South Fork Crow River Lakes Excess Nutrients TMDL Report

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Cover Photo
By
Carver County Staff
Swede Lake
June 1999

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• Priority ranking is based on scheduling of completing project. These TMDLs were scheduled to begin in 2010 and be complete in 2014.
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Identify <u>and explain</u> the implicit or explicit MOS for each pollutant

An implicit MOS was used for all of the lakes based on conservative modeling assumptions.</td><td>39</td></tr>
<tr><td>Seasonal Variation</td><td colspan="2">Statute and regulations require that a TMDL be established with consideration of seasonal variation. The method chosen for including seasonal variation in the TMDL should be described [CWA §303(d)(1)(C), 40 CFR §130.7(c)(1)]
Seasonal Variation Summary for each pollutant</td><td>40</td></tr>
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Note: In a water impaired by both point and nonpoint sources, where a point source is given a less stringent WLA based on an assumption that NPS load reductions will occur, reasonable assurance that the NPS reductions will happen must be explained.

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Note: EPA does not approve effectiveness monitoring plans but providing a general plan is helpful to meet reasonable assurance requirements for nonpoint source reductions. A monitoring plan should describe the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.</td><td>60</td></tr>
<tr><td>Implementation</td><td colspan="2">1. Implementation Strategy included?
The MPCA requires a general implementation strategy/framework in the TMDL.

Note: Projects are required to submit a separate, more detailed implementation plan to MPCA within one year of the TMDLs approval by EPA.

2. Cost estimate included?
The Clean Water Legacy Act requires that a TMDL include an overall approximation (“…a range of estimates”) of the cost to implement a TMDL [MN Statutes 2007, section 114D.25].

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Executive Summary

This Total Maximum Daily Load (TMDL) study addresses a nutrient impairment in three lakes in the Crow River watershed. The goal of this TMDL is to quantify the pollutant reductions needed to meet State water quality standards for nutrients in the lakes of Eagle (10-0121), Oak (10-0093), and Swede (10-0095).

The South Fork Crow River lakes are located in Carver County, west of the Twin Cities Metro. All lakes are in areas that are primarily rural. The Western suburbs of the Twin Cities Metropolitan area are experiencing moderate to high levels of development and there is increasing awareness of water quality issues by the public. With the exception of Eagle Lake, the lakes are not currently used for recreation beyond their aesthetic values, fishing, and some boating, although there is interest from local citizens to improve the lakes for swimming within Oak and Swede. Swimming at Eagle Lake is possible through beach access within a County Park.

The combined drainage area of the lake chain is 3,463 acres, roughly 44 percent is agricultural land and 5 percent being developed acreage. The lakes are connected by channels of varying lengths and the South Fork of the Crow River, which has been identified by the Minnesota Pollution Control Agency (MPCA) as impaired for turbidity, fecal coliform, and fish bioassessment. A future TMDL study is planned for these reaches of the Crow River. The lake system and Crow River flow to the northeast, ultimately discharging into the Mississippi River.

Water quality in all three lakes is considered poor with frequent algal blooms. Monitoring data in the South Fork Crow River chain of lakes suggest that it is a highly productive system, with the greatest water quality problems occurring in Swede Lake.

Eagle Lake, located northwest of the city limits of Norwood Young America, is a hypereutrophic lake. Significant sources of phosphorus appear to be from both internal loading and agricultural runoff. Also contributing to phosphorus loading is Braunworth Lake, which flows into Eagle Lake.

Oak Lake is a hypereutrophic lake located northwest of Lake Waconia. Phosphorus loadings have significant sources from the direct watershed to the lake and internal loading.

Internal sources are the significant phosphorus loading to Swede Lake. This lake is hypereutrophic and located northwest of the Lake Waconia and south of Oak Lake.

For all lakes to meet State standards for the North Central Hardwood Forest Ecoregion phosphorus loading will need to be reduced from 42 to 96 percent. Various activities and strategies are outlined within this TMDL to meet these reduction goals. Activities are in two categories: external load reduction strategies and internal load reduction strategies. External load reduction activities include, but are not limited to, installation of best management practices (BMPs) throughout each subwatershed, landowner education, wetland restoration, installation of buffer strips, incorporating rain gardens into residential landscapes, and impervious disconnection. Internal load reduction strategies include, but are not limited to, aquatic plant management and landowner education.

1 Target Identification and Determination of Endpoints

1.1 Purpose

This Total Maximum Daily Load (TMDL) study addresses nutrient impairments for three lakes within the Crow River Watershed. The goal of this TMDL is to quantify the pollutant reductions needed to meet the water quality standards for nutrients in Eagle, Oak, and Swede Lakes. This nutrient TMDL is being established in accordance with section 303(d) of the Clean Water Act, because the State of Minnesota has determined waters in these three lakes exceed the State established standards for nutrients.

This study provides allocations for three lakes within the Crow River Watershed. Based upon State standards, the TMDL establishes a numeric target of 60 µg/L total phosphorus concentration for all shallow lakes in the North Central Hardwood Forest ecoregion.

1.2 Impaired Waters

All three of the lakes in this project are on the 2010 State of Minnesota 303(d) list of impaired waters. Eagle was originally listed in 2002 and Oak and Swede were listed in 2004 (Table 1.1). The lakes are impaired for excess nutrients, which inhibit the beneficial use of aquatic recreation. Excess nutrients have led to increases in algal blooms in all lakes, discoloration of the water, and nuisance odors. All of which have impaired the designated use of aquatic recreation, including swimming.

Table 1.1 Impaired waters in the South Fork Crow River Lakes.

LAKE	DNR LAKE #	AFFECTED USE	YEAR LISTED	POLLUTANT OR STRESSOR
Eagle	10-0121	Aquatic recreation	2002	Excess nutrients
Oak	10-0093	Aquatic recreation	2004	Excess nutrients
Swede	10-0095	Aquatic recreation	2004	Excess nutrients

The MPCA projected schedule for TMDL report completion, as indicated on Minnesota's 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of these TMDLs. These TMDLs were scheduled to begin in 2010 and be complete in 2014. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with each TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

1.3 Defining Minnesota Water Quality Standards

Water quality in Minnesota lakes is evaluated using three parameters: TP, chlorophyll-a, and Secchi depth. Phosphorus is typically the limiting nutrient in Minnesota lakes, meaning that algal growth will increase with increased phosphorus. Chlorophyll-a is the primary pigment in aquatic algae and has been shown to have a direct correlation with

algal biomass. Secchi depth is a physical measurement of water clarity taken by lowering a white disk until it can no longer be seen from the surface. Greater Secchi depths indicate less light-refracting particulates in the water column and better water quality; conversely, high TP and chlorophyll-a concentrations point to poor water quality.
The protected beneficial use for all lakes is aquatic recreation (swimming). Table 1.2 outlines the previous state standards that were used to determine that Eagle, Oak, and Swede Lakes should be placed on the 303(d) list of impaired waters. In May 2008, the MPCA approved new numerical thresholds based on ecoregions and lake morphometry (Table 1.3). The new rules take into account nutrient cycling differences between shallow and deep lakes, resulting in more refined standards for Minnesota lakes (MPCA 2005).

Table 1.2 Previous state standards lakes (NCHF ecoregion).

Impairment Designation	TP (µg/L)	Chlorophyll-a (µg/L)	Secchi Depth (m)
Full Use	<40	<15	≥1.6
Review	40 - 45	NA	NA
Impaired	>45	>18	<1.1

According to the MPCA, Eagle, Oak, and Swede Lakes are considered "shallow" lakes. Because Carver County falls within the North Central Hardwood Forest (NCHF) Ecoregion (Figure 1.1), those standards were used to determine impairment.

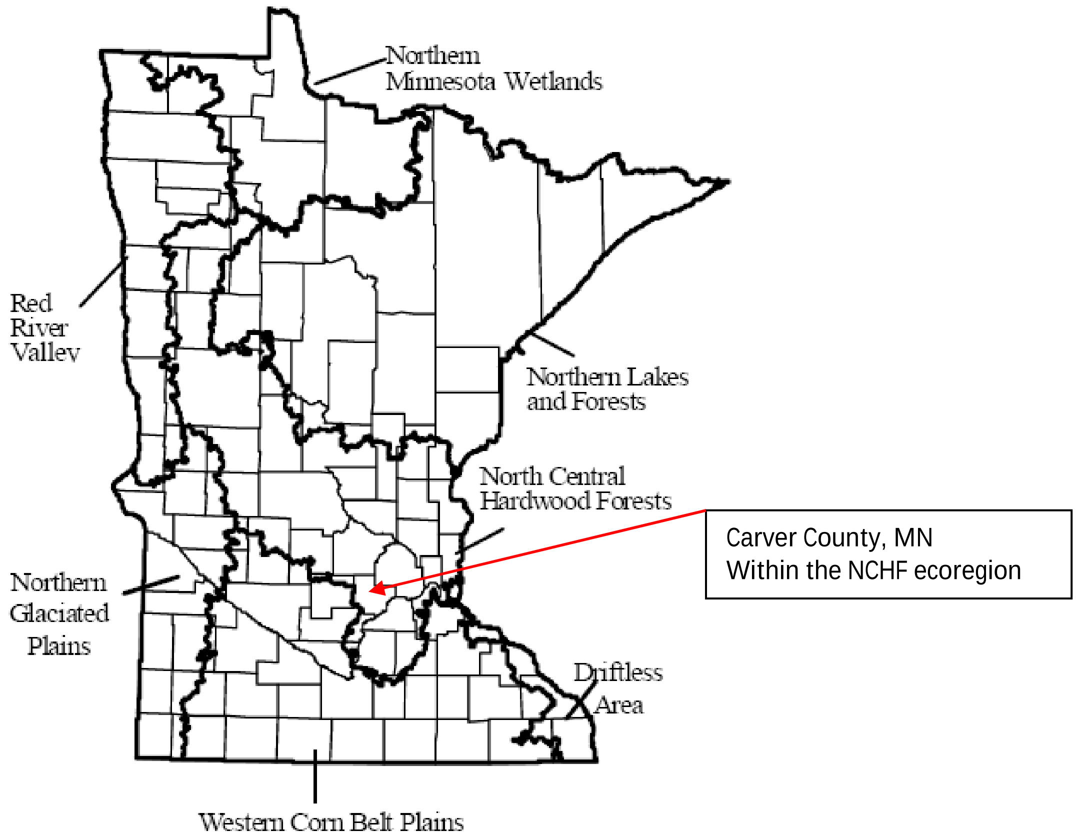


Figure 1.1 Map of Minnesota's ecoregions.

Table 1.3 Current state standards for protecting Class 2B waters. Values are summer averages (June 1 through September 30).

	NORTH CENTRAL HARDWOOD FOREST	
Parameters	**Shallow**[1]	**Deep**
TP concentration (µg/L)	60	40
Chl-a concentration (µg/L)	20	14
Secchi disk transparency (meters)	>1.0	>1.4

[1]Shallow lakes are defined as lakes with a maximum depth of 15 feet or less, or with 80% or more of the lake area shallow enough to support emergent and submerged rooted aquatic plants (littoral zone).

This TMDL has been established with the intent to implement all the appropriate activities that are not considered greater than extraordinary efforts. But these proposed goals will require aggressive action. Upon initial implementation, subsequent monitoring will determine the feasibility in moving to the next level. If all appropriate BMPs and activities have been implemented and the lakes still do not meet their goals, Carver County staff will reevaluate the TMDL and work with the MPCA to evaluate whether more appropriate site-specific standards for the lakes could be pursued and developed.

Inherent in the numerical water quality goals for shallow lakes are desired ecological endpoints. Carver County's management strategies are focused on these endpoints which are restoring the lakes to a diverse, native aquatic plant (macrophyte) dominated state across much of the lake. This type of lake is characterized by low rough fish populations, clearer water, higher wildlife values and positive feedback mechanisms that maintain the lake in this condition (Scheffer 1998). A shift from the algae/invasive macrophyte dominated state to the clear water, native macrophyte dominated state should be a qualitative goal for Crow River Watershed Lakes.

Another goal is to improve public perception of the recreational suitability of the Crow River Watershed Lakes. Public surveys were conducted throughout the Crow River Watershed Lakes to assess public perception of the lakes. Results will be used to identify goals appropriate for increasing this perception of recreational suitability.

Respondents to the Eagle Lake survey have stated that recreational activity on the lake is perceived to be moderate to heavy during the summer season. The major recreational activity on the lake is fishing and boating while other uses include swimming and wildlife observation.

Due to this limited access point, the majority of public comments for Oak Lake were based upon the observation of wildlife and how the water appeared to be. Lakeshore owners did have a variety of uses that should be achieved on the lake, ranging from boating to waterskiing to swimming.

Roughly 64 percent of the residents surveyed around Swede Lake currently view the lake as unswimmable. However, they have optimism that the lake could be used for swimming if this TMDL is successful. Other uses for the lake are periodic fishing, mainly during the winter months. During these times, it is common for large numbers of anglers to be present.

2 Watershed and Lake Characterization

2.1 South Fork Crow River Lakes Watershed Description

The Carver County portion of the Crow River Watershed is located in western Carver County, encompassing roughly 72,600 acres. Boundaries of three cities are completely within Crow River Watershed and portions of a fourth city as well (Figure 2.1). Dominant land use within the watershed is agriculture (66%, 48,109 acres), developed land use is a small portion of the overall area (6%, 4,393 acres) and wetland and water land uses make up 25% (15,765 acres) (Table 2.1).

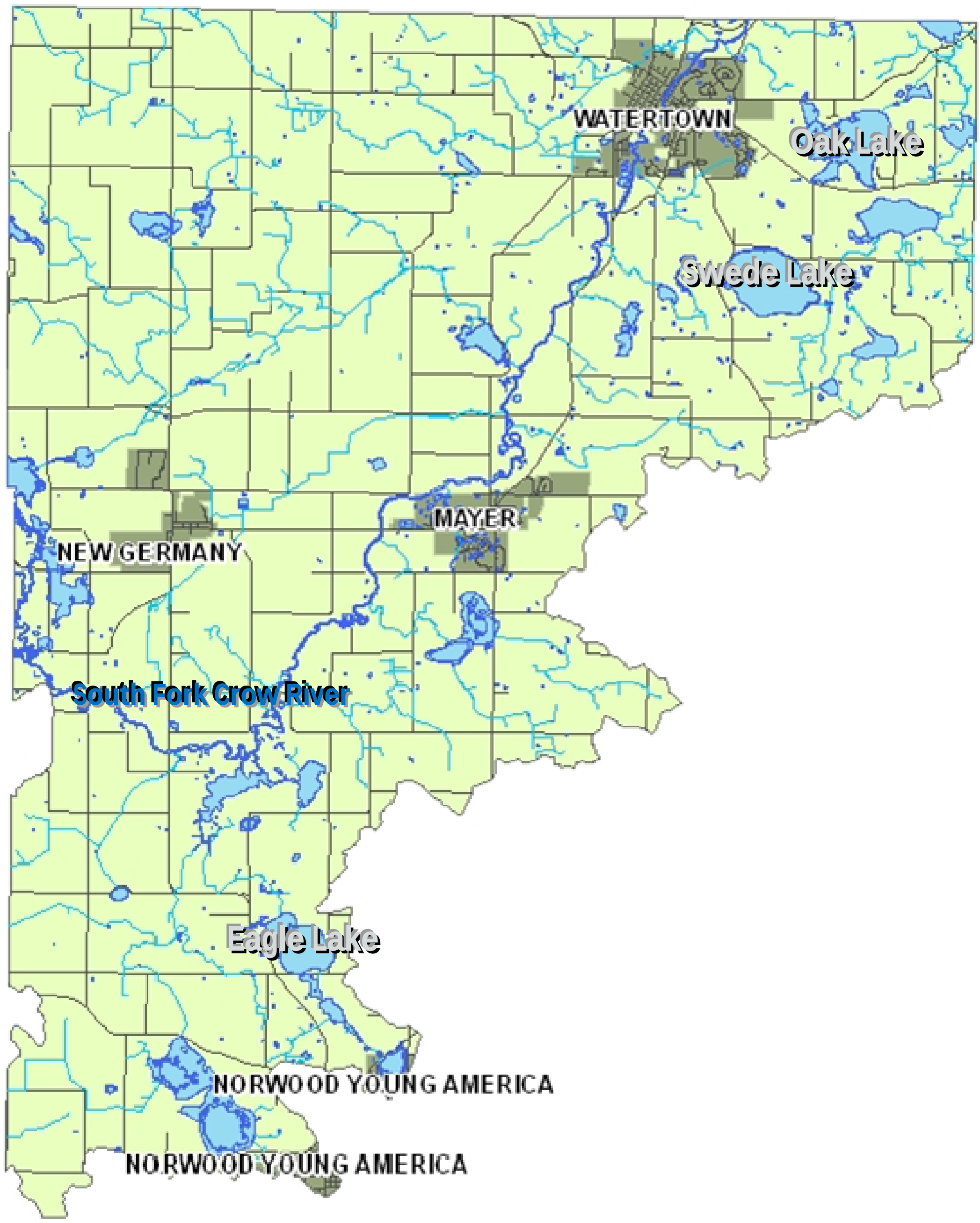


Figure 2.1 South Fork Crow River Watershed

Table 2.1 2005 South Fork Crow River Watershed Land Use.

Land Use	South Fork Crow River Watershed	
	Acres	Percent
Agriculture	48,109	66%
Developed	4,393	6%
Forest/Grassland	8,216	11%
Wetland	2,286	3%
Water	9,549	13%
Total	**72,553**	**100%**

Eagle Lake Subwatershed is located in the southeastern portion of the South Fork Crow River Watershed. The outlet of Eagle Lake ultimately flows to the South Fork of the Crow River, first flowing through a wetland complex two miles downstream of the lake. The northeast portion of the Crow River Watershed within Carver County has both Swede and Oak Lake, with Oak Lake being farther north of the two. Oak Lake direct watershed is relatively small, containing no inlets to the lake. This outlet drains the lake into a ditch flowing to Rice Lake, north of the subwatershed, and ultimately into the Crow River. Swede Lake is located in the northeastern portion of the South Fork Crow River Watershed, just south of Oak Lake. This outlet of the lake flows towards the Crow River, passing through a few lakes before reaching the river.

Table 2.2 Lake characteristics of the South Fork Crow River Lakes.

Parameter	Eagle Lake	Oak Lake	Swede Lake
Surface Area (ac)	181	352	447
Average Depth (ft)	5.82	3.56	6.77
Maximum Depth (ftP	14	11	12
Volume (ac-ft)	1,056	1,252	3,024
Residence Time (days)	415 - 770	914 - 1,634	4,788 - 8,583
Littoral Area (%)	100	100	100
Watershed (excluding lake) (ac)	1,282	850	349
Lakeshed:Lake Area	6.8 : 1	2.4 : 1	1 : 1.3

2.1.1 Eagle Lake

Eagle Lake has a direct watershed of 1,230 acres, excluding the lake. The direct watershed is the area that drains directly to Eagle Lake without first passing through another lake (i.e., Braunworth Lake). The direct watershed can be dissected into two subwatersheds, one draining the inlet (E1) and the other area draining directly to the lake (Figure 2.2). The indirect watershed drains from Braunworth Lake and into the southern inlet (E1). Braunworth Lake has a surface area of 37 acres and a direct watershed of 308 acres. It is likely that Braunworth Lake is impaired based upon field observations of the lake, however, no lake sampling has occurred to verify the exact level of impairment. While the indirect watershed land use information was used in modeling, our discussion throughout this TMDL will focus on the direct watershed where management for Eagle Lake will likely be focused.

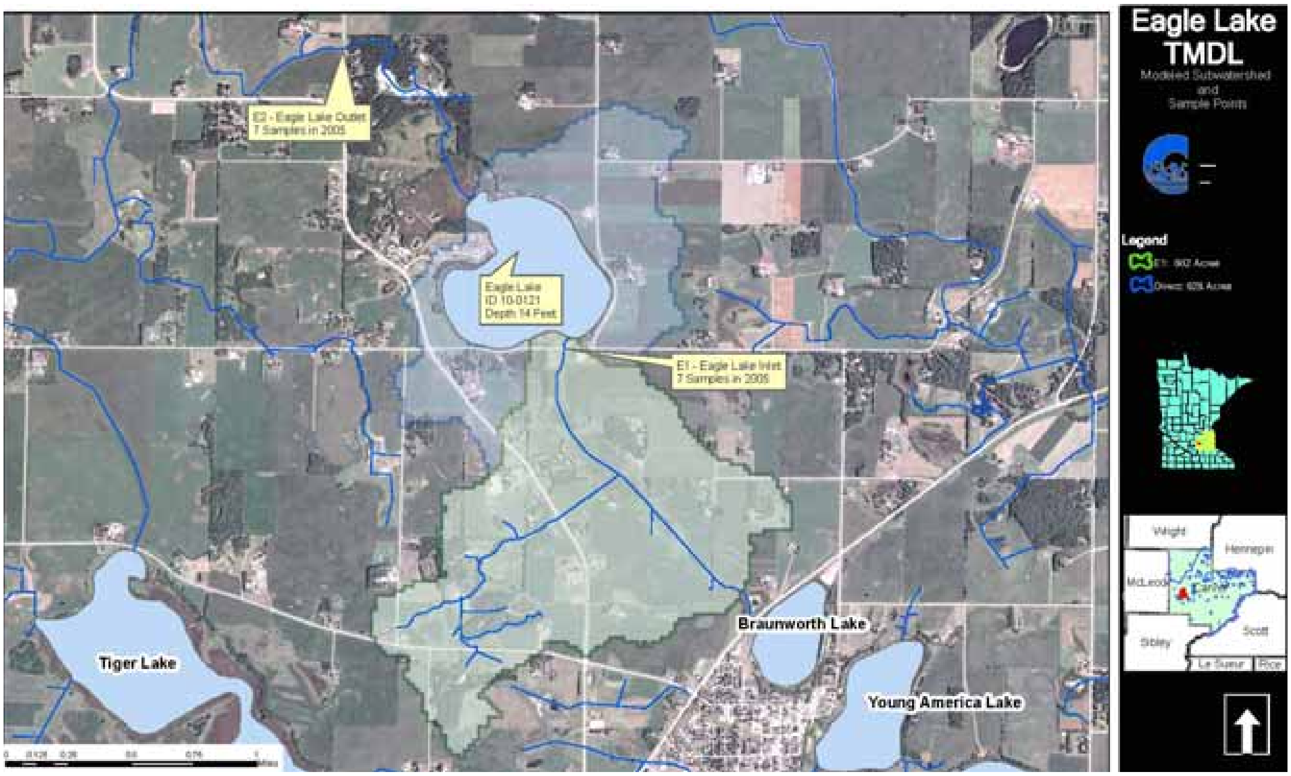


Figure 2.2 Map of Eagle Lake watershed, subwatersheds, and sample points.

2.1.2 Oak Lake

Oak Lake has a direct watershed of 874 acres, excluding the lake. The lake does not have any inlets into the lake. One outlet is located in the northeast corner of the lake (Figure 2.3), flowing ultimately into the South Fork of the Crow River.

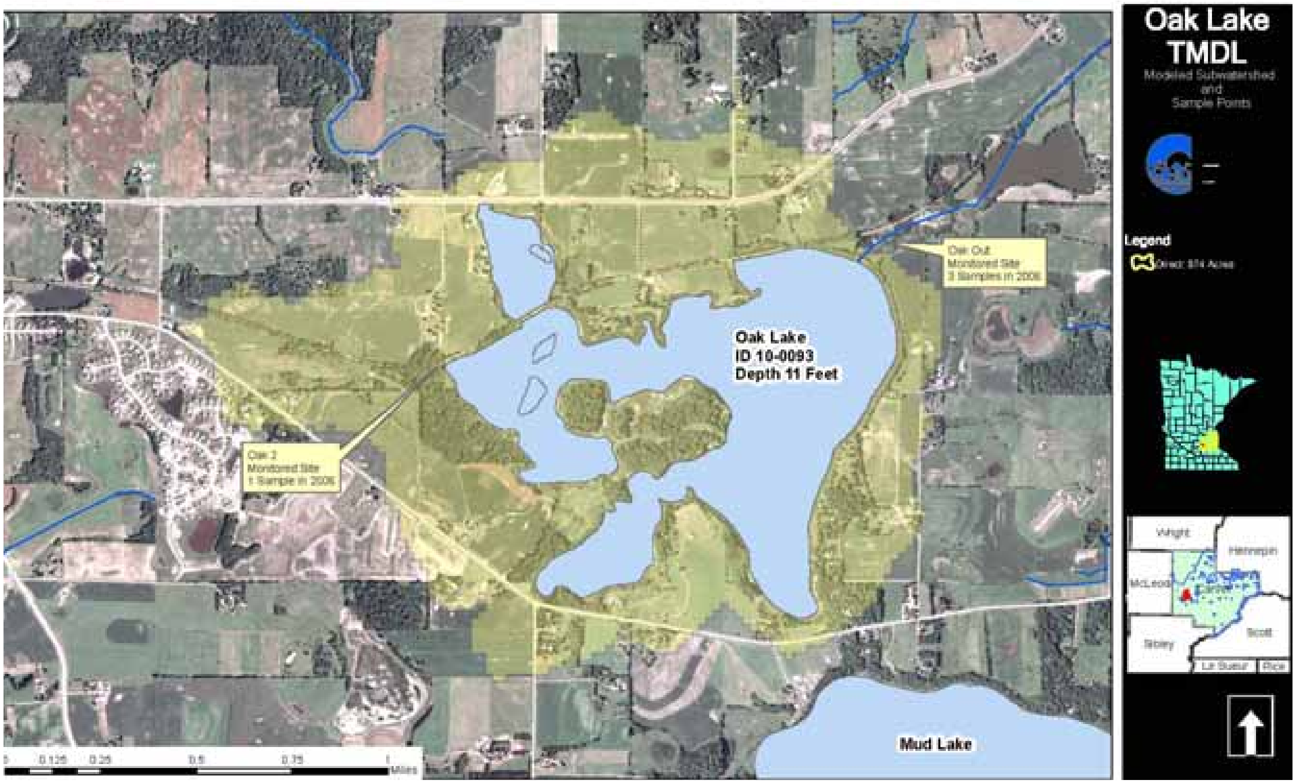


Figure 2.3 Map of Oak Lake watershed, subwatersheds, and sample points.

2.1.3 Swede Lake

The Swede Lake watershed is in the South Fork Crow River Watershed which is within the Upper Mississippi River major watershed. The lake has a direct watershed of 362 acres, excluding the lake (Figure 2.4). The lake has no inlets and a controlled outlet located at the east side of the lake which drains into Mud Lake.

