Shingle and Bass Creeks Biota and Dissolved Oxygen TMDL Implementation Plan

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Prepared for:

**SHINGLE CREEK
WATERSHED MANAGEMENT
COMMISSION**

**MINNESOTA
POLLUTION CONTROL AGENCY**

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1.0 Introduction

The Shingle and Bass Creek Biota and Dissolved Oxygen Total Maximum Daily Load (TMDL) Implementation Plan addresses biotic integrity and dissolved oxygen (DO) impairments on Shingle Creek (HUC 07010206-506) and its tributary Bass Creek (HUC 07010206-784) (see Figure 1.1). Bass Creek is the outlet of Bass Lake, and is about 2.4 miles long. Bass Creek is formed at the outlet weir that controls the level of Boulder Ridge Pond, the last in a series of wetlands downstream of Bass Lake. Shingle Creek is formed at the confluence of Bass Creek and Eagle Creek in Brooklyn Park, and flows 11 miles through Brooklyn Park, Brooklyn Center, and Minneapolis, where it discharges into the Mississippi River. The Shingle Creek watershed is located within the Upper Mississippi River basin.

Shingle Creek was first placed on the State of Minnesota's 303(d) list of impaired waters in 2004 for low levels of dissolved oxygen impairing aquatic life. In 2006 it was placed on the 303(d) list for impaired biotic integrity as measured by bioassessment of macroinvertebrates. Bass Creek was placed on the 303(d) list in 2002 for impaired biotic integrity as measured by fish bioassessment.

The Shingle Creek Watershed Management Commission (SCWMC or Commission) has completed a TMDL analysis for the Minnesota Pollution Control Agency (MPCA) and the United States Environmental Protection Agency (USEPA) to quantify the reduction in oxygen-demanding substances needed to meet State water quality standards for dissolved oxygen in Shingle Creek in accordance with Section 303(d) of the Clean Water Act. The TMDL also identifies additional stressors affecting the biotic integrity of Bass and Shingle Creeks – altered hydrology, lack of habitat, loss of connectedness, and ionic strength (chloride). The previously-completed Shingle Creek Chloride TMDL and Implementation Plan identify the load reductions necessary to reduce chloride concentrations in Shingle Creek.

The final step in the TMDL process is the development of an Implementation Plan that sets forth the activities that will be undertaken to increase dissolved oxygen and improve biotic integrity. This Implementation Plan provides a brief overview of the TMDL findings; describes the principles guiding this Implementation Plan; describes the proposed implementation activities and estimates of their costs; and discusses sequencing, timing, and lead agencies and organizations for the activities.

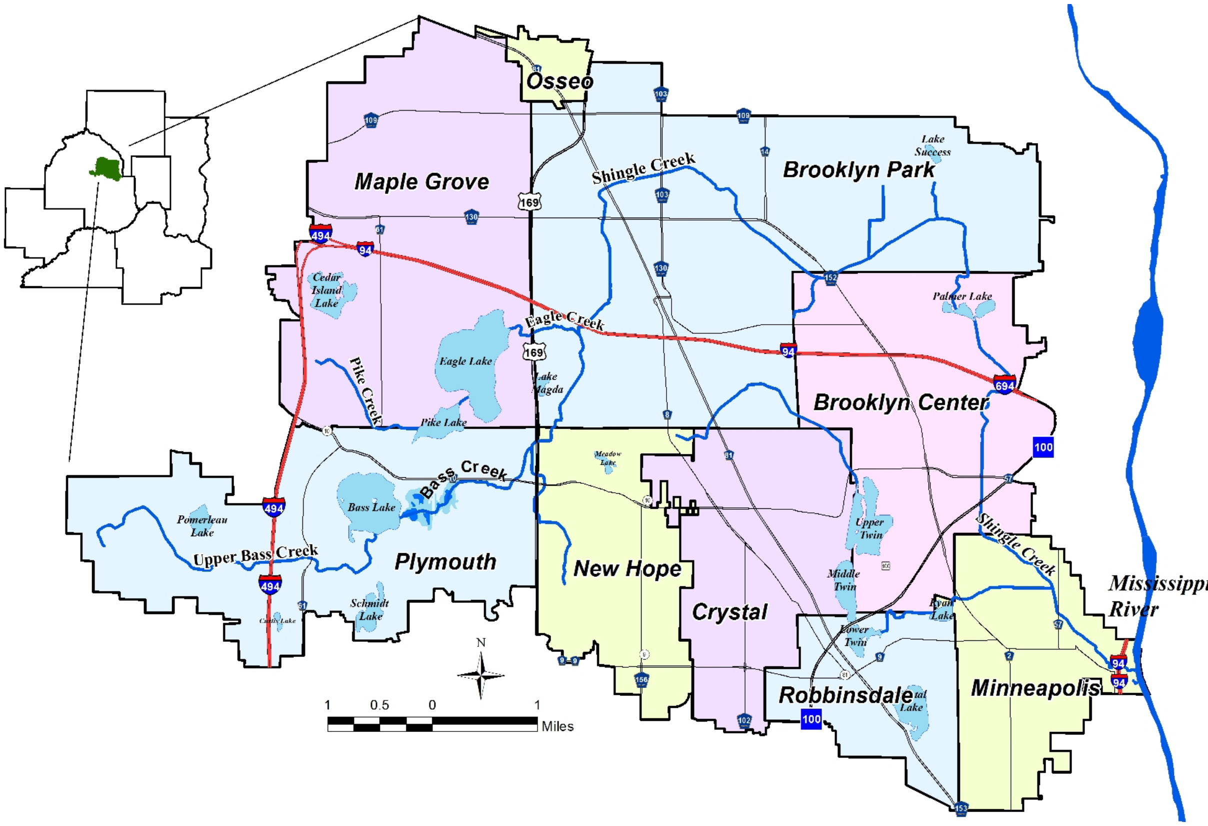

Figure 1.1. The Shingle Creek watershed is located within the Twin Cities Metro Area.

2.0 Shingle and Bass Creeks TMDL Summary

The Shingle Creek watershed covers 44.7 square miles of fully developed, dense urban and suburban land uses. Shingle Creek has been substantially altered from conditions documented in the 1855 Public Land Survey. A portion was straightened and dredged in 1910 to serve as County Ditch #13. Over time most of the rest of the stream has been channelized, widened and dredged to better convey stormwater discharged to the stream. At about River Mile 5, Shingle Creek flows through Palmer Lake, a 400+ acre wetland basin that is the divide between Upper Shingle Creek and Lower Shingle Creek. Bass Creek appears to be an historically intermittent channel too small to be recorded on the Public Land Survey and then later ditched to drain wetlands and/or provide agricultural drainage.

2.1 CURRENT WATER QUALITY

Minnesota's standard for dissolved oxygen in Class 2B waters is a daily minimum of 5.0 mg/L, as set forth in Minn. R. 7050.0222 (4). The Shingle Creek Watershed Management Commission and the USGS (United States Geological Survey) have monitored water quality, (including dissolved oxygen levels) in Shingle Creek for many years. Table 2.1 below shows the criteria the MPCA uses to determine if a stream is impaired by low dissolved oxygen, and how data collected in Shingle Creek compares.

Table 2.1. 2010 revised DO impairment listing criteria and relevant Shingle Creek data 2001-2009.

Criterion	Requirement	Shingle Creek Data
Number of independent observations	20 observations (over at least 2 years)	317 total observations, 65 (21%) less than 5.0 mg/L
May-September observations	Must be taken prior to 9:00 a.m. over at least two years	29 confirmed May-September pre-9:00 a.m. observations
DO standard must be met prior to 9:00 a.m. during May-September AND	90% of the time (no more than 10% below standard)	29 observations, 13 (45%) less than 5.0 mg/L
DO standard must be met during October-April	90% of the time (no more than 10% below standard)	105 observations, 6 (6%) less than 5.0 mg/L
Number of violations	Must be at least 3	At least 21 violations

While Bass Creek is not listed as an Impaired Water for low dissolved oxygen, the limited data that is available suggests that it too falls below the 5.0 mg/L necessary to sustain aquatic life. Figure 2.1 shows the results of a longitudinal survey taken in one morning in August 2007, starting at the Bass Creek headwaters and proceeding downstream to the Shingle Creek outlet into the Mississippi River. Nearly all the readings fell below the 5.0 mg/L standard.

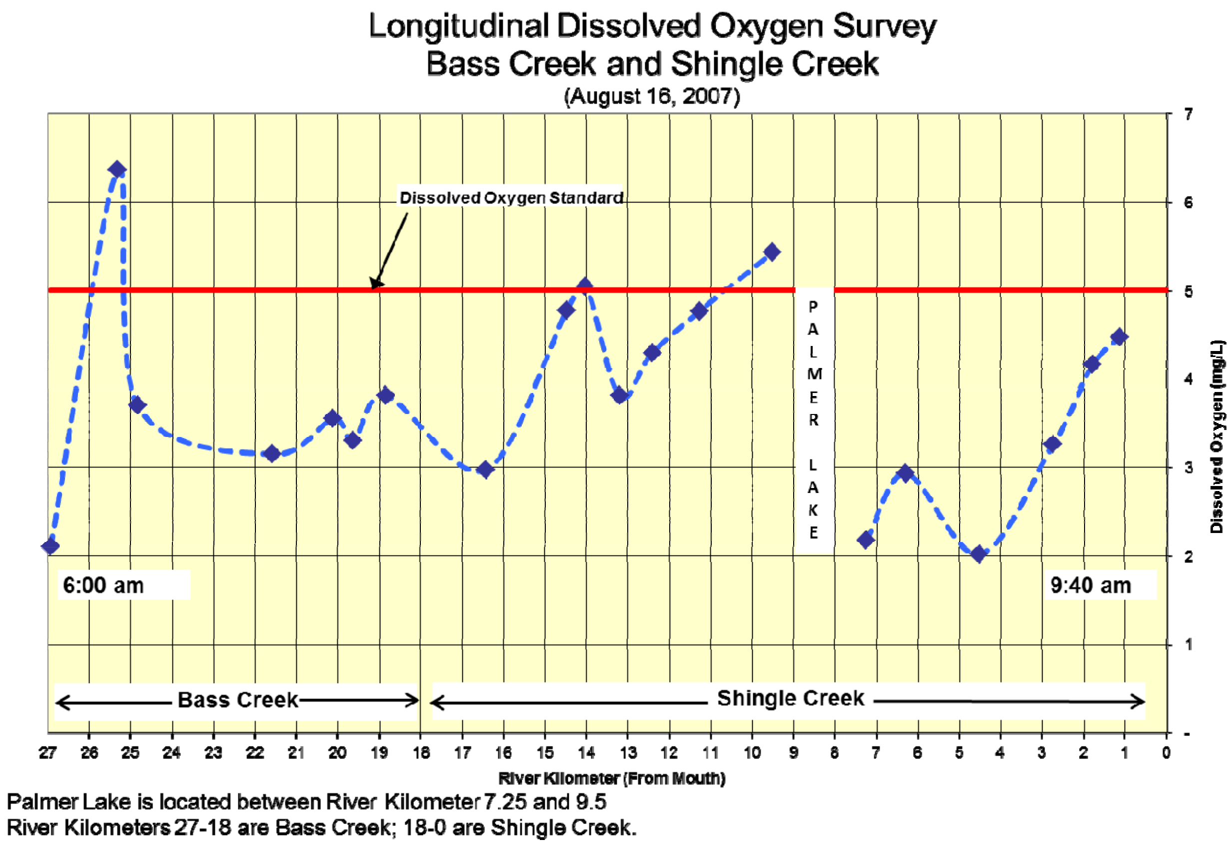

Figure 2.1. Dissolved oxygen in Bass and Shingle Creeks in August 2007.

2.2 CURRENT BIOTIC INTEGRITY

The MPCA has developed an Index of Biotic Integrity (IBI) to evaluate the biological health of streams in the State. Currently, an IBI has been developed for fish and macroinvertebrates. Shingle Creek is impaired based on the macroinvertebrate IBI (M-IBI) while Bass Creek is impaired based on the fish IBI (F-IBI).

Limited data are available to evaluate the integrity of the fish and macroinvertebrate communities and the effects of potential stressors. Fish data is over ten years old and available at only two locations. Droughts in 2008 and 2009 prevented an update of the fish surveys for the streams. Existing data suggests an unexpected fish species richness in Shingle Creek, with a more limited and pollution-tolerant community in Bass Creek. There are more recent and more spatially distributed macroinvertebrate data, but there are only a few data points for each location. The macroinvertebrate community is dominated by pollution-tolerant taxa, although sites with slightly better habitat appear to support some more moderately-tolerant organisms.

Table 2.2 shows the Index of Biotic Integrity scores used to evaluate Shingle and Bass Creeks for biotic impairment.

Table 2.2. Index of Biotic Integrity listing criteria and relevant Shingle and Bass Creek data.

Stream and IBI	Impairment Threshold	Shingle/Bass Creek IBI
Shingle Creek – fish	46	49
Shingle Creek – macroinvertebrates	54	20
Bass Creek –fish	46	12
Bass Creek - macroinvertebrates	54	67

Note: IBI data are from 2000 MPCA and DNR collections.

2.3 EVALUATING WATER QUALITY AND BIOTIC INTEGRITY

QUAL2K modeling was completed to evaluate the potential cause or causes of low dissolved oxygen in Shingle Creek and test various improvement scenarios. Two models were developed for Shingle Creek: one model extended from its headwaters to the inflow of Palmer Lake, and one model extended from the outflow of Palmer Lake to the Mississippi River. No modeling was completed for Bass Creek. A Stressor Identification was completed for both Bass and Shingle Creeks to determine the probable causes of low biotic integrity.

2.3.1 Dissolved Oxygen Modeling Results

The monitoring data and modeling identified sediment oxygen demand (SOD) as playing the biggest role in consuming dissolved oxygen during critical base-flow conditions. The overwidened stream channels decrease velocities and increase sediment-water interaction time, a condition which also exists in Bass Creek. These channels have shallow water depths and wide areas interacting with organic stream sediments, increasing the SOD influence on in-stream dissolved oxygen concentrations.

In addition, in-line, flow through wetlands influence dissolved oxygen levels. Continuous dissolved oxygen measurements recorded at the outlet of Palmer Lake (Lower Shingle Creek) indicate the wetland system experiences large diurnal swings in DO, with minimum daily values falling well below the standard. While continuous DO was not recorded at the I-94 Wetland site (Upper Shingle Creek), observations show concentrations were very close to the standard during mid/late morning field visits. Moreover, DO concentrations were well below the standard during an early morning longitudinal survey conducted on August 17, 2007. These low DO conditions make it extremely difficult, if not impossible for the reaches immediately downstream to achieve the DO standard as a daily minimum.

2.3.2 Stressor Identification Results

A Stressor Identification analysis was prepared for the TMDL using the United States Environmental Protection Agency's (USEPA) and MPCA's Stressor Identification guidance (Jasperson 2009) and the USEPA's Causal Analysis/Diagnosis Decision Information System (CADDIS). CADDIS (USEPA 2007), a methodology for conducting a stepwise analysis of candidate causes of impairment, characterizes the potential relationships between candidate causes and stressors, and identifies the probable stressors based on the strength of evidence from available data. Data are analyzed in terms of associations that might support, weaken or refute the case for a candidate cause. This strength of evidence analysis is a systematic approach that sorts through the available data to determine the most probable cause or causes based on weight of evidence.

Various potential candidate causes were reviewed and ruled out, leaving five stressors that were examined in more detail: low dissolved oxygen; altered habitat; loss of connectedness; altered hydrology; and ionic strength, specifically chloride. The evidence for altered hydrology is strongest followed closely by dissolved oxygen and lack of habitat. While the loss of connectedness and ionic strength are plausible stressors and are likely contributing to the impairment, there is less direct evidence of their role. Altered hydrology, dissolved oxygen, and habitat are interrelated.

2.4 TOTAL MAXIMUM DAILY LOADS FOR BASS AND SHINGLE CREEKS

This TMDL and Implementation Plan include both a numeric TMDL as well as additional actions to address non-TMDL parameters. The numeric TMDL specifically addresses the Shingle Creek DO impairment. It should be noted that even though only Shingle Creek was modeled for the TMDL, the conditions in Upper Shingle Creek are also representative of Bass Creek. Data collected in Bass Creek for this project verify this assumption. In addition, oxygen demand (as CBOD, NBOD, and SOD) acts as a surrogate for the biotic integrity impairment in Shingle Creek as determined by macroinvertebrate bioassessment and Bass Creek as determined by fish bioassessment. Note that even when Shingle and Bass Creeks meet dissolved oxygen requirements in this TMDL, additional restoration strategies will likely need to be implemented in order to meet biotic integrity standards.

The numeric TMDL, which is the Total Load Capacity, is the sum of the wasteload allocation (WLA), load allocation (LA), and the margin of safety (MOS). The TMDL is written to solve the TMDL equation for a target of a daily minimum of 5.0 mg/L dissolved oxygen across all reaches for the critical, low-flow condition. The TMDL is expressed as a Lower Watershed TMDL, which includes Lower Shingle Creek and the watershed below Palmer Lake, and an Upper Watershed TMDL, which includes Upper Shingle and Bass Creeks and the watershed above Palmer Lake.

