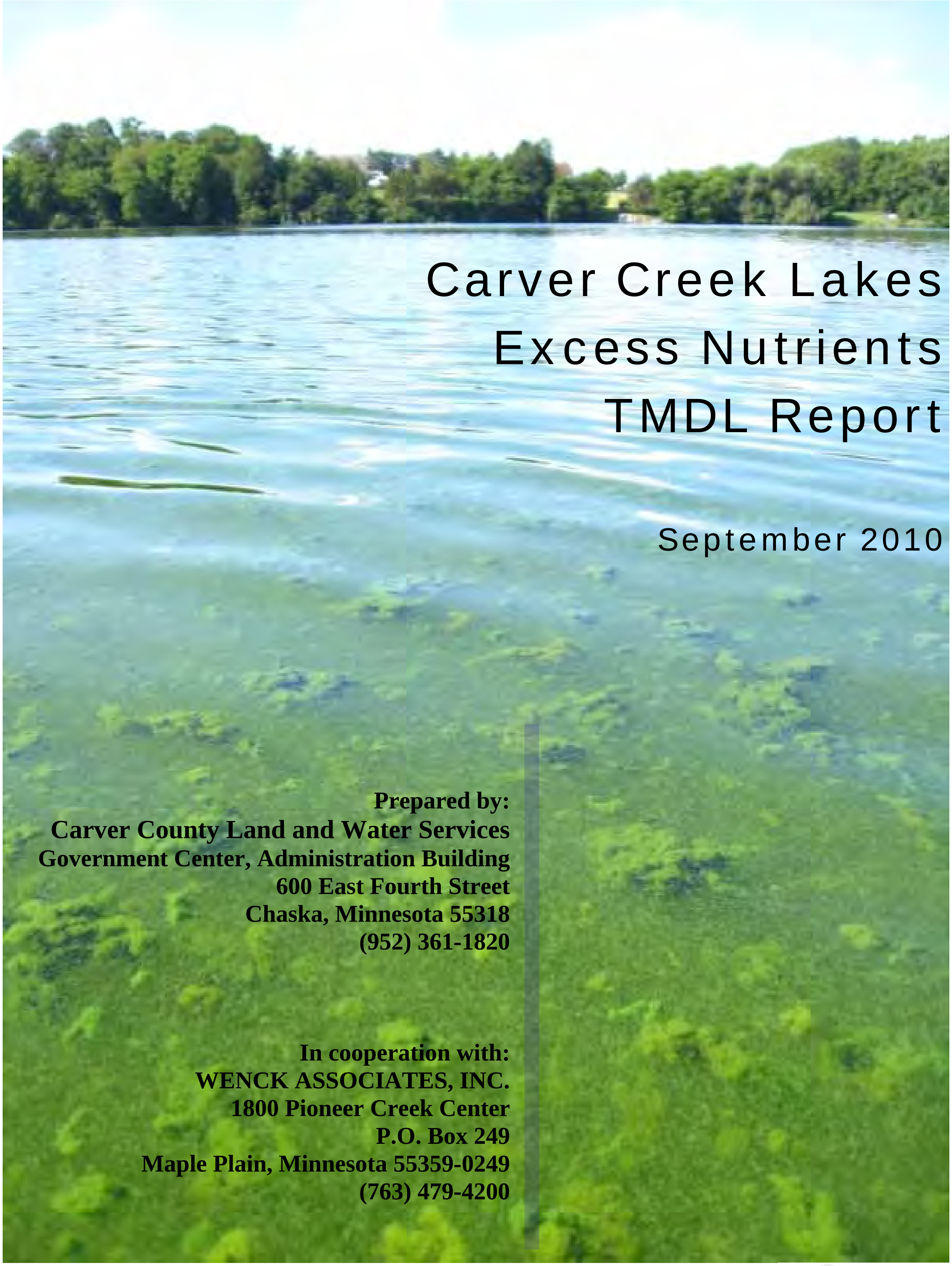

Carver Creek Lakes Excess Nutrients TMDL Report

September 2010

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CARVER COUNTY

Wenck

Cover Photo
By
Shannon Wing
Hydes Lake
July 22, 2008

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Tables

Figures

TMDL Summary Table

EPA/MPCA Required Elements	**Summary**		**TMDL Page #**
Waterbody Name & DNR ID	Goose Lake – 10-0089 Hydes Lake – 10-0088 Miller Lake – 10-0029 Winkler Lake – 10-0066		1
Location	Carver County, West Metro, drains to Minnesota River via Carver Creek		5-16
303(d) Listing Information	Describe the waterbody as it is identified on the State/Tribe's 303(d) list: • Waterbody name, description and ID# for each river segment, lake or wetland • Aquatic recreation (swimming) • Excess nutrients • Priority ranking is based on scheduling of completing project. These TMDLs were scheduled to begin in years ranging from 2003 to 2006 and be complete in 2010. • All lakes listed in 2002, except Winkler (2004)		1
Applicable Water Quality Standards/ Numeric Targets	**Parameter**	**Concentration (µg/L)**	3
	Total Phosphorous	40 for Hydes; 60 for others	
Loading Capacity (expressed as daily load)	Identify the waterbody's loading capacity for the applicable pollutant. Identify the critical condition. **For each pollutant: LC = X/day; and Critical Condition Summary**		57-65
	Goose	See Table 6.2	
	Hydes	See Table 6.4	
	Miller	See Table 6.6	
	Winkler	See Table 6.8	
Wasteload Allocation	Portion of the loading capacity allocated to existing and future point sources [40 CFR §130.2(h)]. **Total WLA = X/day, for each pollutant**		57-65
	Goose	See Table 6.2	
	Hydes	See Table 6.4	
	Miller	See Table 6.6	
	Winkler	See Table 6.8	

	Reserve Capacity (and related discussion in report)	NA	54
Load Allocation	Identify the portion of the loading capacity allocated to existing and future nonpoint sources and to natural background if possible [40 CFR §130.2(g)]. **Total LA = X/day, for each pollutant**		57-65
	Goose	See Table 6.2	
	Hydes	See Table 6.4	
	Miller	See Table 6.6	
	Winkler	See Table 6.8	
Margin of Safety	Include a MOS to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality [CWA §303(d)(1)(C), 40 CFR §130.7(c)(1)]. **Identify and explain the implicit or explicit MOS for each pollutant** An implicit MOS was used for all of the lakes based on conservative modeling assumptions.		53
Seasonal Variation	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**		54