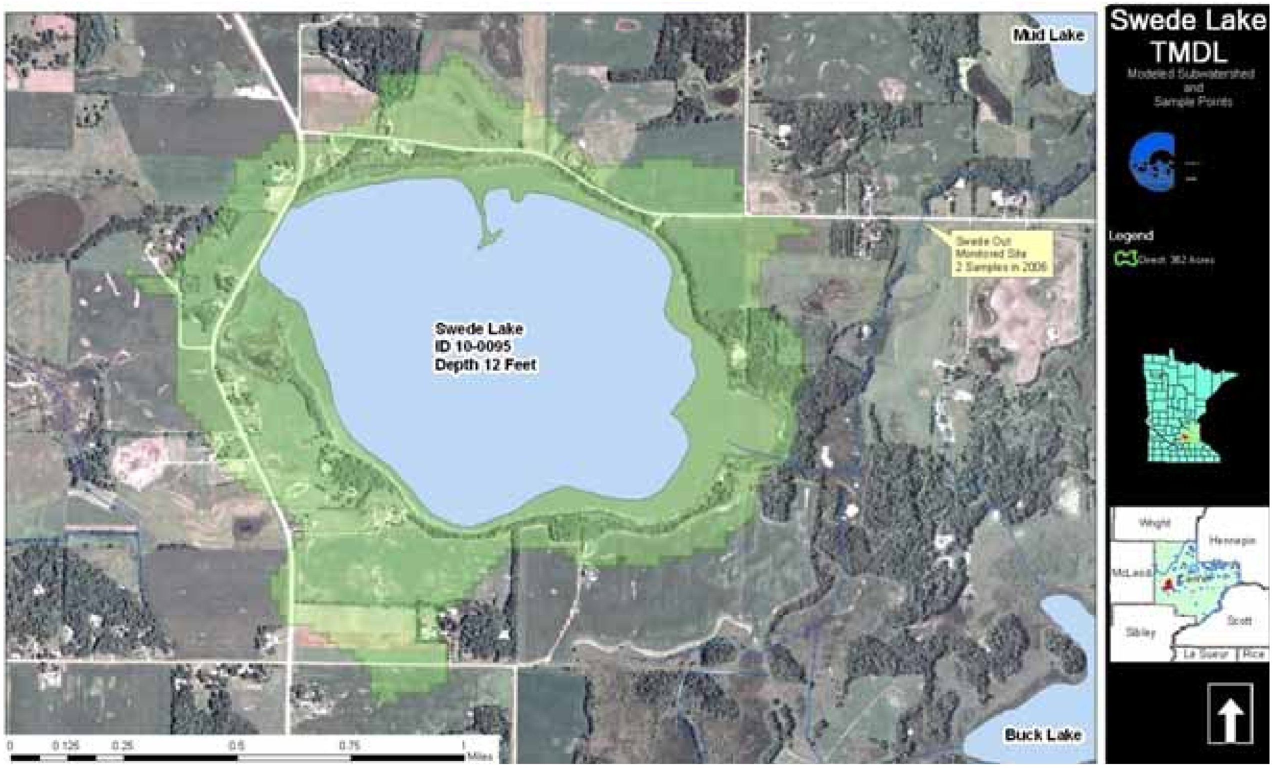


Figure 2.4 Map of Swede Lake watershed, subwatersheds, and sample points.

2.2 Land use

Both Eagle Lake and Oak Lake have agricultural land use as the highest percentage of land use (56 percent and 38 percent, respectively). Swede Lake's major land use is water at 56 percent (Table 2.3). If the direct lake acreage is removed from calculating percentages, agriculture is the major land usage for the entire area ranging from 52 percent in Oak Lake to 67 percent in Eagle Lake, which is similar to the Carver County portion of the South Fork Crow River Watershed. In this report direct watersheds are considered to be those areas draining to the lake without first passing through another lake.

Land use changes between 2005 and 2020 are partly due to the different methodology used to determine each classification. Any changes seen in wetland land use or developed land are largely a reflection of this difference in methodology. Wetland "reductions" in 2020 do not account for any mitigation of wetlands lost during development. Developed land use does not include farmsteads, which were classified as agricultural land use for the 2020 Land Use data.

Table 2.3 2005 land use in the South Fork Crow River Watershed Direct Watersheds.

2005 Land use	Eagle Lake		Oak Lake		Swede Lake		Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	819	56%	457	38%	239	30%	1,515	44%
Developed	46	3%	96	8%	29	4%	172	5%
Forest/Grassland	251	17%	230	19%	73	9%	554	16%
Wetland	165	11%	67	6%	8	1%	240	7%
Water	181	12%	352	29%	447	56%	980	28%
Total	**1,463**	**100%**	**1,202**	**100%**	**796**	**100%**	**3,462**	**100%**

Table 2.4 2020 South Fork Crow River Watershed Lakes Land Use.

2020 Land use	Eagle Lake		Oak Lake		Swede Lake		Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	875	60%	487	41%	239	30%	1,601	46%
Developed	46	3%	77	6%	30	4%	153	4%
Forest/Grassland	196	13%	222	18%	73	9%	491	14%
Wetland	165	11%	64	5%	8	1%	237	7%
Water	181	12%	352	29%	447	56%	980	28%
Total	**1,463**	**100%**	**1,202**	**100%**	**796**	**100%**	**3,462**	**100%**

2.2.1 Eagle Lake

Current land use in the watershed is primarily tilled agriculture (Figure 2.5). Based on future land use (2020), it does not appear that land uses within the direct watershed will change (Table 2.3 and Table 2.4). A regional park (Baylor Regional Park) is located on the northwest side of the lake and includes 201 acres of the lake watershed. There are approximately 27 homes in the watershed. Four feedlots exist in the watershed containing approximately 546 animal units, according to the 2000 feedlot inventory data. No confined animal feeding operations (CAFOs) operate within the Eagle Lake direct watershed.

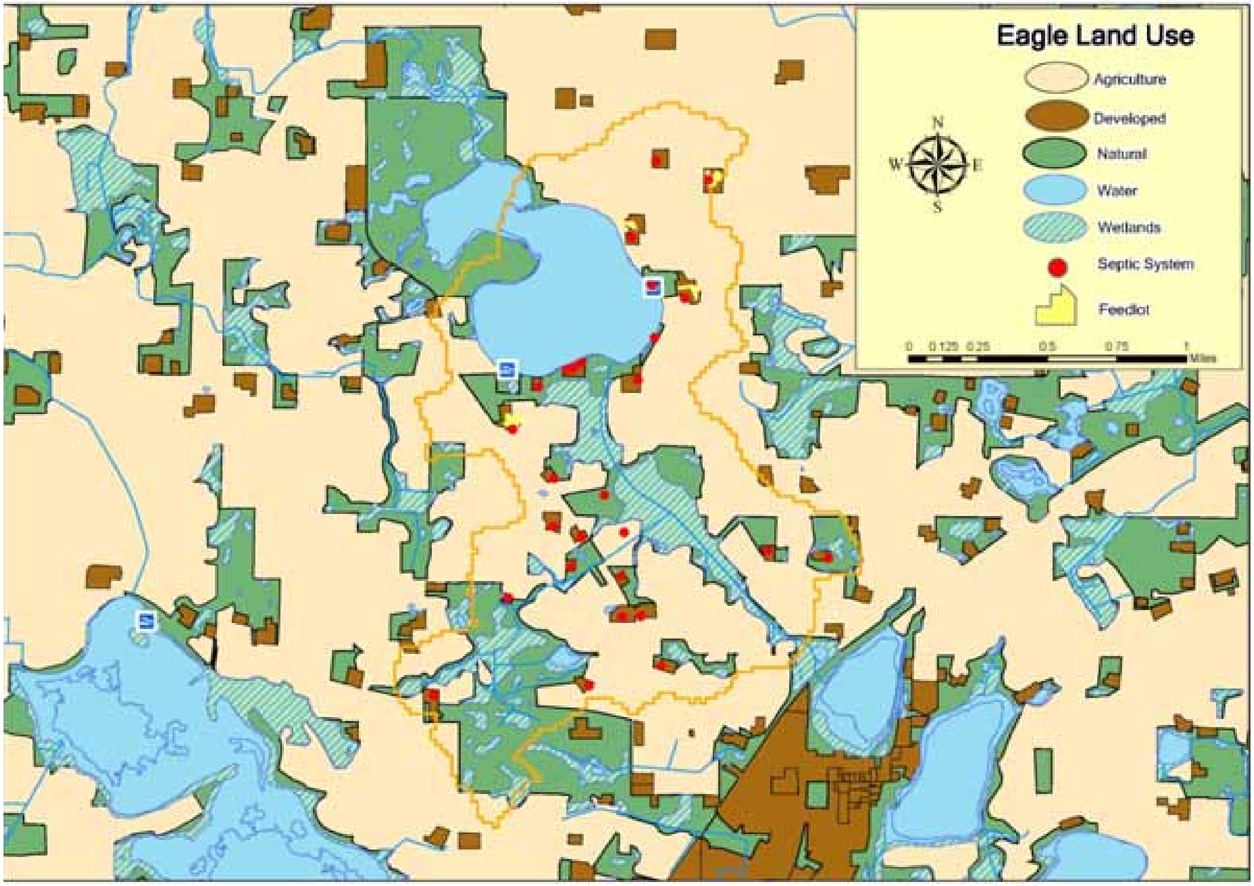


Figure 2.5 Eagle Lake watershed land use.

2.2.2 Oak Lake

Excluding the lake, land use in the direct watershed is predominately agriculture (55%), (Table 2.3 and Table 2.4). According to GIS analysis, there are currently 50 homes in the subwatershed. Two feedlots exist in the watershed with approximately 159 animal units, according to the 2000 feedlot inventory data. No CAFOs operate within the Oak Lake direct watershed. A regional trail runs east – west along the northern shores of the lake (Figure 2.6).

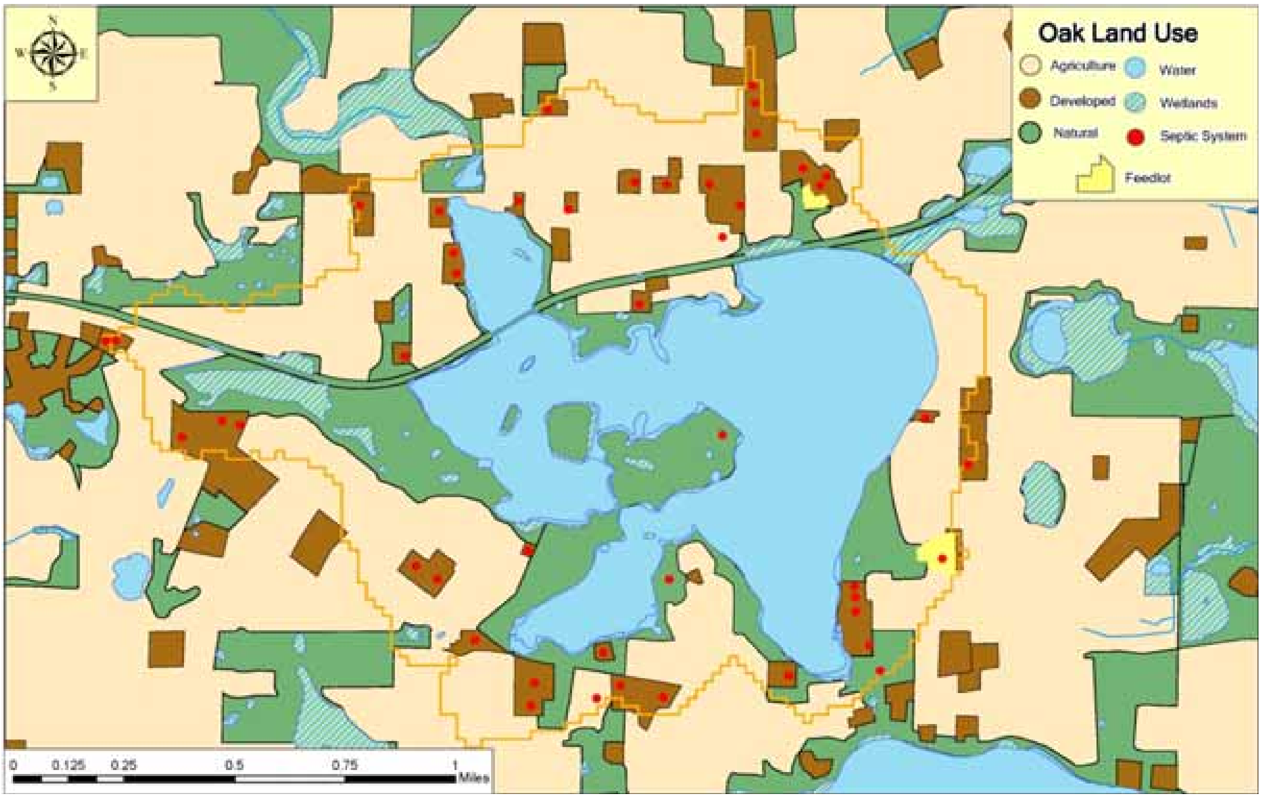


Figure 2.6 Oak Lake watershed land use.

2.2.3 Swede Lake

The watershed surrounding Swede Lake is currently and has historically been predominantly agricultural (Figure 2.7). Excluding the lake, agricultural land compromises over 65 percent of land use and land use within the watershed is not expected to change according to 2030 projections. There are currently 15 homes in the direct watershed all with on-site septic systems. According to Carver County feedlot inventories, there is one feedlot with approximately 23 animal units, according to the 2000 feedlot inventory data. No CAFOs operate within the Swede Lake direct watershed.

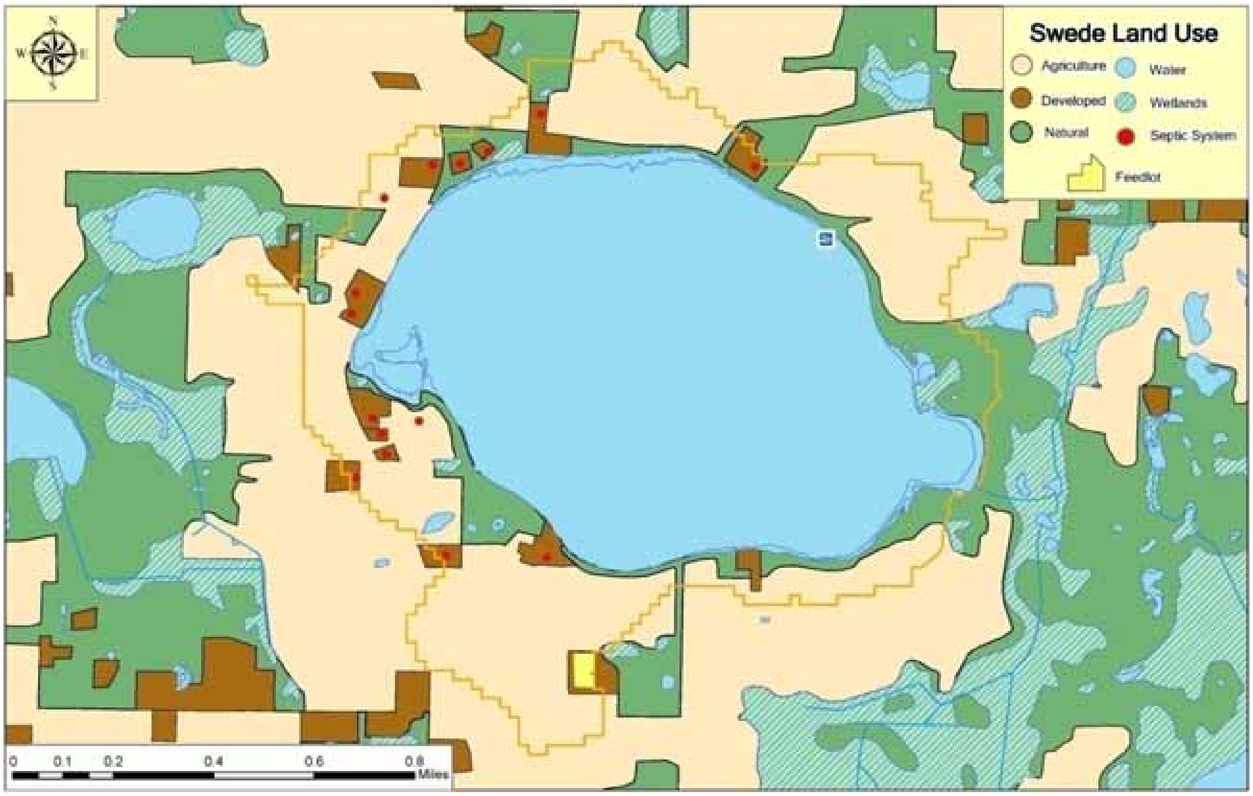


Figure 2.7 Swede Lake watershed land use.

2.3 Fish Population

A general understanding of a lake's fishery is useful as it can have a significant influence on water quality. Diversity of fish species is greatest within Swede Lake, which has thirteen species identified within previous fish surveys (Table 2.5). Carp has been reported in Oak and Swede Lakes, a rough fish that can tolerate poorer water quality. Both abundance and biomass estimates from fish surveys in Swede Lake show that carp has been increasing over the years, as well as another rough fish, black bullhead. Oak Lake has seen a decrease in the population and biomass of the common carp.

All lakes have evidence of past fish kills within the lake, mainly winterkills. Fish kills occur when dissolved oxygen (DO) levels are so low that fish begin to die from the lack of oxygen. Fish kills commonly occur during the summer or winter. Summer kills are the result of high productivity of algae and macrophytes that eventually die back and are subsequently broken down by bacteria. The breakdown by bacteria demands oxygen, which depletes it from the water column. These conditions can result in a summer fish kill. Winter fish kills are the result of snow-covered ice that shades out photosynthesis under the ice. These conditions, coupled with a high sediment oxygen demand can deplete the DO under the ice and result in a fish kill. Sediment oxygen demand is defined as the biological, biochemical, and chemical processes that occur at the sediment-water juncture that uses oxygen. More detailed summaries are available from the county upon request.

Table 2.5 Fish species present within South Fork Crow River Lakes (1995 – 2006)

	Eagle	Oak	Swede
Black Bullhead	X	X	X
Black Crappie	X	X	X
Bluegill	X	X	X
Brown Bullhead	X	X	
Common Carp		X	X
Golden Shiner			X
Green Sunfish	X		X
Hybrid Sunfish	X	X	X
Largemouth Bass	X	X	X
Northern Pike	X	X	
Pumpkinseed Sunfish	X	X	X
Smallmouth Bass			X
Tiger Muskellunge	X		
Walleye	X	X	X
White Crappie		X	
White Sucker			X
Yellow Perch	X		X

2.4 Aquatic Plants

Native aquatic plants benefit lake ecosystems providing spawning and cover for fish, habitat for macroinvertebrates, refuge for prey, and stabilization of sediments. Broadleaf plants present in the lake provide cover for fish, food for waterfowl, and support invertebrates and other small animals that both waterfowl and fish eat. In addition to the mentioned benefits, studies have shown that both emergent and submersed aquatic plants reduce the wind mixing activity that promotes sediment re-suspension in shallow lakes (James, W.F and J.W. Barko, 1994). However, in excess they limit recreation activities such as boating and swimming as well as aesthetic appreciation.

Excess nutrients in lakes can create an environment primed for the takeover by aquatic weeds and exotic plants. Some exotics can lead to special problems in lakes. For example, Eurasian watermilfoil can reduce plant biodiversity in a lake because it grows in great densities and squeezes other plants out. Ultimately, this can lead to a shift in the fish community because these high plant densities favor panfish over larger game fish. Species such as curlyleaf pondweed can cause very specific problems by changing the dynamics of internal phosphorus loading. All in all, there is a delicate balance in the aquatic plant community in any lake ecosystem.

Carver County staff conducted simplified macrophyte surveys of Eagle Lake during the 2004 monitoring season and Oak and Swede Lakes during the 2006 monitoring season. These surveys were conducted once in the spring and once in the fall. Curlyleaf pondweed was found to be in all lakes sampled and Eurasian watermilfoil was found in

Eagle Lake. Aquatic plant diversity was low in all lakes sampled. More detailed aquatic sampling reports are available from the county.

2.5 Shoreline Habitat and Conditions

Naturally vegetated shorelines with abundant amounts of vegetation provide numerous benefits to both lakeshore owners and users. The shoreline areas as defined in this report are areas adjacent to the lake's edge with hydrophytic vegetation and water up to 1.5 feet deep or a water table within 1.5 feet from the surface. Water quality is often improved, plant and animal biodiversity increases, they provide habitat for aquatic and terrestrial species, shorelines are more stable and erosion is decreased, there is a significant reduction in required maintenance, and an increase in aesthetic value. Therefore, identifying projects where natural shoreline habits can be restored or protected will enhance the overall lake ecosystem.

Carver County staff conducted a shoreline survey in June 2005 utilizing aerial images, ArcMap software and general knowledge of each lake. Staff recorded shoreline type such as natural vegetation, sand beach, turf grass to shoreline, pasture, and/or retaining wall (Table 2.6 and Table 2.7). Results from this survey indicate varying land uses along each lake's shoreline. Oak Lake had the highest percentage of 'natural vegetation' at 63 percent. Eagle Lake had the highest percentage of 'lawn' shoreline at 30 percent, and Swede Lake had the highest classified amount of 'agriculture' at 39 percent. More detailed shoreline habitat reports are available from the county.

Table 2.6 Linear length of shoreline habitats around Eagle, Oak, and Swede Lakes.

Lake	Miles of Shoreline						Total
	Natural Vegetation	Agriculture	Lawn	Sand	Wood	Road	
Eagle Lake	0.32	0.68	0.73	0.08	0.44	0.16	2.41
Oak Lake	4.54	1.38	0.58			0.69	7.19
Swede Lake	0.66	1.30	0.32		0.67	0.42	3.37
Total	5.53	3.36	1.63	0.08	1.11	1.27	12.97

Table 2.7 Percentage of shoreline habitats around Eagle, Oak, and Swede Lakes.

Lake	Shoreline %						Total
	Natural Vegetation	Agriculture	Lawn	Sand	Wood	Road	
Eagle Lake	13.38%	28.32%	30.29%	3.38%	18.10%	6.53%	18.56%
Oak Lake	63.16%	19.19%	8.03%			9.62%	55.43%
Swede Lake	19.65%	38.57%	9.49%		19.93%	12.35%	26.01%
Total	42.60%	25.93%	12.54%	0.63%	8.54%	9.75%	100.00%

3 Assessment of Water Quality Data

3.1 Data Sources

3.1.1 Carver County Environmental Services

Carver County and its Water Plan act to coordinate monitoring of county lakes and streams. Monitoring of lakes follows the Water Plan management goal of creating and maintaining a comprehensive, accurate assessment of surface and ground water quality trends over the long term. In order to establish baseline water quality, Carver County set up a network of sampling sites in the 1990s. In accordance with the County Water Plan, watersheds were given a priority (high, medium, low) based on funding available, need for monitoring data, current water quality conditions, current land use, and staff availability. In addition, Carver County promotes volunteer monitoring efforts in an attempt to broaden the public's awareness and expand our monitoring network.

Carver County follows the monitoring techniques set up by the Metropolitan Council Environmental Services (MCES) for the Citizens Assisted Monitoring Program (CAMP) program. This program includes bi-weekly in-lake samples that are analyzed for TP, chlorophyll-a, and total Kjeldahl nitrogen. Additionally, Secchi depth measurements are taken and user perception surveys are filled out during each monitoring event. Monitoring takes place from April to October each year.

3.1.2 Metropolitan Council Environmental Services

South Fork Crow River Lakes are also periodically monitored by the volunteer program CAMP, which is operated by the MCES. Citizen volunteers collect a water sample to be submitted to the MCES for analysis of total phosphorus, total Kjeldahl nitrogen, and chlorophyll-a. Also collected is a Secchi disk reading and general user perceptions of the lake. Each lake is sampled bi-weekly from April to October for a total of 14 samples. Additionally, MCES monitors Twin Cities' Metropolitan Area (TCMA) lakes to provide a comprehensive database that allows cities, counties, and watershed management organizations to better manage these lakes.

3.1.3 Minnesota Pollution Control Agency

Eagle Lake has periodically been monitored by the MPCA Citizen Lake Monitoring Program (CLMP). The CLMP is similar to the Metropolitan Council's CAMP program as it employs the help of citizen volunteers who live on or near the lake to take measurements. The CLMP program has been in existence since 1973. All records and observations are sent to the MPCA and entered into the U.S. Environmental Protection Agency's STORET program.

3.2 Phosphorus, Chlorophyll-a, and Secchi Depth

3.2.1 Eagle Lake

Monitoring conducted over the past ten years has depicted in-lake conditions which are highly eutrophic to hypereutrophic. TP has remained approximately five times the NCHF ecoregion shallow lake standard (average 318 µg/L vs. 60 µg/L) (Table 3.1). In fact, a study conducted by Dick Osgood in 1995 on Eagle Lake indicated that the lake has historically experienced intense blooms of nuisance blue-green algae which have inhibited recreation (1995). In addition, he wrote that the majority of nutrients were coming from internal loading during the growing season. Internal phosphorus loading is the result of anoxic sediments, wind mixing, macrophyte senescence, rough fish, and/or recreation.

Table 3.1 Growing season (June 1 –September 30) mean lake water quality for Eagle Lake and number of samples taken (data obtained from the MPCA website). N is the number of samples.

Year	Total Phosphorus Concentration (µg/L) (n)	Chlorophyll-a Concentration (µg/L) (n)	Secchi disk transparency (meters) (n)	Total Kjeldahl Nitrogen (mg/L) (n)
2005	192 (10)	54 (10)	0.96 (10)	1.57 (10)
2004	211 (10)	49 (10)	0.83 (11)	2.21 (10)
2003	223 (10)	64 (10)	0.62 (10)	2.33 (10)
2002	281 (10)	56 (10)	0.53 (10)	2.60 (10)
2001	354 (10)	88 (10)	0.91 (10)	3.01 (10)
2000	350 (10)	39 (10)	1.56 (11)	1.60 (10)
1999	322 (9)	35 (9)	1.97 (10)	1.84 (9)

Figure 3.1 and 3.2 show nutrient variation during the monitored period and typical within-year TP response to precipitation that Eagle Lake experiences. Increases in TP concentrations along with decreased in Secchi depths can be distinguished in mid-June to early August and then again in mid to late September. Both pulses were compared to daily precipitation to identify potential runoff events that may have caused the two rises in TP. The initial rise in phosphorus was gradual over the growing season and can be attributed to the senescence of curlyleaf pondweed and internal loading. Gradual rises in phosphorus are typical of shallow lakes. Research states that because inflow is naturally low during this period the increase in phosphorus can be attributed to internal loading (Welch & Cooke 1995). The latter rise in TP can be attributed to runoff from surrounding land following an unusually large precipitation event. Because there was little ground cover left on the fields at this time, the large amount of rain likely spurred runoff into the lake. Data from previous years also show a gradual increase of phosphorus during the growing season indicating that internal loading and curlyleaf pondweed are the major drivers in water quality.