2.4.1 TMDL Parameters

Dissolved oxygen is consumed both in the water column and at the sediment interface. This consumption is expressed in terms of the mass of oxygen-demanding substances available per day.

Carbonaceous biochemical oxygen demand (CBOD) represents the oxygen equivalent (amount of oxygen that micro-organisms require to breakdown and convert organic carbon to CO_2) of the carbonaceous organic matter in a sample. A second source is nitrogenous biochemical oxygen demand (NBOD). A wide variety of micro-organisms rapidly transform organic nitrogen (ON) to ammonia nitrogen (NH_3-N). Bacteria then transform NH_3-N to nitrate through an oxygen consuming process called nitrification. Finally, sediment oxygen demand (SOD) is the aerobic decay of organic materials in stream bed sediments and in peat soils in wetlands. SOD rates are defined in units of oxygen used per surface area per day (kg-O_2/m^2/day).

Oxygen-consuming loads are also distributed to the stream from stormwater runoff and groundwater. These diffuse sources are regulated wasteloads.

2.4.2 Numeric TMDL

The Total Maximum Daily Load is the sum of the wasteload and load allocations and a margin of safety. Tables 2.3 and 2.4 show the current loads and the Total Maximum Daily Load allocations by source for the Upper and Lower Watershed for the critical, low-flow condition.

Table 2.3. Current loads and Total Maximum Daily Loads for the Upper Shingle Creek Watershed.

	Oxygen Demand (kg/day) from:						Total Oxygen Demand (kg/day)	
	CBOD		NBOD		SOD			
Source	**Current**	**TMDL**	**Current**	**TMDL**	**Current**	**TMDL**	**Current**	**TMDL**
Load: I-94 Wetland	7.8	7.8	18.3	18.3	--	--	26.1	26.1
Load: Sources of Sediment Flux	--	--	--	--	491.9	12.0	491.9	12.0
Wasteload: Diffuse Sources	--[1]	--[1]	35.8	35.8	--	--	35.8	35.8
Margin of Safety	--	--	--	--	--	1.3	--	1.3
Total	7.8	7.8	54.1	54.1	491.9	13.3	553.8	75.2

Table 2.4. Current loads and Total Maximum Daily Loads for the Lower Shingle Creek Watershed.

	Oxygen Demand (kg/day) from:						Total Oxygen Demand (kg/day)	
	CBOD		NBOD		SOD			
Source	**Current**	**TMDL**	**Current**	**TMDL**	**Current**	**TMDL**	**Current**	**TMDL**
Load: Palmer Lake	67.3	67.3	50.2	50.2	--	--	117.5	117.5
Load: Sources of Sediment Flux	--	--	117.2	38.4	703.0	186.5	820.2	224.9
Wasteload: Diffuse Sources	--[1]	--[1]	11.8	11.8	--	--	11.8	11.8
Margin of Safety	--	--	--	--	--	20.7	--	20.7
Total	67.3	67.3	179.2	100.4	703.0	207.2	949.5	374.9

2.4.3 Strategies to Address TMDL Parameters

The critical condition for dissolved oxygen in Shingle Creek and Bass Creek occurs in the late summer, when flows typically are at their lowest. Therefore, improvement scenarios were tested separately and in various combinations to find a management scenario that was most successful in increasing minimum daily DO to at least 5.0 mg/L during the summer low flow condition. No wasteload reduction from diffuse sources is specified in the TMDL as modeling showed that

[1] It is noted that there may be diffuse sources of CBOD, but for practical purposes the absence of loading is supported by model calibration to in-stream water quality samples.

reducing those direct inputs would have a minimal impact on achieving the DO standard. However, some part of SOD likely originated from diffuse, stormwater inputs. The combination of reducing SOD from diffuse and other sources, increasing wetland outlet DO, and altering the low-flow channel shape was sufficient to meet the required SOD reductions and increase minimum daily DO for both Upper and Lower Shingle Creek. Recommended actions include:

- Modify the streams to include a low-flow channel to decrease wetted surface area contributing to sediment flux, which in turn will decrease SOD while also increasing flow velocities and reaeration. For modeling purposes it was assumed that the width of the low flow channel was roughly one-third of the width of the existing channel while depth was approximately doubled.
- Increase dissolved oxygen in water discharged from flow-through wetlands to ensure the downstream flow does not fall below 5.0 mg/L DO as a daily minimum.
- Increase stormwater treatment and volume reduction in the watershed to reduce diffuse inputs that contribute to sediment oxygen demand.

2.5 NON-TMDL PARAMETERS

The Stressor ID identified five primary stressors affecting biotic integrity in Shingle Creek and Bass Creek. Two of those stressors – low dissolved oxygen and excess chloride - are addressed by achieving TMDL wasteload and load reductions, either through this TMDL or the previously completed chloride TMDL now in implementation.

Three of the stressors – habitat alteration, altered hydrology, and loss of connectedness – are not associated with a specific pollutant for which a TMDL can be developed. However, based on the Stressor ID and Shingle Creek Corridor Study findings, the goals for those stressors are established below.

2.5.1 Habitat Alteration

While each segment and reach of Shingle and Bass Creeks is unique in the types and extent of habitat present or absent, some general habitat goals can be established for these streams. Recommended actions include:

- Channel bottom sediments are fairly uniform fine to coarse sand. Increase the diversity of channel bottom substrate and increase average D_{50} particle size.
- Both Shingle and Bass Creeks are very flat, but riffles and pools can be constructed where there is enough grade to enhance rocky substrate and deepen pools.
- The overwidened channel often results in very shallow stream depths. Add a low-flow channel to increase depth where possible.
- In some locations the streams are heavily shaded, and in others there is no canopy coverage at all. Manage riparian trees and vegetation so that at least 25 percent but no more than 90 percent of the stream surface is shaded.

- Remove or minimize barriers to fish and other aquatic and terrestrial organisms, both in the stream and those that inhibit access to and from floodplain, riparian wetlands, and lakes.
- Create or enhance refugia through the addition of woody debris, root wads, deeper pools, backwaters and side pools.
- Restore native vegetation on the streambanks and riparian zone to stabilize streambanks, filter runoff, and provide overhanging vegetation, providing a buffer at least 20 feet wide on both sides of the two streams.

2.5.2 Altered Hydrology

Urbanization in the Shingle Creek watershed has both increased peak flows and reduced base flows. This is most dramatically seen in Upper Shingle Creek where stream flow is 1 cubic foot per second (cfs) or less more than 25 percent of the time. Figure 2.2 presents a generalized desirable flow duration curve for Upper Shingle Creek. A desirable flow regime would reduce peak flows from the current peaks, maintain a stable flow, and sustain a base-flow that would never fall below a desired “ecological base-flow.” Generally, the stable flow that would characterize most of the regime would be defined as a flow rate and velocity that would 1) provide sufficient reaeration to keep DO levels above 5.0 mg/L; 2) adequately mobilize and flush sediment; and 3) be tolerated by desirable fish and macroinvertebrate organisms.

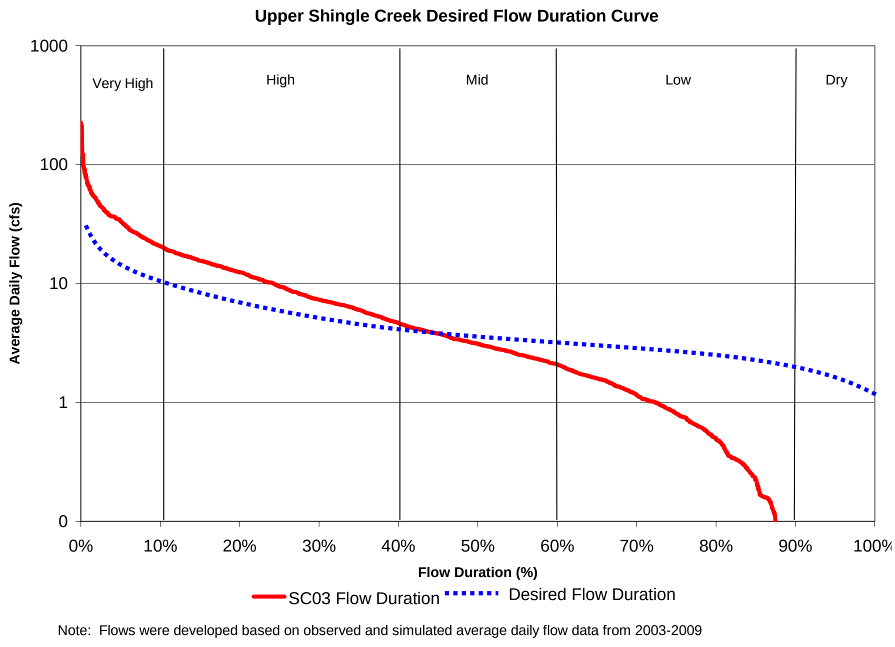

Figure 2.2. Current and desirable flow duration curve for Upper Shingle Creek.

Specific strategies for achieving the desirable flow duration curve will be developed as part of the Shingle Creek WMC’s Third Generation Management Plan in development in 2011-2012. Strategies that would likely be most effective include:

- Increase infiltration and abstraction in the watershed to reduce peak flows and volumes.

- Evaluate the use of extended detention basins to reduce peak flows.
- Evaluate surficial groundwater flows to determine where infiltration would be most effective for increasing base flows.

2.5.3 Loss of Connectedness

The loss of connectedness on Shingle and Bass Creeks relates both to the addition of physical barriers limiting movement as well as loss of contiguousness of landscape that has fragmented habitat. The physical barriers are both human-made, such as drop structures in the stream and lake outlet structures, and natural but human-induced, such as channel incision reducing access to floodplain. Many of the connectedness goals are similar to the habitat goals set forth above. Recommended actions include:

- Remove or minimize barriers to fish and other aquatic and terrestrial organisms, both in the stream and those that inhibit access to and from floodplain, riparian wetlands, and lakes.
- Create or enhance refugia through the addition of woody debris, root wads, deeper pools, backwaters and side pools.
- Restore native vegetation on the streambanks and riparian zone to stabilize streambanks, filter runoff, provide overhanging vegetation, and provide a buffer at least 20 feet wide on both sides of the two streams.
- Create low-flow channels to carry low flow events and base-flow, and maintain a vegetated floodplain within the channel to carry flows from larger events. Regrade streambanks to provide better access to the floodplain.

3.0 Implementation Plan

3.1 TMDL AND IMPLEMENTATION PLAN PROCESS

The activities and Best Management Practices (BMPs) identified in this Implementation Plan are the result of a series of Technical Advisory Committee (TAC) and stakeholder meetings led by the Shingle Creek Watershed Management Commission (SCWMC). The TAC included stakeholder representatives from local cities, Minnesota Department of Natural Resources (DNR), the Metropolitan Council, and the Minnesota Pollution Control Agency. All meetings were open to interested individuals and organizations. Technical Advisory Committee meetings to review this TMDL and Implementation Plan were held on June 4, 2008, January 7, 2010, and May 13, 2010. The TMDL was reviewed by the Commission at its August 14, 2009 and January 14, 2010 meetings. Public input on the Implementation Plan was taken at a volunteer planting event on Shingle Creek on May 21, 2011.

This Implementation Plan was distributed to the affected stakeholders for review and posted on the SCWMC website www.shinglecreek.org for public review and comment. This Implementation Plan was reviewed by the TAC at its June 23, 2011 meeting. On September 8, 2011 the Shingle Creek Watershed Management Commission reviewed this draft Implementation Plan and all comments received and approved this Plan.

3.2 IMPLEMENTATION PLAN PRINCIPLES

Through the discussion of policies and practices, current activities, and ongoing research, the TAC developed principles to guide development and implementation of the load reduction plan. These principles, in no order, include:

1. Undertake Stream Restoration Projects. Meeting the TMDL Wasteload Allocation and biotic integrity goals will require the long-term ecological restoration of the channels. The TMDL and the Shingle Creek Corridor Study (Wenck 2005) set forth general design principles to guide the design of future stream restoration projects. Several projects on Shingle Creek have already been completed or are in design.

2. Proactively Manage the Riparian Zone. Maintenance of much of the riparian zone is inconsistent and is characterized by "benign neglect." Actions such as maintaining a native buffer, removing invasive species, removing leaning and undercut trees, and selective tree thinning are actions that can improve stream stability and habitat in advance of undertaking stream restoration.

3. Retrofit BMPs in the Watershed As Opportunities Arise. The cities in the watershed have agreed that watershed BMPs to increase infiltration and stream baseflow and reduce stream peak flows should be undertaken to work toward the desirable flow duration curve. These BMPs would have the ancillary benefit of reducing transport of pollutants to the streams that

may become diffuse sources of sediment oxygen demand. Options for retrofitting BMPs are limited. Each stakeholder agreed to evaluate and include volume management BMPs in street and highway projects, and to consider opportunities such as redevelopment to add or upsize BMPs.

4. Foster Stewardship. City staff, especially maintenance staff, will be provided opportunities for education and training to better understand how their areas of responsibility relate to the protection and improvement of Bass and Shingle Creeks.

5. Communicate with the Public. Public education should take a variety of forms, and should include both general and specialized information, targeted but not limited to:

   - General public
   - Elected and appointed officials
   - Developers
   - Property owners and managers

3.3 IMPLEMENTATION PLAN

Implementation will be a joint effort, with the SCWMC taking responsibility for ongoing coordination, general education and monitoring activities. The cities, county, and other jurisdictions holding stormwater permits under the State of Minnesota National Pollutant Discharge Elimination System (NPDES) General Stormwater Permit will be responsible for BMP implementation. The permittees will incorporate these BMPs into their Storm Water Pollution Prevention Programs (SWPPP), and will work with the SCWMC to periodically assess progress advancing the implementation principles detailed above. These agencies will report to the SCWMC or include in their Annual Reports their annual activities, and the Commission will summarize those activities into its own Water Quality Monitoring Annual Report.

3.3.1 Implementation Approach

The impairments to Bass and Shingle Creeks developed over time as the watershed urbanized. As the watershed developed, the native prairie and savanna was cleared to support farming. Over the past century the farms and remaining undeveloped land were converted to residential use, increasing the volume of stormwater runoff and the amount of pollutants conveyed to the streams. The streams were incorporated into the county and municipal storm drainage systems, and were straightened, widened, and dredged, first to facilitate agriculture and then to efficiently convey stormwater. Just as these modifications and impacts took many years, improvement will take many years through ongoing retrofit of the watershed with BMPs as well as eventual redevelopment of existing land uses with lower-impact development and stormwater treatment. However, it will take several decades to see any significant redevelopment in this watershed.

The TMDL study and this Implementation Plan identify general improvements to increase dissolved oxygen and biotic integrity. Some of these actions are nonstructural and could be undertaken at any time, such as buffer establishment and tree thinning, and some are structural actions that would be completed as part of a construction project. These are “short term” projects that could be accomplished in the next 10-20 years. However, these projects alone will not be sufficient to achieve the desirable flow duration curve for these streams. An essential "long-term" component of this Implementation Plan is to routinely retrofit volume management BMPs in this fully developed watershed as redevelopment or construction provide opportunities.

3.3.2 Implementation Strategies

The following sections discuss the general BMP strategies that were identified in the TMDL process to increase dissolved oxygen and restore biotic integrity; the general sequence of implementation activities; and the stakeholders who would take the lead in implementing each activity. BMP strategies are listed below and described in more detail in Sections 4 and 5 and Appendix A of this Plan.

<u>Sediment Oxygen Demand (SOD) Load Reduction Strategies</u>

- Evaluate options to increase dissolved oxygen at wetland outlets, and implement the most feasible option(s).
- Undertake stream restoration projects to modify channel morphology incorporating a low-flow channel. Where projects have already occurred, review and implement enhancements if necessary.
- Reduce and treat stormwater runoff to the stream.

<u>Biotic Integrity Restoration Strategies</u>

- Incorporate habitat enhancements into stream restoration projects.
- Remove or bypass fish barriers.
- Restore access to floodplain and riparian wetlands.
- Increase infiltration and abstraction in the watershed.
- Reduce chloride loading.

3.3.3 Sequencing

Some of the above activities may be undertaken immediately, while others would be undertaken as opportunities arise. In general implementation will proceed as follows:

<u>First Five Years</u>

- Complete stream restoration projects.
- Conduct workshop for city staff discussing maintenance strategies for stormwater management and stream corridor maintenance.
- Evaluate options for providing a fish passage to bypass the Webber Park drop structure.
- Increase education and outreach in the watershed to encourage volume management.
- Implement BMP and volume management projects as opportunities arise.
- Continue annual monitoring water quality and flow in Shingle Creek.
- Periodically monitor water quality and flow in Bass Creek.
- Conduct biological monitoring every three to five years in both streams.
- At the end of five years evaluate progress toward achieving water quality and biotic integrity standards.
- Amend the Implementation Plan as necessary based on progress.