Reasonable Assurance	**Summarize Reasonable Assurance** 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. In a water impaired solely by NPS, reasonable assurances that load reductions will be achieved are not required (by EPA) in order for a TMDL to be approved.		76
	Approach	**Specific Approach**	
	Regulatory	Watershed Rules	

		NPDES Phase II Stormwater Permits	
		NPDES Permits	
		Feedlot Permitting	
		County ISTS Ordinance	
	Non-regulatory	Education	
		Incentives	
Monitoring	**Monitoring Plan included?** 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.		80
Implementation	**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]. Note: EPA is not required to and does not approve TMDL implementation plans.		69
Public Participation	• Public Comment period (dates) • Comments received? • Summary of other key elements of public participation process Note: EPA regulations require public review [40 CFR §130.7(c)(1)(ii), 40 CFR §25] consistent with State or Tribe's own continuing planning process and public participation requirements.		66

Executive Summary

This Total Maximum Daily Load (TMDL) study addresses a nutrient impairment in four lakes in the Carver Creek 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 Goose (10-0089), Hydes (10-0088), Miller (10-0029), and Winkler (10-0066).

The Carver Creek Lakes are located in Carver County, west of the Twin Cities Metro. The 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. 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.

The entire Carver Creek Watershed area is 55,076 acres, roughly 54 percent is agricultural land and 10 percent being developed acreage. The lakes are connected by channels of varying lengths and Carver Creek, which has been identified by the Minnesota Pollution Control Agency (MPCA) as turbidity impaired and is part of a current TMDL study. The lake system and Carver Creek flow to the southeast, ultimately discharging into the Minnesota River.

Water quality in all four lakes is considered poor with frequent algal blooms. Monitoring data in the Carver Creek chain of lakes suggest that it is a highly productive system, with the greatest water quality problems occurring in Winkler Lake.

Goose Lake is a hypereutrophic lake located west of Lake Waconia. Phosphorus loadings have significant sources from inlets to the lake. These sources include the direct watersheds of Swan, Donders, and Rutz Lakes all contributing to Goose Lake.