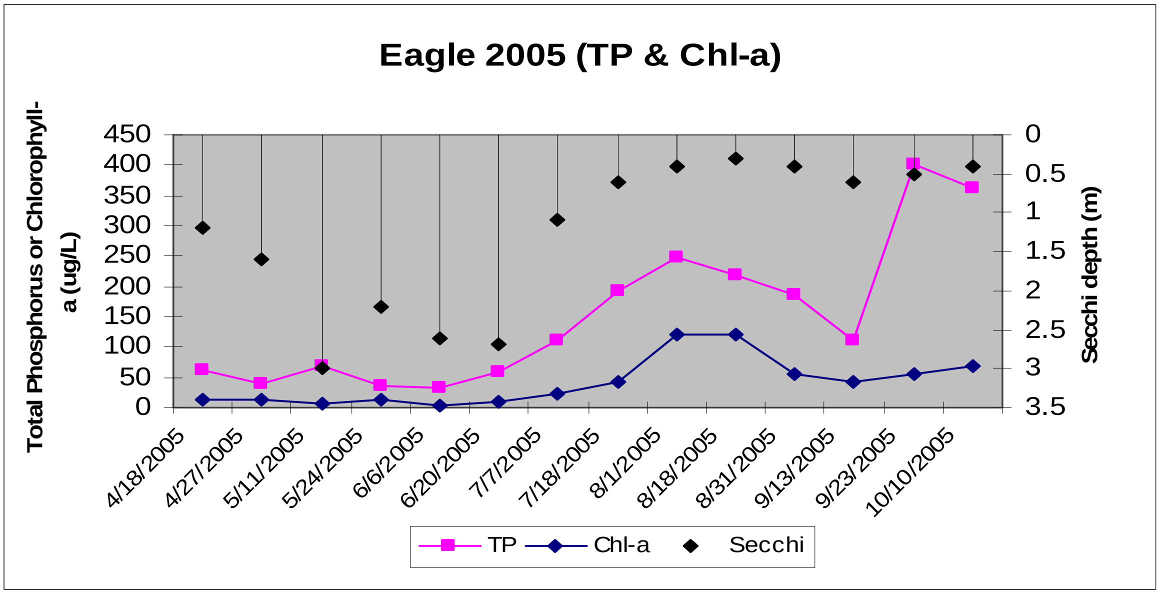


Figure 3.1 Eagle Lake total phosphorus, chlorophyll-a, and Secchi depth for the summer 2005 growing season.

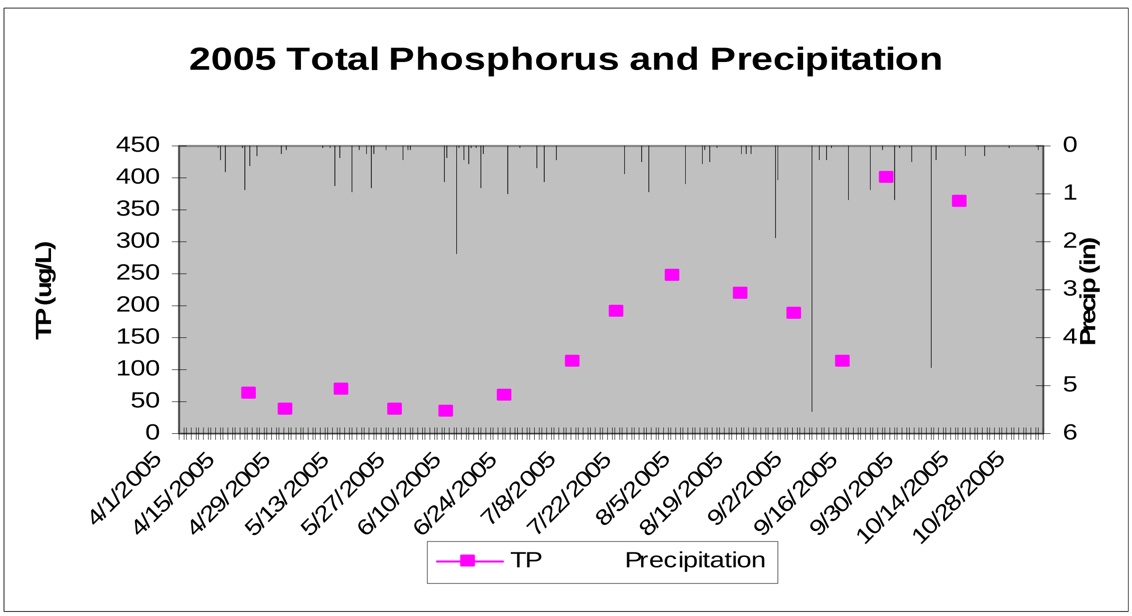


Figure 3.2 Eagle Lake total phosphorus and daily precipitation during the 2005 summer growing season.

Clearer detection of between-year changes in TP can be visualized in Figure 3.3, which indicates that internal loading may be influencing water quality. For example, above average rainfall occurred in 2002 and 2004, while TP decreased slightly from the previous year. In 2000 when the rainfall was below average, TP levels increased. Typically, when external loading is dominating loading, phosphorus concentrations will increase with rainfall. In contrast, when internal loading is dominating, phosphorus concentrations and rainfall show an inverse relationship.

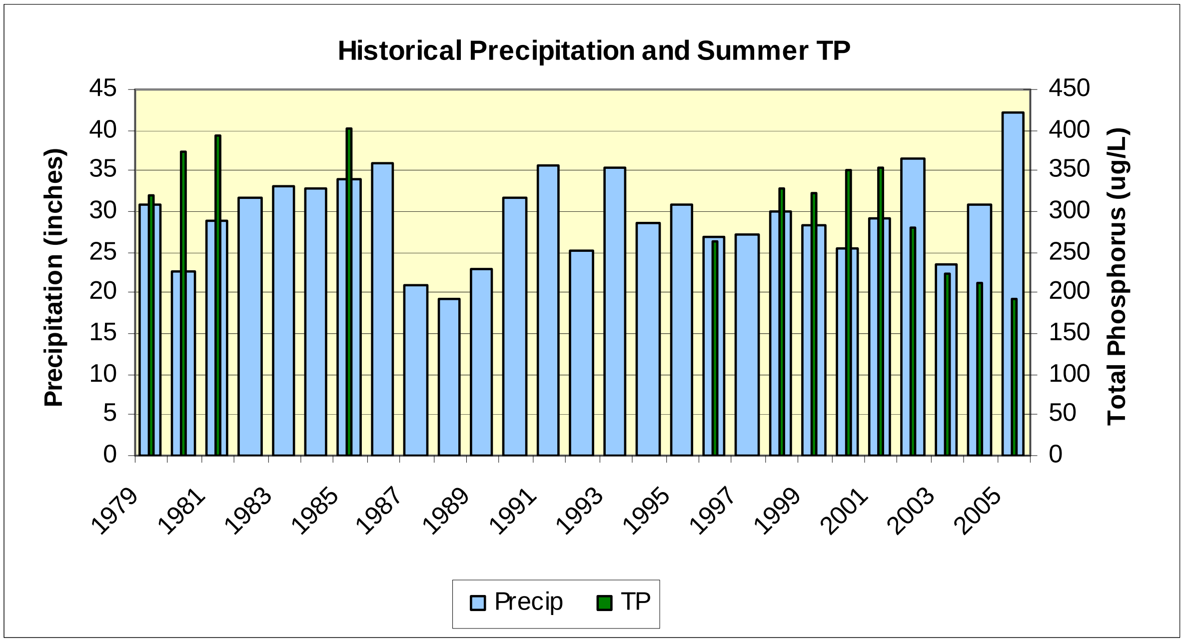


Figure 3.3 Growing season (June 1 –September 30) mean total phosphorus and annual precipitation for Eagle Lake. The small green bars are total phosphorus.

3.2.2 Oak Lake

Water quality conditions in recent years have a degrading trend, with recent total phosphorus concentrations over three times the NCHF ecoregion shallow lake standard (203 µg/L vs. 60 µg/L). Table 3.2 outlines the water quality parameters tested from 2006 to 2001 and the summer mean results. TP concentrations have increased from 88 µg/L to 205 µg/L within seven monitoring seasons. Both chlorophyll-a and total Kjeldahl nitrogen concentrations had similar increases (39 µg/L to 74 µg/L for chlorophyll-a and 1.778 mg/L to 2.633 mg/L for total Kjeldahl nitrogen). Transparency had a decrease in readings, also pointing to decreasing water quality.

Table 3.2 Growing season (June 1 –September 30) mean lake water quality for Oak Lake. N is the number of samples collected each season.

Year	Total Phosphorus Concentration (µg/L) (n)	Chlorophyll-a Concentration (µg/L) (n)	Secchi disk transparency (meters) (n)	Total Kjeldahl Nitrogen (mg/L) (n)
2006	203 (9)	74 (9)	0.8 (18)	2.633 (9)
2005	131 (9)	65 (9)	1.1 (22)	2.192 (9)
2004	112 (8)	59 (8)	1.0 (20)	1.731 (8)
2003	191 (7)	41 (7)	1.1 (13)	1.750 (7)
2002	111 (8)	44 (8)	0.7 (21)	1.666 (8)
2001	88 (9)	39 (4)	1.6 (19)	1.778 (9)

Figures 3.4 and 3.5 show both the interaction of phosphorus, chlorophyll-a and Secchi disk, as well as precipitation and phosphorus levels. Clearer detection of between-year changes in TP can be visualized in Figure 3.6, which indicates that internal loading may be influencing water quality. For example, above average rainfall occurred in 2002 and 2004, while TP decreased slightly from the previous year. In 2003 when the rainfall was below average, TP levels increased. Typically, when external loading is dominating loading, phosphorus concentrations will increase with rainfall. In contrast, when internal loading is dominating, phosphorus concentrations and rainfall show an inverse relationship.

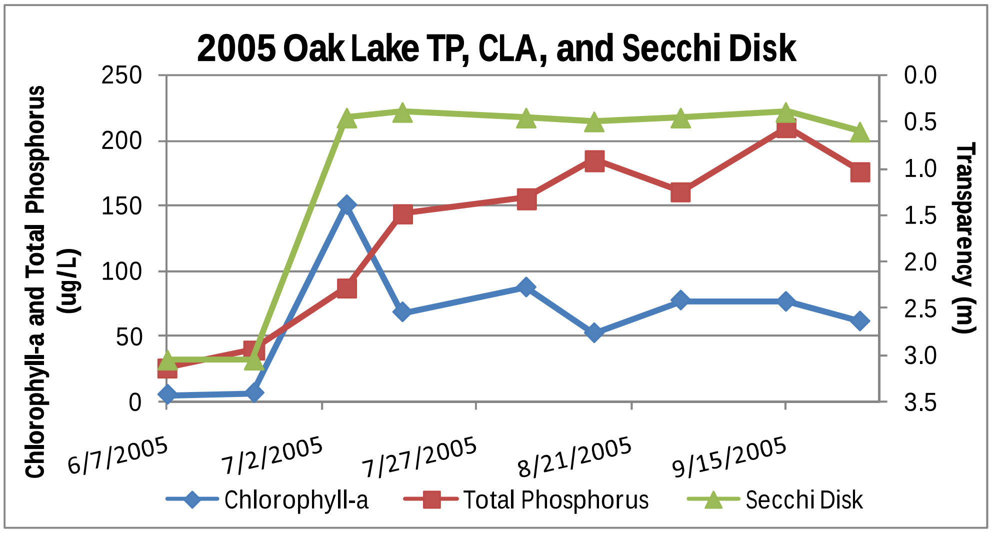


Figure 3.4 Oak Lake total phosphorus, chlorophyll-a, and Secchi disk readings for 2005 summer growing season.

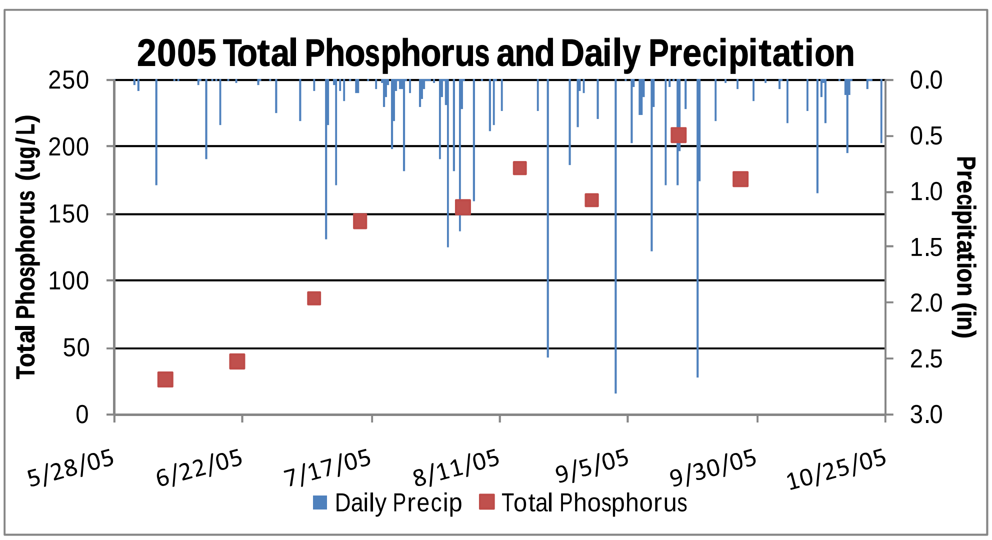


Figure 3.5 2005 total phosphorus and daily precipitation for Oak Lake.

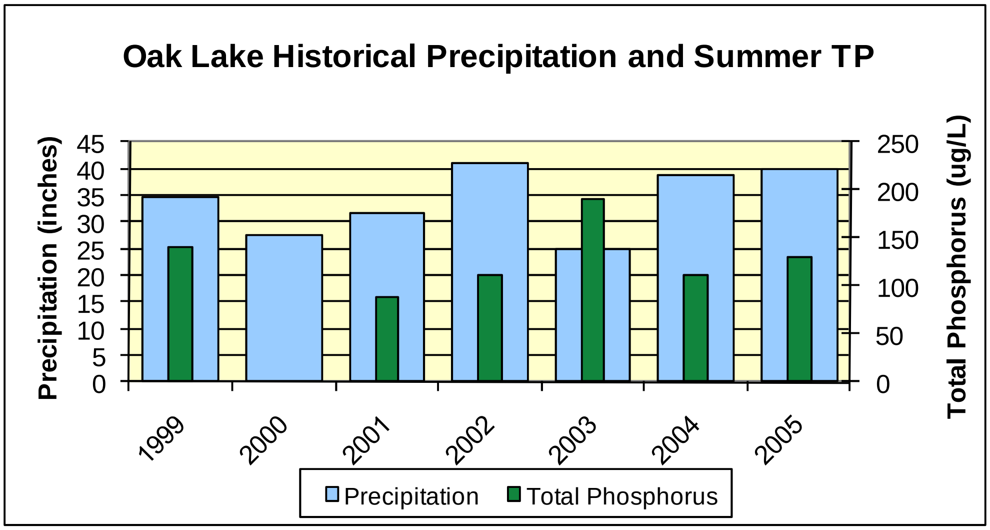


Figure 3.6 Growing season (June 1 –September 30) mean total phosphorus and annual precipitation for Oak Lake. The small green bars are total phosphorus.

3.2.3 Swede Lake

Current monitoring has depicted in-lake conditions that are highly eutrophic to hypereutrophic. Average growing season TP over the last ten years has averaged over five times higher than the NCHF Shallow Lake Standard (60 µg/L). Table 3.3 outlines the water quality parameters tested from 2005 to 1996 and the summer mean results. TP concentrations have increased from 141 µg/L to 294 µg/L within ten monitoring seasons.

Table 3.3 Growing season (June 1 –September 30) mean lake water quality for Swede Lake. N is the number of samples collected each season.

Year	Total Phosphorus Concentration (µg/L)(n)	Chlorophyll-a Concentration (µg/L)(n)	Secchi disk transparency (meters)(n)	Total Kjeldahl Nitrogen (mg/L)(n)
2005	294 (8)	75 (8)	0.7 (17)	4.050 (8)
2004	236 (7)	65 (7)	0.5 (16)	2.914 (7)
2003	312 (11)	132 (11)	0.6 (21)	2.500 (11)
2002	224 (9)	31 (9)	1.1 (12)	2.141 (9)
2001	203 (6)	97 (3)	0.7 (21)	2.750 (6)
1996	141 (7)	--	0.5 (19)	2.014 (8)

Figure 3.7 and 3.8 show typical nutrient variation and within-year TP response to precipitation that Swede Lake experiences. TP concentrations show some response to precipitation but typically increase throughout the growing season. Such responses are typical of shallow lakes because inflow is naturally low during this period, and increases can be attributed to internal loading (Welch & Cooke 1995). Chlorophyll-a concentrations are high and respond to fluctuations in changes in TP, as do Secchi depths. Finally, over the last ten years, total Kjeldahl nitrogen has remained above 2,000 µg/L, or the threshold at which marks a negative response in water quality (MPCA 2005).

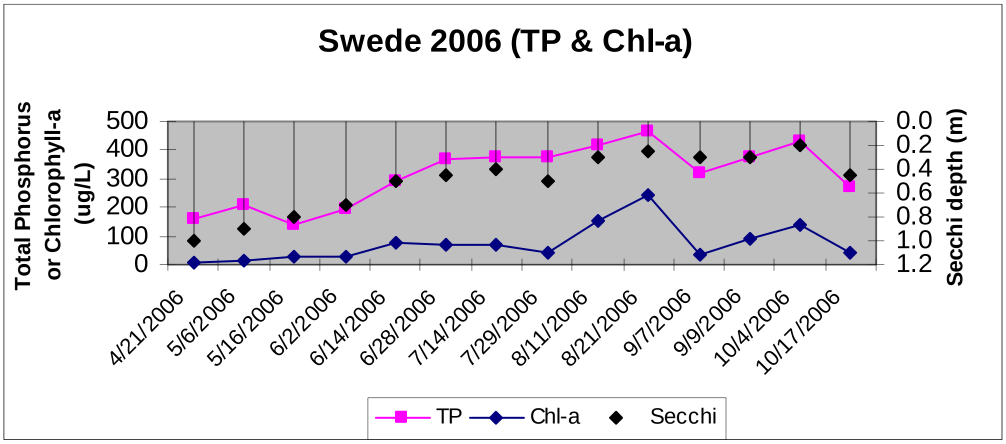
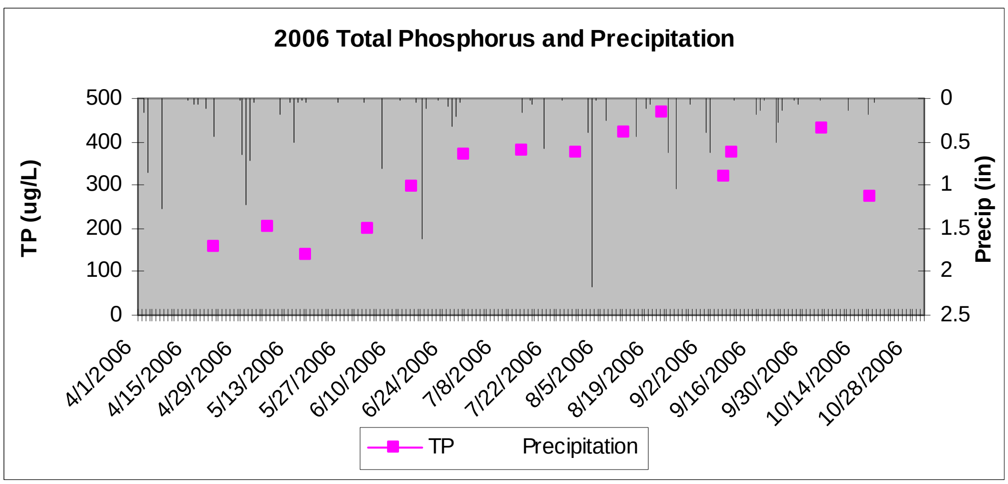


Figure 3.7 Swede Lake total phosphorus, chlorophyll-a, and Secchi depth for the summer of 2006 growing season.



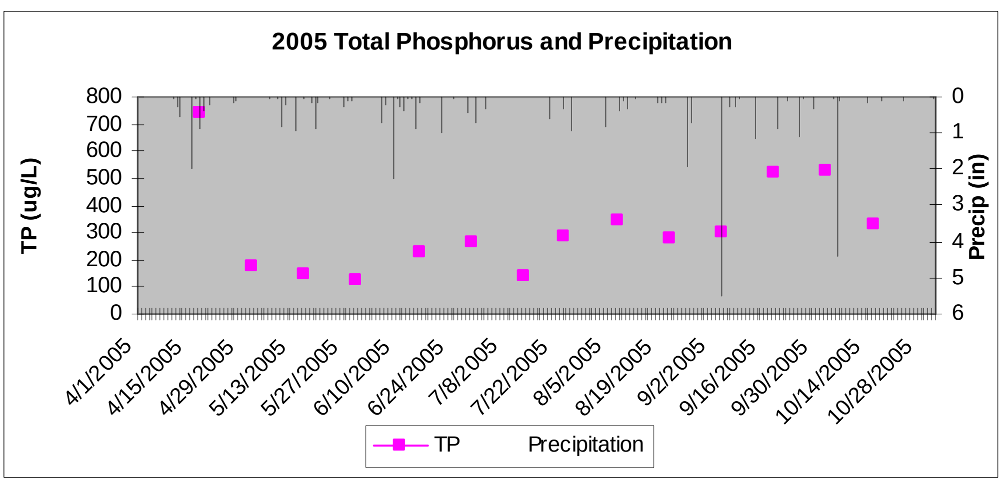


Figure 3.8 Swede Lake total phosphorus and daily precipitation during the 2005 and 2006 summer growing season.

Due to the small watershed size of the lake, internal loading plays a factor in nutrient loading to the lake. Indications that internal loading is playing a role in year-to-year changes in TP can be visualized in Figure 3.9. Note that years of below average precipitation (29 inches) yield TP increases.

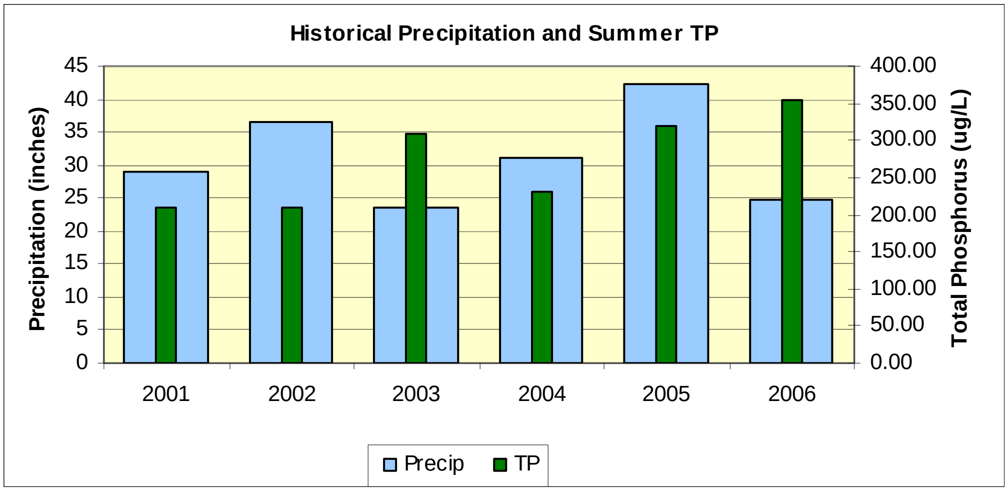


Figure 3.9 Swede Lake in lake total phosphorus and annual precipitation. The small green bars are total phosphorus.

4 Phosphorus Source Assessment

4.1 Introduction

Understanding the sources of nutrients to a lake is a key component in developing a TMDL for lake nutrients. This section provides a brief description of the potential sources of phosphorus to the lakes.

4.2 Point Sources

The South Fork Crow River Lakes currently do not have any point or National Pollutant Discharge Elimination System (NPDES) permitted sources discharging to either ditches, streams, or individual lakes at this time.

4.3 Nonpoint Sources

4.3.1 Internal Phosphorus Release

Internal phosphorus loading has been demonstrated to be an important aspect of the phosphorus budgets of lakes, especially when lakes are shallow and well-mixed. However, measuring or estimating internal loads can be difficult, especially in shallow lakes that may mix many times throughout the year. Various factors that contribute to the recycling of internal phosphorus include: die-off of curlyleaf pondweed which releases phosphorus during the early summer growing season (late June to early July), frequent wind mixing that entrains P-rich sediments back into the water column, bioturbation from benthivorous fish such as carp and bullhead, increased temperatures that promote bacterial decomposition, and internal phosphorus release when sediment anoxia releases poorly bound phosphorus in a form readily available for phytoplankton production (MPCA 2006).

4.3.2 Urban/Development Runoff

The development of stormwater sewer systems has increased the speed and efficiency of transporting urban runoff to local waterbodies. This runoff carries materials like grass clippings, fertilizers, leaves, car wash wastewater, soil, oil and grease and animal waste; all of which contain phosphorous. These materials may add to increased internal loads through the breakdown of organics and subsequent release from the sediments. The addition of organic material into the lakes increases the sediment oxygen demand, further exacerbating the duration and intensity of sediment phosphorus release from lake sediments.

4.3.3 Agricultural Runoff

Agricultural runoff can supply a significant phosphorus load to surface waters by transporting eroded soil particles and excess fertilizers.

Nutrients such as phosphorus, nitrogen, and potassium in the form of fertilizers, manure, sludge, irrigation water, legumes, and crop residues are applied to enhance production. When they are applied in excess of plant needs, nutrients can wash into aquatic ecosystems where they can promote excessive plant growth and kill fish.

Animal agriculture can affect water quality, especially nutrients. Animal manure, which contains large amounts of both phosphorus and nitrogen, is often applied to agricultural fields as fertilizer. A regional Minnesota study suggests that the applied manure represents a 74 percent greater amount of phosphorus than the University of Minnesota recommended amounts (Mulla et al. 2001). This can average an extra 35 pounds per acre of phosphorus, which will ultimately be available for runoff. It is believed, however, that in more recent years more efficient use of manure is being achieved in Minnesota due to both economic and environmental concerns (Minnesota Corn Growers Association, Devonna Zeug, pers. comm., 2010). In addition, properly applied manure can improve soil's ability to infiltrate water, thus reducing the potential for runoff (MPCA, 2005). Additionally, runoff from some feedlots can transport animal manure to surface waters.