Second Five Years and Beyond

- Continue stream restoration projects.
- Continue monitoring program.
- Every five years evaluate progress toward achieving water quality and biotic integrity standards.
- Amend the Implementation Plan as necessary based on progress.

3.3.4 Stakeholder Responsibilities

The primary stakeholders in this Plan are the Shingle Creek Watershed Management Commission (SCWMC) and the cities within the watershed. In addition, property owners in the watershed have a role to play in implementing BMPs on their private properties. The SCWMC Education and Outreach program will provide property owners and managers with information on BMPs that would have the most impact on improving water quality. In general, the SCWMC will take the lead on coordination, monitoring, education and outreach, and cost sharing.

Cities alone or in collaboration will construct improvement projects such as stream restoration and implement other BMPs. Municipal stormwater discharges are regulated under the General National Pollution Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit for Municipal Separate Storm Sewer Systems. Member cities, Hennepin County, Mn/DOT and two technical colleges are NPDES permitted dischargers and must meet wasteload allocations as set forth in the TMDL. Because there is not enough information available to assign diffuse loads to individual permitted dischargers, the wasteload allocations are combined in this TMDL as categorical wasteload allocations assigned to all permitted dischargers in the contributing watershed as listed below with either the MS4 permit identification number or permit number (Minneapolis).

- Brooklyn Center – MS400006
- Brooklyn Park – MS400007
- Crystal – MS400012
- Maple Grove – MS400102
- New Hope – MS400039
- Osseo – MS400043
- Plymouth – MS400112
- Robbinsdale – MS400046
- Hennepin County – MS400138
- MnDOT Metro District – MS400170
- Minneapolis - MN0061018
- North Hennepin Technical College – MS400295
- Hennepin Technical College-Brooklyn Park – MS400198

There are no municipal wastewater dischargers in the watershed. There are three active industrial dischargers in the watershed, but none of their permits include limits or monitoring requirements for oxygen demanding characteristics (NH_3, BOD, COD, CBOD) indicating that oxygen demand is not a concern with these types of effluents. Consequently, they do not require wasteload allocations because their activities do not contribute to the impairment. Stormwater activities from individually permitted, non-MS4 NPDES/SDS stormwater discharges have not been given an individual WLA and will be considered in compliance with provisions of this TMDL if they follow the conditions of the individual permit and implement the appropriate Best Management Practices.

The cities cooperated in developing the TMDL and Implementation Plan and will continue to work together through the ongoing Commission Technical Advisory Committee (TAC). This collective approach allows for greater reductions for some permit holders with greater opportunity and less for those with greater constraints.

3.4 ADAPTIVE MANAGEMENT

Adaptive management is an iterative approach of implementation, evaluation, and course correction (see Figure 3.2). It is appropriate here because it is difficult to predict the biotic response to habitat and other improvements. Future conditions and technological advances may alter the specific course of actions detailed in this Plan. Continued monitoring and course corrections responding to monitoring results offer the best opportunity for meeting the goals established in this TMDL and Implementation Plan.

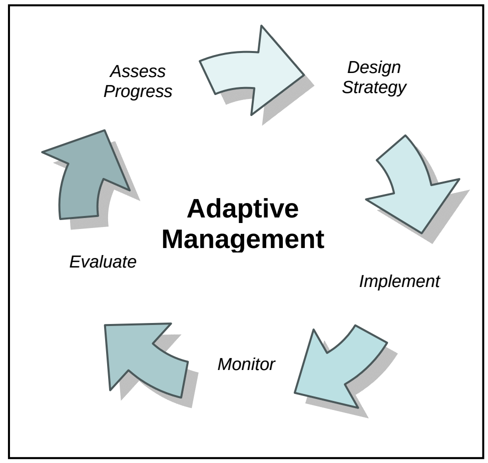

Figure 3.1. Adaptive management.

3.4.1 Interim Milestones

Interim measures to assess the progress of this TMDL include the following:

- Miles and percent of stream restored according to the Design Principles.
- Number and types of new Best Management Practices retrofit into the watershed.
- Riparian corridor maintenance projects undertaken by city staff.
- Completion of biological monitoring.
- Trends in dissolved oxygen monitoring data taken prior to 9 a.m.
- Number of informational pieces made available to property owners in the watershed on small BMP practices.

These milestones will provide information documenting the progress towards achieving the TMDL likely even before we are able to show improvement in dissolved oxygen and biotic integrity. Monitoring is discussed in Section 4.5.

4.0 Implementation Activities

The SCWMC has agreed to take the lead on general coordination, education, and ongoing monitoring. The Commission will also collect implementation information and compile BMP activities undertaken by all parties. This information will be incorporated into the Commission's annual Water Quality Report.

MS4 permittees and other stakeholders ultimately will implement the other identified BMPs. Not all stakeholders will undertake all these activities. Those activities for which permittees will take the lead will be incorporated into their individual NPDES Stormwater Pollution Prevention Programs (SWPPPs), and implementation actions will be reported in their NPDES annual reports.

4.1 WATERSHED-WIDE ACTIONS

A portion of the sediment oxygen demand in Bass and Shingle Creeks originates in stormwater runoff from the watershed. Oxygen-demanding load to the streams could be reduced by implementing BMPs that reduce nutrient inputs, and by reducing runoff volume. In addition, the Impaired Biota TMDL Stressor Identification determined that altered hydrology contributes significantly to the biotic impairment as well as localized areas of streambank instability. The growth in impervious surface in the watershed has led to an increase in the rate and volume of stormwater runoff during storm events. It has also reduced infiltration and reduced baseflow. Increasing infiltration will reduce peak flows and volumes, and increase base flows.

4.1.1 Increase Infiltration in Watershed

Increased infiltration will reduce peak runoff rates to Shingle and Bass Creeks, and increase baseflows. Most of the Shingle Creek watershed is fully developed. The cities and the Commission will work with future developers and redevelopers to incorporate infiltration and other abstraction strategies into projects where possible. The cost of this strategy is dependent on the BMP, and may range from a single property owner installing an individual rain garden to retrofitting parks and open space with native vegetation rather than mowed turf. The Commission's Education and Outreach Committee regularly provides education and outreach information to member cities on these topics for publication in city newsletters, neighborhood and block club fliers, and the city's website. Volume reduction might range from a few cubic feet of volume for a small infiltration practice such as a rain garden to an acre-foot of volume reduction per year for a regional infiltration basin.

Estimated Cost: Varies by specific project
Funding Source: City, Mn/DOT, Commission

4.1.2 Retrofit BMPs to Add Stormwater Treatment in the Watershed

Additional stormwater treatment to reduce phosphorus and sediment load to Shingle and Bass Creek will reduce sediment oxygen demand that originates from diffuse inputs of oxygen demand from the watershed. Most of the lower Shingle Creek watershed developed prior to the implementation of watershed rules and standards requiring treatment of stormwater runoff. Treatment Best Management Practices (BMPs) will be sought across the watershed as those opportunities arise. Treatment options may include but are not limited to:

- New or enhanced stormwater ponding;
- Infiltration and biofiltration basins, rain gardens, and other types of abstraction such as native vegetation or reforestation; and
- In-line or off-line treatment manufactured devices such as hydrodynamic separators, filters, and vaults.

In areas that developed prior to stormwater management rules, the cities in the watershed, Hennepin County, and Mn/DOT now routinely incorporate BMPs into street and highway projects and other public improvements. Depending on the type of BMP, location, easement or right of way requirements, and other factors, costs can range from $5,000 for a baffled sump manhole to $250,000 or more for a detention pond.

Estimated Cost: Varies by specific project
Funding Source: City, Mn/DOT, SCWMC through county levy, grant funds

4.1.3 Develop Desirable Flow Duration Curve Strategies

The Commission is developing its Third Generation Management Plan in 2011-2012. As part of that process the Commission and its Technical Advisory Committee (TAC) will review options and develop strategies to progress toward the desirable flow duration curve set forth in the TMDL and this Implementation Plan. The Commission's calibrated SWMM model will be used to test the impact of various levels of additional volume management and extended detention on the period of record flow duration curve. These scenarios will help to establish specific goals, both in volume and location in the watershed. Groundwater data will be reviewed to estimate groundwater-surface water interaction to help determine where additional infiltration would be most helpful in augmenting base flows in the streams and where municipal and irrigation well pumping may be impacting base flow.

Estimated Cost: $5,000
Funding Source: Operating budget for Third Generation Management Plan (budget is $70,000)

4.1.4 Rules and Standards Review

The Commission periodically directs the TAC to review and if necessary recommend revisions to the Commission's development rules to address the effectiveness of the regulatory program in meeting TMDL requirements. The TAC will be reviewing those rules as part of the Commission's Third Generation Management Plan, which is under development in 2011-2012, and then periodically after that as necessary.

Estimated Cost: $2,000
Funding Source: General operating budget for Management Plan activities (current budget is $3,000)

4.1.5 Implement Other TMDLs

Thirteen lakes in the watershed are impaired by excess nutrients, and TMDLs and Implementation Plans have been approved and improvements are underway. In addition, a TMDL addressing the chloride impairment to Shingle Creek is now in implementation. Actions taken to reduce nutrient and chloride load and to reduce runoff volume as part of those Implementation Plans will also be beneficial in reducing that part of sediment oxygen demand that originated from diffuse sources in the watershed.

Estimated Cost: Varies by specific project
Funding Source: City, Mn/DOT, SCWMC through county levy, grant funds

4.2 REACH-SPECIFIC ACTIONS

The TMDL identified a number of potential in-stream and near-stream implementation actions to increase dissolved oxygen and improve biotic integrity. Ecological restoration of the stream channel to incorporate a low-flow channel, improve reaeration, and enhance habitat is the primary means to accomplish this improvement. Section 3.3.2 above lists general actions; actions appropriate to each individual reach on Bass and Shingle Creeks are identified in this section.

Because the QUAL2K model used in the TMDL to develop the wasteload allocations had difficulty modeling the complex interactions occurring in Palmer Lake, two models were actually developed: an Upper Shingle Creek and a Lower Shingle Creek. The SOD loads and reductions shown by reach are generated within the QUAL2K models. During model calibration, various input parameters were adjusted by reach in an iterative process until the model output for each reach was calibrated to the observed water quality data. One of the model-predicted parameters is SOD rate. For many reaches additional SOD beyond the model-predicted SOD rate had to be added, or prescribed in order to calibrate to observed DO data. When the model was calibrated, the current load was calculated for each reach by multiplying its unique SOD rate (model+prescribed) times the area of wetted perimeter in the reach. The model-predicted SOD rate by reach from the selected scenario was then multiplied by the area of wetted perimeter in the reach to calculate the SOD TMDL.

The following sections are organized by the reaches established in the models. No modeling was completed for Bass Creek. Implementation is organized by the Bass Creek reaches established in the Shingle Creek Corridor Study Phase II (2007), which analyzed conditions in various tributaries and other small streams in the Shingle Creek watershed.

4.2.1 Lower Shingle Creek Actions

Lower Shingle Creek extends from the Palmer Lake outlet to the confluence with the Mississippi River. It is subdivided into eight reaches. Figure 4.1 below shows the extent and length of each reach. The primary implementation action is the ecological restoration of Shingle Creek, but it is important to note that stream restoration alone will not meet the DO standard. The flow discharged from headwaters wetland Palmer Lake is low in dissolved oxygen from both natural and man-made causes. Reaeration of that flow may be necessary to achieve the DO goal.

Figure 4.1. Lower Shingle Creek reaches.

4.2.1.1 Reach 1: Palmer Lake Outlet to Shingle Creek Parkway

This short reach extends from the outlet of Palmer Lake to Shingle Creek Parkway (Table 4.1 and Figure 4.2). The reach experiences wide fluctuations in dissolved oxygen in flow discharged from the 400+ acre flow-through wetland. Small riffles at the 69th Avenue crossing and just downstream provide some reaeration although it is insufficient to achieve the daily minimum 5 mg/L DO standard. Most of the reach is silty-bottomed. Streambanks between Palmer Lake and 69th Avenue are experiencing some erosion and soil loss due to the heavy tree canopy.

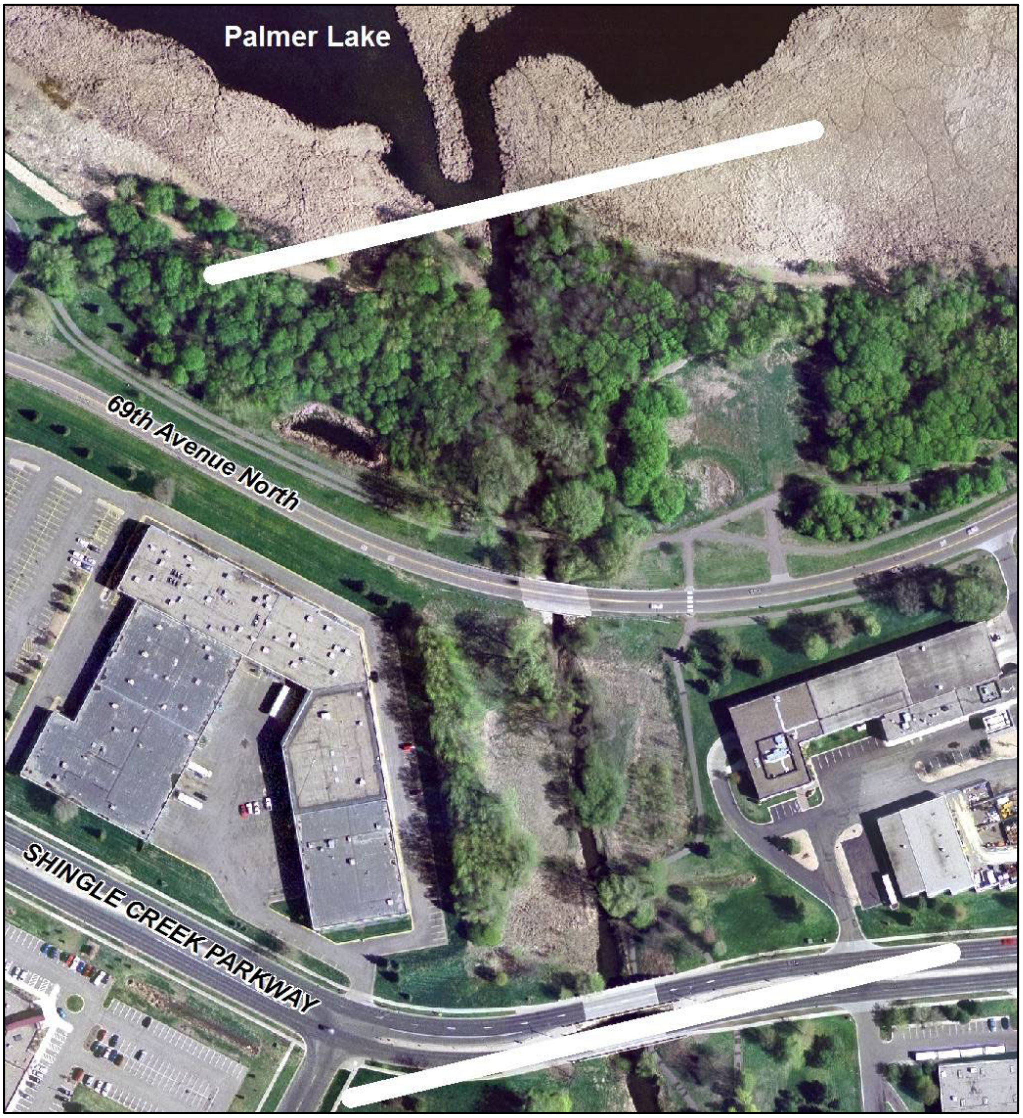

Figure 4.2. Lower Shingle Creek Reach 1.

Table 4.1. Lower Shingle Creek Reach 1 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
1	Palmer Lake Outlet to Shingle Creek Pkwy	0.13	18.7	8.4	55.1%

Implementation actions will focus in two areas (Table 4.2). The first is developing and implementing BMPs to increase aeration of the flow discharged from Palmer Lake. This will likely include the installation of aeration structures between the Palmer Lake outlet and 69th Avenue. The second action is to thin the heavy tree canopy in that same subreach to allow the establishment of a native herbaceous buffer to stabilize the streambanks.

Table 4.2. Issues and implementation actions, Lower Shingle Creek Reach 1.

Issue	Action	Expected Outcome	Estimated Cost
DO in discharge from the wetland falls below 5 mg/L and reaeration in downstream reach is not able to increase DO above that level	Provide reaeration structures at wetland outlet to increase DO in wetland discharge	Dissolved oxygen added so that the stream does not fall below 5 mg/L as a daily minimum	$50,000
Excessive canopy and sparse or bare streambanks	Thin trees and establish native buffer, 400 feet, both sides	Stabilized streambanks, reduced erosion and bank loss	$20,000

4.2.1.2 Reach 2: Shingle Creek Parkway to Bass Lake Road

This lengthy reach extends from Shingle Creek Parkway to a point 1,400 feet upstream of Bass Lake Road (Table 4.3 and Figure 4.3). From Shingle Creek Parkway to I-94, the stream flows through a narrow remnant wetland. In Brooklyn Center Centennial Park south of I-94, the stream was relocated in the 1980s from its old county ditch alignment and reconstructed with wide, sweeping curves to make way for park improvements. Downstream of that segment the stream flows through another remnant wetland.

