment, maintenance and upgrades).
	Conduct biennial updates to District's Hydrologic & Hydraulic model to reflect new development activity and incorporate any new information collected by the District and/or member communities (e.g. structure inventories)
	Develop comprehensive database for storm sewer and structures located in the District by compiling what has been surveyed to date, coordinating with member communities and evaluating the need to supplement with future structure inventory surveys. Require, as a condition of permitted projects, the submittal of as-built electronic GIS files to keep the database up to date with new development.
	Continue to stay abreast of pollutants of emerging concern research
	Conduct routine assessments of the Brown's Creek corridor to monitor beaver dams and changes to the system.
	Conduct a source assessment to identify probable cause of high dissolved phosphorus concentration in Brown's Creek.
	Conduct sediment cores on Long Lake to determine the historic characteristics of the lake.
Conduct an annual assessment of the monitoring data to evaluate how well it is being collected and evaluated.	*Addressed through administration of the BCWD Baseline Monitoring Program.*
	Update the watershed conditions report every 5 years to assess the impact of BCWD programs on water quality, evaluate trends in watershed conditions (including groundwater dependent natural resources) and evaluate the need to make course corrections in strategy

SUB-ISSUE: Monitoring Needs ISSUE:

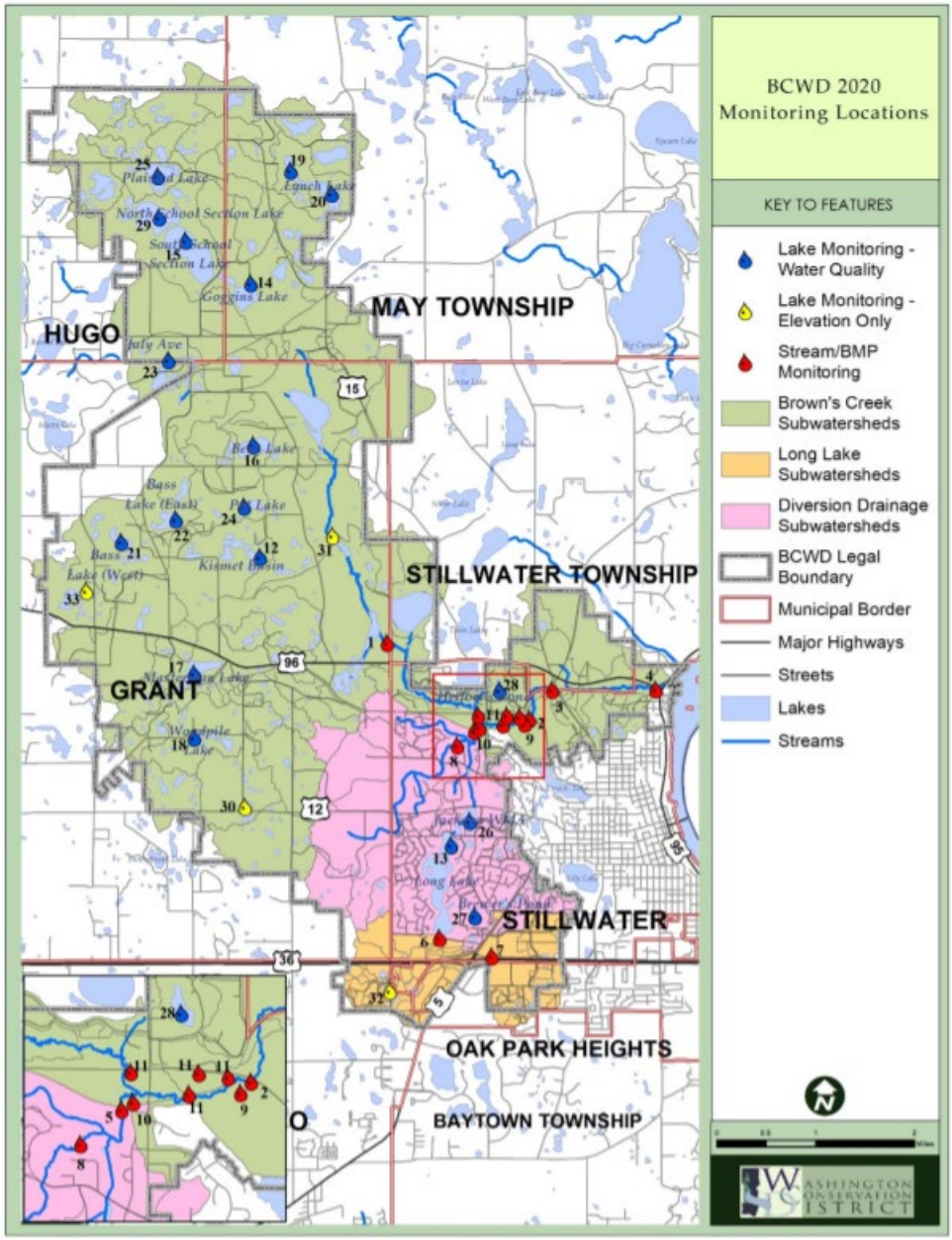
POLICY: The District prioritizes cost effective monitoring and research that measures the progress made towards achieving the District goals to conserve, protect, and restore natural resources	
GOALS	**IMPLEMENTATION ITEM**
Utilize data as part of a regular evaluation of performance of District programs and District rules	*Addressed through administration of the BCWD regulatory standards and criteria.*
SUB-ISSUE: Accessibility of Monitoring and Research Data ISSUE:	
POLICY: The District values information sharing among agencies and stakeholder groups and will make format and content of its data resources accessible.	
GOALS	**IMPLEMENTATION ITEM**
Continue to monitor stormwater management facilities to evaluate long-term performance and obtain design information on infiltration rates, suspended solids removal rates and phosphorus removal rates as appropriate to the facility.	*Addressed through administration of the BCWD Baseline Monitoring Program.*
Monitor any facilities constructed or installed by the BCWD for at least five years following facility installation to evaluate performance.	Develop GIS database of relevant current and historical monitoring data and provide the database to the public via the District website.
Each stormwater management facility in the District will be regularly inspected and maintained as appropriate to the type of facility.	Develop GIS database of relevant current and historical groundwater dependent natural resources monitoring data and provide the database to the public via the District website.
	Develop GIS database of relevant current and historical monitoring data and provide the database to the public via the District website
	Addressed through administration of the BCWD Baseline Monitoring Program.

The BCWD also has a weather station, which it installed at the City of Stillwater's Public Works Facility in 2011 to collect local climate data (precipitation, air temperature, dew point, relative humidity, solar radiation, wind speed, gust speed and wind direction) in support of future modeling efforts (BCWD, 2019).

In addition to its routine monitoring program, the District undertakes special monitoring activities to address specific issues and to answer watershed management questions as needed. For example, the District began collecting instream temperature data upon completing the Brown's Creek TMDL Implementation Plan. The objective of this monitoring effort is to better understand in-stream temperature patterns related to shading, directly connected ponds and stormwater management facilities, and untreated impervious areas. Over time, the District has also developed a groundwater monitoring program to better understand and evaluate baseflow contributions to the District's groundwater-dependent natural resources (BCWD, 2019).

Annual water quality summaries are available on the BCWD website.

Figure 11. Map of 2020 monitoring sites (BCWD website)



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