4.3.4 Septic Systems

Failing or nonconforming direct discharge SSTS can be a significant source of phosphorus to surface waters. Septic systems, also called onsite wastewater disposal systems, can act as sources of nitrogen, phosphorus, organic matter, and bacterial and viral pathogens for reasons related to inadequate design, inappropriate installation, neglectful operation, and/or exhausted lifetime. Inappropriate installation often involves improper sighting, including locating in areas with inadequate separation distances to groundwater, inadequate absorption area, fractured bedrock, sandy soils (especially in coastal areas), inadequate soil permeability, or other conditions that prevent or do not allow adequate treatment of wastewater if not accounted for. Inappropriate installation can also include smearing of trench bottoms during construction, compaction of the soil bed by heavy equipment, and improperly performed percolation tests (Gordon, 1989; USEPA, 1993). In terms of system operation, as many as 75 percent of all system failures have been attributed to hydraulic overloading (Jarrett et al., 1985). Also, regular inspection and maintenance is necessary and often does not occur. Finally, conventional septic systems are designed to operate over a specified period of time. At the end of the expected life span, replacement is generally necessary. Homeowners may be unaware of this issue or unable to afford a replacement. Based on Carver County survey data, approximately 45 to 65 percent of the systems in the county are likely failing (Carver County 2005).

4.3.5 Atmospheric Deposition

Precipitation contains phosphorus that can ultimately end up in the lakes as a result of direct input on the lake surface or as a part of stormwater runoff from the watershed. Although atmospheric inputs must be accounted for in development of a nutrient budget, direct inputs to the lake surface are very difficult if not impossible to control and are consequently considered part of the background load.

4.3.6 Wetlands

Wetlands have the ability to remove pollutants from runoff passing through the wetland or riparian area by slowing the water and allowing sediments to settle out, acting as a sink for phosphorus, and converting nitrate to nitrogen gas through denitrification (EPA Web). However, wetlands can become contaminated with agricultural and/or urban runoff, thus becoming another source of excess phosphorus that may end up in the lake when large rain events flush through the wetland system resuspending nutrients and sediments. No data has been collected regarding the phosphorus concentrations in the wetlands of South Fork Crow River watershed.

5 Linking Water Quality Targets and Sources

5.1 Modeling Introduction

A detailed nutrient budget can be a useful tool for identifying management options and their potential effects on water quality. Additionally, lake response models can be developed to understand how different lake variables respond to changes in nutrient loads. With this information, managers can make educated decisions about how to allocate restoration dollars and efforts, as well as predict the resultant effect of such efforts.

5.2 Selection of Models and Tools

Modeling was completed in order to translate the target in-lake phosphorus concentration into allocations, loading responses and final goal reductions of phosphorus loading from the watershed and within the lake. The models used throughout the process included BATHTUB, a Reckhow-Simpson spreadsheet and a Canfield-Bachmann spreadsheet.

The Reckhow-Simpson Model was used for estimating watershed loads for unmonitored subwatersheds. This model relies on phosphorus export coefficients and land uses to estimate phosphorus loading. Development of export coefficients is described in section 5.2.1. Unmonitored watershed phosphorus loads and source allocations were estimated utilizing this model. In addition, the model allowed us to estimate the relative phosphorus contribution of each land-use category with in the watershed.

For this TMDL, the BATHTUB model was selected to link phosphorus loads with in-lake water quality. A publicly available model, BATHTUB was developed by William W. Walker for the U.S. Army Corps of Engineers (Walker 1999). BATHTUB has been used successfully in many lake studies in Minnesota and throughout the United States. BATHTUB is a steady-state annual or seasonal model that predicts a lake's summer (June – September) mean surface water quality. BATHTUB's time-scales are appropriate because watershed P loads are determined on an annual or seasonal basis, and the summer season is critical for lake use and ecological health. BATHTUB has built-in statistical calculations that account for data variability and provide a means for estimating confidence in model predictions. The heart of BATHTUB is a mass-balance P model that accounts for water and P inputs from tributaries, watershed runoff, the atmosphere, sources internal to the lake, and (if appropriate) groundwater; and outputs through the lake outlet, groundwater (if appropriate), water loss via evaporation, and P sedimentation and retention in the lake sediments. BATHTUB allows choice among several different mass-balance P models. Canfield and Bachmann (1981) developed a series of calculations that estimated in-lake total phosphorus concentrations, which is a model choice within BATHTUB. BATHTUB's in-lake water quality predictions include two response variables, chlorophyll-a concentration and Secchi depth, in addition to TP concentration. Empirical relationships between in-lake TP, chlorophyll-a, and Secchi depth form the basis for predicting the two response variables. Among the key empirical model parameters is the ratio of the inverse of Secchi depth (the inverse being proportional to the light extinction coefficient) to the chlorophyll-a concentration. The ratio's default value in the model is 0.025 meters squared per milligram (m^2/mg); however, the experience of Minnesota Pollution Control Agency staff supports a lower value, as low as 0.015 m^2/mg, as typical of Minnesota lakes in general.

BATHTUB was used to estimate nutrient inflows from each of the major subwatersheds within the entire South Fork Crow Lake watershed area. For South Fork Crow Lakes, monitored lake and subwatershed data was used to calibrate models. Unmonitored subwatershed loads estimated via the Reckhow-Simpson Model were input into BATHTUB. After running the BATHTUB model for two years for validation, a phosphorus budget was developed for current conditions. The final BATHTUB model allowed us to estimate the relative contributions of each subwatershed and within the lake. Thus, the development of a benchmark budget allows managers to begin to assess the sources of nutrient loads and target areas for load reductions.

Several models (subroutines) are available for use within the BATHTUB model. The selection of the subroutines is based on past experience in modeling lakes in Minnesota, and is focused on subroutines that were developed based on data from natural lakes. Table 5.1 depicts the model subroutines that were chosen for all lakes modeled within this TMDL. Selection of models is also dependant on data availability. For instance, you cannot reliably use models that require orthophosphorus data if you do not have that data. For more information on these model equations, see the BATHTUB model documentation (Walker 1999).

Table 5.1 BATHTUB model options.

Model Options	**Code**	**Description**
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	0	None
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

A Canfield-Bachmann algorithm was used to estimate the total annual phosphorus load necessary to achieve the current observed in-lake water quality and target goals, outside of BATHTUB. The Excel Spreadsheet with the Canfield-Bachmann algorithm uses an established relationship between in-lake TP concentrations, watershed load, atmospheric load, lake morphology, and sedimentation rates. The spreadsheet algorithm was calibrated utilizing observed water quality data and known waterbody parameters. This method was preferred within this study due to the minimal amount of data available to complete an accurate model of each waterbody. By using this Canfield-Bachmann equation, historic loads and load reductions were calculated for Eagle, Oak, and Swede Lakes.

5.3 Watershed Model Coefficients

The Reckhow-Simpson model estimates phosphorus loads for a watershed using land-use areas derived from available GIS data, along with runoff coefficients and phosphorus export values (loading rates per unit area) corresponding to the land use classes. These values were used when monitoring was not completed in specific subwatersheds.

5.3.1 Watershed Runoff

Watershed runoff was estimated using runoff coefficients that assumed average watershed slopes of less than 2% (Ward And Elliott 1995). Runoff coefficients used are presented in Table 5.2.

Table 5.2 Runoff coefficients used to estimate runoff from the South Fork Crow River Lake Watersheds.

Land Use	Watershed Runoff Coefficients		
	Eagle	Oak	Swede
Developed	0.22	0.22	0.22
Forest/Grassland	0.07	0.07	0.07
Water	0	0	0
Agriculture	0.25	0.23	0.22
Wetland	0	0	0

Runoff coefficients were developed by applying literature values to the entire Carver Creek watershed and then adjusting the values to better predict monitored annual runoff volumes. Although Eagle, Oak, and Swede Lakes are situated in the Crow River Watershed, Carver Creek runoff coefficients were utilized because of the completeness of data and similarity in land use structure. Actual watershed runoff was monitored at Carver Creek site CA 1.7 which is monitored continuously by the Watershed Outlet Monitoring Program (WOMP) by the MCES.

5.3.2 Watershed Phosphorus Export

To determine phosphorus export, both for concentrations and total loads, export coefficients were utilized and are outlined in Table 5.2. Calculated concentrations and loads are used within the BATHTUB model to represent subwatersheds that do not have actual monitored sample data. Land use areas and precipitation depths for each year were needed to calculate runoff phosphorus concentrations for each lake. Land use areas were based on GIS files provided by the Carver County GIS Department. Land use loading rates (Tables 5.3 to 5.5) were applied to the watershed land use to estimate watershed phosphorus loads. Phosphorus export coefficients based upon literature values that best represented conditions in the South Fork Crow Lakes watershed (EPA 1980). Runoff TP concentrations were computed from runoff depths calculated using runoff coefficients outline in Section 5.3.1and the resulting land use phosphorus loads derived from export values (Tables 5.3 to 5.5). When considering loading rates for the developed areas, it was assumed that no BMPs were in place within the watershed.

Table 5.3 Phosphorus loading rates for Eagle Lake used to predict direct watershed runoff concentrations.

	Total Phosphorus Loading Rate (kg/ha)			Total Phosphorus Concentration[1] (µg/L)		
Loading Rates (kg/ha)	Low	Average	High	Low	Average	High
Developed	0.3	0.4	0.6	153.6	245.8	368.7
Forest/Grassland	0.01	0.04	0.08	19.3	77.3	154.5
Agriculture	0.2	0.5	1.0	108.4	270.4	540.8
Wetland	0	0	0	0	0	0

[1]Based on estimated water volumes for an average precipitation year (29.11 inches).

Table 5.4 Phosphorus loading rates for Oak Lake used to predict direct watershed runoff concentrations.

	Total Phosphorus Loading Rate (kg/ha)			Total Phosphorus Concentration[1] (µg/L)		
Loading Rates (kg/ha)	Low	Average	High	Low	Average	High
Developed	0.3	0.4	0.6	153.6	245.8	368.7
Forest/Grassland	0.01	0.04	0.08	19.3	77.3	154.5
Agriculture	0.2	0.5	1.0	117.6	293.9	587.8
Wetland	0	0	0	0	0	0

[1]Based on estimated water volumes for an average precipitation year (29.11 inches).

Table 5.5 Phosphorus loading rates for Swede Lake used to predict direct watershed runoff concentrations.

	Total Phosphorus Loading Rate (kg/ha)			Total Phosphorus Concentration[1] (µg/L)		
Loading Rates (kg/ha)	Low	Average	High	Low	Average	High
Developed	0.3	0.4	0.6	153.6	245.8	368.7
Forest/Grassland	0.01	0.04	0.08	15.0	60.1	120.2
Agriculture	0.2	0.5	1.0	122.9	307.3	614.5
Wetland	0	0	0	0	0	0

[1]Based on estimated water volumes for an average precipitation year (29.11 inches).

5.3.3 Septic System Load

Septic system loads were estimated based on the following: number of septic systems in the watershed, 2.8 capita per residence, standard phosphorus loading rate, and phosphorus retention by the system and soils. The standard phosphorus load rate was assumed to be 1.5 kg/capita/year with a 70% retention coefficient. However, this calculation does not account for failing systems in the watershed. Based on County survey data, approximately 45 to 65 percent of the systems in the County are failing

(Carver County 2005). The failing systems would have lower phosphorus retention than 70 percent but would still retain a fair amount of phosphorus as it travels to surface waters. Since it is difficult to estimate the export rate for failing systems, it was assumed that the 70 percent retention reasonably represents the watershed with failing septic systems. However, we recognize that we may have slightly underestimated the load from septic systems.

5.3.4 Internal Load

Internal load terms were determined based on a residual process utilizing the BATHTUB model. After accounting for and entering land use and nutrient loads corresponding to the segment and tributaries using a 1.0 mg/m^2/day of internal loading, the model was run. Predicted and observed values were evaluated. At this point, if the in-lake predicted phosphorus values remained below that of the observed, additional internal loading was added until the predicted and observed nutrients were within 10 percent of each other. This process suggests that the internal load is the load remaining after all external sources have been accounted for.

5.3.5 Atmospheric Load

Atmospheric loading rates were set at a rate of 20 mg/m2/yr based on conversations with the MPCA and literature values (Bruce Wilson personal communication).

5.4 Phosphorus Budget Components

5.4.1 Eagle Lake

5.4.1.1 Internal Load

Using the process outlined in Section 5.3.4, final internal loading terms were determined to be 11 and 2.75 mg/m^2/day for 2000 and 2005, respectively.

5.4.1.2 Atmospheric Load

Using rates determined in Section 5.3.5, the atmospheric loading for Eagle Lake is set at 15 kg/yr.

5.4.1.3 Upstream Lakes

Braunworth Lake drains directly to Eagle Lake; consequently, water and nutrients flow out of Braunworth and into Eagle Lake. This exchange has been included in the BATHTUB modeling (Table 5.6). Only one sampling session was conducted on Braunworth Lake in 1999. As such, tributary input data was calculated using methods outlined in Section 5.3. Due to the limited data sets for Braunworth Lake there is uncertainty in the model. To improve the confidence of the models, additional monitoring may occur in the lake as part of the implementation of the TMDL.

Table 5.6 BATHTUB model inputs to Eagle Lake from Braunworth Lake.

Year	Lake	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)	Load (kg/yr)
2005	Braunworth	0.72	460	0.09	41
2000	Braunworth	0.72	763	0.06	46

5.4.1.4 Tributary and Watershed Load

Table 5.7 outlines the inputs used within the BATHTUB model for both the 2000 and 2005 modeled years. These values are calculated using methods as described in Section 5.3.

Table 5.7 BATHTUB model inputs for Eagle Lake

Year	Watershed	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)	Load (kg/yr)
2000	E1	3.45	354	0.39	138
2000	Direct	1.74	343	0.24	82
2005	E1	3.45	213	0.66	141
2005	Direct	1.74	207	0.40	83

5.4.1.5 Septic System Load

There are a total of 27 septic systems within the Eagle Lake Watershed. For BATHTUB modeling purposes, methods outlined in Section 5.3.3 were used to calculate loads within all subwatersheds. Table 5.8 outlines the septic system BATHTUB model inputs.

Table 5.8 Septic system BATHTUB model inputs for Eagle Lake.

	E1		Direct	
Component	**2000**	**2005**	**2000**	**2005**
Flow (hm^3/yr)	<0.1	<0.1	<0.1	<0.1
TP Concentration (µg/L)	151		227	
TP Load (kg/yr)	15.1	15.1	22.7	22.7

5.4.2 Oak Lake

5.4.2.1 Internal Load

Oak Lake posed a challenge for internal loading due to the multiple pools that the lake was divided into for the BATHTUB Model. Each pool had individualized internal loadings, tailored towards the observed physical and chemical data collected by Carver County Staff during both the 2005 and 2006 monitoring seasons. Using the process outlined in Section 5.3.4, final internal loading terms for the Upper Pool were determined to be 0 mg/m^2/day for both 2005 and 2006. Final internal loading terms for the Mid Pool were determined to be 2.35 and 4.5 mg/m^2/day for 2005 and 2006 respectively. Near Dam Pool final internal loading terms were determined to be 4.9 and 3 mg/m^2/day for 2005 and 2006 respectively.

5.4.2.2 Atmospheric Load

Using rates determined in Section 5.3.5, the atmospheric loading for Oak Lake is set at 31 kg/yr.

5.4.2.3 Tributary and Watershed Load

Table 5.9 outlines the inputs used within the BATHTUB model for both the 2005 and 2006 modeled years. These values are calculated using methods as described in Section 5.3.

Table 5.9 BATHTUB model inputs for Oak Lake

Year	Watershed	Watershed Area (km^2)	P Concentration (μg/L)	Outflow (hm^3/yr)	Load (kg/yr)
2005	Direct	2.58	246	0.46	113
2005	Site 2	0.53	273	0.08	22
2005	Site 3	0.33	298	0.07	21
2006	Direct	2.58	422	0.27	114
2006	Site 2	0.53	467	0.05	23
2006	Site 3	0.33	510	0.04	20

5.4.2.4 Septic System Load

There are a total of 37 septic systems within the Oak Lake Watershed. For BATHTUB modeling purposes, methods outlined in Section 5.3.3 were used to calculate loads within all subwatersheds. Table 5.10 outlines the septic system BATHTUB model inputs.

Table 5.10 Septic system BATHTUB model inputs for Oak Lake.

	Direct		Site 2		Site 3	
Component	2005	2006	2005	2006	2005	2006
Flow (hm^3/yr)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TP Concentration (μg/L)	312.9		75.1		75.1	
TP Load (kg/yr)	31.3	31.3	7.5	7.5	7.5	7.5

5.4.3 Swede Lake

5.4.3.1 Internal Load

Using the process outlined in Section 5.3.4, final internal loading terms were determined to be 7.25 and 9.25 mg/m^2/day for 2005 and 2006, respectively.

5.4.3.2 Atmospheric Load

Using rates determined in Section 5.3.5, the atmospheric loading for Swede Lake is set at 35 kg/yr.

5.4.3.3 Tributary and Watershed Load

Table 5.11 outlines the inputs used within the BATHTUB model for both the 2005 and 2006 modeled years. These values are calculated using methods as described in Section 5.3.

Table 5.11 BATHTUB model inputs for Swede Lake

Year	Watershed	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)	Load (kg/yr)
2005	Direct	1.41	257	0.28	72
2006	Direct	1.41	440	0.17	75

5.4.3.4 Septic System Load

There are a total of 15 septic systems within the Swede Lake Watershed. For BATHTUB modeling purposes, methods outlined in Section 5.3.3 were used to calculate loads within all subwatersheds. Table 5.12 outlines the septic system BATHTUB model inputs.

Table 5.12 Septic system BATHTUB model inputs for Swede Lake.

Component	Direct 2005	Direct 2006
Flow (hm^3/yr)	<0.1	<0.1
TP Concentration (µg/L)	187.7	
TP Load (kg/yr)	18.8	18.8

5.5 Model Validation

A benchmark phosphorus budget was developed using BATHTUB and Reckhow-Simpson models. The BATHTUB model was calibrated utilizing monitored data while the Reckhow-Simpson model was used to predict unmonitored variables using runoff coefficients. Modeling the entire watershed as a collection of subwatersheds allowed for better estimation of nutrient contributions associated with each tributary's subwatershed. After running the BATHTUB model for two years for validation, a phosphorus budget was developed for current conditions. Through the development of a benchmark budget, managers can begin to access the sources of nutrient loads and target areas for load reductions.

Several model options (subroutines) are available for use within the BATHTUB model. Based on past experience in modeling lakes in Minnesota, few selected subroutines were developed from data on natural lakes. We chose the Canfield-Bachmann model for natural lakes to predict in-lake TP concentrations and the P, N, Light, T equation for predicting chlorophyll-a. Secchi depth was predicted using the VS. CHLA & TURBIDITY equation. For more information on these model equations, see the BATHTUB model documentation (Walker 1999). Model coefficients are also available in the model for calibration or adjustment based on known cycling characteristics. The coefficients were left at the default values except for the Secchi/Chl-a slope, which was decreased from 0.025 to 0.015 based on the relationships from Minnesota Lakes.

5.5.1 Eagle Lake

Model results from the 2000 and 2005 are presented as the predicted and observed values and a coefficient of variation (standard error of the mean) within Table 5.13. The model represents reasonable agreement with only slight deviation in both 2000 and 2005.

Table 5.13 Observed and predicted in-lake water quality for Eagle Lake in 2000 and 2005.

Year	Variable	Predicted		Observed	
		Mean	CV[1]	Mean	CV[1]
2005	Total Phosphorus (µg/L)	171	0.33	174	0.21
	Chlorophyll-a (µg/L)	54	0.31	55	0.27
	Secchi Depth (meters)	1.0	0.37	1.0	0.31
2000	Total Phosphorus (µg/L)	386	0.40	386	0.12
	Chlorophyll-a (µg/L)	44	0.29	44	0.42
	Secchi Depth (meters)	1.4	0.44	1.6	0.24

[1]Coefficient of variation

5.5.2 Oak Lake

Model results from the 2005 and 2006 are presented as predicted and observed values and a coefficient of variation within Table 5.14. The model represents reasonable agreement with only slight deviation in both 2005 and 2006.

Table 5.14 Observed and predicted in-lake water quality for Oak Lake in 2005 and 2006.

Year	Variable	Predicted		Observed	
		Mean	CV[1]	Mean	CV[1]
2006	Total Phosphorus (µg/L)	176	0.38	175	0.10
	Chlorophyll-a (µg/L)	66	0.35	68	0.11
	Secchi Depth (meters)	0.5	0.20	0.5	0.10
2005	Total Phosphorus (µg/L)	125	0.36	129	0.16
	Chlorophyll-a (µg/L)	58	0.37	57	0.22
	Secchi Depth (meters)	0.6	0.21	1.0	0.35

[1]Coefficient of variation

5.5.3 Swede Lake

Model results are presented as the predicted and observed values and a coefficient of variation within Table 5.15. The model represents reasonable agreement within all three parameters.

Table 5.15 Observed and predicted in-lake water quality for Swede Lake in 2005 and 2006 (June 1-September 30).

Year	Variable	Predicted		Observed	
		Mean	CV[1]	Mean	CV[1]
2005	Total Phosphorus (µg/L)	292	0.42	294	0.13
	Chlorophyll-a (µg/L)	76	0.34	75	0.30
	Secchi Depth (meters)	0.7	0.37	0.7	0.25
2006	Total Phosphorus (µg/L)	343	0.44	344	0.08
	Chlorophyll-a (µg/L)	101	0.30	96	0.01
	Secchi Depth (meters)	0.4	0.22	0.4	0.12

[1]Coefficient of variation

5.6 Benchmark Phosphorus Budget

One of the key aspects of developing TMDLs is an estimate of the nutrient budget for the lake. Monitoring data and modeling were used to estimate the current sources of phosphorus to the South Fork Crow River Lakes. Nutrient and water budgets are presented below. These budgets do not account for any groundwater exchange. It is assumed that the lake acts as both a groundwater discharge and recharge area and that there is no net affect on the water or nutrient budget.

5.6.1 Eagle Lake

The largest external loads come from the monitored inlet, E1, where nutrient loads are approximately 15 percent during an above average precipitation year (Table 5.16**).** Loads from this subwatershed and the direct watershed are derived from the high percent of agricultural land use. Internal loading represents an extremely high percentage of the nutrients to the lake. In fact, internal loads represented 70 percent of all loading. The predicted internal loads are somewhat similar to past predicted internal loading percentages outlined by Dick Osgood in a report to the Carver County Park Commission (1995). There are approximately twenty seven septic systems remaining in the watershed which consequently represent a small proportion of the load (3 percent). The nutrient budget here was estimated for an above average precipitation year; keep in mind that a lake's assimilative capacity varies with precipitation levels. For example, the internal load represented here is 70 percent of the budget, during a drier year it represents over 91 percent of the total nutrient budget.

Table 5.16 Summary of BATHTUB model outputs for Eagle Lake based on 2005 data.

Subwatershed	Area km^2	Water Inflow hm^3/yr	Estimated TP Load kg/yr	Percent of Total Load
E1	3.4	0.7	141	13%
Direct Inflow	1.7	0.4	83	8%
Braunworth	0.7	0.1	41	4%
E1 Septic Systems		<0.1	15	1%
Direct Septic Systems		<0.1	23	2%
Total External		**1.2**	**302**	**29%**
Atmospheric Deposition	0.7	0.8	15	1%
Internal Load			738	70%
Total Internal			**753**	**71%**
TOTAL P LOADING			**1,055**	**100%**

5.6.2 Oak Lake

Direct drainage to Oak Lake represents the largest phosphorus input of all external sources. This loading held a 5 percent share of all phosphorus loading, however it was 56 percent of the external sources. Land use in this area is predominately agriculture, which might explain the relative high source of phosphorus loading. It should be noted that the direct watershed is a small watershed, which enforces model outputs for low external loadings. The majority of phosphorus loading is occurring internally, accounting for about 90 percent of all phosphorus loads. The BATHTUB model outputs in Table 5.17 highlight a low precipitation year, resulting in a higher internal load. However, even with an above average precipitation year, internal loading is still roughly 85 percent of all loading.

Table 5.17 Summary of BATHTUB model outputs for Oak Lake based on 2006 data.

Subwatershed	Area km^2	Water Inflow km^2/yr	Estimated TP Load kg/yr	Percent of Total Load
Site 2	0.5	0.05	23	1%
Site 3	0.3	0.04	20	1%
Direct	2.6	0.27	114	5%
Direct Septic	0	<0.1	31	1%
Site 2 Septic	0	<0.1	8	0.3%
Site 3 Septic	0	<0.1	8	0.3%
Total External			**204**	**9%**
Atmospheric Deposition	1.5	0.9	31	1%
Internal Load			2,246	90%
Total Internal			**2,277**	**91%**
TOTAL P LOADING			**2,481**	**100%**

5.6.3 Swede Lake

Swede Lake is a drained lake, with a small, highly agricultural watershed that has potential to contribute to phosphorus loads in the lake. Much of the shoreline is surrounded by a fringe of cattails and vegetation which act as buffers to overland flow of nutrients. Although the direct watershed may be contributing little to the overall phosphorus load currently (Table 5.18), runoff and fluctuating water levels can cause nutrients to run off land into the lake. The above mentioned issues, along with a long residence time, have allowed for the build-up of nutrients in lake sediments that causes internal loading. Thus, internal loading is currently the main culprit causing high nutrient loads to the lake. Septic systems account for a very small portion of the overall nutrient load.

Table 5.18 Summary of BATHTUB model outputs for Swede Lake based on 2006 data.

Subwatershed	Area km^2	Water Inflow hm^3/yr	Estimated TP Load kg/yr	Percent of Total Load
Direct (D1)	1.4	0.2	75	1%
Septic Systems		<0.1	19	0.3%
Total External		**0.2**	**94**	**1%**
Atmospheric Deposition	1.8	1.1	36	0.6%
Internal Load			6,114	98%
Total Internal			**6,150**	**99%**
TOTAL P LOADING			**6,244**	**100%**

6 TMDL Allocations

TMDL = WLA + LA + MOS + RC

Where:

TMDL = Total Maximum Daily Load
WLA = Wasteload Allocation (for point sources)
LA = Load Allocation (for nonpoint sources)
MOS = Margin of Safety
RC = Reserve Capacity

6.1 TMDL Allocations Introduction

The TMDL presented here is developed to be protective of aquatic recreation beneficial uses in lakes, as embodied in the Minnesota lake Water Quality Standards. Loads are expressed both as annual and daily loads; however, an annual load is more relevant to this TMDL study because the growth of phytoplankton is more responsive to changes in the annual load than the daily load. These changes have been made pursuant to 40 CFR 130.2(I) that specifies that TMDLs may be expressed in other terms where appropriate.