There are several large storm sewer outfalls in this reach. Most of the outfalls have been retrofit with water quality treatment, including new Mn/DOT ponds treating runoff from I-94; and City of Brooklyn Center ponds and underground devices to treat runoff from the adjacent neighborhoods.

Table 4.3. Lower Shingle Creek Reach 2 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
2	Shingle Creek Parkway to 1,400 feet upstream of Bass Lake Road	1.59	477.2	135.5	71.6%

A project to restore 2,700 feet of stream channel from I-94 to the terminus of the reach is underway in 2011. This project thinned trees and planted buffers and live stakes; added in-stream habitat; added riffles for reaeration; and installed tree pins to create segments of a low-flow channel. This project likely accomplished the identified SOD load reduction. The TMDL design principles for ecological stream restoration were used to develop the habitat and other stream improvements. No specific actions are identified for the two wetland segments of this reach.

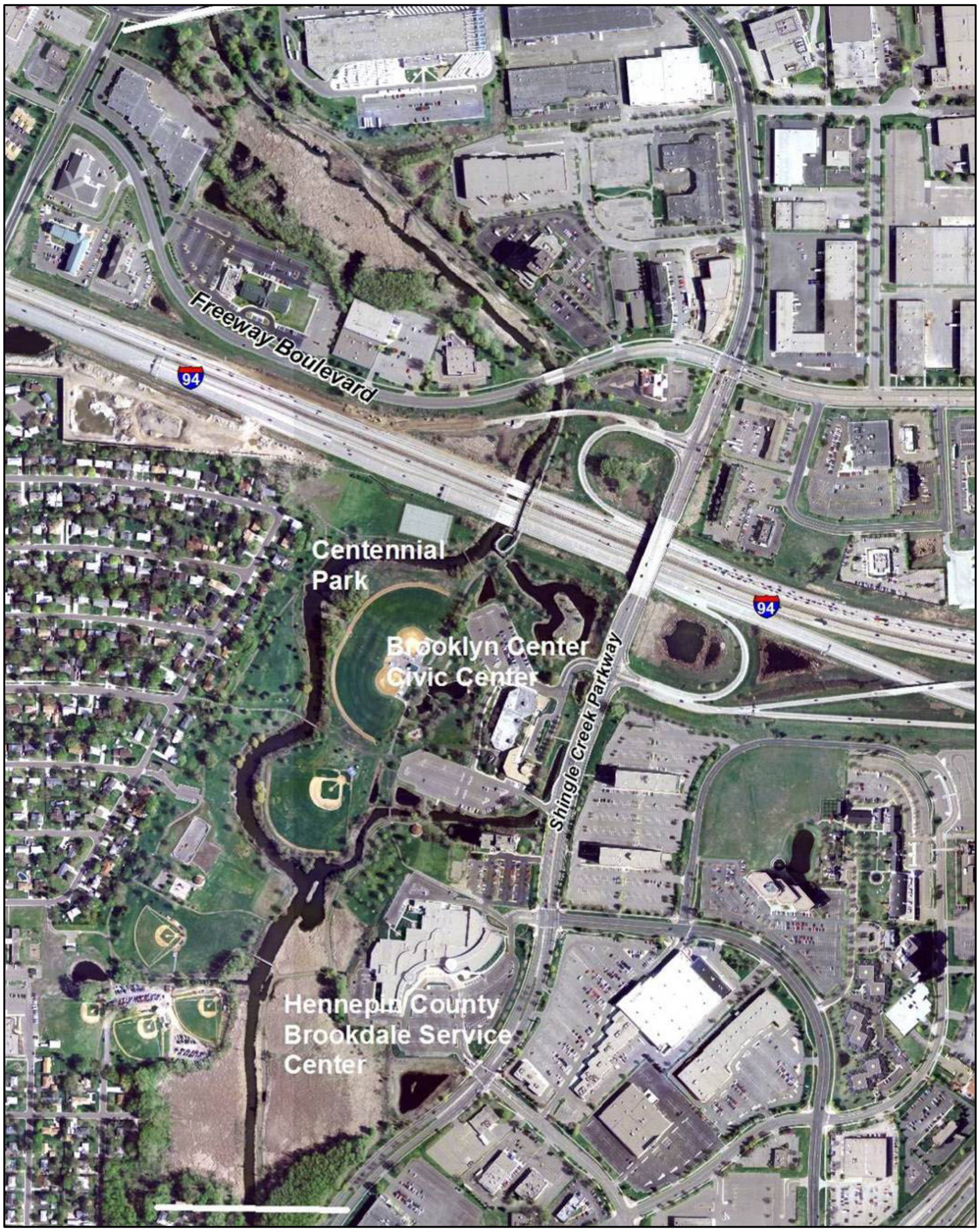

Figure 4.3. Lower Shingle Creek Reach 2.

4.2.1.3 Reach 3: Upstream of Bass Lake Road to Weir

This reach extends from a point 1,400 feet upstream of Bass Lake Road (Table 4.4 and Figure 4.4) and is wooded. The reach has been straightened as part of County Ditch #13. As noted above in Reach 2, in 2011 the City of Brooklyn Center undertook a stream restoration project between I-94 and Bass Lake Road. This project thinned trees and planted buffers and live stakes; added in-stream habitat; added riffles for reaeration; and installed tree pins to create segments of low-flow channel. This project likely accomplished the identified SOD load reduction. The TMDL design principles for ecological stream restoration were used to develop the habitat and other stream improvements.

Table 4.4. Lower Shingle Creek Reach 3 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
3	1,400 feet upstream of Bass Lake Road to Weir	0.28	42.6	16.2	62.0%

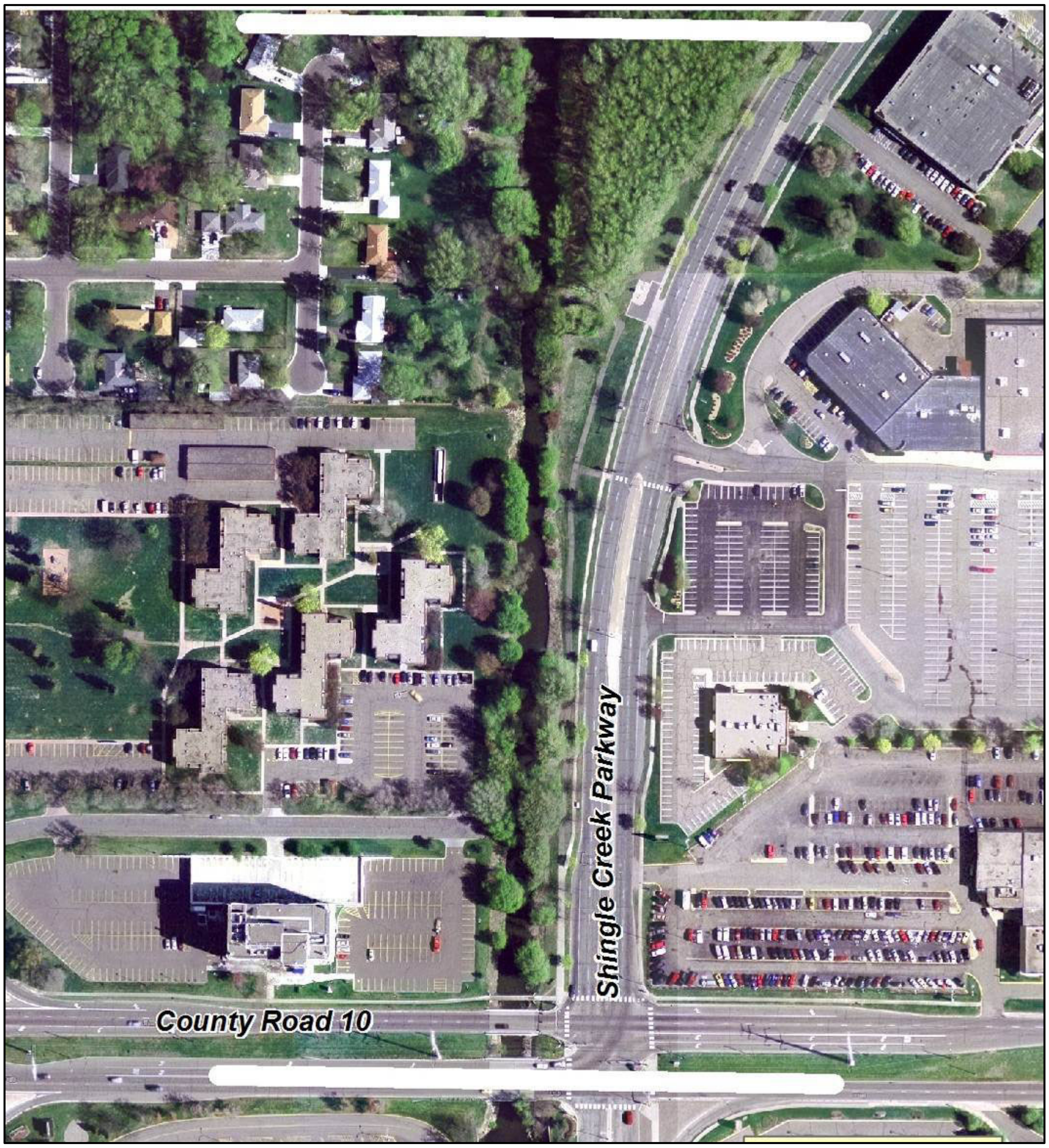

Figure 4.4. Lower Shingle Creek Reach 3.

4.2.1.4 Reaches 4 and 5: Weir to Highway 100

These reaches include the broad-crested weir at Bass Lake Road (reach 4) just upstream of the culverts that carry Shingle Creek below the Brookdale Shopping Center parking lot, and the twin 700 foot, 12 x 12 foot box culverts (Table 4.5 and Figure 4.5).

Table 4.5. Lower Shingle Creek Reaches 4 and 5 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
4	Weir	.006	1.2	1	16.7%
5	Weir to Highway 100 (box culverts)	0.17	17.6	14.1	19.9%

Figure 4.5. Lower Shingle Creek Reaches 4 and 5.

Brookdale is being redeveloped in 2011-2012 as Shingle Creek Crossing. As part of that project a low-flow bypass open channel will be constructed as a site amenity (Table 4.6 and Figure 4.6) which will include reaeration structures and habitat enhancements, and will also serve as a fish and wildlife bypass. Modifications will be made at the weir to improve aesthetics and enhance reaeration.

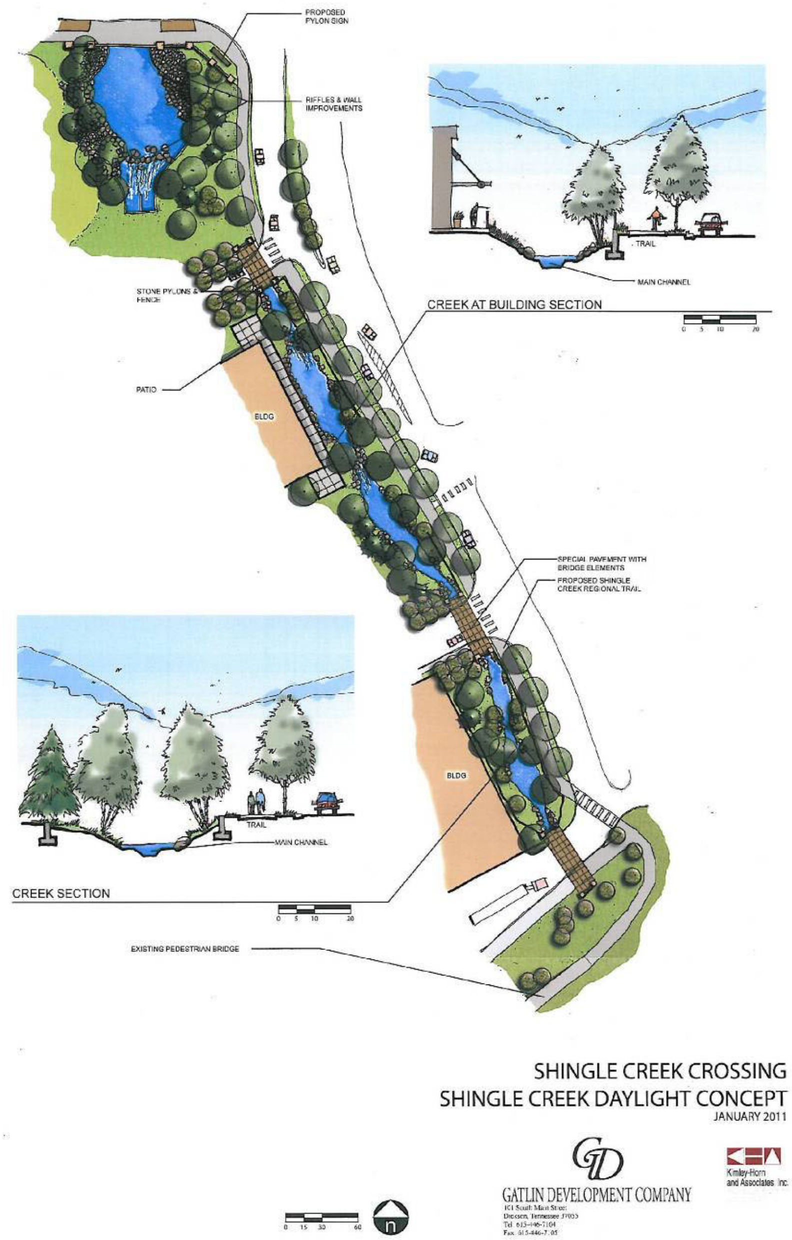

Figure 4.6. Proposed Reach 5 Shingle Creek daylighting project.

Table 4.6. Issues and implementation actions, Lower Shingle Creek Reaches 4 and 5

Issue	Action	Expected Outcome	Estimated Cost
Shingle Creek is contained with a box culvert, that is likely a barrier to aquatic organisms	Daylight Shingle Creek	Improved reaeration, increased habitat, increased species abundance and diversity, restoration of connectedness	Completed privately by developer

4.2.1.5 Reach 6: Highway 100 to USGS Station at Queen Avenue

This reach extends from Highway 100 in Brooklyn Center to the USGS monitoring station in Minneapolis just upstream of the Queen Avenue Bridge (Table 4.7 and Figure 4.7). It passes through Centerbrook Golf Course in Brooklyn Center, and a wooded corridor in Minneapolis. The Shingle Creek Regional Pond System, a series of ponds on the Golf Course and in Minneapolis, was completed in the 1990s to provide detention and treatment for the redevelopment of the Brookdale Shopping Center and adjacent commercial development.

Table 4.7. Lower Shingle Creek Reach 6 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
6	Highway 100 to USGS monitoring station at Queen Avenue North	0.53	39.5	9.7	75.4%

The upstream segment of this reach flows through Centerbrook Golf Course in Brooklyn Center. The left bank is turf grass to a narrow unmowed strip along the creek, while the right bank is vegetated with a dense band of trees and shrubs. This segment would benefit from tree thinning and buffer establishment, although the location of the fairways may limit the width of the buffer on the stream's left bank.

Through the wooded park corridor downstream of the golf course, tree thinning would allow the stream banks to revegetate (Table 4.8). The substrate is sand and small cobble, and there is a wide riffle at the outfall from the last pond in the Regional Pond series. Additional in-stream woody habitat and reaeration structures would improve water quality and biotic integrity.

Table 4.8. Issues and implementation actions, Lower Shingle Creek Reach 6

Issue	Action	Expected Outcome	Estimated Cost
Within Centerbrook Golf Course, dense tree canopy on right bank and narrow unmowed buffer on left bank	Thin trees on 900 feet of stream. Establish 5' minimum native buffer.	Filter runoff, stabilize streambanks, improved aesthetics	$100,000
Lack of habitat	Install in-stream habitat features such as root wads, tree pins, and riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows	
South of Centerbrook, dense tree canopy and areas of bank instability	Restore 1,150 feet of streambank: thin trees, stabilize banks as necessary, vegetate streambanks	Stabilized banks and buffer will reduce sediment loss and filter runoff	$250,000
Lack of aeration	Supplement existing riffles, narrow the channel with tree pins and other structures to provide a low-flow channel	Increased aeration, increased velocity at low flows, increased species diversity and abundance	
Lack of habitat	Install in-stream woody habitat features such as root wads, tree pins	Improved habitat, varied substrate	

Figure 4.7. Lower Shingle Creek Reach 6.

4.2.1.6 Reach 7: USGS Station at Queen Avenue to Webber Park

This reach extends from the USGS monitoring station in Minneapolis (Table 4.9 and Figure 4.8) just upstream of the Queen Avenue Bridge to the Shingle Creek WMC monitoring station SC-0 in Webber Park in Minneapolis. As with much of Shingle Creek, it is straightened and overwide, and is heavily canopied.

Table 4.9. Lower Shingle Creek Reach 7 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
7	USGS monitoring station at Queen Avenue north to Webber Park monitoring station	1.29	71.5	15.5	78.3%

Figure 4.8. Lower Shingle Creek Reach 7.