Both internal and external sources have significant phosphorus loadings to Hydes Lake. This lake is hypereutrophic and located southwest of the City of Waconia.

Miller Lake, located northeast of the City of Cologne, is a hypereutrophic lake. Agriculture is the primary land use and is the major contributor to the external phosphorus load to Miller Lake.

Winkler Lake, located northwest of the City of Cologne, is a hypereutrophic lake. External phosphorus loading from agricultural land uses are the major source of phosphorus to the lake. Rice Lake also contributes to the phosphorus loading of Winkler Lake.

Wasteload and Load Allocations for all lakes to meet State standards for the North Central Hardwood Forest ecoregion translate to phosphorus load reductions ranging from 58 to 97 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, alum treatments, aquatic plant management, and landowner education.

1.0 Target Identification and Determination of Endpoints

1.1 Purpose

This Total Maximum Daily Load (TMDL) study addresses a nutrient impairment in the Carver Creek lakes. The goal of this TMDL is to provide wasteload allocations (WLAs) and load allocations (LAs) and quantify the pollutant reductions needed to meet the state water quality standards for nutrients in Goose, Hydes, Miller, and Winkler Lakes, in Carver County, Minnesota. The Carver Creek Lakes TMDL for nutrients is being established in accordance with section 303(d) of the Clean Water Act, because the State of Minnesota has determined these waters in the Carver Creek watershed exceed the state established standards for nutrients.

1.2 Impaired Waters

All four of the lakes in this project are on the 2010 State of Minnesota 303(d) list of impaired waters. Goose, Hydes, and Miller Lakes were originally listed in 2002 and Winkler Lake was 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 Carver Creek chain of lakes.

LAKE	DNR LAKE #	AFFECTED USE	YEAR LISTED	POLLUTANT OR STRESSOR
Goose	10-0089	Aquatic recreation	2002	Excess nutrients
Hydes	10-0088	Aquatic recreation	2002	Excess nutrients
Miller	10-0029	Aquatic recreation	2002	Excess nutrients
Winkler	10-0066	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 years ranging from 2003 to 2006 and be complete in 2010. 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 water body; 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

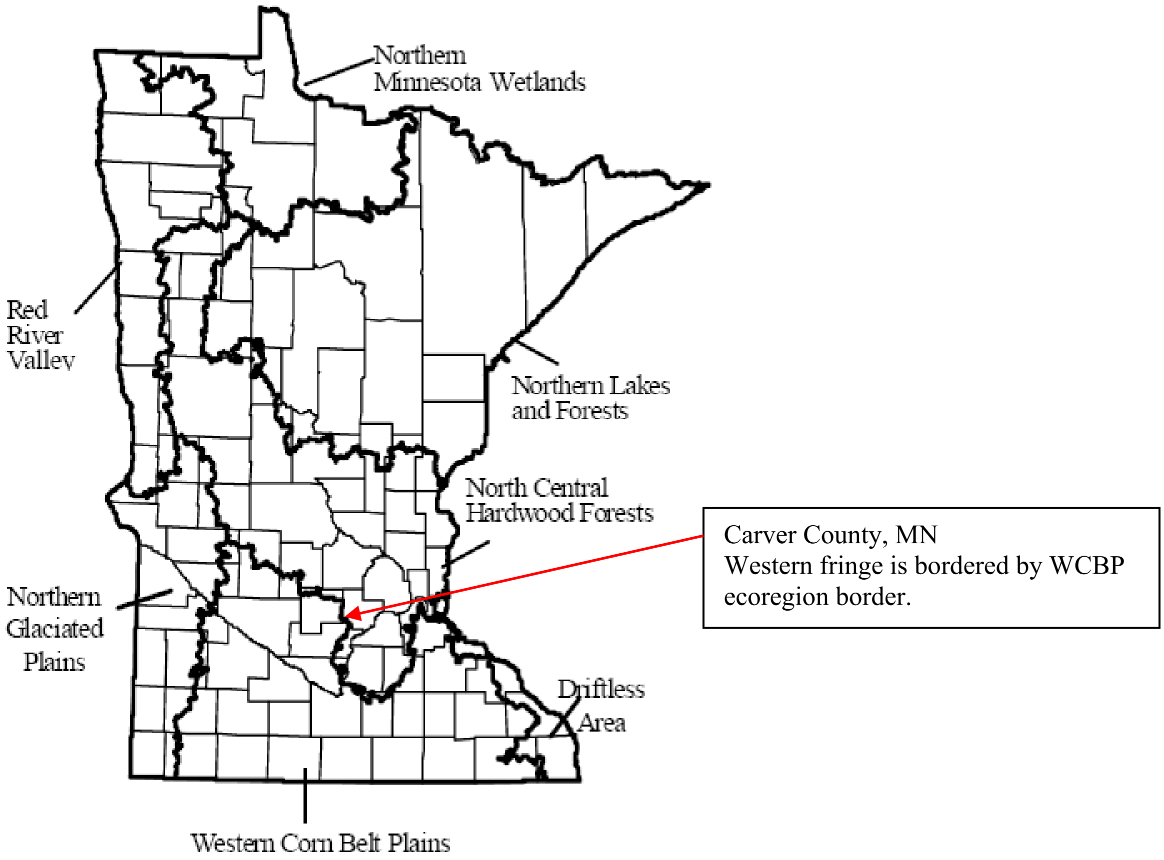
Water quality in Minnesota lakes is evaluated using three parameters: TP, chlorophyll-a, and Secchi depth. Phosphorus is typically the limiting nutrient in Minnesota lakes, meaning that algal growth will increase with increased phosphorus. Chlorophyll-a is the primary pigment in aquatic algae and has 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 Goose, Hydes, Miller, and Winkler Lakes should be placed on the 303(d) list of impaired waters in Minnesota. In May 2008, the MPCA approved new numerical thresholds based on ecoregion and lake morphometry. The new rules take into account geographic differences across the state and nutrient cycling differences between shallow and deep lakes, resulting in more refined standards for Minnesota lakes (MPCA 2005).