6.1.1 Loading Capacity Determinations

The loading capacity of each of the three lakes was determined by fitting the lake's phosphorus load to the shallow lake State Standard, using the BATHTUB model. The loading capacity is the same as the TMDL. Section 6.3 presents each lake's TMDL and TMDL allocation.

6.1.2 Critical Condition

The Minnesota lake Water Quality Standards specify as critical the summer growing season (June-September). Minnesota lakes typically demonstrate impacts from excessive nutrients during the summer, including excessive algal blooms and fish kills. Consequently, the lake response models have focused on the summer growing season as the critical condition. Additionally, these lakes tend to have relatively short residence times and therefore respond to summer growing season loads.

6.1.3 Margin of Safety (MOS)

A margin of safety has been incorporated into this TMDL by using a conservative modeling approach to account for an inherently imperfect understanding of the lake system and to ultimately ensure that the nutrient reduction strategy is protective of the water quality standard.

The lake response model for total phosphorus used for this TMDL uses the rate of lake sedimentation, or the loss of phosphorus from the water column as a result of settling, to predict total phosphorus concentration. Sedimentation can occur as algae die and settle, as organic material settles, or as algae are grazed by zooplankton. Sedimentation rates in shallow lakes can be higher than rates for deep lakes. Shallow lakes differ from deep lakes in that they tend to exist in one of two states: turbid water and clear water. Lake response models assume that even when total phosphorus concentration in the lake is at or better than the state water quality standard the lake will continue to be in that turbid state. However, as nutrient load is reduced and other internal load management activities such as fish community management occur to provide a more balanced lake system, shallow lakes will tend to "flip" to a clear water condition. In that balanced, clear water condition, light penetration allows rooted aquatic vegetation to grow and stabilize the sediments, and zooplankton to thrive and graze on algae at a much higher rate than is experienced in turbid waters. Thus in a clear water state more phosphorus will be removed from the water column through settling than the model would predict.

The TMDL is set to achieve water quality standards while still in a turbid water state. To achieve the beneficial use, the lake must flip to a clear water state which can support the response variables at higher total phosphorus concentrations due to increased zooplankton grazing, reduced sediment resuspension, etc. Therefore, this TMDL is inherently conservative by setting allocations for the turbid water state.

6.1.4 Reserve Capacity (RC)

Reserve Capacity (RC) is that portion of the TMDL that accounts for future growth. This is most relevant for those entities in the WLA category. However, this watershed does not have (or is expected to have in the foreseeable future) either regulated MS4s or permitted wastewater treatment facilities. As such, there is no need to set aside a load for future growth. As land use continues to change within the watershed, the overall phosphorus loading will need to meet the overall allocation provided to the watershed runoff load.

6.1.5 Seasonal Variation

Seasonal variation is accounted for through the utilization of annual loads and developing targets for the summer period where the frequency and severity nuisance algal growth will be the greatest. Although the critical period is the summer, lake water quality responds mainly to long-term changes such as changes in the annual load. Therefore, seasonal variation is accounted for in the annual loads. Additionally, by setting the TMDL to meet targets established for the most critical period (summer), the TMDL will inherently be protective of water quality during all other seasons.

6.2 TMDL Allocation Approach

Each lake's TMDL was allocated to a combination of load allocation and wasteload allocation. The approach to making these allocations is described in the following two sections.

6.2.1 Load Allocations (LAs)

Load allocations (LAs) include watershed runoff loading from non-regulated Municipal Separate Storm Sewer System ("non-MS4") areas (i.e., watershed load not covered by a NPDES permit), as well as atmospheric and internal loadings. In addition, the loading from upstream lakes within a lake's watershed are also placed in the LA category. The subdividing of loading allocations (into WLAs, LAs and MOS) to those upstream lakes is done in the separate TMDLs for those upstream lakes.

Atmospheric loadings are assumed to remain the same as in the benchmark phosphorus budgets (Section 5.5.2) regardless of precipitation levels. The atmospheric loading rate was assumed to be 20 kg/km2/yr in all cases.

Upstream lake loadings were calculated assuming that water discharging from those lakes meet State Standards of TP concentrations of either 40 µg/L or 60 µg/L depending upon if it is a deep or shallow lake, respectively. Discharge rates were determined using the runoff coefficients outlined in Section 5.2. From these, a total yearly load was calculated.

Watershed runoff loadings were based upon 2020 Land Use GIS shapefiles within 2030 boundaries for the municipalities in order to account for expected future growth.

Derivation of the LAs for internal loading and non-MS4 area loading were done as follows:

1) Using the total loading capacity (TMDL) as determined per Section 5.5.2 subtracted the following loads:
    a. any WLAs for wastewater facilities and construction/industrial stormwater
    b. upstream lake loading
    c. atmospheric allocation

   The resulting load is the combined allowable load for the direct watershed runoff and internal loading.
2) Determined future external loading to each lake from the direct watershed (if no reductions were to be done) using export coefficients as outlined in Table 5.5 multiplied by 2020 land use areas.
3) Estimated future internal loading to each lake (if no reductions were to be done) as the internal loading from benchmark BATHTUB modeling per Section 5.5.2.
4) Determined the ratio of combined allowable load calculated in step 1 to the sum of the overall future loading from step 2 plus internal loading from step 3.
5) Multiplied the following loads by the calculated ratio in step 4:
    a. non-MS4 area loading (from step 2)
    b. internal loading (from step 3)

The resulting loads are the non-MS4 area LA and internal loading LA.

6.2.2 Wasteload Allocations (WLAs)

Wasteload allocations (WLAs) are required for regulated MS4 discharges, municipal and industrial wastewater discharges, and stormwater runoff from both industrial and construction sites.

6.2.2.1 Municipal Separate Storm Sewer Systems (MS4s)

Currently there are no regulated discharges from MS4s in any of the three direct watersheds. Future growth within these three direct watersheds will also not result in regulated discharges from MS4s.

6.2.2.2 Municipal and Industrial Wastewater Discharges
No NPDES permitted wastewater facilities are located within the South Fork Crow River Direct Watersheds.

6.2.2.3 Construction Stormwater and Industrial Stormwater
Construction storm water activities are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install, and maintain all BMPs required under the permit, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

Industrial storm water activities are considered in compliance with provisions of the TMDL if they obtain an Industrial General Permit under the NPDES program and properly select, install and maintain all BMPs required under the permit.

The land area representing construction and industrial stormwater would be expected to make up a very small portion of the watersheds at any one time. Therefore, WLAs for construction and industrial stormwater combined were conservatively set at 0.1% of the loading capacity (TMDL) for each lake.

6.2.3 Adaptive Management
The WLAs and LAs for the Carver Five Lakes represent aggressive goals. Consequently, implementation will be conducted using adaptive management principals. The County will continue to monitor each lake to identify improvements and adapt implementation strategies accordingly. It is difficult to predict the nutrient reduction that would occur from implemented strategies because we do not know the exact contribution of each pollutant source to the lake, and many of the strategies affect more than one source. Continued monitoring and "course corrections" (in regards to the use of Best Management Practices) responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL.

6.3 Specific TMDL Allocations
The TMDL and TMDL allocations are described for each of the three lakes in the following sections.

6.3.1 Eagle Lake TMDL
Using the Canfield-Bachmann equation, loads and load reductions were calculated for Eagle Lake. This TMDL is written to solve the equation for a shallow lake in the NCHF ecoregion of Minnesota with a standard of 60 µg/L phosphorus as a final goal. Table 6.1 presents the TMDL and its components, which are discussed in the following subsections.

Table 6.1 TMDL allocations for Eagle Lake. MOS is implicit and RC is zero.

Load Units	TMDL	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA External	LA Upstream Lakes
kg/yr	164	0.16	15	132	12	4
kg/day	0.45	0.0004	0.04	0.36	0.03	0.01

In Table 6.1, the "upstream lakes" load represents the phosphorus discharging from Braunworth Lake. Upstream lakes are assumed to meet their water quality standards. This is the most reasonable way to account for the upstream lakes' effects on Eagle Lake under future conditions. It also implies that Eagle Lake's TMDL does not affect the TMDLs of the upstream lakes.

6.3.1.1 Load Allocations

Section 6.2.1 outlines the methodology used to determine establishing Load Allocations for Eagle Lake TMDL. Atmospheric loading is set at 15 kilograms per year (kg/yr). Internal loading has been established to be 132 kg/yr and the external loading is limited to 12 kg/yr.

6.3.1.2 Wasteload Allocations

Construction and Industrial stormwater within the Eagle Direct Watershed, as outlined in Section 6.2.2 has a designated TMDL WLA of 0.16 kg/yr. No MS4s are designated, nor are there any NPDES permitted wastewater facilities located within the direct watershed boundaries of Eagle Lake.

6.3.1.3 Load Response

In addition to meeting a phosphorus limit of 60 µg/L, a lake must either meet or exceed one of two other parameters (chlorophyll-a or Secchi). BATHTUB modeling of the TMDL load results in Eagle Lake meeting the Secchi Depth requirement of greater than 1 meter (Table 6.2). Chlorophyll-a concentrations are still above the State Standards of 20 µg/L. To view BATHTUB inputs and results for this model, see Appendix C.

Table 6.2 BATHTUB modeling of TMDL Loads for Eagle Lake.

Results	Eagle Lake
TP Concentration	60
Chlorophyll-a Concentration	43
Secchi Depth	1.4

6.3.1.4 Modeled Historic Loads

Using the Canfield-Bachmann equation, historic loads were calculated for Eagle Lake (Figure 6.1). The calculations provide some insight into the assimilative capacity of the lake under different hydrologic conditions as well as over time. Additionally, these results provide a sense for the level of effort necessary to achieve the TMDL.

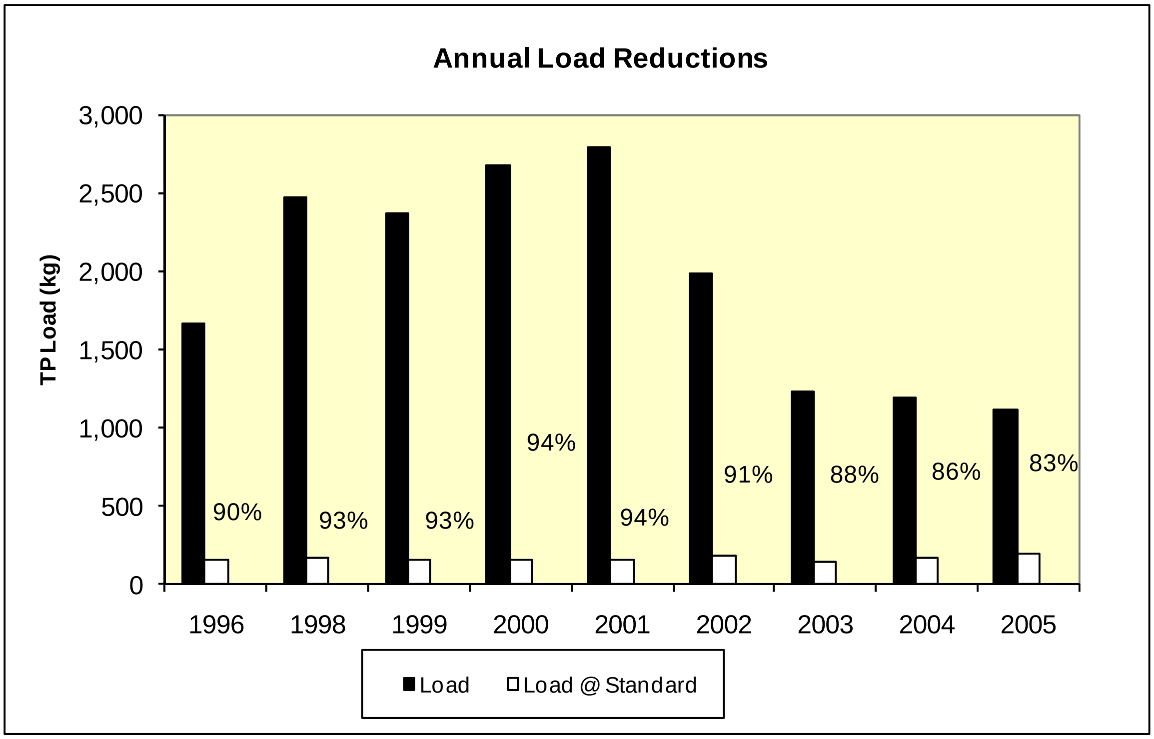


Figure 6.1 Predicted annual loads for monitored conditions and predicted loads at the standard of 60 µg/L total phosphorus over the last ten years for Eagle Lake. Percentages represent the necessary reductions to meet the NCHF standard.

Eagle Lake requires an 83 to 94 percent phosphorus load reduction to meet the water quality standard of a summer average of 60 µg/L TP. For the years monitored the lowest allowable load was 148 kilograms of phosphorus and the maximum allowable load was 195 kilograms of phosphorus.

6.3.2 Oak Lake TMDL

Using the Canfield-Bachmann equation, loads and load reductions were calculated for Oak Lake. This TMDL is written to solve the equation for a shallow lake in the NCHF ecoregion of Minnesota with a standard of 60 µg/L phosphorus as a final goal. Table 6.3 presents the TMDL and its components, which are discussed in the following sections.

Table 6.3 TMDL allocations for Oak Lake. MOS is implicit and RC is zero.

Load Units	TMDL	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA External
kg/yr	147	0.15	31	75	41
kg/day	0.40	0.0004	0.08	0.20	0.11

6.3.2.1 Load Allocations

Section 6.2.1 outlines the methodology used to determine establishing Load Allocations for Oak Lake TMDL. Atmospheric loading is set at 31 kg/yr. Internal loading has been established to be 75 kg/yr and the external loading is limited to 41 kg/yr.

6.3.2.2 Wasteload Allocations

Construction and Industrial stormwater within the Oak Direct Watershed, as outlined in Section 6.2.2 has a designated TMDL WLA of 0.17 kg/yr. No MS4s are designated, nor are there any NPDES permitted wastewater facilities located within the direct watershed boundaries of Oak Lake.

6.3.2.3 Load Response

In addition to meeting a phosphorus limit of 60 µg/L, a lake must either meet or exceed one of two other parameters (chlorophyll-a or Secchi). BATHTUB modeling of the TMDL load results in Oak Lake meeting the Secchi Depth requirement of greater than 1 meter (Table 6.4). Chlorophyll-a concentrations are still above the State Standards of 20 µg/L. To view BATHTUB inputs and results for this model, see Appendix C.

Table 6.4 BATHTUB modeling of TMDL Loads for Oak Lake.

Results	Oak Lake
TP Concentration	60
Chlorophyll-a Concentration	48
Secchi Depth	1.3

6.3.2.4 Modeled Historic Loads

Using the Canfield-Bachmann equation, historic loads and load reductions were calculated for Oak Lake (Figure 6.2). The calculations provide some insight into the assimilative capacity of the lake under different hydrologic conditions as well as over time. Additionally, these results provide a sense for the level of effort necessary to achieve TMDL and whether that the TMDL.

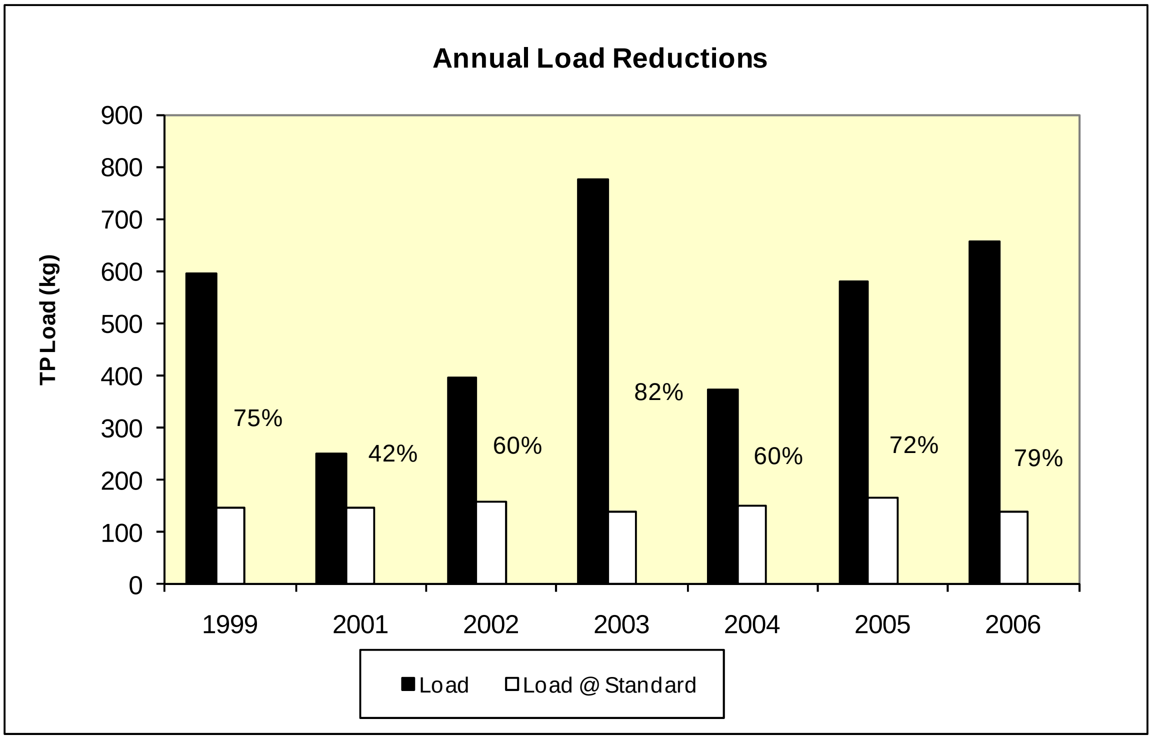


Figure 6.2 Predicted annual loads for monitored conditions and predicted loads at the standard of 60 µg/L TP concentration for Oak Lake. Percentages represent the necessary reductions to meet the NCHF standard.

Other than 2001, Oak Lake requires a 60 to 82 percent phosphorus load reduction to meet the water quality standard of a summer average of 60 µg/L total phosphorus. For the years monitored the lowest allowable load was 139 kilograms of phosphorus and the maximum allowable load was 165 kilograms of phosphorus

6.3.3 Swede Lake TMDL

Using the Canfield-Bachmann equation, loads and load reductions were calculated for Swede Lake. This TMDL is written to solve the equation for a shallow lake in the NCHF ecoregion of Minnesota with a standard of 60 µg/L phosphorus as a final goal. Table 6.5 presents the TMDL and its components, which are discussed in the following sections.

Table 6.5 TMDL allocations for Swede Lake. MOS is implicit and RC is zero.

Load Units	TMDL	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA External
kg/yr	236	0.24	35	197	4
kg/day	0.65	0.0006	0.10	0.54	0.01

6.3.3.1 Load Allocations

Section 6.2.1 outlines the methodology used to determine establishing Load Allocations for Swede Lake TMDL. Atmospheric loading is set at 35 kg/yr. Internal loading has been established to be 197 kg/yr and the external loading is limited to 4 kg/yr.

6.3.3.2 Wasteload Allocations

Construction and Industrial stormwater within the Swede Direct Watershed, as outlined in Section 6.2.2 has a designated TMDL WLA of 0.24 kg/yr. No MS4s are designated, nor are there any NPDES permitted wastewater facilities located within the direct watershed boundaries of Swede Lake.

6.3.3.3 Load Response

In addition to meeting a phosphorus limit of 60 μg/L, a lake must either meet or exceed one of two other parameters (chlorophyll-a or Secchi). BATHTUB modeling of the TMDL load results in Swede Lake meeting the Secchi Depth requirement of greater than 1 meter (Table 6.6). Chlorophyll-a concentrations are still above the State Standards of 20 μg/L. To view BATHTUB inputs and results for this model, see Appendix C.

Table 6.6 BATHTUB modeling of TMDL Loads for Swede Lake.

Results	Swede Lake
TP Concentration	60
Chlorophyll-a Concentration	38
Secchi Depth	1.5

6.3.3.4 Historic Modeled Loads

Using the Canfield-Bachmann equation, historic loads and load reductions were calculated for Swede Lake (Figure 6.3). The calculations provide some insight into the assimilative capacity of the lake under different hydrologic conditions as well as over time. Additionally, these results provide a sense for the level of effort necessary to achieve TMDL and whether that the TMDL.

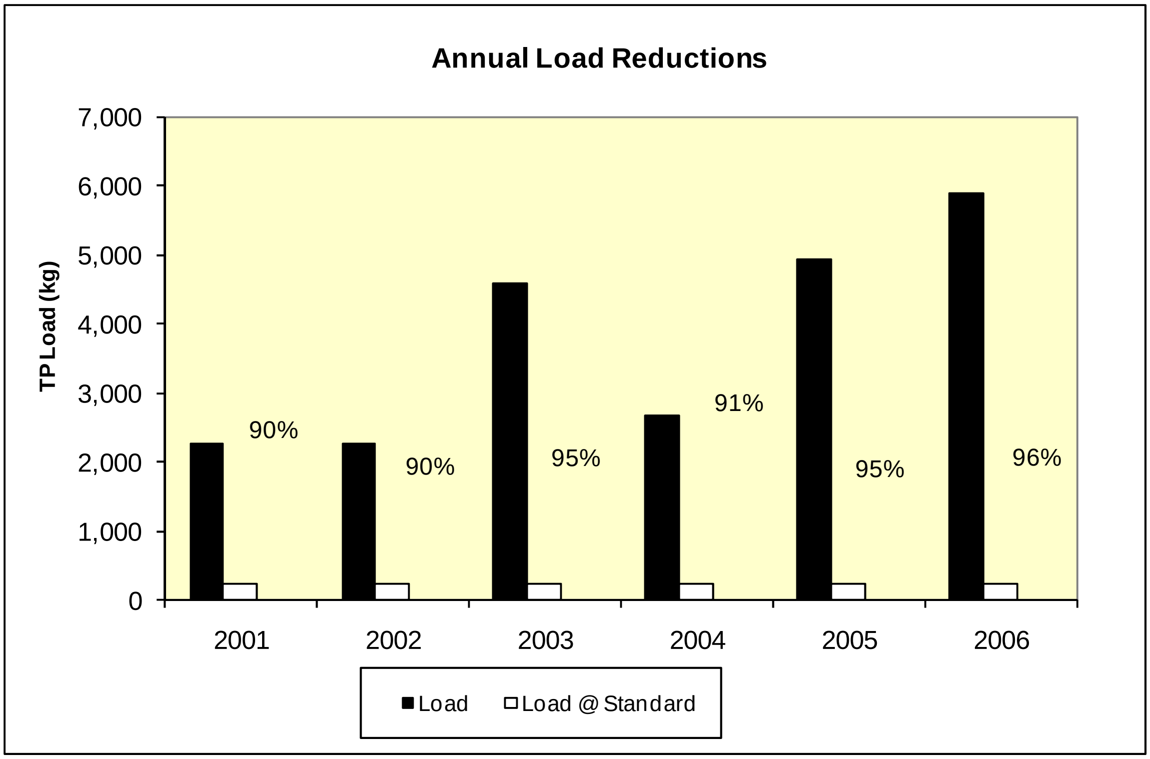


Figure 6.3 Predicted annual loads for monitored conditions and predicted loads at the standard of 60 µg/L total phosphorus over the last ten years for Swede Lake. Percentages represent the necessary reduction to meet the standard.

Swede Lake requires a 90 to 96 percent reduction to meet the NCHF shallow lake water quality standard of summer average of 60 µg/L TP (Figure 6.3). For the years monitored the lowest allowable load was 233 kilograms of phosphorus and the maximum allowable load was 244 kilograms of phosphorus.

7 Public Participation

7.1 Introduction

The County has an excellent track record with inclusive participation of its citizens, as evidenced through the public participation in completion of the Carver County Water Management Plan, approved in 2001. The County has utilized stakeholder meetings, citizen surveys, workshops and permanent citizen advisory committees to gather input from the public and help guide implementation activities. The use of this public participation structure has aided in the development of this and other TMDLs in the County.

7.2 Technical Advisory Committee

The Water, Environment, & Natural Resource Committee (WENR) was established as a permanent advisory committee. The WENR is operated under the County's standard procedures for advisory committees. The WENR works with staff to make recommendations to the County Board on matters relating to watershed planning.

The make-up of the WENR is as follows:

1 County Board Member
1 Soil and Water Conservation District Member
5 citizens – (1 appointed from each commissioner district)
1 City of Chanhassen (appointed by city)
1 City of Chaska (appointed by city)
1 City of Waconia (appointed by city)
1 appointment from all other cities (County Board will appoint)
2 township appointments (County Board will appoint– must be on existing township board.)
4 other County residents (1 from each physical watershed area – County)

The full WENR committee received updates on the TMDL process from its conception in 2004.

As part of the WENR committee, two sub-committees are in place and have held specific discussions on excess nutrient TMDLs. These are the Technical sub-committee and the Policy/Finance sub-committee.

TMDL progress, methods, data results and implementation procedures were presented and analyzed at the WENR meetings mentioned above. Committee members commented on carp removal possibilities, sources, internal loading rates, and future monitoring plans. All issues commented on were considered in the development of the Draft TMDL.

7.3 Public Involvement

Stakeholders that would be impacted by the South Fork Crow River TMDL will be given the opportunity to voice their opinions of the TMDL. Stakeholder involvement has involved and will include the following components; public survey, public meeting, and personal meetings. Public meetings are to be held during the public comment period of the Draft TMDL. In addition, an opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from July 19 to August 18, 2010.

8 Implementation Strategy

8.1 Introduction

Carver County, through their Water Management Plan, has embraced a basin wide goal for protecting water quality in the Carver County Water Resource Management Area (CCWRMA), including the South Fork Crow River Lakes. Currently, Carver County has developed detailed action strategies to address several of the issues identified in this TMDL. The Carver SWCD is active in these watersheds and works with landowners to implement best management practices on their land.

This implementation strategy charts the course the County will take to incorporate TMDL results into local management activities as well as the Water Management Plan. The ultimate goal of implementation efforts is to achieve the identified load reductions in each of the South Fork Crow River Lake watersheds in order to meet the State water quality standard and protect the aquatic recreation beneficial use.