Streambanks in this reach are relatively stable. Thinning the dense tree canopy will allow sunlight to penetrate to the streambank and allow an herbaceous buffer to establish, further stabilizing the banks (Table 4.10). Some riffles were added to the stream in Creekview Park and downstream of Humboldt Avenue as part of the development of the Humboldt Greenway. Additional wood substrate would be valuable, such as root wads and tree pins harvested from tree removals on site.

Table 4.10. Issues and implementation actions, Lower Shingle Creek Reach 7.

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer,	Thin trees on 1.2 miles of stream, stabilize and vegetate banks as necessary, and establish buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff	$1.5 million
Lack of varied habitat	Install in-stream habitat features such as root wads, tree pins, and additional riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install additional rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	

4.2.1.7 Reach 8: Webber Park to the Mississippi River

This reach extends from the Shingle Creek WMC monitoring station SC-0 in Webber Park in Minneapolis (Table 4.11 and Figure 4.9) to the Mississippi River. A seven foot drop structure in Webber Park was added in the 1980s as part of the construction of I-94 and is a significant fish barrier that disconnects Shingle Creek from the Mississippi River ecosystem. Downstream of I-94 the stream passes through North Mississippi Regional Park before discharging into the Mississippi River just upstream of the Camden Bridge in Minneapolis.

Table 4.11. Lower Shingle Creek Reach 8 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
8	Webber Park monitoring station to Mississippi River	0.7	34.8	6.9	80.2%

As with other reaches of Shingle Creek, this reach would benefit from tree thinning and buffer establishment (Table 4.12). Many trees on the streambank from Webber Park down to the Mississippi River were broken or uprooted in the May 2011 North Minneapolis tornado. A portion of the stream through Webber Park is concrete-lined with a low-head dam and drop structure, and should be evaluated for possible removal and biostabilization. A fish passage should be provided for the Webber Park drop structure as a means to restore connectivity.

Table 4.12. Issues and implementation actions, Lower Shingle Creek Reach 8.

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability	Restore 2,800 feet of stream: thin trees, stabilize banks as necessary, vegetate streambanks and plant buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff	$750,000
Concrete-lined channel	Evaluate removal of concrete lining in Webber Park	More natural substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	

Issue	Action	Expected Outcome	Estimated Cost
Lack of habitat	Install in-stream woody habitat features such as root wads, tree pins, riffles and rock vanes	Improved habitat, varied substrate	
"Webber Park Falls," a seven foot drop structure, is a significant fish and aquatic organism barrier	Provide a fish passage around the structure	Increased connectivity.	$50,000

Figure 4.9. Lower Shingle Creek Reach 8.

4.2.2 Upper Shingle Creek Actions

Upper Shingle Creek extends from the large wetland known as the Northland Wetland or the I-94 Wetland to the Palmer Lake inlet. It is subdivided into eight reaches. Figure 4.10 below shows the extent and length of each reach. As with Lower Shingle Creek, the primary implementation action is the ecological restoration of Shingle Creek, but it is important to note that stream restoration alone will not meet the DO standard. Reaeration downstream of the headwaters wetland outlet is necessary to achieve that goal.

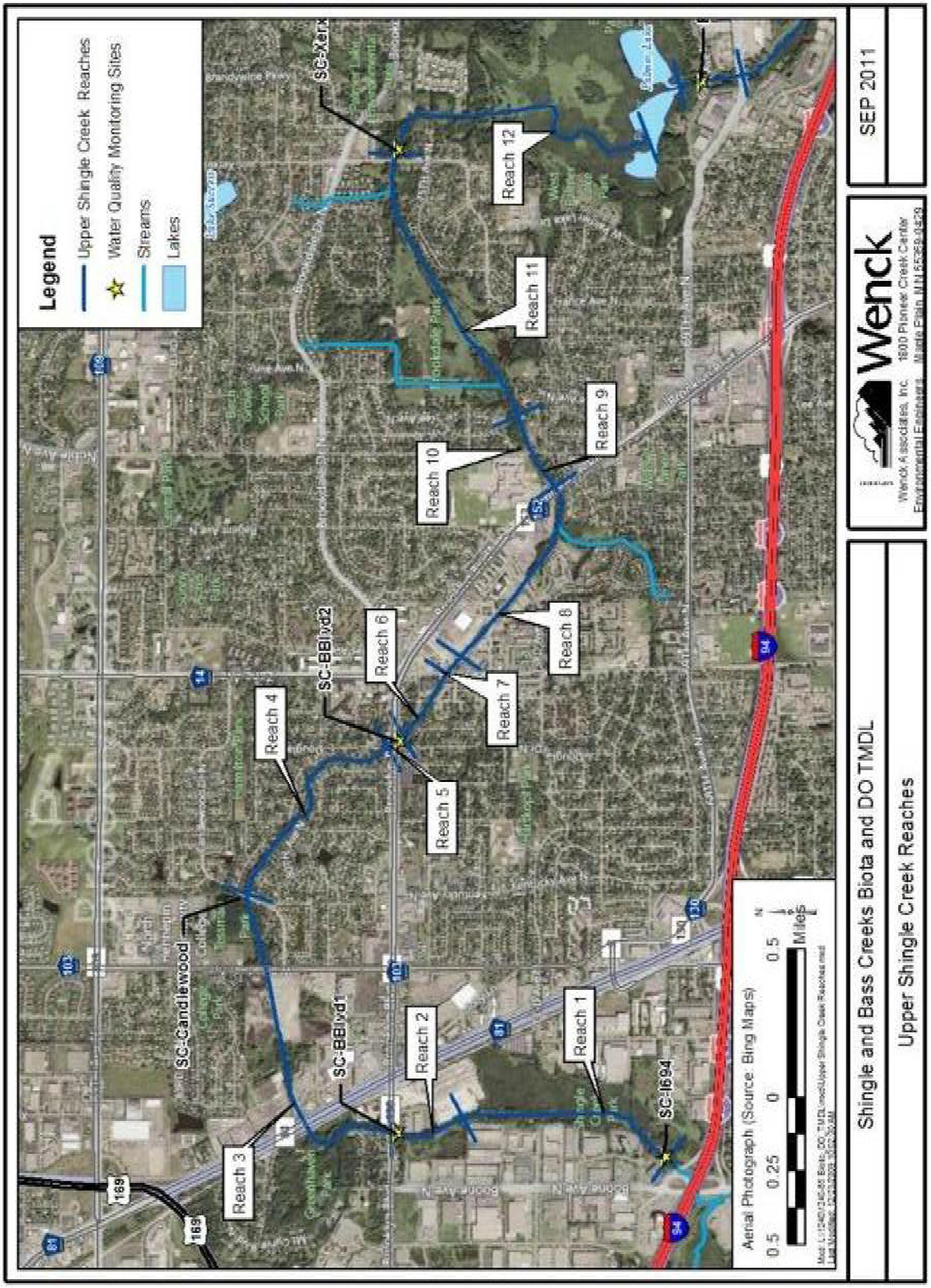

Figure 4.10. Upper Shingle Creek reaches.

4.2.2.1 Reaches 1 and 2: I-94 to Brooklyn Boulevard

Upper Shingle Creek Reach 1 extends from I-94 to the outlet of the large wetland known as the Northland Wetland or the I-94 Wetland (Table 4.13 and Figure 4.11). This wetland is channelized, and is bordered by industrial uses. Reach 2 flows through a heavily wooded area. The channel is narrow and meandering at low flows.

Continuous dissolved oxygen data were not available at the outlet of this wetland for the TMDL, but grab samples suggest that the discharge from this wetland experiences wide diurnal fluctuations, and often falls below the daily minimum standard of 5 mg/L. Existing reaeration in Reach 2 is insufficient to raise the dissolved oxygen level when it falls below 5 mg/L.

Table 4.13. Upper Shingle Creek Reaches 1 and 2 description and load reductions.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
1	I-94 to wetland outlet	0.6	69.5	1.1	98.4%
2	Wetland outlet to Brooklyn Boulevard	0.29	13.1	0.2	98.5%

Figure 4.11. Upper Shingle Creek Reaches 1 and 2.

Implementation actions will focus in two areas (Table 4.14). The first is developing and implementing BMPs to increase aeration of the flow discharged from the I-94 Wetland. These will likely include the installation of aeration structures in Reach 2. The second action is to thin the heavy tree canopy in Reach 2 to allow the establishment of a native herbaceous buffer to stabilize the streambanks.

Table 4.14. Issues and implementation actions, Upper Shingle Creek Reaches 1 and 2

Issue	Action	Expected Outcome	Estimated Cost
DO in discharge from the wetland falls below 5 mg/L and reaeration in downstream reach is not able to increase DO above that level	Conduct feasibility study and implement reaeration BMPs to increase DO in wetland discharge	Dissolved oxygen added so that the stream does not fall below 5 mg/L as a daily minimum	$50,000
Excessive canopy and sparse or bare streambanks	Thin trees and establish native buffer, 1,700 feet, both sides	Stabilized streambanks, reduced erosion and bank loss	$80,000

4.2.2.2 Reach 3: Brooklyn Boulevard to Candlewood Drive

This reach extends from Brooklyn Boulevard to Candlewood Drive, and flows through two wetlands (Table 4.15 and Figure 4.12). The first is a natural wetland just upstream from Bottineau Boulevard, the other is a wetland upstream of Broadway constructed by a developer who intended to redirect Shingle Creek into a meandering channel through the new wetland. The developer declared bankruptcy before completing the work. The balance of the reach is wooded and straightened. The segment from Broadway to Candlewood, adjacent to North Hennepin Community College, passes through a Hennepin County Regionally Significant Biological Area.

Table 4.15. Upper Shingle Creek Reach 3 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
3	Brooklyn Boulevard to Candlewood Drive	1.19	48.7	0.8	98.4%

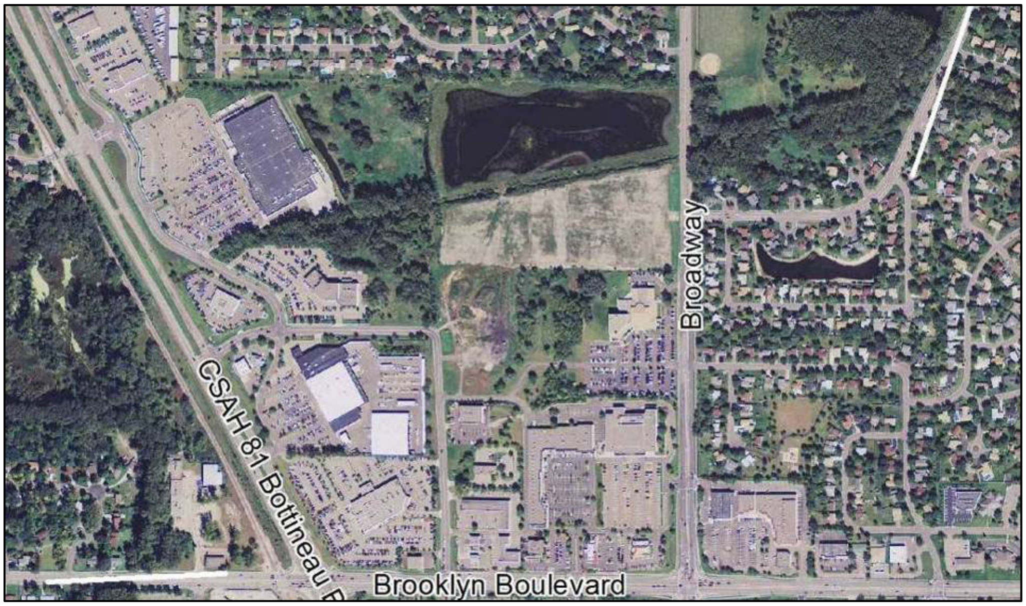

Figure 4.12. Upper Shingle Creek Reach 3.

As with other reaches on Shingle Creek, tree thinning, buffer installation, channel reshaping and enhanced in-stream habitat would likely improve water quality and biotic integrity (Table 4.16). The newly-constructed meandering corridor includes several new deep pools that will provide fish habitat. However, if Shingle Creek is diverted into the new channel, its increased length will likely reduce velocity and may require enhancement with rock riffles or other structural elements to provide sufficient aeration.

Table 4.16. Issues and implementation actions, Upper Shingle Creek Reach 3

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer	Restore 3,500 feet of stream: thin trees, stabilize banks as necessary, and plant buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff, improved substrate for habitat, increased DO	$700,000
Lack of habitat	Install in-stream habitat features such as root wads, tree pins, and additional riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	

4.2.2.3 Reach 4: Candlewood Drive to Rock Cascade #1

This reach extends from Candlewood Avenue to Rock Cascade #1, which is located just upstream of Brooklyn Boulevard (Table 4.17 and Figure 4.13). It passes through a residential area and immediately abuts back yards. Prior to reconstruction in the mid-2000s, a sheet pile dam at Brooklyn Boulevard maintained wide recreational pools through this reach.

Table 4.17. Upper Shingle Creek Reach 4 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
4	Candlewood Avenue to Rock Cascade #1	0.82	84.9	1.1	98.7%

This reach was restored in a series of projects and includes streambank stabilization, buffer establishment, low flow channel, in-stream habitat, rock canes and riffles, and constructed pools. The stream was narrowed in some places by filling the channel braid on one side of some islands and by constructing in-stream brush mattresses. The sheet pile dam was replaced with Rock Cascade #1. The project should be monitored for effectiveness at enhancing DO and biotic integrity (Table 4.18).

Table 4.18. Issues and implementation actions, Upper Shingle Creek Reach 4

Issue	Action	Expected Outcome	Estimated Cost
Ecological restoration project completed	Monitor completed project	Increased dissolved oxygen, increased low-flow velocity, improved species diversity	In monitoring program

Figure 4.13. Upper Shingle Creek Reach 4.

4.2.2.4 Reaches 5 and 6: Rock Cascade #1 to Zane Avenue North

Reach 5 is the rock cascade upstream of Brooklyn Boulevard that replaced an old sheet pile dam and Reach 6 extends from that cascade to Zane Avenue downstream in Brooklyn Park (Table 4.19 and Figure 4.14). In the early 2000's the City of Brooklyn Park undertook a stream stabilization project on this segment that added a boulder toe and a vegetated buffer.

Table 4.19. Upper Shingle Creek Reaches 5 and 6 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
5	Rock Cascade #1 to Brooklyn Boulevard	0.1	4.8	0.9	81.3%
6	Brooklyn Boulevard to Zane Avenue	0.26	6.8	0.4	94.1%

Figure 4.14. Upper Shingle Creek Reaches 5 and 6.

This project could be enhanced by selective tree thinning and by adding woody substrate (Table 4.20). Root wads could be added to the banks and tree pins to provide additional substrate and to create a low-flow channel.

Table 4.20. Issues and implementation actions, Lower Shingle Creek Reaches 5 and 6

Issue	Action	Expected Outcome	Estimated Cost
Lack of woody substrate	Add root wads and tree pins to create a low flow channel and to enhance previous 1,400 foot stream stabilization project.	Increased species diversity	$70,000
Trapezoidal, flat bottomed channel		Increased velocity and reaeration at low flows	

4.2.2.5 Reaches 7 and 8: Zane Avenue to Brooklyn Boulevard

The City of Brooklyn Park partnered with a land developer to undertake a significant restoration of 2,000 feet of Shingle Creek in this reach (Table 4.21 and Figures 4.15 and 4.16). Trees were thinned, a vegetative buffer planted, streambanks regraded, and rock vanes were added. A 70-foot long rock cascade replaced a four-foot drop structure. The rock vanes create a low-flow channel.