Table 1.2 Previous state standards for 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, Goose, Miller, and Winkler are considered “shallow” lakes, and Hydes is a “deep” lake. Because Carver County falls within the North Central Hardwood Forest (NCHF) ecoregion (Figure 1.1), those standards were used to determine impairment.



Carver County, MN
Western fringe is bordered by WCBP ecoregion border.

Figure 1.1 Map of Minnesota's ecoregions.

Table 1.3 MPCA lake water quality standards for North Central Hardwood Forest Ecoregion. Values are summer averages (June 1 through September 30).

	NORTH CENTRAL HARDWOOD FORESTS	
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 percent 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. These proposed goals will require aggressive action. 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 Carver Creek Lakes.

Another goal is to improve public perception of the recreational suitability of Hydes, Miller, and Winkler Lakes. Public surveys were conducted to assess public perception of the recreational suitability of these lakes. The results of the surveys will be used to identify goals appropriate for increasing the public perception of recreational suitability. Currently, public perception of these lakes range from 70 to 89 percent of respondents believing that either "swimming is impaired but boating ok" or "no aesthetics possible".

While a high percentage of respondents feel that the lakes cannot be used for recreation, all lakes were viewed as potentially having some type of recreation available. For Goose Lake, a skiing club uses the lake and accounts for the majority of boat traffic. Fishing is limited and wildlife observation has been listed as a recreational activity for the lake.

Residents around Hydes Lake have listed fishing as the top recreational activity on the lake. Other recreational opportunities on the lake include swimming, waterskiing, and wildlife observation. It is projected that the majority of users participating in these types of recreation live on the lake.

While close to 90 percent of the respondents within the Miller Lake Direct Watershed indicated that their perception of usability was "no swimming- boating ok" to "no possible usage", limited fishing was indicated as the top use. Other recreational opportunities listed were waterfowl hunting, wildlife observation, and canoeing. While there is currently little opportunity for recreation, interviews with landowners indicated that the lake was historically used for waterskiing, swimming, and fishing.

While lake perception surveys have not been collected for Winkler Lake, the Minnesota DNR classified this water body as best suited for waterfowl and aquatic furbearers. As such the only recreational use for the lake is hunting/trapping associated with the wildlife present.

2.0 Watershed and Lake Characterization

2.1 Carver Creek Lakes Watershed Description

Carver Creek Watershed is located in central Carver County, encompassing 55,076 acres and parts of three cities (Figure 2.1). Land use in the watershed is predominately agriculture (54 percent), with small portions of developed and natural areas scattered throughout (10 percent and 18 percent, respectively) (Table 2.1).