8.2 The Carver County Water Management Plan

To respond to the County's established goals for Natural Resource Management, the Water Management Plan describes the set of issues requiring implementation action. MN Rule 8410 describes a list of required plan elements. Items not covered in this plan will be addressed as necessary to accomplish the higher priority goals. Each issue is summarized in the Water Management Plan followed by background information, a specific goal, and implementation steps. The issues included in the plan which addresses nutrient TMDL sources and reductions are:

- SSTS
- Feedlots
- Stormwater Management
- Construction Site Erosion & Sediment Control
- Land Use Practices for Rural & Urban Areas
- Water Quality

8.3 Source Reduction Strategies

To reach the reduction goals, the County will rely largely on its current Water Management Plan, which identifies the Carver SWCD as the local agency for implementing BMPs. Implementation goals not covered in the Water Management Plan will be identified and amended to the Implementation Plan, which will be developed within a year of the final approval of the TMDL report by the EPA. It will list BMPs to be applied in the watershed and the order of importance for which they will be applied. An important aspect of the Implementation Plan will be public input.

The strategies listed below will be utilized to assist in reducing pollutant loads. It is difficult to predict nutrient load reductions that would occur from each strategy. Because of this monitoring will need to be carried out after the implementation of each strategy.

Internal loading has been identified as a major source of nutrients to all South Fork Crow River Lakes. Due to this fact, internal loading reduction strategies will be a major focus.

The following is a list of the best management practices as outlined by the Water Management Plan and additional strategies as identified by the TMDL study.

8.4 Lake Strategies

Lake restoration activities can be grouped into two main categories: those aimed at reducing external nutrient loads, and those practices aimed at reducing internal loads. Focus of lake strategies will depend upon on each individual lake characteristics and nutrient balances.

Total costs to implement this TMDL, which encompasses internal and external load reduction strategies for Eagle, Oak, and Swede Lakes has been estimated between $1,686,000 to $2,507,000. Individual strategies and costs associated with them are broken out in the following sections.

8.4.1 External Loading Reduction Strategies

8.4.1.1 SSTS

Based on the results of the TMDL, failing septic systems contribute little to the nutrient loading into Eagle, Oak, and Swede Lakes. However, direction should be taken to ensure that the systems conform to standards. Failing and improperly maintained SSTSs present a substantial threat to the quality of surface and groundwater.

Goals:

- Elimination of all non-conforming systems that are or are likely to become a pollution or health hazard.
- Ensure that all SSTS repairs, replacements, and new systems are properly designed and installed.
- Ensure that all SSTS are properly managed, operated and maintained.

Cost for Implementation: $90,000 to $130,000

Eagle Lake: $30,000 to $50,000
Oak Lake: $30,000 to $40,000
Swede Lake: $30,000 to $40,000

8.4.1.2 Feedlots

Feedlots without runoff controls may contribute to nutrient loading during wet conditions. Surface water concerns include: contamination by open lot runoff into a waterbody, ditch or open tile inlet. Runoff from the four feedlots in the watershed may contribute to the overall loads; therefore rules addressing feedlot management included in the water management plan will be included in the implementation strategies. In order to address this pollution, the County will rely on goals and policies set forth in the Water Management Plan. Properly managed feedlots will assist in meeting nutrient standards during wet conditions.

Goals:

- Feedlots must be managed so that the quality of surface water and groundwater is not impaired.
- Utilize existing regulations and rules (County Feedlot Management Ordinance Chapter 54, and MPCA Rule-Chapter 7020) to ensure compliance.

Cost for Implementation: $45,000 to $80,000
Eagle Lake: $10,000 to $15,000
Oak Lake: $10,000 to $15,000
Swede Lake: $25,000 to $50,000

8.4.1.3 Landowner Practices

Runoff from residential landscapes is potentially a major source of nutrients, particularly phosphorus, entering lakes and streams. These sources include runoff generated from driveways, rooftops, decks, lawn maintenance activities, and washing of cars. Several cost-effective practices are available for landowners to reduce or eliminate phosphorus and nutrient loads.

Goals:

- Landscaping to reduce runoff and promote infiltration, such as vegetated swales or rain gardens.
- Minimizing the amount of impervious surface, either through innovative BMPs, such as porous pavement, or reduction of actual impervious surface.
- Proper application of lawn and garden fertilizers and chemical herbicides.
- Planting and maintaining native vegetation to help water quality by soaking up rainfall, reducing runoff, and retaining sediment.
- Creating/maintaining buffers of at least 50 feet at waterways, with the goal of creating 100 foot buffers to maximize water quality benefits.
- Removal of leaf litter from lakeshore lawns
- Mulching or bagging of grass clippings
- Car washing on lawns instead of on driveways

Total Cost for Implementation: $200,000 to $400,000
Eagle Lake: $100,000 to $150,000
Oak Lake: $50,000 to $150,000
Swede Lake: $50,000 to $100,000

8.4.1.4 Stormwater Management

The current land use of the Eagle, Oak, and Swede Lake watersheds are under five percent developed. Although urban stormwater currently does not play a role in nutrient loads to the watersheds, changes in land use not currently foreseen may need to be addressed for future use. In addition, construction activity in growth areas can deliver phosphorus laden sediment if not controlled properly. The requirements set forth in the Water Management Plan and rules along with NPDES Phase II should ensure that anticipated increases in urban stormwater runoff do not contribute to nutrient loading.

Goal:

- Attenuate stormwater and minimize degradation of Carver County's water resources through reducing the amount and rate of surface water runoff from agricultural and urban land uses.
- Ensure proper erosion control practices are properly installed onsite during construction

Cost for Implementation: $25,000 to $50,000

Eagle Lake: $15,000 to $25,000
Oak Lake: $5,000 to $15,000
Swede Lake: $5,000 to $10,000

8.4.1.5 Agricultural BMPs

Agricultural land is the major land use within the South Fork Crow River Watershed, thus producing the highest amounts of phosphorus loads entering each lake. Farming practices have greatly reduced the runoff generated from fields. However, new and innovative BMPs are becoming more available for farmers. With these new BMPs and including proven techniques, further reductions in both volume and nutrients are still possible for the agricultural land uses.

Goals:

- Identify and prioritize key erosion and restoration areas
- Educate land owners on new and innovative BMPs and well as proven techniques
- Design and implement cropland BMPs
- Installation of buffer strips in locations identified.

Cost for Implementation: $500,000 to $650,000

Eagle Lake: $200,000 to $250,000
Oak Lake: $150,000 to $200,000
Swede Lake: $150,000 to $200,000

8.4.2 Internal Loading Reduction Strategies

8.4.2.1 Rough Fish Management

Rough fish populations have historically been high in all South Fork Crow River Lakes. Species such as black bullhead and carp increase the mixing of sediments, releasing phosphorus into the water column. Implementation plans must include the management of rough fish species by including the following management practices:

Goals:

- Investigate partnership with U of M in research of effective carp removal methods
- Installation of fish barriers paired with intensified efforts for removal of rough fish
- Stocking of pan fish to assist in destruction of carp reproduction efforts.
- Increased surveys to monitor the results of management efforts.

Cost for Implementation: $160,000 to $205,000

Eagle Lake: $50,000 to $60,000

Oak Lake: $50,000 to $60,000
Swede Lake: $60,000 to $85,000

8.4.2.2 Aquatic Plant Management

Macrophyte surveys and monitoring efforts on Eagle, Oak, and Swede Lakes indicate that curlyleaf pondweed is a source of phosphorus within each lake. Curlyleaf pondweed is the dominant species in each lake. Curlyleaf pondweed grows under the ice, but dies back relatively early, releasing nutrients to the water column in summer, possibly leading to algal blooms. The Minnesota DNR has led past efforts to reduce invasive species in the lake. However, recent surveys indicate that curlyleaf pondweed has re-established itself as the dominant species in the lake.

Goals:

- Establish a native plant community
- Draw-down to aid in establishing native aquatic plants
- Manual, chemical, or mechanical removal of curl leaf pondweed.
- Monitor the lake to ensure that non-native invasive species are not introduced into the plant community.

Cost for Implementation: $190,000 to $280,000
Eagle Lake: $50,000 to $80,000
Oak Lake: $70,000 to $100,000
Swede Lake: $70,000 to $100,000

8.4.2.3 Boat Traffic Management

At high speeds boat motors can cause disturbance not only to the aquatic plant community but to the sediments on the bottom of the lake. The wave action causes the release of phosphorus from the disturbed sediments. No wave zones will aid in controlling the disturbance to sediments.

Goals:

- Establish Restricted Areas to protect aquatic resources
- Enforcement and Education of regulations promoting awareness among boaters where slow or no wake zones are ignored.

Cost for Implementation: $6,000 to $12,000
Eagle Lake: $2,000 to $4,000
Oak Lake: $2,000 to $4,000
Swede Lake: $2,000 to $4,000

8.4.2.4 Phosphorus Inactivation/Alum Treatments

Phosphorus inactivation utilizing aluminum sulfate (alum) is a common and successful technique to control phosphorus due to internal loading. Alum is a chemical addition that forms a non-toxic precipitate with phosphorus and thereby reduces its availability for algal growth.

Goals:
- Fully evaluate whether alum is a viable option to reduce internal phosphorus loading
- Establish treatment area, dosing amounts and costs needed to treat the lakes

Cost for Implementation: $300,000 to $450,000
Eagle Lake: $100,000 to $150,000
Oak Lake: $100,000 to $150,000
Swede Lake: $100,000 to $150,000

8.4.2.5 Bio-manipulation
For shallow lake ecosystems, switching a lake from algae dominated to a clear water state requires a reverse switch which typically consists of bio-manipulation. This process consists of the complete restructuring of the fish community and works best if nutrient levels (both internal and external) are reduced prior to manipulation. Upon removal of fish, zooplankton such as daphnia populations will increase and graze away phytoplankton thereby allowing for clear water. Clear water will then allow for the growth of aquatic plants, return of healthy zooplankton populations, and the return of a more stable clear-water lake.

Goals:
- External nutrient reductions as indicated by implementation plan.
- Internal nutrient reductions as indicated by implementation plan.
- Manipulation of fish community- and reintroduction following zooplankton and aquatic plant establishment.

Total cost for implementation: $170,000 to $250,000
Eagle Lake: $50,000 to $75,000
Oak Lake: $70,000 to $100,000
Swede Lake: $50,000 to $75,000

9 Reasonable Assurance

9.1 Introduction

When establishing a TMDL, reasonable assurances must be provided demonstrating the ability to reach and maintain water quality endpoints. Several factors control such reasonable assurances, including a thorough knowledge of the ability to implement BMPs in an overall effective manner. Carver County is in a position to implement the TMDL and ultimately achieve water quality standards.

9.2 Carver County

The Carver County Board of Commissioners (County Board), acting as the water management authority for the former Bevens Creek (includes Silver Creek), Carver Creek, Chaska Creek, East Chaska Creek, and South Fork Crow River watershed management organization areas, has established the "Carver County Water Resource Management Area" (CCWRMA). The purpose of establishing the CCWRMA is to fulfill the County's water management responsibilities under Minnesota Statute and Rule. This structure was chosen because it will provide a framework for water resource management as follows:

- Provides a sufficient economic base to operate a viable program;
- Avoids duplication of effort by government agencies;
- Avoids creation of a new bureaucracy by integrating water management into existing County departments and related agencies;
- Establishes a framework for cooperation and coordination of water management efforts among all of the affected governments, agencies, and other interested parties; and
- Establishes consistent water resource management goals and standards for at least 80% of the county.

The County Board is the governing body of the CCWRMA for surface water management and for groundwater management. In function and responsibility, the County Board is equivalent to a joint powers board or a watershed district board of managers. All lakes in within South Fork Crow River Watershed are part of the CCWRMA.

The County is uniquely qualified through its zoning and land use powers to implement corrective actions to achieve TMDL goals. The County has stable funding for water management each year, but will likely need assistance for full TMDL implementation in a reasonable time frame, and will continue its baseline-monitoring program. Carver County has established a stable source of funding through a watershed levy in the CCWRMA taxing district (adopted 2001). This levy allows for consistent funding for staff, monitoring, engineering costs and also for on the ground projects. The County has also been very successful in obtaining grant funding from local, state and federal sources due to its organizational structure.

Carver County recognizes the importance of the natural resources within its boundaries, and seeks to manage those resources to attain the following goals:

1. Protect, preserve, and manage natural surface and groundwater storage and retention systems;
2. Effectively and efficiently manage public capital expenditures needed to correct flooding and water quality problems;
3. Identify and plan for measures to effectively protect and improve surface and groundwater quality;
4. Establish more uniform local policies and official controls for surface and groundwater management;
5. Prevent erosion of soil into surface water systems;
6. Promote groundwater recharge;
7. Protect and enhance fish and wildlife habitat and water recreational facilities; and
8. Secure additional benefits associated with the proper management of surface and ground water.

Water management involves the following County agencies: Carver County Land and Water Services Division, Carver County Extension, and the Carver Soil and Water Conservation District (SWCD). The County Land and Water Services Division is responsible for administration of the water plan and coordinating implementation. Other departments and agencies will be called upon to perform water management duties that fall within their area of responsibility. These responsibilities may change as the need arises. The key entities meet regularly as part of the Joint Agency Meeting (JAM) process to coordinate priorities, activities, and funding.

9.3 Regulatory Approach

9.3.1 Watershed Rules

Water Rules establish standards and specifications for the common elements relating to watershed resource management including: Water Quantity, Water Quality, Natural Resource Protection, Erosion and Sediment Control, Wetland Protection, Shoreland Management, and Floodplain Management. Of particular benefit to Nutrient TMDL reduction strategies are the stormwater management and infiltration standards which are required of new development in the CCWRMA. The complete water management rules are contained in the Carver County Code, Section 153.

9.3.2 Feedlot Permitting

The County Feedlot Management Program includes the feedlot permitting process. The permit process ensures that the feedlot meets State pollution control standards and locally adopted standards. The County has had a locally operated permitting process under delegation from the MPCA since 1980. The County adopted a Feedlot Ordinance in 1996. The Feedlot Ordinance incorporates State standards plus additional standards and procedures deemed necessary to appropriately manage feedlots in Carver County.

9.3.3 County SSTS Ordinance

The SSTS ordinance regulates the design, location, installation, construction, alteration, extension, repair, and maintenance of SSTSs. The County currently enforces the ordinance in unincorporated areas; cities are responsible in their jurisdiction. The law gives responsibility to the County throughout the county unless a city specifically develops and implements its own program and SSTS ordinance.

9.4 Non-Regulatory Approach

9.4.1 Education

Implementation relies on three overall categories of activities: 1) Regulation, 2) Incentives, and 3) Education. All three categories must be part of an implementation program. The County has taken the approach that regulation is only a supplement to a strong education and incentive based program to create an environment of low risk. Understanding the risk through education can go a long way in preventing problems. In addition, education can be a simpler, less costly and a more community friendly way of achieving goals and policies. It can provide the framework for more of a "grass roots" implementation rather than a "top-down" approach of regulation and incentives. However, education by itself will not always meet intended goals, has certain limitations, and is more of a long-term approach.

Carver County created the Environmental Education Coordinator position in 2000 with the responsibility for development and implementation of the water education work plan. Several issues associated with the water plan were identified as having a higher priority for education efforts. These issues were identified through discussions with the advisory committees, and include ease of immediate implementation, knowledge of current problem areas, and existing programs. The higher priority objectives are not organized in any particular order. The approach to implement the TMDL will mimic the education strategy of the water plan. Each source reduction strategy will need an educational component and will be prioritized based on the number of landowners, type of source, and coordination with existing programs.

9.4.2 Incentives

Many of the existing programs, on which the water management plan relies, are incentive based offered through the County and the Carver SWCDs. Some examples include state and federal cost share funds directed at conservation tillage, crop nutrient management, rock inlets, conservation buffers, and low interest loan programs for SSTS upgrades. Reducing nutrient sources will depend upon a similar strategy of incorporating incentives into implementation practices. After the approval of the TMDL by the EPA, and following the County's entrance into the implementation phase, it is anticipated that the County will apply for funding to assist landowners in the application of BMPs identified in the Implementation Plan.

10 Monitoring

Monitoring will continue for all South Fork Crow River TMDL lakes as prioritized by the Water Plan (Table 10.1). However, after implementation of nutrient reduction strategies a stepped-up approach of monitoring will be conducted.

Table 10.1 Monitoring commitment for South Fork Crow River Lakes.

Lake	Priority	Frequency	Schedule	
Eagle	High	Bi-Weekly	Annually	April - October
Oak	Moderate	Bi-Weekly	Rotating	April - October
Swede	Moderate	Bi-Weekly	Rotating	April - October

Adaptive management relies on the County conducting additional monitoring as BMPs are implemented in order to determine if the implementation measures are effective and how effective they are. This monitoring will assist in evaluating the success of projects and identify changes needed in management strategies. Revision of management and monitoring strategies will occur as needed.

10.1 Eagle Lake

Additional areas that may need to be monitored include additional sampling and flow monitoring at the inlet and outlet, monitoring Braunworth Lake water quality, and sediment samples to further account for internal loading. Furthermore, an assessment of the current fish community will be considered to aid in determining existent rough fish populations. This monitoring will assist in evaluating the success of projects and identify changes needed in management strategies. Revision of management and monitoring strategies will occur as needed.

10.2 Oak Lake

Additional monitoring may include sampling of inlets not monitored during the initial TMDL study to further refine loading estimates.

10.3 Swede Lake

Additional monitoring may include more detailed monitoring at the inlet and outlet to refine loading estimates.

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Tributary Monitoring

Water quality parameters such as temperature, transparency, and dissolved oxygen (DO) were measured in the field with a hand-held electronic meter. Nutrient grab samples and composite samples were analyzed for TP, total suspended solids, nitrate + nitrite, total ammonia nitrogen, volatile suspended solids, turbidity, dissolved phosphorus, alkalinity and chemical oxygen demand by the Metropolitan Council Laboratory in St. Paul, MN. Flow was also monitored during water quality sampling events utilizing a hand-held SonTec Flow Tracker.

Eagle Lake

Water quality was monitored in 2005 at the primary inlet to Eagle Lake (E1; Figure 2.2). Flow was monitored during the water quality sampling events; however stage was not monitored continuously to develop a daily discharge record. Water quality was monitored in 2005 with a handheld electronic meter in the field and with chemical analyses performed by the Metropolitan Council Laboratory. Temperature, transparency and dissolved oxygen were measured in the field. Grab samples were analyzed for TP, total suspended solids, nitrate + nitrite, total ammonia nitrogen, volatile suspended solids, turbidity, dissolved phosphorus, alkalinity and chemical oxygen demand. Flow was monitored during the water quality sampling events, utilizing a hand-held SonTec FlowTracker. A total of seven samples targeting both base and high flows were taken. However, high flows only indicate that the water at the inlet was flowing as the water here typically has a very low flow. The results of tributary monitoring in 2005 are integrated in computer modeling exercises.

Table A.1 Eagle Lake Inlet (E1) and Outlet (E2) monitored phosphorus concentrations.

Date	Total Phosphorous (ug/L)		Dissolved Phosphorous (ug/L)		Ortho Phosphate (ug/L)	
	E1	E2	E1	E2	E1	E2
4/13/2005	341	208	286	125	211	90
5/5/2005	63	77	61	48	40	24
5/31/2005	200	185	200	155	168	134
6/13/2005	276	221	221	184	202	173
6/27/2005	1120	283	420	197	520	209
7/14/2005	966	593	208	441	126	321
10/6/2005	385	312	307	217	296	195

Table A.2 Eagle Lake Inlet (E1) monitored flow.

E1	
Date	**Discharge cfs**
4/13/2005	2.99
4/22/2005	4.076
4/27/2005	2.394
5/5/2005	0.89
5/31/2005	1.231
7/14/2005	No Flow
10/11/2005	4.791

Table A.3 Eagle Lake Outlet (E2) monitored flow.

E2	
Date	**Discharge cfs**
4/13/2005	4.227
4/20/2005	7.701
4/27/2005	3.548
5/5/2005	0.914
5/31/2005	4.244
6/16/2005	6.012
7/14/2005	0.674
10/11/2005	11.95

Oak Lake

Water quality was monitored in 2006 at the primary inlet and outlet to Oak Lake (Oak2 and Oak Out; Figure 2.3). Flow was monitored during the water quality sampling events; however stage was not monitored continuously to develop a daily discharge record. Water quality was monitored in 2006 with a handheld electronic meter in the field and with chemical analyses performed by the Metropolitan Council Laboratory. Temperature, transparency and dissolved oxygen were measured in the field. Grab samples were analyzed for TP, total suspended solids, nitrate + nitrite, total ammonia nitrogen, volatile suspended solids, turbidity, dissolved phosphorus, alkalinity and chemical oxygen demand. Flow was monitored during the water quality sampling events, utilizing a hand-held SonTec FlowTracker. A total of four samples targeting both base and high flows were taken, with only one sample taken at the Oak Inlet (Oak2). However, high flows only indicate that the water at the inlet was flowing as the water here typically has a very low flow. The results of tributary monitoring in 2006 are integrated in computer modeling exercises.

Table A.4 Oak Lake Inlet (Oak2) and Outlet (Oak Out) monitored phosphorus concentrations.

Date	Total Phosphorous (ug/L)		Dissolved Phosphorous (ug/L)		Ortho Phosphate (ug/L)	
	Oak2	Oak Out	Oak2	Oak Out	Oak2	Oak Out
6/6/2006	1730	162	1620	32	1500	12
6/21/2006		268		58		14
7/5/2006		293		54		15

Table A.5 Oak Lake Outlet (Oak Out) monitored flow.

Oak Out	
Date	**Discharge cfs**
5/22/2006	0.253
6/1/2006	0.463
6/27/2006	0.02

Swede Lake

Water quality was monitored in 2006 at the primary outlet from Swede Lake (Outlet; Figure 2.4). Flow was monitored during the water quality sampling events; however stage was not monitored continuously to develop a daily discharge record. A total of six flow measurements were taken during the 2006 monitoring season. Water quality was monitored in 2006 with a handheld electronic meter in the field and with chemical analyses performed by the Metropolitan Council Laboratory. Temperature, transparency and dissolved oxygen were measured in the field. Grab samples were analyzed for TP, total suspended solids, nitrate + nitrite, total ammonia nitrogen, volatile suspended solids, turbidity, dissolved phosphorus, alkalinity and chemical oxygen demand. Flow was monitored during the water quality sampling events, utilizing a hand-held SonTec FlowTracker. A total of seven samples targeting both base and high flows were taken. However, high flows only indicate that the water at the inlet was flowing as the water here typically has a very low flow. The results of tributary monitoring in 2005 are integrated in computer modeling exercises.

Table A.6 Swede Lake Outlet monitored phosphorus concentrations.

Date	Total Phosphorous (ug/L)	Dissolved Phosphorous (ug/L)	Ortho Phosphate (ug/L)
6/6/2006	359	152	131
6/21/2006	357	189	100
7/5/2006	405	77	39

Table A.7 Swede Lake Outlet monitored flow.

Swede Out	
Date	**Discharge cfs**
6/27/2006	0.175
7/10/2006	0.447
9/25/2006	-0.035
9/28/2006	-0.61
9/29/2006	0.028
10/2/2006	-0.027

BATHTUB Benchmark Models

Eagle Lake

2000 Inputs

New Eagle Lake 2000

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\South Fork Crow River TMDL\Individual Lakes\Eagle Lake\Models\NewE**

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.65	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	20	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean
1	Eagle	0	1	0.734468	1.78	1.16	1.78	0.12	0	0	0.08	3.89	0	0	11	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	386	0.123772	1663	0.115331	44	0.418035	1.64	0.237001	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	0.5	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	E1	1	1	3.448	0.39	0.1	0	0	353.7	0.2	0	0	0	0	0	0
2	Direct	1	1	1.74	0.24	0	0	0	343	0	0	0	0	0	0	0
3	E1 septic	1	3	3.48	0.1	0	0	0	151	0	0	0	0	0	0	0
4	dierct septic	1	1	1.74	0.1	0	0	0	227	0	0	0	0	0	0	0
5	Braunworth	1	1	0.716	0.06	0	0	0	763.4	0	0	0	0	0	0	0

2000 Mass Balance

New Eagle Lake 2000

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Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	E1	3.4	0.4	1.52E-03	0.10	0.11
2	1	1	Direct	1.7	0.2	0.00E+00	0.00	0.14
3	3	1	E1 septic	3.5	0.1	0.00E+00	0.00	0.03
4	1	1	dierct septic	1.7	0.1	0.00E+00	0.00	0.06
5	1	1	Braunworth	0.7	0.1	0.00E+00	0.00	0.08
PRECIPITATION				0.7	0.5	9.12E-03	0.20	0.65
TRIBUTARY INFLOW				7.6	0.8	1.52E-03	0.05	0.10
POINT-SOURCE INFLOW				3.5	0.1	0.00E+00	0.00	0.03
***TOTAL INFLOW				11.9	1.4	1.06E-02	0.08	0.12
ADVECTIVE OUTFLOW				11.9	0.9	3.44E-02	0.22	0.07
***TOTAL OUTFLOW				11.9	0.9	3.44E-02	0.22	0.07
***EVAPORATION					0.5	2.38E-02	0.30	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	E1	137.9	4.2%	9.51E+02	94.6%	0.22	353.7	40.0
2	1	1	Direct	82.3	2.5%	0.00E+00		0.00	343.0	47.3
3	3	1	E1 septic	15.1	0.5%	0.00E+00		0.00	151.0	4.3
4	1	1	dierct septic	22.7	0.7%	0.00E+00		0.00	227.0	13.0
5	1	1	Braunworth	45.8	1.4%	0.00E+00		0.00	763.4	64.0
PRECIPITATION				14.7	0.4%	5.39E+01	5.4%	0.50	30.8	20.0
INTERNAL LOAD				2950.9	90.3%	0.00E+00		0.00		
TRIBUTARY INFLOW				288.8	8.8%	9.51E+02	94.6%	0.11	365.5	37.8
POINT-SOURCE INFLOW				15.1	0.5%	0.00E+00		0.00	151.0	4.3
***TOTAL INFLOW				3269.5	100.0%	1.01E+03	100.0%	0.01	2391.0	275.7
ADVECTIVE OUTFLOW				329.1	10.1%	2.10E+04		0.44	385.6	27.7
***TOTAL OUTFLOW				329.1	10.1%	2.10E+04		0.44	385.6	27.7
***RETENTION				2940.4	89.9%	2.15E+04		0.05		

Overflow Rate (m/yr)	1.2	Nutrient Resid. Time (yrs)	0.1542
Hydraulic Resid. Time (yrs)	1.5322	Turnover Ratio	6.5
Reservoir Conc (mg/m3)	386	Retention Coef.	0.899