Table 4.21. Upper Shingle Creek Reaches 7 and 8 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
7	Zane Avenue to Rock Cascade #2	0.1	4.2	0.8	81.0%
8	Rock Cascade #2 to Brooklyn Boulevard	0.74	169.4	1.2	99.3%

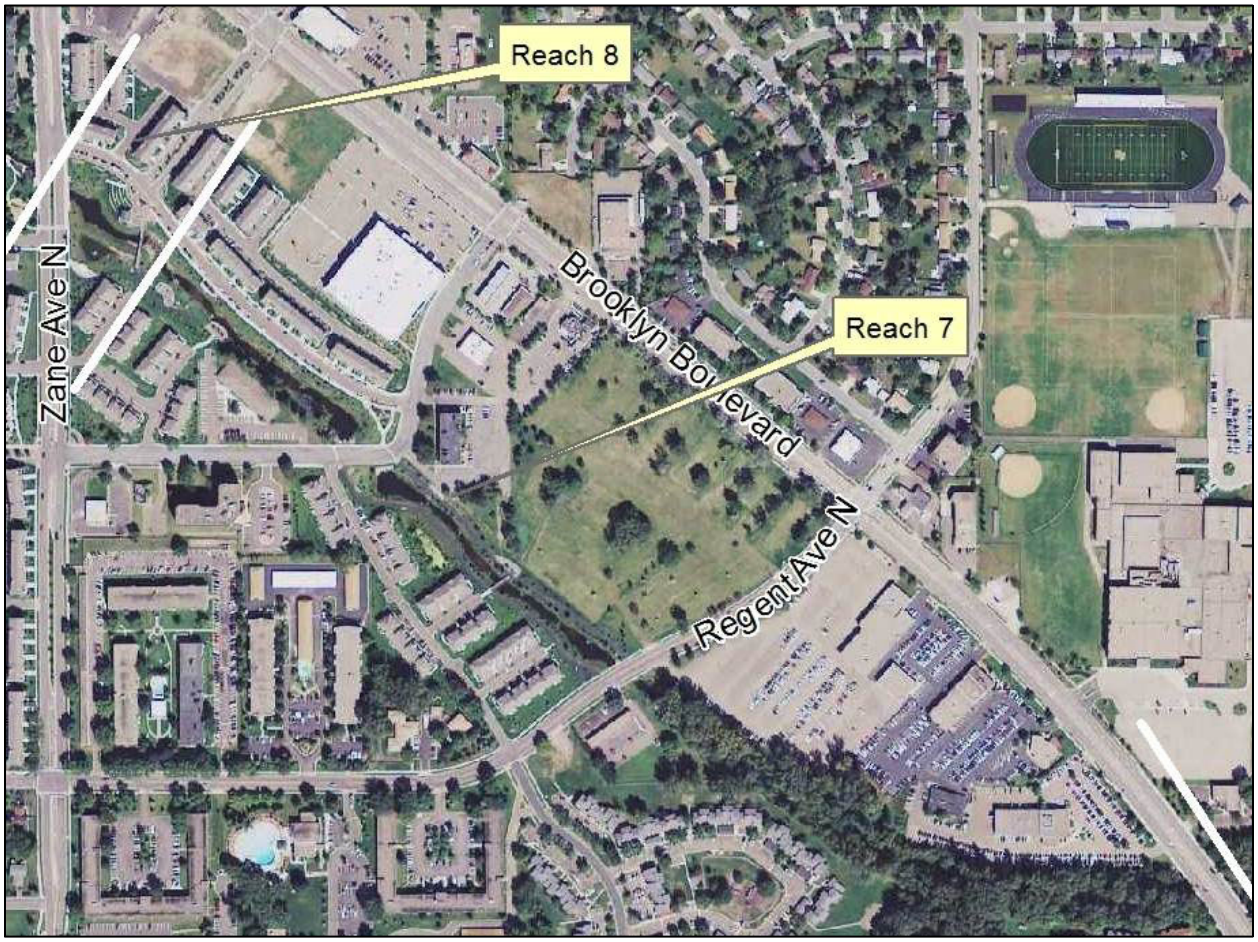

Figure 4.15. Upper Shingle Creek Reaches 7 and 8.

The restoration project could be enhanced by the addition of woody substrate as root wads (Table 4.22). In addition, the tree canopy was removed during the reconstruction project, and the stream is now overly sunny. Some additional trees and shrubs should be planted to provide some shading and woody debris. The final 1,700 feet from 73rd to Brooklyn Boulevard will be restored at such time as the adjacent commercial properties are redeveloped.

Table 4.22. Issues and implementation actions, Upper Shingle Creek Reaches 7 and 8

Issue	Action	Expected Outcome	Estimated Cost
Lack of woody substrate in restored segments	Install root wads, selectively plant trees	Increased species diversity	$50,000

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer, lack of habitat in segment from 73rd to Brooklyn Boulevard	Restore 1,700 feet of stream: thin trees, stabilize banks as necessary, plant buffer, install in-stream habitat.	Stabilized banks and buffer will reduce sediment loss and filter runoff, improved substrate for habitat, added reaeration structures	$350,000

Figure 4.16. Reach 8 before reconstruction (left) and after (right).

4.2.2.6 Reaches 9 and 10: Brooklyn Boulevard to Drop Structure

This reach, which extends from Brooklyn Boulevard to a two foot drop structure in Brookdale Park in Brooklyn Park (Table 4.23 and Figure 4.17), has been straightened from its historic, meandering alignment. It has a heavy tree canopy and the flat-bottomed channel is coarse to fine sand with few pools. Portions of the streambank have been armored with riprap. There is bank scour on both banks downstream of the drop structure.

Table 4.23. Upper Shingle Creek Reaches 9 and 10 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
9	Brooklyn Boulevard to Drop Structure in Park	0.31	10.8	0.7	93.5%
10	Drop Structure in Park	.001	4.3	0.9	79.1%

A restoration project is proposed for this reach in 2012. This project will thin trees, stabilize banks, add woody and rock substrate and habitat, and add a vegetated buffer (Table 4.24). The bank scour will be corrected and riprap removed and replaced with bioengineered streambank stabilization. This reach is adjacent to Park Center High School. Science students from the school have monitored stream macroinvertebrates at this location through the RiverWatch program since 1995. The proposed project will include a stabilized, safe access into the stream for the school and may include an outdoor classroom at this site.

Because of the adjacent homes it is not possible to remove the drop structure in Brookdale Park and remeander the stream. However, this project will include installation of a fish bypass.

Figure 4.17. Upper Shingle Creek Reaches 9 and 10.

Table 4.24. Issues and implementation actions, Lower Shingle Creek Reaches 9 and 10

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer, lack of habitat	Restore 1,430 feet of stream: thin trees, stabilize banks as necessary, plant buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff	$350,000
Lack of habitat	Install in-stream habitat features such as root wads, tree pins, and riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows	
Adjacent high school provides long-term monitoring of macroinvertebrates	Install stabilized stream access; install outdoor classroom area with seating	Improved safety, increased visibility and access to the stream	

4.2.2.7 Reach 11: Drop Structure in Park to Xerxes Avenue

This reach, which extends from a two foot drop structure in Brookdale Park to Xerxes Avenue North in Brooklyn Park (Table 4.25 and Figure 4.18), has been straightened from its historic, meandering alignment. It has a heavy tree canopy and the flat-bottomed channel is coarse to fine sand with few pools and some aggrading sand bars. There is a small artificial riffle downstream of the drop structure. Pools in the riparian wetland in the park are connected to the stream by channels and may be serving as off-line refugia.

Table 4.25. Upper Shingle Creek Reach 11 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
11	Drop Structure in Park to Xerxes Avenue	0.98	35.5	2.4	93.2%

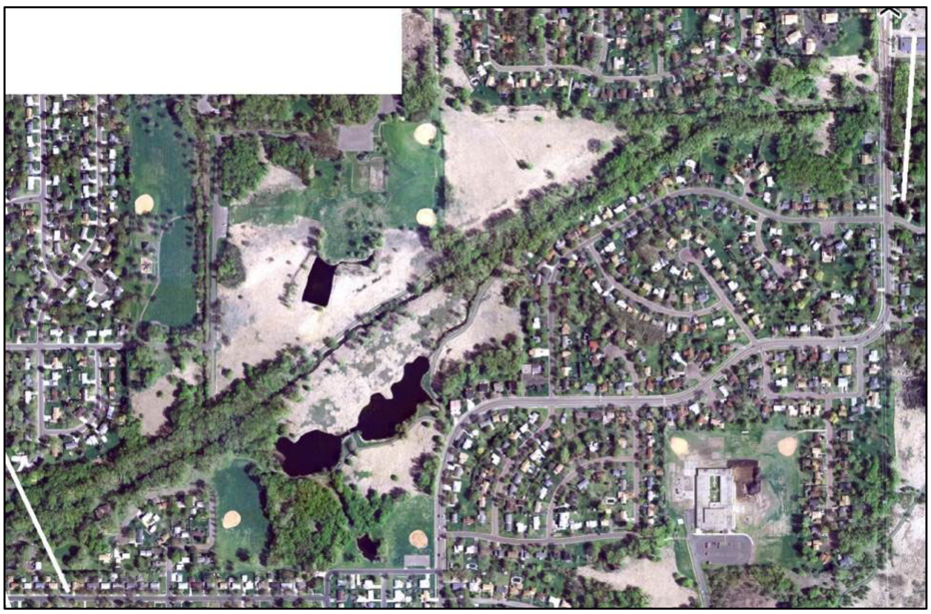

Figure 4.18. Upper Shingle Creek Reach 11.

Within the upland segments of the corridor there is a thick tree canopy that should be thinned and the bank stabilized as necessary (Table 4.26). As on other reaches, tree pins could be used to create a low-flow channel and increase habitat, and rock riffles could provide reaeration. A vegetative buffer should be established between the Creek and adjacent residences. The side channels and off-line pools on the south side of the stream should be investigated and potentially excavated to provide deeper off-line refugia.

Table 4.26. Issues and implementation actions, Upper Shingle Creek Reach 11

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer	Restore 3,000 feet of stream: thin trees, stabilize banks as necessary, plant buffer	Stabilized banks and buffer will reduce sediment loss and stream aggradation, and filter runoff	$500,000

Issue	Action	Expected Outcome	Estimated Cost
Lack of habitat	Install in-stream habitat features such as root wads, tree pins, and additional riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	
Refugia for aquatic organisms are necessary for both low and high flows	Investigate and if feasible excavate the existing side channels and pools to create deeper off-line refugia	Increased organism abundance and species complexity	$30,000

4.2.2.8 Reach 12: Xerxes Avenue to Palmer Lake

Upper Shingle Creek Reach 12 extends from Xerxes Avenue North in Brooklyn Park to Palmer Lake (Table 4.27 and Figure 4.19). Xerxes Avenue is the upstream terminus of County Ditch #13. Just downstream of Xerxes Avenue on the right side is a small, shallow backwater area that serves as a high-flow refuge for aquatic organisms. There are two subreaches: from Xerxes to the wetland basin and from the wetland basin to Palmer Lake. Within the wetland basin the stream has remeandered a channel from the original ditch alignment.

Table 4.27. Upper Shingle Creek Reach 12 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
12	Xerxes Avenue to Palmer Lake	1.09	39.9	2.9	92.7%

Between Xerxes and the wetland there is a thick tree canopy that should be thinned and the bank stabilized as necessary (Table 4.28). Tree pins could be used to create a low-flow channel and increase habitat. A vegetative buffer should be established between the Creek and adjacent residences. No specific actions are identified within the wetland basin.

Table 4.28. Issues and implementation actions, Upper Shingle Creek Reach 12

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer	Restore 1,000 feet of stream: thin trees, stabilize banks as necessary, plant buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff	$75,000
Lack of habitat	Install in-stream habitat features such as root wads, tree pins, and additional riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	

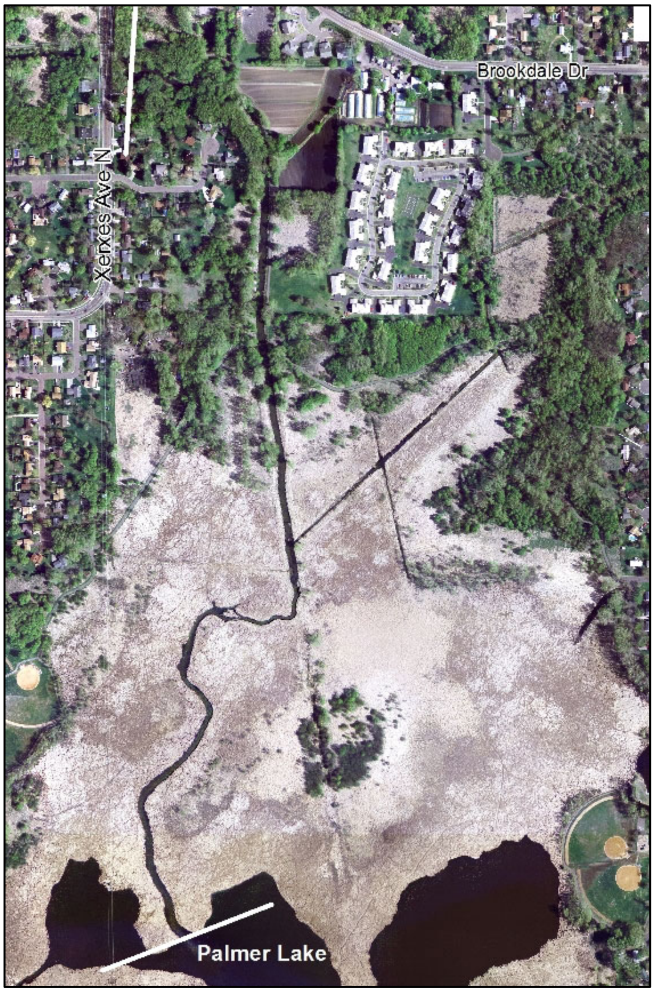

Figure 4.19. Upper Shingle Creek Reach 12.

4.2.3 Bass Creek Actions

No hydrologic or hydraulic modeling was completed for Bass Creek because Bass Creek is not listed on the State of Minnesota 303(d) list of Impaired Waters for Dissolved Oxygen. During the TMDL and Stressor Identification development, it became clear that many of the same issues affecting dissolved oxygen and biotic integrity in Shingle Creek were present in Bass Creek. The TMDL determined that dissolved oxygen is a surrogate for impaired biota in Bass Creek. The Upper Watershed TMDL includes Upper Shingle and Bass Creeks and the watershed above Palmer Lake. The same actions that are recommended for Shingle Creek to increase dissolved oxygen and address biotic integrity are recommended for Bass Creek.

The Bass Creek headwater is the outlet weir of Boulder Ridge Pond, last in a series of wetlands at the outlet of Bass Lake (Figure 4.20). It flows 2.2 miles, where it forms Shingle Creek at its confluence with Eagle Creek, which is the outlet of Eagle Lake.

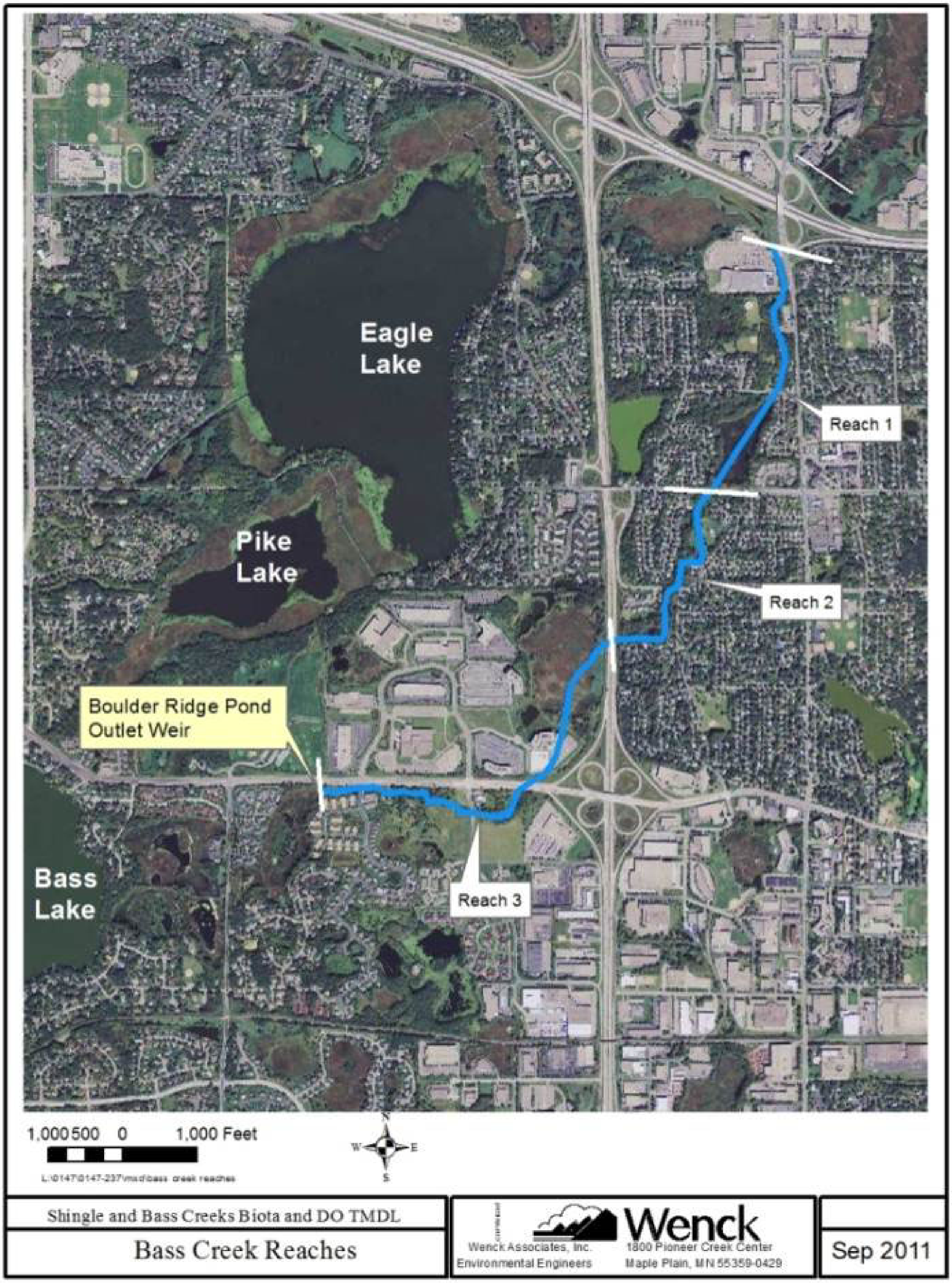

Figure 4.20. Bass Creek reaches.