2000 Predicted vs Observed

New Eagle Lake 2000

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Eagle**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	385.6	0.39	99.0%	386.0	0.12	99.0%
TOTAL N MG/M3	1663.0	0.12	78.6%	1663.0	0.12	78.6%
C.NUTRIENT MG/M3	119.8	0.12	93.5%	119.9	0.12	93.5%
CHL-A MG/M3	43.7	0.29	97.7%	44.0	0.42	97.8%
SECCHI M	1.4	0.44	61.9%	1.6	0.24	70.9%
ORGANIC N MG/M3	1159.0	0.28	96.0%			
TP-ORTHO-P MG/M3	75.6	0.33	83.5%			
ANTILOG PC-1	1436.4	0.42	91.2%	681.5	0.45	78.3%
ANTILOG PC-2	19.5	0.31	98.3%	25.5	0.34	99.6%
(N - 150) / P	3.9	0.42	1.6%	3.9	0.17	1.6%
INORGANIC N / P	1.6	0.82	0.2%			
TURBIDITY 1/M	0.1	3.89	1.1%	0.1	3.89	1.1%
ZMIX * TURBIDITY	0.1	3.89	0.0%	0.1	3.89	0.0%
ZMIX / SECCHI	1.3	0.45	1.3%	1.1	0.26	0.5%
CHL-A * SECCHI	59.4	0.44	99.4%	72.2	0.48	99.7%
CHL-A / TOTAL P	0.1	0.47	19.4%	0.1	0.43	19.7%
FREQ(CHL-a>10) %	98.1	0.02	97.7%	98.1	0.03	97.8%
FREQ(CHL-a>20) %	82.9	0.14	97.7%	83.2	0.20	97.8%
FREQ(CHL-a>30) %	61.6	0.29	97.7%	62.1	0.40	97.8%
FREQ(CHL-a>40) %	43.3	0.43	97.7%	43.8	0.60	97.8%
FREQ(CHL-a>50) %	29.9	0.55	97.7%	30.3	0.78	97.8%
FREQ(CHL-a>60) %	20.6	0.66	97.7%	20.9	0.93	97.8%
CARLSON TSI-P	90.0	0.06	99.0%	90.0	0.02	99.0%
CARLSON TSI-CHLA	67.7	0.04	97.7%	67.7	0.06	97.8%
CARLSON TSI-SEC	55.6	0.12	38.1%	52.9	0.06	29.1%

2005 Inputs

New Eagle Lake 2005
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\South Fork Crow River TMDL\Individual Lakes\Eagle Lake\Models\NewEagle200
Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.1	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	20	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Eagle	0	1	0.734468	1.78	1.16	1.78	0.12	0	0	0.15	2.01	0	0	2.75	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	174	0.2146	1476	0.156201	55	0.270061	1.022	0.310116	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	0.8	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	E1	1	1	3.448	0.66	0.1	0	0	212.9	0.2	0	0	0	0	0	0
2	Direct	1	1	1.736	0.4	0	0	0	206.5	0	0	0	0	0	0	0
3	E1 septic	1	3	0.01	0.1	0	0	0	151	0	0	0	0	0	0	0
4	direct septic	1	3	0.01	0.1	0	0	0	227	0	0	0	0	0	0	0
5	Braunworth	1	1	0.716	0.09	0	0	0	459.5	0	0	0	0	0	0	0

2005 Mass Balances

New Eagle Lake 2005

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Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	E1	3.4	0.7	4.36E-03	0.10	0.19
2	1	1	Direct	1.7	0.4	0.00E+00	0.00	0.23
3	3	1	E1 septic	0.0	0.1	0.00E+00	0.00	10.00
4	3	1	direct septic	0.0	0.1	0.00E+00	0.00	10.00
5	1	1	Braunworth	0.7	0.1	0.00E+00	0.00	0.13
PRECIPITATION				0.7	0.8	2.61E-02	0.20	1.10
TRIBUTARY INFLOW				5.9	1.2	4.36E-03	0.06	0.19
POINT-SOURCE INFLOW				0.0	0.2	0.00E+00	0.00	10.00
***TOTAL INFLOW				6.7	2.2	3.05E-02	0.08	0.32
ADVECTIVE OUTFLOW				6.7	1.6	5.43E-02	0.14	0.25
***TOTAL OUTFLOW				6.7	1.6	5.43E-02	0.14	0.25
***EVAPORATION					0.5	2.38E-02	0.30	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	Load Variance %Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	E1	140.5	13.3%	9.87E+02	94.8%	0.22	212.9	40.8
2	1	1	Direct	82.6	7.8%	0.00E+00		0.00	206.5	47.6
3	3	1	E1 septic	15.1	1.4%	0.00E+00		0.00	151.0	1510.0
4	3	1	direct septic	22.7	2.2%	0.00E+00		0.00	227.0	2270.0
5	1	1	Braunworth	41.4	3.9%	0.00E+00		0.00	459.5	57.8
PRECIPITATION				14.7	1.4%	5.39E+01	5.2%	0.50	18.2	20.0
INTERNAL LOAD				737.7	69.9%	0.00E+00		0.00		
TRIBUTARY INFLOW				264.5	25.1%	9.87E+02	94.8%	0.12	230.0	44.8
POINT-SOURCE INFLOW				37.8	3.6%	0.00E+00		0.00	189.0	1890.0
***TOTAL INFLOW				1054.7	100.0%	1.04E+03	100.0%	0.03	488.8	158.5
ADVECTIVE OUTFLOW				280.3	26.6%	9.13E+03		0.34	170.5	42.1
***TOTAL OUTFLOW				280.3	26.6%	9.13E+03		0.34	170.5	42.1
***RETENTION				774.4	73.4%	9.58E+03		0.13		

Overflow Rate (m/yr)	2.2	Nutrient Resid. Time (yrs)	0.2114
Hydraulic Resid. Time (yrs)	0.7953	Turnover Ratio	4.7
Reservoir Conc (mg/m3)	171	Retention Coef.	0.734

2005 Predicted vs Observed

New Eagle Lake 2005

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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Eagle**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	170.5	0.33	92.1%	174.0	0.21	92.4%
TOTAL N MG/M3	1476.0	0.16	72.7%	1476.0	0.16	72.7%
C.NUTRIENT MG/M3	92.7	0.16	88.4%	93.3	0.18	88.5%
CHL-A MG/M3	53.9	0.31	98.8%	55.0	0.27	98.9%
SECCHI M	1.0	0.37	48.2%	1.0	0.31	47.1%
ORGANIC N MG/M3	1396.9	0.30	98.3%			
TP-ORTHO-P MG/M3	95.4	0.34	88.8%			
ANTILOG PC-1	1684.4	0.45	92.9%	1308.8	0.38	90.0%
ANTILOG PC-2	20.5	0.25	98.6%	20.5	0.30	98.6%
(N - 150) / P	7.8	0.38	12.5%	7.6	0.27	11.9%
INORGANIC N / P	1.1	5.18	0.0%			
TURBIDITY 1/M	0.2	2.01	5.6%	0.2	2.01	5.6%
ZMIX * TURBIDITY	0.3	2.01	0.1%	0.3	2.01	0.1%
ZMIX / SECCHI	1.7	0.38	3.9%	1.7	0.32	4.2%
CHL-A * SECCHI	56.2	0.34	99.2%	56.2	0.41	99.2%
CHL-A / TOTAL P	0.3	0.38	77.4%	0.3	0.34	77.4%
FREQ(CHL-a>10) %	99.2	0.01	98.8%	99.3	0.01	98.9%
FREQ(CHL-a>20) %	90.1	0.09	98.8%	90.7	0.08	98.9%
FREQ(CHL-a>30) %	73.7	0.22	98.8%	74.8	0.18	98.9%
FREQ(CHL-a>40) %	56.8	0.34	98.8%	58.1	0.29	98.9%
FREQ(CHL-a>50) %	42.5	0.46	98.8%	43.8	0.39	98.9%
FREQ(CHL-a>60) %	31.4	0.57	98.8%	32.6	0.48	98.9%
CARLSON TSI-P	78.3	0.06	92.1%	78.5	0.04	92.4%
CARLSON TSI-CHLA	69.7	0.04	98.8%	69.9	0.04	98.9%
CARLSON TSI-SEC	59.4	0.09	51.8%	59.7	0.07	52.9%

Oak Lake
2005 Inputs

Oak Lake three bays 2005
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\South Fork Crow River TMDL\Individual Lakes\Oak Lake\Models\NewOak05.b
Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.1	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	20	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Upper Pool	2	1	0.13	2	0.5	2	0.12	0	0	0.84	0.2	0	0	0	0	0	0
2	Mid Pool	0	1	1.3	2.1	1	2.1	0.12	0	0	0.8	0.2	0	0	2.35	0	0	0
3	Near Dam	2	1	0.1	2	0.5	2	0.12	0	0	0.5	0.2	0	0	4.9	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	58	0	1290	0	8	0	1.04	0	0	0	0	0	0	0	0	0
2	0	0	132	0	2150	0	62	0	1	0	0	0	0	0	0	0	0	0
3	0	0	178	0	1980	0	62	0	0.7	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	7	0	1	0	0.25	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	site 2	1	1	0.532	0.08	0.1	0	0	272.7	0.2	0	0	0	0	0	0
2	site 3	3	1	0.332	0.07	0.1	0	0	298.2	0.2	0	0	0	0	0	0
3	direct	2	1	2.577	0.46	0.1	0	0	246.4	0.2	0	0	0	0	0	0
4	Site 2 Septic	1	3	0.01	0.1	0	0	0	75.1	0	0	0	0	0	0	0
5	Site 3 Septic	3	3	0.01	0.1	0	0	0	75.1	0	0	0	0	0	0	0
6	Direct Septic	2	3	0.01	0.1	0	0	0	312.9	0	0	0	0	0	0	0

2005 Mass Balances

Oak Lake three bays 2005

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Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	site 2	0.5	0.1	6.40E-05	0.10	0.15
2	1	3	site 3	0.3	0.1	4.90E-05	0.10	0.21
3	1	2	direct	2.6	0.5	2.12E-03	0.10	0.18
4	3	1	Site 2 Septic	0.0	0.1	0.00E+00	0.00	10.00
5	3	3	Site 3 Septic	0.0	0.1	0.00E+00	0.00	10.00
6	3	2	Direct Septic	0.0	0.1	0.00E+00	0.00	10.00
PRECIPITATION				1.5	1.7	1.13E-01	0.20	1.10
TRIBUTARY INFLOW				3.4	0.6	2.23E-03	0.08	0.18
POINT-SOURCE INFLOW				0.0	0.3	0.00E+00	0.00	10.00
***TOTAL INFLOW				5.0	2.6	1.16E-01	0.13	0.52
ADVECTIVE OUTFLOW				5.0	1.5	2.19E-01	0.31	0.30
***TOTAL OUTFLOW				5.0	1.5	2.19E-01	0.31	0.30
***EVAPORATION					1.1	1.03E-01	0.30	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	site 2	21.8	1.4%	2.38E+01	2.6%	0.22	272.7	41.0
2	1	3	site 3	20.9	1.4%	2.18E+01	2.4%	0.22	298.2	62.9
3	1	2	direct	113.3	7.4%	6.42E+02	69.7%	0.22	246.4	44.0
4	3	1	Site 2 Septic	7.5	0.5%	0.00E+00		0.00	75.1	751.0
5	3	3	Site 3 Septic	7.5	0.5%	0.00E+00		0.00	75.1	751.0
6	3	2	Direct Septic	31.3	2.0%	0.00E+00		0.00	312.9	3129.0
PRECIPITATION				30.6	2.0%	2.34E+02	25.4%	0.50	18.2	20.0
INTERNAL LOAD				1294.8	84.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				156.0	10.2%	6.88E+02	74.6%	0.17	255.8	45.3
POINT-SOURCE INFLOW				46.3	3.0%	0.00E+00		0.00	154.4	1543.7
***TOTAL INFLOW				1527.8	100.0%	9.22E+02	100.0%	0.02	589.2	305.5
ADVECTIVE OUTFLOW				194.1	12.7%	7.40E+03		0.44	127.6	38.8
***TOTAL OUTFLOW				194.1	12.7%	7.40E+03		0.44	127.6	38.8
***RETENTION				1333.6	87.3%	8.05E+03		0.07		

Overflow Rate (m/yr)	1.0	Nutrient Resid. Time (yrs)	0.2602
Hydraulic Resid. Time (yrs)	2.0959	Turnover Ratio	3.8
Reservoir Conc (mg/m3)	125	Retention Coef.	0.873

2005 Predicted vs Observed

Oak Lake three bays 2005

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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **4** **Area-Wtd Mean**

	Predicted Values--->			Observed Values--->		
Variable	Mean	CV	Rank	Mean	CV	Rank
TOTAL P MG/M3	124.6	0.36	85.6%	128.7		86.4%
TOTAL N MG/M3	2065.8		87.1%	2065.8		87.1%
C.NUTRIENT MG/M3	97.7	0.23	89.6%	99.7		90.0%
CHL-A MG/M3	57.9	0.37	99.1%	57.4		99.1%
SECCHI M	0.6	0.21	23.4%	1.0		45.1%
ORGANIC N MG/M3	1537.0	0.34	98.9%			
TP-ORTHO-P MG/M3	117.6	0.36	92.5%			
ANTILOG PC-1	2503.5	0.51	96.2%	1425.4		91.1%
ANTILOG PC-2	14.5	0.18	93.9%	20.1		98.5%
(N - 150) / P	15.7	0.38	45.3%	15.2		43.5%
INORGANIC N / P	111.5	30.09	90.8%			
TURBIDITY 1/M	0.8	0.17	61.3%	0.8	0.17	61.3%
ZMIX * TURBIDITY	1.6	0.20	19.9%	1.6	0.20	19.9%
ZMIX / SECCHI	3.5	0.23	28.9%	2.1	0.10	8.4%
CHL-A * SECCHI	34.0	0.22	95.6%	56.2		99.2%
CHL-A / TOTAL P	0.4	0.29	90.4%	0.4		89.4%
FREQ(CHL-a>10) %	93.0	0.04	99.1%	93.3		99.1%
FREQ(CHL-a>20) %	85.8	0.09	99.1%	85.9		99.1%
FREQ(CHL-a>30) %	73.8	0.20	99.1%	73.8		99.1%
FREQ(CHL-a>40) %	60.0	0.33	99.1%	59.9		99.1%
FREQ(CHL-a>50) %	47.4	0.46	99.1%	47.1		99.1%
FREQ(CHL-a>60) %	36.8	0.57	99.1%	36.5		99.1%
CARLSON TSI-P	73.4	0.07	85.6%	73.8		86.4%
CARLSON TSI-CHLA	69.4	0.05	99.1%	69.4		99.1%
CARLSON TSI-SEC	67.1	0.05	76.6%	60.3		54.9%

Segment: **1** **Upper Pool**

	Predicted Values--->			Observed Values--->		
Variable	Mean	CV	Rank	Mean	CV	Rank
TOTAL P MG/M3	57.4	0.64	58.0%	58.0		58.4%
TOTAL N MG/M3	1290.0		65.3%	1290.0		65.3%
C.NUTRIENT MG/M3	49.1	0.48	65.5%	49.5		65.9%
CHL-A MG/M3	7.6	0.73	39.4%	8.0		41.8%
SECCHI M	1.0	0.21	48.4%	1.0		48.0%
ORGANIC N MG/M3	394.4	0.34	35.9%			
TP-ORTHO-P MG/M3	29.4	0.39	49.2%			
ANTILOG PC-1	249.8	0.83	50.6%	206.6		44.8%
ANTILOG PC-2	5.0	0.44	31.1%	5.7		40.7%
(N - 150) / P	19.9	0.66	59.0%	19.7		58.4%
INORGANIC N / P	32.0	1.19	52.9%			
TURBIDITY 1/M	0.8	0.20	64.3%	0.8	0.20	64.3%
ZMIX * TURBIDITY	1.7	0.23	20.9%	1.7	0.23	20.9%
ZMIX / SECCHI	1.9	0.24	5.8%	1.9	0.12	5.9%
CHL-A * SECCHI	8.0	0.69	36.6%	8.3		38.7%
CHL-A / TOTAL P	0.1	0.27	27.1%	0.1		29.0%
FREQ(CHL-a>10) %	22.8	1.56	39.4%	25.1		41.8%
FREQ(CHL-a>20) %	3.1	2.60	39.4%	3.7		41.8%
FREQ(CHL-a>30) %	0.6	3.25	39.4%	0.7		41.8%
FREQ(CHL-a>40) %	0.1	3.71	39.4%	0.2		41.8%
FREQ(CHL-a>50) %	0.0	4.07	39.4%	0.1		41.8%
FREQ(CHL-a>60) %	0.0	4.37	39.4%	0.0		41.8%
CARLSON TSI-P	62.6	0.15	58.0%	62.7		58.4%
CARLSON TSI-CHLA	50.5	0.14	39.4%	51.0		41.8%
CARLSON TSI-SEC	59.3	0.05	51.6%	59.4		52.0%

Segment:	2	Mid Pool				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	127.6	0.35	86.2%	132.0		87.0%
TOTAL N MG/M3	2150.0		88.4%	2150.0		88.4%
C.NUTRIENT MG/M3	101.3	0.23	90.4%	103.5		90.8%
CHL-A MG/M3	60.9	0.38	99.2%	62.0		99.3%
SECCHI M	0.6	0.23	20.9%	1.0		46.0%
ORGANIC N MG/M3	1606.3	0.35	99.2%			
TP-ORTHO-P MG/M3	123.3	0.36	93.2%			
ANTILOG PC-1	2629.2	0.52	96.5%	1496.4		91.6%
ANTILOG PC-2	15.1	0.18	94.8%	21.9		99.0%
(N - 150) / P	15.7	0.36	45.3%	15.2		43.3%
INORGANIC N / P	128.0	30.83	92.9%			
TURBIDITY 1/M	0.8	0.20	62.2%	0.8	0.20	62.2%
ZMIX * TURBIDITY	1.7	0.23	20.9%	1.7	0.23	20.9%
ZMIX / SECCHI	3.6	0.24	31.4%	2.1	0.12	7.9%
CHL-A * SECCHI	35.5	0.23	96.1%	62.0		99.5%
CHL-A / TOTAL P	0.5	0.30	91.9%	0.5		91.5%
FREQ(CHL-a>10) %	99.5	0.01	99.2%	99.6		99.3%
FREQ(CHL-a>20) %	93.1	0.09	99.2%	93.5		99.3%
FREQ(CHL-a>30) %	79.8	0.21	99.2%	80.5		99.3%
FREQ(CHL-a>40) %	64.4	0.35	99.2%	65.4		99.3%
FREQ(CHL-a>50) %	50.4	0.48	99.2%	51.5		99.3%
FREQ(CHL-a>60) %	38.8	0.60	99.2%	39.8		99.3%
CARLSON TSI-P	74.1	0.07	86.2%	74.6		87.0%
CARLSON TSI-CHLA	70.9	0.05	99.2%	71.1		99.3%
CARLSON TSI-SEC	67.8	0.05	79.1%	60.0		54.0%

Segment:	3	Near Dam				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	173.8	0.32	92.4%	178.0		92.8%
TOTAL N MG/M3	1980.0		85.6%	1980.0		85.6%
C.NUTRIENT MG/M3	114.6	0.14	92.8%	115.8		92.9%
CHL-A MG/M3	84.5	0.33	99.8%	62.0		99.3%
SECCHI M	0.6	0.26	19.7%	0.7		28.4%
ORGANIC N MG/M3	2121.8	0.33	99.8%			
TP-ORTHO-P MG/M3	158.2	0.35	96.0%			
ANTILOG PC-1	3799.1	0.46	98.2%	2086.5		94.9%
ANTILOG PC-2	18.9	0.13	98.0%	16.6		96.4%
(N - 150) / P	10.5	0.33	24.1%	10.3		23.0%
INORGANIC N / P	0.1	4.65	0.0%			
TURBIDITY 1/M	0.5	0.20	41.1%	0.5	0.20	41.1%
ZMIX * TURBIDITY	1.0	0.23	7.0%	1.0	0.23	7.0%
ZMIX / SECCHI	3.5	0.26	30.3%	2.9	0.12	18.9%
CHL-A * SECCHI	47.8	0.15	98.5%	43.4		98.0%
CHL-A / TOTAL P	0.5	0.31	92.4%	0.3		81.7%
FREQ(CHL-a>10) %	99.9	0.00	99.8%	99.6		99.3%
FREQ(CHL-a>20) %	97.8	0.03	99.8%	93.5		99.3%
FREQ(CHL-a>30) %	91.3	0.09	99.8%	80.5		99.3%
FREQ(CHL-a>40) %	81.5	0.17	99.8%	65.4		99.3%
FREQ(CHL-a>50) %	70.4	0.26	99.8%	51.5		99.3%
FREQ(CHL-a>60) %	59.6	0.35	99.8%	39.8		99.3%
CARLSON TSI-P	78.5	0.06	92.4%	78.9		92.8%
CARLSON TSI-CHLA	74.1	0.04	99.8%	71.1		99.3%
CARLSON TSI-SEC	68.2	0.05	80.3%	65.1		71.6%

2006 Inputs

New Oak Lake three bays 2006

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\South Fork Crow River TMDL\Individual Lakes\Oak Lake\Models\NewOak06.btb**

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.6	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	20	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Upper Pool	2	1	0.13	2	0.5	2	0.12	0	0	0.84	0.12	0	0	0	0	0	0
2	Mid Pool	0	1	1.3	2.1	1	2.1	0.12	0	0	1.11	0.23	0	0	4.5	0	0	0
3	Near Dam	2	1	0.1	2	0.5	2	0.12	0	0	0.67	0.37	0	0	3	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	59	0.16704	1357	0.13594	7.4	0.2447	1.05	0.10064	0	0	0	0	0	0	0	0
2	0	0	186	0.09987	2633	0.1155	74	0.12266	0.45	0.09699	0	0	0	0	0	0	0	0
3	0	0	182	0.13183	1986	0.05432	66.5	0.12646	0.6	0.12849	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	9.5	0	1	0	0.25	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	site 2	1	1	0.532	0.05	0.1	0	0	466.6	0.2	0	0	0	0	0	0
2	site 3	3	1	0.332	0.04	0.1	0	0	510.3	0.2	0	0	0	0	0	0
3	direct	2	1	2.577	0.27	0.1	0	0	421.6	0.2	0	0	0	0	0	0
4	Direct Septic	2	1	0.01	0.1	0	0	0	312.9	0	0	0	0	0	0	0
5	Site 2 Septic	1	1	0.01	0.1	0	0	0	75.1	0	0	0	0	0	0	0
6	Site 3 Septic	3	1	0.01	0.1	0	0	0	75.1	0	0	0	0	0	0	0

2006 Mass Balances

New Oak Lake three bays 2006

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Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	site 2	0.5	0.1	2.50E-05	0.10	0.09
2	1	3	site 3	0.3	0.0	1.60E-05	0.10	0.12
3	1	2	direct	2.6	0.3	7.29E-04	0.10	0.10
4	1	2	Direct Septic	0.0	0.1	0.00E+00	0.00	10.00
5	1	1	Site 2 Septic	0.0	0.1	0.00E+00	0.00	10.00
6	1	3	Site 3 Septic	0.0	0.1	0.00E+00	0.00	10.00
PRECIPITATION				1.5	0.9	3.37E-02	0.20	0.60
TRIBUTARY INFLOW				3.5	0.7	7.70E-04	0.04	0.19
***TOTAL INFLOW				5.0	1.6	3.45E-02	0.12	0.32
ADVECTIVE OUTFLOW				5.0	0.5	1.38E-01	0.73	0.10
***TOTAL OUTFLOW				5.0	0.5	1.38E-01	0.73	0.10
***EVAPORATION					1.1	1.03E-01	0.30	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	site 2	23.3	0.9%	2.72E+01	2.9%	0.22	466.6	43.9
2	1	3	site 3	20.4	0.8%	2.08E+01	2.2%	0.22	510.3	61.5
3	1	2	direct	113.8	4.6%	6.48E+02	69.7%	0.22	421.6	44.2
4	1	2	Direct Septic	31.3	1.3%	0.00E+00		0.00	312.9	3129.0
5	1	1	Site 2 Septic	7.5	0.3%	0.00E+00		0.00	75.1	751.0
6	1	3	Site 3 Septic	7.5	0.3%	0.00E+00		0.00	75.1	751.0
PRECIPITATION				30.6	1.2%	2.34E+02	25.2%	0.50	33.3	20.0
INTERNAL LOAD				2246.3	90.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				203.9	8.2%	6.96E+02	74.8%	0.13	308.9	58.7
***TOTAL INFLOW				2480.8	100.0%	9.30E+02	100.0%	0.01	1572.1	496.1
ADVECTIVE OUTFLOW				95.0	3.8%	5.77E+03		0.80	187.4	19.0
***TOTAL OUTFLOW				95.0	3.8%	5.77E+03		0.80	187.4	19.0
***RETENTION				2385.8	96.2%	6.54E+03		0.03		

Overflow Rate (m/yr)	0.3	Nutrient Resid. Time (yrs)	0.2267
Hydraulic Resid. Time (yrs)	6.2919	Turnover Ratio	4.4
Reservoir Conc (mg/m3)	176	Retention Coef.	0.962

2006 Predicted vs Observed

New Oak Lake three bays 2006

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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	176.3	0.38	92.6%	174.9	0.10	92.5%
TOTAL N MG/M3	2482.3	0.10	92.2%	2482.3	0.11	92.2%
C.NUTRIENT MG/M3	130.1	0.22	94.7%	129.5	0.11	94.6%
CHL-A MG/M3	66.4	0.35	99.4%	67.9	0.12	99.5%
SECCHI M	0.5	0.20	16.4%	0.5	0.10	16.2%
ORGANIC N MG/M3	1749.8	0.33	99.5%			
TP-ORTHO-P MG/M3	139.1	0.33	94.7%			
ANTILOG PC-1	3725.0	0.47	98.1%	3349.8	0.14	97.7%
ANTILOG PC-2	13.2	0.19	91.5%	12.7	0.10	90.2%
(N - 150) / P	13.6	0.42	37.2%	13.7	0.13	37.7%
INORGANIC N / P	19.6	1.79	33.7%			
TURBIDITY 1/M	1.1	0.21	73.5%	1.1	0.21	73.5%
ZMIX * TURBIDITY	2.2	0.23	32.4%	2.2	0.23	32.4%
ZMIX / SECCHI	4.3	0.21	42.8%	4.3	0.14	43.6%
CHL-A * SECCHI	31.3	0.24	94.3%	31.6	0.14	94.5%
CHL-A / TOTAL P	0.4	0.33	83.3%	0.4	0.14	84.4%
FREQ(CHL-a>10) %	93.5	0.04	99.4%	93.1	0.01	99.5%
FREQ(CHL-a>20) %	88.1	0.06	99.4%	88.4	0.01	99.5%
FREQ(CHL-a>30) %	79.0	0.14	99.4%	79.8	0.04	99.5%
FREQ(CHL-a>40) %	67.3	0.25	99.4%	68.5	0.08	99.5%
FREQ(CHL-a>50) %	55.5	0.36	99.4%	56.9	0.11	99.5%
FREQ(CHL-a>60) %	44.9	0.46	99.4%	46.3	0.14	99.5%
CARLSON TSI-P	78.2	0.07	92.6%	78.1	0.02	92.5%
CARLSON TSI-CHLA	70.7	0.05	99.4%	70.8	0.01	99.5%
CARLSON TSI-SEC	70.1	0.04	83.6%	70.2	0.02	83.8%