4.2.3.1 Reach 1: 63rd Avenue to Eagle Creek

Bass Creek Reach 1 extends from 63rd Avenue in Brooklyn Park to its confluence with Eagle Creek (Table 4.29 and Figure 4.21). The large flow-through wetland between 63rd Avenue and Cherokee Drive is known as the Cherokee Wetland. Downstream of that wetland the stream flows through Bass Creek Park and then highway ditch to its confluence with Eagle Creek.

Table 4.29. Bass Creek Reach 1 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
1	63rd Avenue to Eagle/Shingle Creeks	0.7	Not modeled	Not modeled	Not modeled

Figure 4.21. Bass Creek Reach 1.

It has been observed that the Cherokee Wetland often dries out by summer and will go through a sequence of wetting and drying as precipitation is received. Monitoring should be undertaken at the inlet and outlet to determine if this wetland is exporting nutrients into Bass Creek. Within Bass Creek Park, the heavy tree canopy prevents the establishment of a stabilizing understory, and the banks are unstable and experiencing erosion and mass wasting. Ecological restoration should be undertaken within the park to improve dissolved oxygen and increase habitat (Table 4.30).

Table 4.30. Issues and implementation actions, Bass Creek Reach 1

Issue	Action	Expected Outcome	Estimated Cost
Dense tree canopy, areas of bank instability, lack of buffer	Restore 1,400 feet of stream: thin trees, stabilize banks as necessary, plant buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff	$300,000
Lack of habitat	Install in-stream habitat features such as root wads, tree pins, and riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	
Cherokee Wetland often dries out and rewets during the summer months	Monitor Cherokee Wetland inlet and outlet water quality and diel dissolved oxygen	Assessment of wetland's contribution to lack of dissolved oxygen	In Commission monitoring budget

4.2.3.2 Reach 2: TH 169 to 63rd Avenue N

Bass Creek Reach 2 extends from TH 169 in New Hope to 63rd Avenue in Brooklyn Park (Table 4.31 and Figure 4.22). The stream flows through a residential area and through Cavelle Park. Portions of the streambank in the residential area have been hard armored with a boulder toe.

Table 4.31. Bass Creek Reach 2 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
2	TH 169 to 63rd Avenue	0.45	N/A	N/A	N/A

This reach would benefit from tree thinning and buffer installation. Some ninety-degree bends in the stream have been stabilized with several courses of rock boulders. Enhancing that streambank with live stakes would soften the appearance of the stream and add variety to habitat (Table 4.32). Narrowing the stream with root wads and tree pins would provide a low-flow channel as well as woody substrate.

Table 4.32. Issues and implementation actions, Bass Creek Reach 2

Issue	Action	Expected Outcome	Estimated Cost
Tree canopy, lack of buffer	Restore 2,400 feet of stream: thin trees, stabilize banks as necessary, plant buffer	Stabilized banks and buffer will reduce sediment loss and filter runoff	$300,000
Lack of habitat and lack of woody substrate	Install in-stream habitat features such as root wads, tree pins, and riffles	Improved habitat, varied substrate	
Lack of aeration	Narrow the channel with tree pins and other structures to provide a low-flow channel; install rock riffles	Increased aeration, increased velocity at low flows, increased species diversity and abundance	

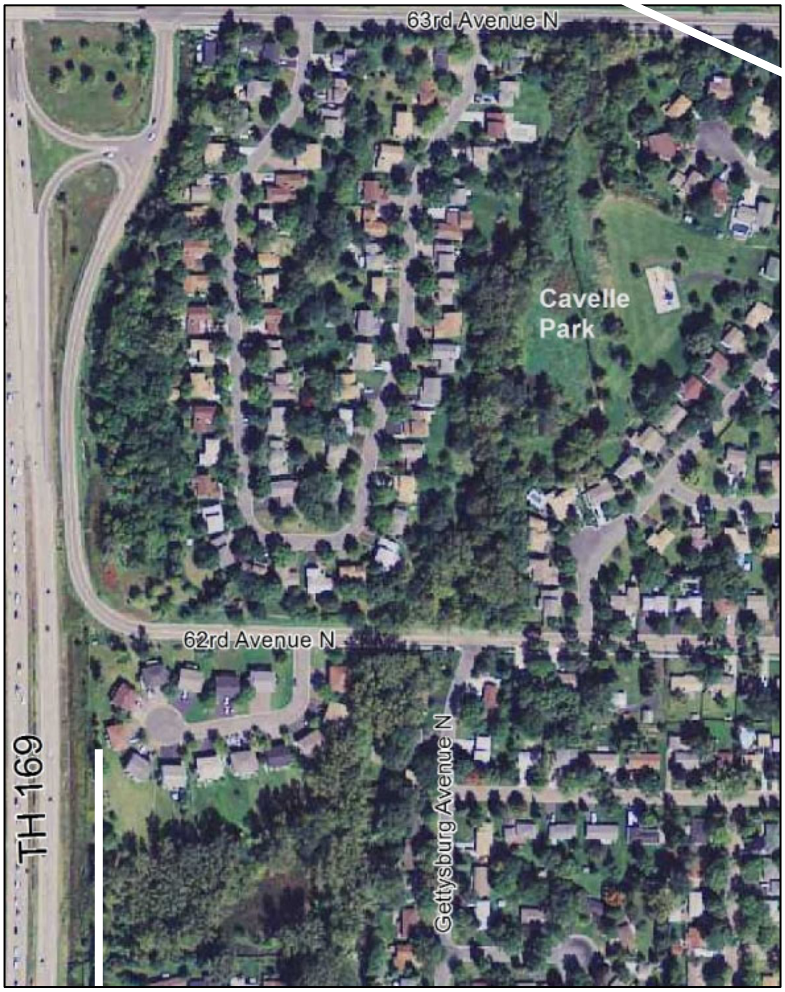

Figure 4.22. Bass Creek Reach 2.

4.2.3.3 Reach 3: Boulder Ridge Pond Outlet Weir to TH 169

Bass Creek Reach 3 extends from the Boulder Ridge Pond outlet weir in Plymouth to TH 169 in New Hope (Table 4.33 and Figure 4.23). The stream flows mainly through highway ditch on Bass Lake Road and TH 169, although there is a short segment that flows through a wooded upland area.

Table 4.33. Bass Creek Reach 3 description and load reduction.

Reach	Description	Length (Mi)	SOD Load Allocation (kg-SOD/day)		Reduction
			Current	TMDL	
3	Boulder Ridge Pond Outlet weir to TH 169	1.1	Not modeled	Not modeled	Not modeled

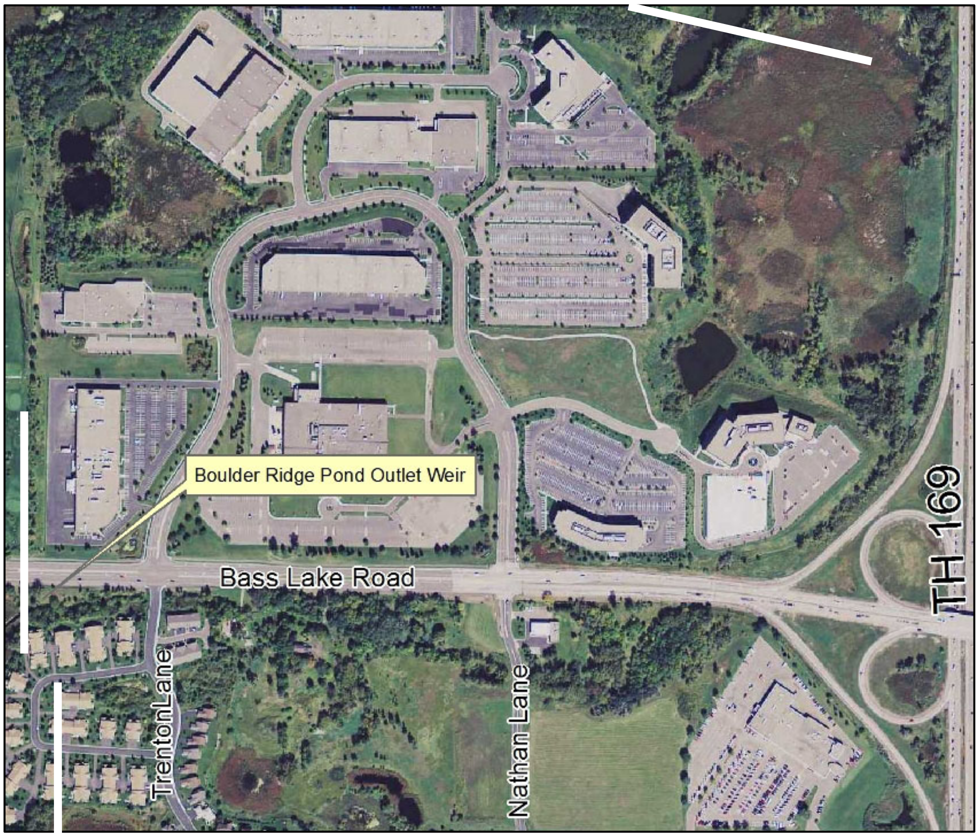

Figure 4.23. Bass Creek Reach 3.

The segments of this reach that flow through highway ditch would benefit from periodic maintenance to thin trees, and to remove obstructions to flow and accumulated material in the channel. In the segment between Nathan Lane and Bass Lake Road, tree thinning and buffer installation would be beneficial as would the addition of woody substrate such as root wads to increase habitat variety (Table 4.34).

Table 4.34. Issues and implementation actions, Bass Creek Reach 3

Issue	Action	Expected Outcome	Estimated Cost
Obstructions in channel, accumulated sediment	County road ditch maintenance	Improved flow	$10,000
Dense tree canopy, lack of buffer, lack of habitat	Restore 900 feet of stream: thin trees, stabilize banks as necessary, plant buffer, install in-stream habitat.	Stabilized banks and buffer will reduce sediment loss and filter runoff, improved substrate for habitat, increased DO	$100,000

4.3 COORDINATION AND REPORTING

4.3.1 Coordination

One of the primary Commission roles in managing the watershed is serving as a coordinator of water resource policies and activities. The Commission will continue in that role in the implementation of this TMDL. General activities now undertaken by the Commission will be continued or expanded as the Commission moves from management planning to implementation coordination. The following bulleted items are activities that are included as part of the Commission's general administrative budget and no additional cost is expected from their implementation:

- Provide advice and assistance to member cities on their implementation activities;
- Research and disseminate information on changing BMP technology and practices;
- Collect annual implementation activity data;
- Recommend activities such as vegetation or fishery management, in consultation with the DNR;
- Periodically update the Commission's Capital Improvement Program (CIP);
- Maintain the watershed SWMM and P8 models;
- Conduct public hearings on proposed projects; and
- Share the cost of qualifying improvement projects.

Estimated Cost: Ongoing activity
Funding Source: General operating budget, county levy for project share

4.3.2 Annual Report on Monitoring and Activities

An annual report on implementation activities is necessary under the adaptive management approach established in the TMDL. Each year the Commission will collect from the permittees in the watershed a listing of the activities undertaken in the previous year. This report will summarize those activities and provide the permittees assigned a categorical wasteload allocation the necessary information for their annual NPDES reports. The report will detail BMP implementation, associated load and volume reductions, and current monitoring data to evaluate activity effectiveness. At the end of each five year period this report will include an assessment of progress and identification of any revisions to the Implementation Plan. This report will be a part of the Commission's annual Water Quality Monitoring Report. The format and content of the Water Quality Monitoring Report is being revised to include reporting on the three stream TMDLs and 13 lake TMDLs in the watershed.

Estimated Cost: $10,000-12,000
Funding Source: General operating budget (currently budgeted at $10,000)

4.4 EDUCATION AND OUTREACH

The Commission operates an ongoing education and outreach program that is managed by the standing Education and Public Outreach Committee (EPOC). The EPOC is a group comprised of city staff, Commissioners, and watershed resident volunteers that develop and implement educational materials and programming.

The Commission undertook a professional opinion survey in fall 2007 to better understand what people know and how public education and outreach can most effectively communicate how individual property owners can impact water quality through the implementation of individual Best Management Practices in the watershed. The results of this survey guide the Commission's annual education and outreach plan, which selects two or three topics each year for special focus. Past topics have included proper use of fertilizers and the phosphorus fertilizer ban; Ten Things You Can Do to Improve Water Quality; and proper use of ice-control salt. The EPOC has also developed specialty brochures for residential associations and small commercial building managers.

The Commission is a founding member of the West Metro Water Alliance (WMWA), a consortium of five watershed management organizations, Hennepin County, and Three Rivers Park District. WMWA partners on education and outreach activities that are common to all the watersheds, such as training and educational workshops and media campaigns. The EPOC and WMWA will continue to provide both general and targeted education and outreach regarding the improvement of Bass and Shingle Creeks, and all the waters in western Hennepin County.

Estimated Cost: Ongoing activity
Funding Source: General operating budget for Education activities (current budget is $28,700)

4.5 MONITORING

4.5.1 Water Quality Monitoring

The SCWMC will lead monitoring and tracking of the effectiveness of activities implemented to manage runoff volume and improve dissolved oxygen in Shingle and Bass Creeks. This monitoring will continue to be detailed in the Commission's Annual Water Quality Monitoring Report. The Commission routinely monitors flow and water quality at two sites on Shingle Creek, and partners with the USGS to monitor a third site. While Bass Creek is not routinely monitored, the Commission will periodically collect flow and water quality data in Bass Creek.

Estimated Cost: $35,000 annually
Funding Source: Monitoring budget for stream monitoring (current budget is $35,000)

As described above, the Commission annually publishes a Water Quality Monitoring Report that compiles and interprets monitoring data from the lakes, streams, and wetlands in the watershed. The monitoring data collected by the Commission and other agencies will be analyzed to determine the linkage between BMP implementation and water quality and biotic integrity in Bass and Shingle Creeks, and to assess progress toward meeting the Total Maximum Daily Load goals.

Estimated Cost: $15,000
Funding Source: Reallocated operating budget for management plans (current budget is $15,000)

4.5.2 Biologic Monitoring

The Commission partners with Hennepin County Environmental Services to implement RiverWatch macroinvertebrate monitoring by high school students. This monitoring occurs in the spring and the fall at four sites on Shingle Creek. Every three to five years this student monitoring will be supplemented by more intensive fish and macroinvertebrate monitoring by Commission technical staff on both Bass and Shingle Creeks.

Estimated Cost: $3,000
Funding Source: Reallocated operating budget for management plans (current budget is $15,000)

5.0 Summary

The implementation activities described in Section 4.0 above are summarized in Table 5.1. As noted in the TMDL, these actions are recommended to achieve the dissolved oxygen standards and biotic integrity goals. In general, the Shingle Creek Watershed Management Commission will take the lead on coordinating implementation, reporting, education and outreach, and monitoring, while the member cities will undertake capital improvement projects. Table 5.1 indicates the responsible parties for these actions: for most of the capital improvement projects the Commission's role will be limited to grant writing and financial participation in 25 percent of the cost, and the lead agency will be the city in which the project is located.

While Table 5.1 includes an estimated implementation schedule, completion of capital projects will likely be driven by availability of grant funding and match funds. The schedule shown is more indicative of a general priority ranking. Projects shown in the 2012-2015 timeframe are planned or have been discussed for that time frame. The 2015-2020 projects would be next in priority, but at this time no projects have been advanced. The 2020-2025 projects are future, long-term projects. It should be noted that land development or redevelopment, street or highway projects, or other opportunities may advance consideration of any of these projects at any time, regardless of priority.

Larger ecological restoration projects will likely be funded through a combination of Clean Water Fund, Section 319, and other grants supplemented by Commission and city funding. Smaller projects may be suitable for smaller grant programs, including those that award funding in the form of Minnesota Conservation Corps labor. Many of these projects include volunteer labor opportunities, which will be incorporated wherever possible as an education and outreach activity.

Table 5.1. Summary of Bass and Shingle Creeks Impaired Biota/Dissolved Oxygen TMDL implementation actions.