Segment: 1 Upper Pool

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	60.9	0.73	60.5%	59.0	0.17	59.2%
TOTAL N MG/M3	1357.0	0.14	68.2%	1357.0	0.14	68.2%
C.NUTRIENT MG/M3	52.1	0.55	68.1%	50.9	0.16	67.1%
CHL-A MG/M3	8.1	0.81	42.7%	7.4	0.24	37.9%
SECCHI M	1.0	0.17	48.0%	1.0	0.10	48.5%
ORGANIC N MG/M3	405.9	0.39	38.1%			
TP-ORTHO-P MG/M3	30.3	0.42	50.4%			
ANTILOG PC-1	271.5	0.93	53.1%	190.2	0.25	42.3%
ANTILOG PC-2	5.1	0.46	33.3%	5.4	0.18	37.4%
(N - 150) / P	19.8	0.77	59.0%	20.5	0.22	60.7%
INORGANIC N / P	31.1	1.34	51.9%			
TURBIDITY 1/M	0.8	0.12	64.3%	0.8	0.12	64.3%
ZMIX * TURBIDITY	1.7	0.17	20.9%	1.7	0.17	20.9%
ZMIX / SECCHI	1.9	0.21	5.9%	1.9	0.15	5.7%
CHL-A * SECCHI	8.5	0.73	39.6%	7.8	0.26	35.0%
CHL-A / TOTAL P	0.1	0.27	27.4%	0.1	0.29	24.1%
FREQ(CHL-a>10) %	26.1	1.62	42.7%	21.3	0.54	37.9%
FREQ(CHL-a>20) %	3.9	2.76	42.7%	2.8	0.93	37.9%
FREQ(CHL-a>30) %	0.8	3.46	42.7%	0.5	1.19	37.9%
FREQ(CHL-a>40) %	0.2	3.96	42.7%	0.1	1.38	37.9%
FREQ(CHL-a>50) %	0.1	4.36	42.7%	0.0	1.54	37.9%
FREQ(CHL-a>60) %	0.0	4.68	42.7%	0.0	1.67	37.9%
CARLSON TSI-P	63.4	0.17	60.5%	62.9	0.04	59.2%
CARLSON TSI-CHLA	51.2	0.16	42.7%	50.2	0.05	37.9%
CARLSON TSI-SEC	59.4	0.04	52.0%	59.3	0.02	51.5%

Segment: 2 Mid Pool

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	187.4	0.38	93.5%	186.0	0.10	93.4%
TOTAL N MG/M3	2633.0	0.12	93.4%	2633.0	0.12	93.4%
C.NUTRIENT MG/M3	138.9	0.22	95.5%	138.3	0.11	95.5%
CHL-A MG/M3	70.9	0.35	99.6%	74.0	0.12	99.6%
SECCHI M	0.5	0.21	13.1%	0.4	0.10	12.5%
ORGANIC N MG/M3	1857.6	0.33	99.6%			
TP-ORTHO-P MG/M3	148.4	0.33	95.4%			
ANTILOG PC-1	4054.5	0.47	98.4%	3725.4	0.15	98.1%
ANTILOG PC-2	13.7	0.20	92.5%	13.2	0.11	91.5%
(N - 150) / P	13.2	0.40	35.7%	13.3	0.16	36.1%
INORGANIC N / P	19.9	1.91	34.3%			
TURBIDITY 1/M	1.1	0.23	75.2%	1.1	0.23	75.2%
ZMIX * TURBIDITY	2.3	0.26	34.9%	2.3	0.26	34.9%
ZMIX / SECCHI	4.6	0.22	47.0%	4.7	0.15	48.5%
CHL-A * SECCHI	32.6	0.25	95.0%	33.3	0.16	95.3%
CHL-A / TOTAL P	0.4	0.34	85.0%	0.4	0.16	86.7%
FREQ(CHL-a>10) %	99.8	0.00	99.6%	99.8	0.00	99.6%
FREQ(CHL-a>20) %	95.8	0.05	99.6%	96.4	0.02	99.6%
FREQ(CHL-a>30) %	85.9	0.15	99.6%	87.4	0.04	99.6%
FREQ(CHL-a>40) %	73.0	0.26	99.6%	75.2	0.08	99.6%
FREQ(CHL-a>50) %	60.0	0.36	99.6%	62.6	0.12	99.6%
FREQ(CHL-a>60) %	48.4	0.47	99.6%	51.1	0.15	99.6%
CARLSON TSI-P	79.6	0.07	93.5%	79.5	0.02	93.4%
CARLSON TSI-CHLA	72.4	0.05	99.6%	72.8	0.02	99.6%
CARLSON TSI-SEC	71.2	0.04	86.9%	71.5	0.02	87.5%

Segment: 3 Near Dam

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	182.3	0.38	93.1%	182.0	0.13	93.1%
TOTAL N MG/M3	1986.0	0.05	85.7%	1986.0	0.05	85.7%
C.NUTRIENT MG/M3	117.2	0.16	93.1%	117.1	0.09	93.1%
CHL-A MG/M3	82.8	0.36	99.8%	66.5	0.13	99.4%
SECCHI M	0.5	0.26	17.0%	0.6	0.13	22.0%
ORGANIC N MG/M3	2095.2	0.34	99.8%			
TP-ORTHO-P MG/M3	159.2	0.36	96.1%			
ANTILOG PC-1	3931.1	0.48	98.3%	2574.5	0.17	96.4%
ANTILOG PC-2	17.6	0.18	97.2%	15.4	0.13	95.2%
(N - 150) / P	10.1	0.39	22.1%	10.1	0.14	22.2%
INORGANIC N / P	0.0	3.07	0.0%			
TURBIDITY 1/M	0.7	0.37	54.3%	0.7	0.37	54.3%
ZMIX * TURBIDITY	1.3	0.39	13.5%	1.3	0.39	13.5%
ZMIX / SECCHI	3.8	0.26	35.2%	3.3	0.17	26.9%
CHL-A * SECCHI	43.3	0.22	97.9%	39.9	0.18	97.3%
CHL-A / TOTAL P	0.5	0.33	90.7%	0.4	0.18	83.6%
FREQ(CHL-a>10) %	99.9	0.00	99.8%	99.7	0.00	99.4%
FREQ(CHL-a>20) %	97.6	0.03	99.8%	94.8	0.02	99.4%
FREQ(CHL-a>30) %	90.8	0.10	99.8%	83.5	0.06	99.4%
FREQ(CHL-a>40) %	80.6	0.19	99.8%	69.5	0.10	99.4%
FREQ(CHL-a>50) %	69.3	0.29	99.8%	56.0	0.14	99.4%
FREQ(CHL-a>60) %	58.3	0.38	99.8%	44.3	0.18	99.4%
CARLSON TSI-P	79.2	0.07	93.1%	79.2	0.02	93.1%
CARLSON TSI-CHLA	73.9	0.05	99.8%	71.8	0.02	99.4%
CARLSON TSI-SEC	69.3	0.05	83.0%	67.4	0.03	78.0%

Swede Lake
2005 Inputs

New Swede 2005
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Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	1.1	0.2
Evaporation (m)	1	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	20	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seq	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Swede	0	1	1.809627	2.0698	1.5	2.0698	0.12	0	0	0.37	1.62	0	0	7.25	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seq	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	294	0.129974	4050	0.08642	75	0.297972	0.669	0.251544	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seq	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	0.65	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Direct inflow	1	1	1.414	0.28	0.1	0	0	256.9	0.2	0	0	0	0	0	0
2	Direct septic	1	3	0	0.1	0.1	0	0	188	0.2	0	0	0	0	0	0

2005 Mass Balances

New Swede 2005

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Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Direct inflow	1.4	0.3	7.84E-04	0.10	0.20
2	3	1	Direct septic		0.1	1.00E-04	0.10	
PRECIPITATION				1.8	2.0	1.58E-01	0.20	1.10
TRIBUTARY INFLOW				1.4	0.3	7.84E-04	0.10	0.20
POINT-SOURCE INFLOW					0.1	1.00E-04	0.10	
***TOTAL INFLOW				3.2	2.4	1.59E-01	0.17	0.74
ADVECTIVE OUTFLOW				3.2	0.6	4.54E-01	1.20	0.17
***TOTAL OUTFLOW				3.2	0.6	4.54E-01	1.20	0.17
***EVAPORATION					1.8	2.95E-01	0.30	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Direct inflow	71.9	1.5%	2.59E+02	42.8%	0.22	256.9	50.9
2	3	1	Direct septic	18.8	0.4%	1.77E+01	2.9%	0.22	188.0	
PRECIPITATION				36.2	0.7%	3.27E+02	54.2%	0.50	18.2	20.0
INTERNAL LOAD				4792.0	97.4%	0.00E+00		0.00		
TRIBUTARY INFLOW				71.9	1.5%	2.59E+02	42.8%	0.22	256.9	50.9
POINT-SOURCE INFLOW				18.8	0.4%	1.77E+01	2.9%	0.22	188.0	
***TOTAL INFLOW				4918.9	100.0%	6.04E+02	100.0%	0.00	2075.0	1525.9
ADVECTIVE OUTFLOW				164.0	3.3%	4.11E+04		1.24	292.4	50.9
***TOTAL OUTFLOW				164.0	3.3%	4.11E+04		1.24	292.4	50.9
***RETENTION				4754.9	96.7%	4.16E+04		0.04		

Overflow Rate (m/yr)	0.3	Nutrient Resid. Time (yrs)	0.2226
Hydraulic Resid. Time (yrs)	6.6770	Turnover Ratio	4.5
Reservoir Conc (mg/m3)	292	Retention Coef.	0.967

2005 Predicted vs Observed

New Swede 2005

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDI**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Swede**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	292.4	0.42	97.8%	294.0	0.13	97.8%
TOTAL N MG/M3	4050.0	0.09	98.5%	4050.0	0.09	98.5%
C.NUTRIENT MG/M3	217.4	0.24	98.8%	218.0	0.11	98.8%
CHL-A MG/M3	76.0	0.34	99.7%	75.0	0.30	99.7%
SECCHI M	0.7	0.37	26.0%	0.7	0.25	26.4%
ORGANIC N MG/M3	1917.4	0.32	99.7%			
TP-ORTHO-P MG/M3	139.9	0.34	94.7%			
ANTILOG PC-1	4653.8	0.47	98.8%	2607.4	0.36	96.4%
ANTILOG PC-2	16.9	0.33	96.7%	18.2	0.28	97.6%
(N - 150) / P	13.3	0.45	36.1%	13.3	0.15	35.8%
INORGANIC N / P	14.0	0.88	22.4%			
TURBIDITY 1/M	0.4	1.62	28.6%	0.4	1.62	28.6%
ZMIX * TURBIDITY	0.8	1.62	3.4%	0.8	1.62	3.4%
ZMIX / SECCHI	3.1	0.37	23.4%	3.1	0.27	22.8%
CHL-A * SECCHI	50.3	0.45	98.8%	50.2	0.39	98.8%
CHL-A / TOTAL P	0.3	0.43	67.1%	0.3	0.32	66.1%
FREQ(CHL-a>10) %	99.8	0.00	99.7%	99.8	0.00	99.7%
FREQ(CHL-a>20) %	96.7	0.04	99.7%	96.6	0.04	99.7%
FREQ(CHL-a>30) %	88.3	0.12	99.7%	87.9	0.11	99.7%
FREQ(CHL-a>40) %	76.6	0.22	99.7%	75.9	0.19	99.7%
FREQ(CHL-a>50) %	64.3	0.32	99.7%	63.5	0.28	99.7%
FREQ(CHL-a>60) %	52.8	0.41	99.7%	52.0	0.36	99.7%
CARLSON TSI-P	86.0	0.07	97.8%	86.1	0.02	97.8%
CARLSON TSI-CHLA	73.1	0.05	99.7%	73.0	0.04	99.7%
CARLSON TSI-SEC	65.9	0.08	74.0%	65.8	0.05	73.6%

2006 Inputs

New Swede 2006

File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\South Fork Crow River TMDL\Individual Lakes\Swede Lake\Models\NewSwede2

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.6	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	20	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Swede	0	1	1.809627	2.0698	1.5	2.0698	0.12	0	0	0.99	0.27	0	0	9.25	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	344	0.079039	3500	0.081788	96	0.013222	0.411	0.116051	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Direct inflow	1	1	1.414	0.17	0.1	0	0	439.5	0.2	0	0	0	0	0	0
2	Direct septic	1	3	0	0.1	0.1	0	0	188	0.2	0	0	0	0	0	0

2006 Mass Balance

New Swede 2006
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\South Fork Crow River TMDL\Individual Lakes\Swede Lake\Models\NewSwede2006.btb

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Direct inflow	1.4	0.2	2.89E-04	0.10	0.12
2	3	1	Direct septic		0.1	1.00E-04	0.10	
PRECIPITATION				1.8	1.1	4.72E-02	0.20	0.60
TRIBUTARY INFLOW				1.4	0.2	2.89E-04	0.10	0.12
POINT-SOURCE INFLOW					0.1	1.00E-04	0.10	
***TOTAL INFLOW				3.2	1.4	4.75E-02	0.16	0.42
ADVECTIVE OUTFLOW				3.2	0.1	1.92E-01	4.92	0.03
***TOTAL OUTFLOW				3.2	0.1	1.92E-01	4.92	0.03
***EVAPORATION					1.3	1.44E-01	0.30	

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**
Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Direct inflow	74.7	1.2%	2.79E+02	44.7%	0.22	439.5	52.8
2	3	1	Direct septic	18.8	0.3%	1.77E+01	2.8%	0.22	188.0	
PRECIPITATION				36.2	0.6%	3.27E+02	52.4%	0.50	33.3	20.0
INTERNAL LOAD				6113.9	97.9%	0.00E+00		0.00		
TRIBUTARY INFLOW				74.7	1.2%	2.79E+02	44.7%	0.22	439.5	52.8
POINT-SOURCE INFLOW				18.8	0.3%	1.77E+01	2.8%	0.22	188.0	
***TOTAL INFLOW				6243.6	100.0%	6.24E+02	100.0%	0.00	4605.2	1936.8
ADVECTIVE OUTFLOW				30.5	0.5%	2.25E+04		4.92	342.5	9.5
***TOTAL OUTFLOW				30.5	0.5%	2.25E+04		4.92	342.5	9.5
***RETENTION				6213.2	99.5%	2.30E+04		0.02		

Overflow Rate (m/yr)	0.0	Nutrient Resid. Time (yrs)	0.2055
Hydraulic Resid. Time (yrs)	42.0673	Turnover Ratio	4.9
Reservoir Conc (mg/m3)	342	Retention Coef.	0.995

2006 Predicted vs Observed

New Swede 2006

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDI**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Swede**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	342.5	0.44	98.6%	344.0	0.08	98.6%
TOTAL N MG/M3	3500.0	0.08	97.5%	3500.0	0.08	97.5%
C.NUTRIENT MG/M3	216.4	0.19	98.8%	216.8	0.08	98.8%
CHL-A MG/M3	100.5	0.30	99.9%	96.0	0.01	99.9%
SECCHI M	0.4	0.22	9.6%	0.4	0.12	10.2%
ORGANIC N MG/M3	2524.1	0.30	99.9%			
TP-ORTHO-P MG/M3	198.3	0.31	97.7%			
ANTILOG PC-1	7596.1	0.40	99.6%	5189.7	0.11	99.0%
ANTILOG PC-2	15.2	0.17	95.0%	14.7	0.09	94.2%
(N - 150) / P	9.8	0.46	20.9%	9.7	0.11	20.7%
INORGANIC N / P	6.8	1.35	6.8%			
TURBIDITY 1/M	1.0	0.27	71.0%	1.0	0.27	71.0%
ZMIX * TURBIDITY	2.0	0.30	29.0%	2.0	0.30	29.0%
ZMIX / SECCHI	5.2	0.22	55.5%	5.0	0.16	53.7%
CHL-A * SECCHI	40.2	0.20	97.4%	39.5	0.12	97.2%
CHL-A / TOTAL P	0.3	0.44	73.7%	0.3	0.08	71.1%
FREQ(CHL-a>10) %	100.0	0.00	99.9%	100.0	0.00	99.9%
FREQ(CHL-a>20) %	98.9	0.01	99.9%	98.7	0.00	99.9%
FREQ(CHL-a>30) %	95.0	0.05	99.9%	94.1	0.00	99.9%
FREQ(CHL-a>40) %	88.0	0.11	99.9%	86.5	0.01	99.9%
FREQ(CHL-a>50) %	79.3	0.17	99.9%	77.1	0.01	99.9%
FREQ(CHL-a>60) %	69.9	0.24	99.9%	67.3	0.01	99.9%
CARLSON TSI-P	88.3	0.07	98.6%	88.4	0.01	98.6%
CARLSON TSI-CHLA	75.8	0.04	99.9%	75.4	0.00	99.9%
CARLSON TSI-SEC	73.2	0.04	90.4%	72.8	0.02	89.8%

BATHTUB TMDL Load Response Models

Eagle Lake

TMDL Inputs

Eagle Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three Lake TMDL Model Runs\Eagle Lake TMDL.btb**

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0	0.0
Evaporation (m)	0	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	0	0.50
Total N	1000	0.50
Ortho P	0	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Eagle Lake	0	1	0.734468	1.780313	0.5	1.7	0	0	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Total P load	1	1	1	0.791	0	0	0	207.01	0	0	0	0	0	0	0

TMDL Mass Balance

Eagle Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three Lake TMDL Model Runs\Eagle Lake TMDL.btb

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Total P load	1.0	0.8	0.00E+00	0.00	0.79
TRIBUTARY INFLOW				1.0	0.8	0.00E+00	0.00	0.79
***TOTAL INFLOW				1.7	0.8	0.00E+00	0.00	0.46
ADVECTIVE OUTFLOW				1.7	0.8	0.00E+00	0.00	0.46
***TOTAL OUTFLOW				1.7	0.8	0.00E+00	0.00	0.46

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Total P load	163.7	100.0%	0.00E+00		0.00	207.0	163.7
TRIBUTARY INFLOW				163.7	100.0%	0.00E+00		0.00	207.0	163.7
***TOTAL INFLOW				163.7	100.0%	0.00E+00		0.00	207.0	94.4
ADVECTIVE OUTFLOW				47.5	29.0%	2.21E+02		0.31	60.1	27.4
***TOTAL OUTFLOW				47.5	29.0%	2.21E+02		0.31	60.1	27.4
***RETENTION				116.2	71.0%	2.21E+02		0.13		

Overflow Rate (m/yr)	1.1	Nutrient Resid. Time (yrs)	0.4796
Hydraulic Resid. Time (yrs)	1.6531	Turnover Ratio	2.1
Reservoir Conc (mg/m3)	60	Retention Coef.	0.710

TMDL Predicted

Eagle Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 **

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Eagle Lake**

	Predicted Values--->		
Variable	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	60.1	0.28	59.9%
CHL-A MG/M3	42.8	0.40	97.6%
SECCHI M	1.4	0.37	62.9%
ORGANIC N MG/M3	1137.9	0.36	95.7%
TP-ORTHO-P MG/M3	73.9	0.44	82.9%
ANTILOG PC-1	775.7	0.71	81.1%
ANTILOG PC-2	22.0	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%
ZMIX / SECCHI	1.2	0.37	1.0%
CHL-A * SECCHI	59.3	0.11	99.4%
CHL-A / TOTAL P	0.7	0.26	97.9%
FREQ(CHL-a>10) %	97.9	0.03	97.6%
FREQ(CHL-a>20) %	82.0	0.21	97.6%
FREQ(CHL-a>30) %	60.3	0.41	97.6%
FREQ(CHL-a>40) %	42.0	0.60	97.6%
FREQ(CHL-a>50) %	28.7	0.76	97.6%
FREQ(CHL-a>60) %	19.6	0.91	97.6%
CARLSON TSI-P	63.2	0.06	59.9%
CARLSON TSI-CHLA	67.4	0.06	97.6%
CARLSON TSI-SEC	55.3	0.10	37.1%

Oak Lake
TMDL Inputs

Oak Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three Lake TMDL Model Runs\Oak Lake TMDL.btb**

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0	0.0
Evaporation (m)	0	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	0	0.50
Total N	1000	0.50
Ortho P	0	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seq	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Oak Lake	0	1	1.42641	1.087169	0.5	1	0	0	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seq	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seq	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Total P load	1	1	1	0.426	0	0	0	344.71	0	0	0	0	0	0	0

TMDL Mass Balance

Oak Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three Lake TMDL Model Runs\Oak Lake TMDL.btb

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Total P load	1.0	0.4	0.00E+00	0.00	0.43
TRIBUTARY INFLOW				1.0	0.4	0.00E+00	0.00	0.43
***TOTAL INFLOW				2.4	0.4	0.00E+00	0.00	0.18
ADVECTIVE OUTFLOW				2.4	0.4	0.00E+00	0.00	0.18
***TOTAL OUTFLOW				2.4	0.4	0.00E+00	0.00	0.18

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Total P load	146.8	100.0%	0.00E+00		0.00	344.7	146.8
TRIBUTARY INFLOW				146.8	100.0%	0.00E+00		0.00	344.7	146.8
***TOTAL INFLOW				146.8	100.0%	0.00E+00		0.00	344.7	60.5
ADVECTIVE OUTFLOW				25.6	17.4%	8.61E+01		0.36	60.1	10.5
***TOTAL OUTFLOW				25.6	17.4%	8.61E+01		0.36	60.1	10.5
***RETENTION				121.3	82.6%	8.61E+01		0.08		

Overflow Rate (m/yr)	0.3	Nutrient Resid. Time (yrs)	0.6342
Hydraulic Resid. Time (yrs)	3.6403	Turnover Ratio	1.6
Reservoir Conc (mg/m3)	60	Retention Coef.	0.826

TMDL Predicted

Oak Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 **

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Oak Lake**

Variable	Mean	CV	Rank
	Predicted Values--->		
TOTAL P MG/M3	60.1	0.36	59.9%
CHL-A MG/M3	47.5	0.50	98.2%
SECCHI M	1.3	0.47	58.1%
ORGANIC N MG/M3	1246.5	0.45	97.1%
TP-ORTHO-P MG/M3	82.4	0.54	85.6%
ANTILOG PC-1	936.5	0.89	84.7%
ANTILOG PC-2	21.9	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%
ZMIX / SECCHI	0.8	0.46	0.1%
CHL-A * SECCHI	59.9	0.11	99.4%
CHL-A / TOTAL P	0.8	0.27	98.6%
FREQ(CHL-a>10) %	98.6	0.03	98.2%
FREQ(CHL-a>20) %	86.1	0.21	98.2%
FREQ(CHL-a>30) %	66.7	0.44	98.2%
FREQ(CHL-a>40) %	48.7	0.67	98.2%
FREQ(CHL-a>50) %	34.7	0.86	98.2%
FREQ(CHL-a>60) %	24.6	1.03	98.2%
CARLSON TSI-P	63.2	0.08	59.9%
CARLSON TSI-CHLA	68.5	0.07	98.2%
CARLSON TSI-SEC	56.7	0.12	41.9%

Swede Lake
TMDL Input

Swede Lake TMDL
File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three Lake TMDL Model Runs\Swede Lake TMDL.btb**
Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0	0.0
Evaporation (m)	0	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	0	0.50
Total N	1000	0.50
Ortho P	0	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Swede Lake	0	1	1.809628	2.069798	0.5	2	0	0	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Total P load	1	1	1	0.196	0	0	0	1203.53	0	0	0	0	0	0	0

TMDL Mass Balances

Swede Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three Lake TMDL Model Runs\Swede Lake TMDL.btb

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Total P load	1.0	0.2	0.00E+00	0.00	0.20
TRIBUTARY INFLOW				1.0	0.2	0.00E+00	0.00	0.20
***TOTAL INFLOW				2.8	0.2	0.00E+00	0.00	0.07
ADVECTIVE OUTFLOW				2.8	0.2	0.00E+00	0.00	0.07
***TOTAL OUTFLOW				2.8	0.2	0.00E+00	0.00	0.07

Overall Mass Balance Based Upon — **Predicted** — **Outflow & Reservoir Concentrations**

Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Total P load	235.9	100.0%	0.00E+00		0.00	1203.5	235.9
TRIBUTARY INFLOW				235.9	100.0%	0.00E+00		0.00	1203.5	235.9
***TOTAL INFLOW				235.9	100.0%	0.00E+00		0.00	1203.5	84.0
ADVECTIVE OUTFLOW				10.9	4.6%	2.07E+01		0.42	55.6	3.9
***TOTAL OUTFLOW				10.9	4.6%	2.07E+01		0.42	55.6	3.9
***RETENTION				225.0	95.4%	2.07E+01		0.02		

Overflow Rate (m/yr)	0.1	Nutrient Resid. Time (yrs)	0.8829
Hydraulic Resid. Time (yrs)	19.1100	Turnover Ratio	1.1
Reservoir Conc (mg/m3)	56	Retention Coef.	0.954

TMDL Predicted

Swede Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Three**

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Swede Lake**

	Predicted Values--->		
Variable	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	55.6	0.42	56.6%
CHL-A MG/M3	38.0	0.52	96.5%
SECCHI M	1.5	0.47	67.9%
ORGANIC N MG/M3	1029.0	0.45	93.6%
TP-ORTHO-P MG/M3	65.4	0.55	79.4%
ANTILOG PC-1	628.9	0.91	76.4%
ANTILOG PC-2	22.0	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.2		0.0%
ZMIX / SECCHI	1.3	0.46	1.3%
CHL-A * SECCHI	58.5	0.12	99.3%
CHL-A / TOTAL P	0.7	0.26	97.5%
FREQ(CHL-a>10) %	96.7	0.06	96.5%
FREQ(CHL-a>20) %	76.6	0.34	96.5%
FREQ(CHL-a>30) %	52.8	0.63	96.5%
FREQ(CHL-a>40) %	34.7	0.89	96.5%
FREQ(CHL-a>50) %	22.6	1.11	96.5%
FREQ(CHL-a>60) %	14.7	1.29	96.5%
CARLSON TSI-P	62.1	0.10	56.6%
CARLSON TSI-CHLA	66.3	0.08	96.5%
CARLSON TSI-SEC	53.8	0.12	32.1%