Location and Reach		Action	Responsible Party	Estimated Schedule	Estimated Cost
Watershed-wide		Retrofit BMPs to add stormwater treatment	Cities	Ongoing	Varies by project
		Increase infiltration in watershed	Cities	Ongoing	Varies by project
		Develop desirable flow duration curve strategies	SCWMO	2011-2013	$5,000
		Rules and standards review	SCWMO	As necessary	$2,000
		Implement other TMDLs	SCWMO, cities	Ongoing	Varies by project
		Coordination	SCWMO	Annually	Admin budget
		Reporting	SCWMO	Annually	$10,000/yr
		Education and outreach	SCWMO, cities	Annually	$30,000/yr
		Stream water quantity and quality monitoring	SCWMO	Annually	$35,000/yr
		Biologic monitoring	SCWMO	Every 3-5 years	$3,000
Lower Shingle Creek	Reach 1	Reaeration at wetland outlet	Brooklyn Center, SCWMO	2012-2015	$50,000
	Reach 1	Stabilize streambanks	Brooklyn Center, SCWMO	2012-2015	$20,000
	Reach 2	Ecological stream restoration	Brooklyn Center, SCWMO	Completed	--

Location and Reach		Action	Responsible Party	Estimated Schedule	Estimated Cost
	Reach 3	Ecological stream restoration	Brooklyn Center, SCWMO	Completed	--
	Reach 4 & 5	Daylight stream	Private developer	2012-2015	--
	Reach 6	Ecological stream restoration on Golf Course	Brooklyn Center, SCWMO	2020-2025	$100,000
	Reach 6	Ecological stream restoration	Minneapolis, SCWMO	2020-2025	$250,000
	Reach 7	Ecological stream restoration	Minneapolis, SCWMO	2020-2025	$1,500,000
	Reach 8	Ecological stream restoration	Minneapolis, SCWMO	2012-2015	$750,000
	Reach 8	Fish passage at Webber Park	Minneapolis, SCWMO	2012-2015	$50,000
Upper Shingle Creek	Reach 1	Add reaeration structures	Brooklyn Park, SCWMO	2020-2025	$50,000
	Reach 2	Thin trees, establish buffer	Brooklyn Park	2015-2020	$80,000
	Reach 3	Ecological stream restoration	Brooklyn Park, SCWMO	2020-2025	$700,000
	Reach 4	Ecological stream restoration	Brooklyn Park, SCWMO	Completed	--
	Reach 5 & 6	Enhance restoration	Brooklyn Park	2015-2020	$70,000
	Reach 7 & 8	Enhance restoration	Brooklyn Park	2015-2020	$50,000
	Reach 7 & 8	Restore balance of reach (Regent to Brooklyn Boulevard)	Brooklyn Center, Brooklyn Park, SCWMO	2020-2025	$350,000
	Reach 9 & 10	Ecological stream restoration, fish bypass	Brooklyn Center, Brooklyn Park, SCWMO	2012-2015	$350,000
	Reach 11	Ecological stream restoration	Brooklyn Park, SCWMO	2015-2020	$500,000
	Reach 11	Enhance off-line refugia	Brooklyn Park, SCWMO	2012-2015	$30,000
	Reach 12	Ecological stream restoration	Brooklyn Park, SCWMO	2020-2025	$75,000
Bass Creek	Reach 1	Ecological stream restoration	Brooklyn Park, SCWMO	2015-2020	$300,000
	Reach 1	Monitor Cherokee Wetland	SCWMO	2015-2020	Monitoring budget
	Reach 2	Ecological stream restoration	Brooklyn Park, New Hope, SCWMO	2015-2020	$300,000
	Reach 3	Periodic ditch maintenance	Hennepin County	As needed	$10,000
	Reach 3	Ecological stream restoration	Plymouth, SCWMO	2020-2025	$100,000
TOTAL		**One Time Cost**			**$5,615,000**
		Ongoing Annual Cost (monitoring, education, reporting)			**$75,000**

6.0 Literature Cited

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Appendix A
Stream Ecological Restoration Design Principles and Maintenance Standards
Shingle Creek Corridor Study

The Shingle Creek Watershed Management Commission completed a Shingle Creek Corridor Study in 2004-2005 to assess existing conditions in the creek and to develop management standards for the restoration of water quality and ecological integrity. The following management standards were adopted in 2005 and are advisory but integral to the Commission's vision and goals for the Creek.

Ecological Restoration Project Design Standards

While individual projects present design challenges that are unique to that reach, the following standards are principles that should be used to guide the design of projects, whether they are large-scale restoration projects or channel maintenance and repair projects.

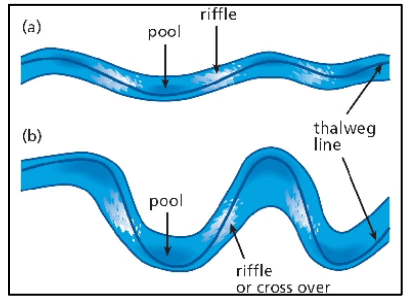
1. General Principles

No change to 100 year elevation	Improvement projects or management strategies shall not increase the 100-year elevation of Shingle Creek nor its tributaries or floodplain storage areas.
No wetland fill or floodplain fill without compensating storage in reach	Improvement projects or management strategies that impact wetlands shall be subject to the requirements of the Wetland Conservation Act. Any fill that impacts flood storage in wetlands or floodplains shall be mitigated with compensating storage within the same subreach or reach.
Use bioengineering and soft techniques where possible, using hard armoring only where erosive conditions require more stability	The ecological restoration concept is to return the creek where possible to its native form and function. Bioengineering techniques such as the use of root wads, live stakes, brush mattresses, and long-rooted native vegetation are the preferred methods of stabilizing streambanks. However, it is recognized that under streamflow conditions these techniques may not be sufficient to provide adequate stability, for example, in the vicinity of stormsewer outfalls. Hard armoring is acceptable under those conditions, with attention paid to softening the appearance of the armoring where it does not compromise stability.
Restore native vegetation to the riparian zone	Presettlement, the creek corridor landscape was primarily prairie and oak savanna. The current corridor landscape is a mix of developed area, turfed park and open space, and cattail wetland. The long-term goal is to restore the creek riparian areas to native vegetation characteristic of these landscape types.

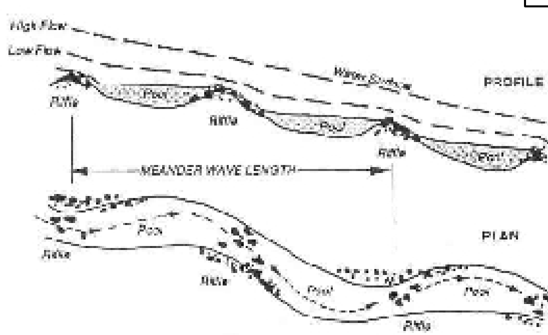
2. Channel Design Principles

Restore historic function and increase aeration by re-creating natural meandering and pool-riffle sequences

Natural channels meander within their floodplain. The thalweg, or deepest part of the channel, meanders as well, creating alternating pools and riffles that create **habitat** and **aerate** the stream, increasing the dissolved oxygen concentrations.

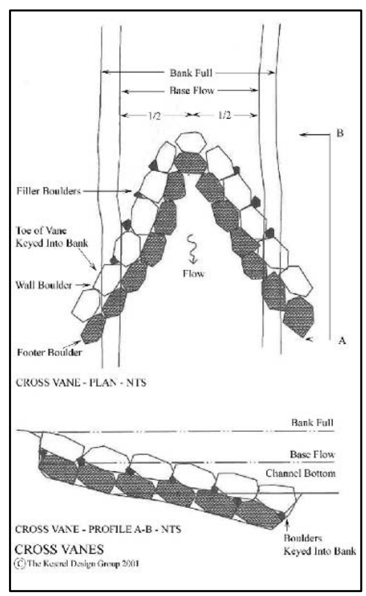


Federal Interagency Stream Restoration Working Group



Remove drop structures and install rock vanes every one-foot drop in elevation

Rock vanes provide a way to "step down" elevation changes while at the same time creating a riffle-pool sequence. This allows for the removal of fish barriers, and creates new **habitat** structures. The rock vane also functions as a riffle, **aerating** the stream. The V shape pointing upstream directs flow into the pool in the middle of the channel, **reducing streambank erosion**.



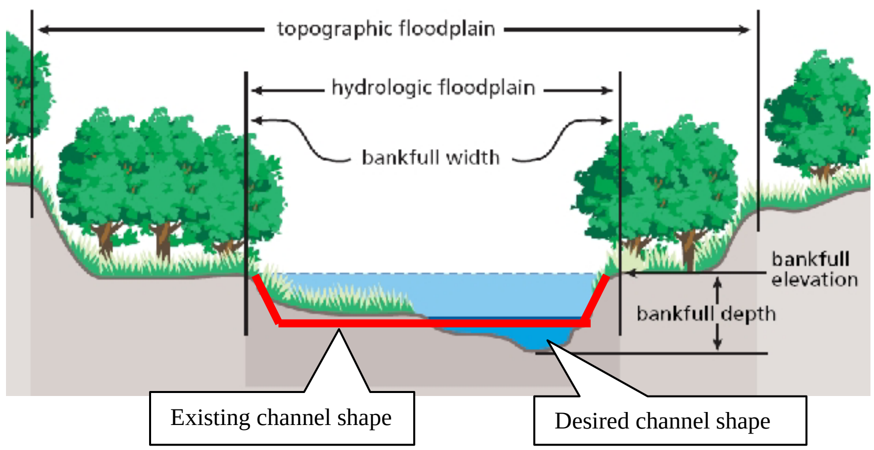
(Left) Seven rock vanes were placed in Pike Creek between Hemlock Lane and Pike Lake in Maple Grove.

Create low flow channels to carry smaller events and base flow, and maintain a vegetated floodplain within the channel to carry flows from larger events.

Shingle Creek has naturally created a narrow channel to carry low flows and base flow here downstream of Candlewood Drive in Brooklyn Park.

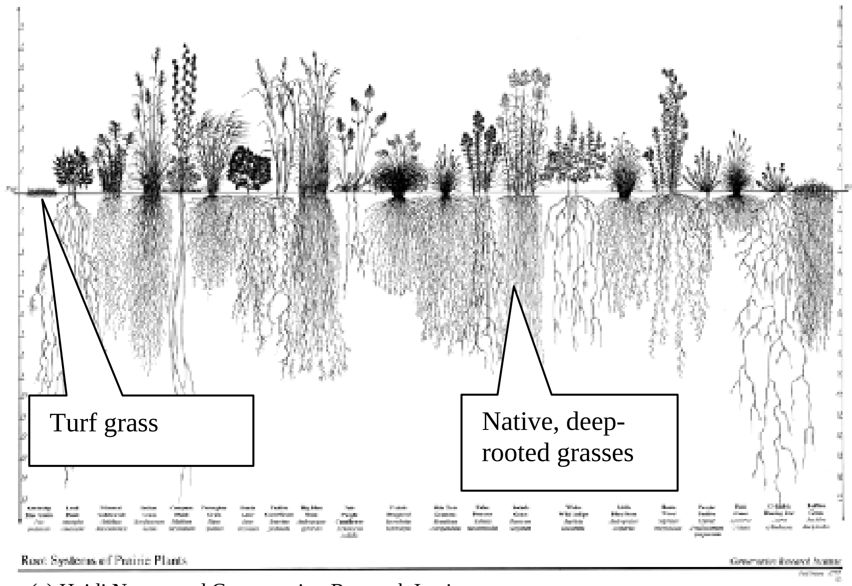
As shown below, the existing flat-bottomed trapezoidal shaped channel should be replaced by a channel shape designed to carry a variety of flows.

The narrow, low flow channel should meander within the existing channel to lengthen the stream channel and reduce velocity.



3. Streambank Design Principles

Use deep-rooted native vegetation to create buffers at least five feet wide next to creek



(c) Heidi Natura and Conservation Research Institute

Turf grass roots can be only a few inches deep, but native grasses can have roots 10 to 15 feet deep. Turf grass provides no streambank stability. Native plants are resilient, anchor the streambank, take up nutrients more efficiently than turf grass, and help slow floodwater velocity.

Hard armor banks opposite storm sewer outfalls

New or reconstructed outfalls should be aligned at an angle pointing downstream to avoid erosive effects on the streambank opposite the outfall. Where it is not possible to align the outfall this way, the opposite bank should be armored with riprap.

Remove leaning and undercut trees

Leaning and undercut trees should be removed either through routine maintenance or as a part of any streambank project. Because their root system is often exposed, they provide little bank stability and are at greater risk of falling. Falling can result in streambank failure and increased erosion. The debris can also block flow and cause debris and sediment to accumulate.

Remove artificial shoring and streambank surfaces	This streambank in Brooklyn Park is armored with riprap covered with concrete. Other reaches include placed riprap, wood shoring walls, and concrete block walls.  Use natural materials such as root wads, live stakes, brush mattresses, and deep-rooted native vegetation to provide streambank stability, using hard armoring only where absolutely necessary.
Remove existing riprap that does not meet design standards	Riprap should be made of rock resistant to wear and sized to withstand high shear stress. Limestone and other soft rock are worn by streamflow and chemical processes and will lose its structural integrity over time.
Fill voids in rip rap with soil and plant native vegetation between the rocks	 This technique provides more streambank stability, promotes infiltration, and softens the appearance of the riprap. Here on Pike Creek in Maple Grove, live willow stakes were planted between the riprap.

4. Habitat Design Principles

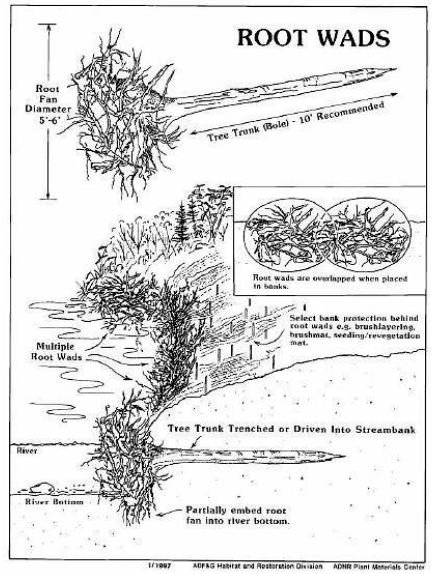
Remove or minimize fish barriers

Remove drop structures as described in Channel Design Principles above. Culverts at stream crossings can also be a barrier to fish passage. Instead of cylindrical pipe, crossings should use an open-bottomed arch to simulate natural conditions.

Create low and high flow refugia

Low flow refuges are typically deep pools associated with low-flow channels. Larger rocks and cobble found in riffles and rocky substrate provide some refuge from high flows. Offline refuges include structures such as fish bunkers as well as backwater and side pools.

Woody debris and overhanging vegetation provide refuge for fish and invertebrates alike. Root wads used for streambank stabilization and erosion control are effective refuges for fish and invertebrates.



Restore native vegetation in riparian zone to improve habitat

Remove the invasive and cultivated vegetation in the riparian zone and replace with native, long-rooted herbaceous vegetation, a shrub layer, and tree species appropriate for and native to the vegetative community. Overhanging vegetation provides habitat for fish and invertebrates, and leaves and small woody detritus are an important source of organic carbon.

Increase Substrate Diversity	 Increasing substrate diversity leads to areas readily colonized by macroinvertebrate communities. An important design feature is to ensure that good stream substrates such as cobble do not become embedded by sediment deposited as a result of reduced channel velocities. The diversity of habitat should include cobble, boulders, and sands as well as woody debris such as submerged logs, fine woody debris, and leaf packs.

Maintenance Standards

Maintenance within the stream corridor is inconsistent. Snags are routinely removed or not removed. Turf maintenance and mowing occurs up to the streambank or a wide buffer is left unmowed. Invasive vegetation is removed or not.

Each of the cities has policies regarding maintenance of parks and open space, and utilizes the stream corridor for different purposes. The following standards are principles that should be used to guide the management of the corridor to help achieve the goals of ecological restoration.

1. General Principles

Maintain a twenty foot minimum width buffer	The Commission currently requires a vegetated buffer a minimum twenty feet wide and averaging thirty feet wide adjacent to watercourses or wetlands for property that undergoes development or redevelopment. In many locations along the creek, on both private and publicly owned land, the vegetated buffer is often just a narrow area left unmowed. At a minimum these should be widened, with invasive species removed and native plants introduced.
Remove large woody debris and snags only when impacting channel capacity and flood flows and increasing erosion potential	Snags are standing dead trees, while large woody debris includes fallen trees both in the water and out as well as limbs and other tree parts. As long as a snag is not leaning or undercut (see below) or otherwise in danger of falling, it provides valuable habitat for terrestrial life as well as an organic carbon source for terrestrial and aquatic life as it decays and breaks up. Large woody debris provides aquatic habitat as well as an organic carbon source for aquatic life.

Remove leaning and undercut trees	Undercut and leaning trees are hazardous because the root structure is usually comprised. They are more likely to fall from high winds or high velocity flows, and can cause streambank failure and erosion.
Remove invasive vegetation promptly	Buffer areas should be inspected regularly for invasive vegetation, and any found should be removed promptly. Many invasive species are hardy and adventitious, and can quickly crowd out more beneficial species. A healthy riparian zone requires a variety of plant species.  Purple loosestrife, an invasive plant. (North Dakota
Enact and enforce standards specifying buffer maintenance adjacent to Shingle Creek and its tributaries	Where privately-owned property abuts the creek, or where there is only a narrow city-owned or controlled parcel between private property and the creek, each city should consider enacting and enforcing standards regarding buffer maintenance. In several locations, adjacent private property owners have mowed city-owned property up to the streambank, eliminating the vegetated buffer. The Commission currently requires a minimum twenty-foot wide vegetated buffer adjacent to watercourses or wetlands for property that undergoes development or redevelopment.