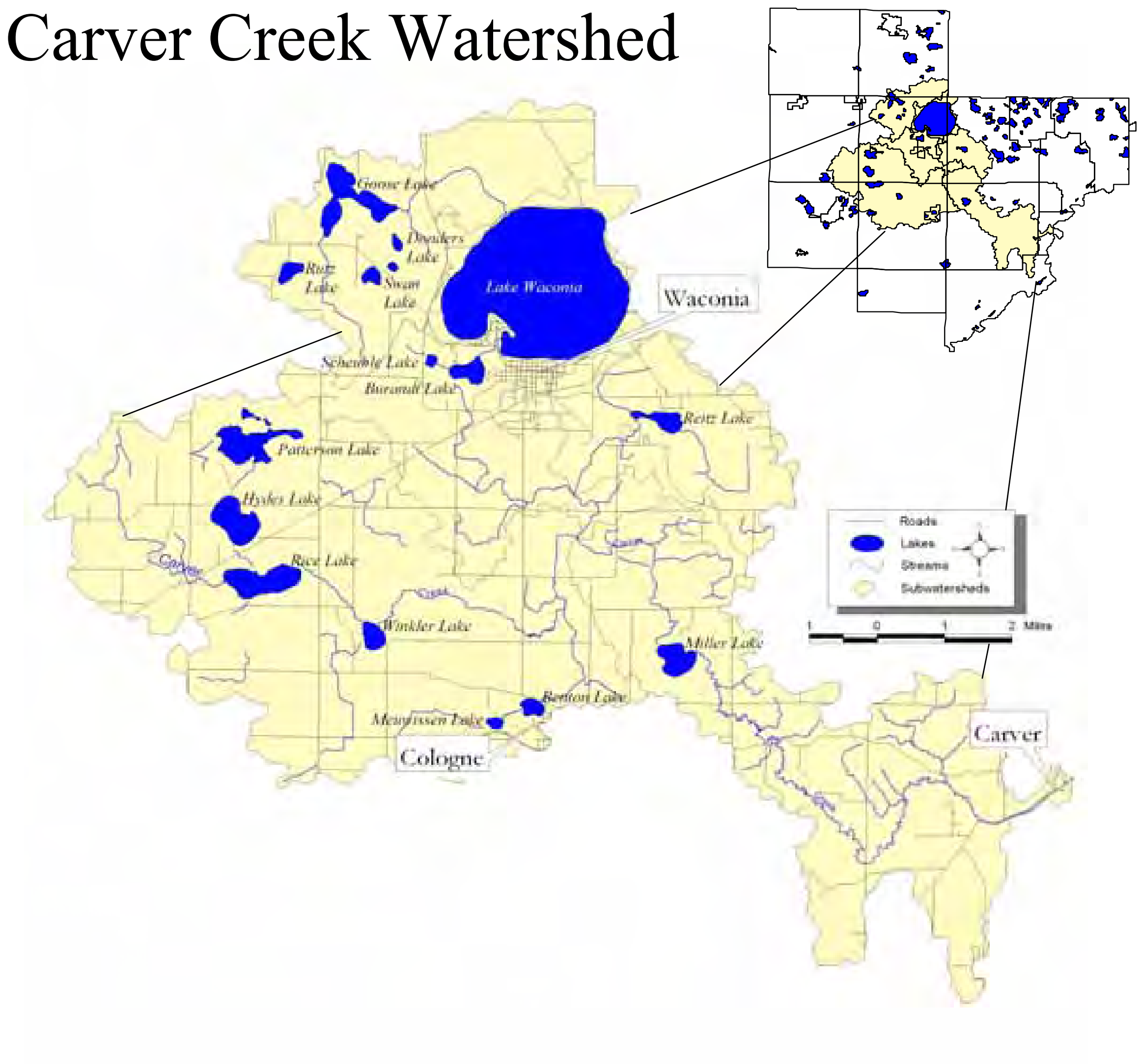


Figure 2.1 Carver Creek lakes and watershed.

Table 2.1 2005 Carver Creek Watershed Land Use.

Land Use	Carver Creek Watershed	
	Acres	Percent
Agriculture	29,880	54%
Developed	5,291	10%
Forest/Grassland	9,699	18%
Wetland	5,122	9%
Water	5,084	9%
Total	**55,076**	**100%**

The Goose Lake Subwatershed is located in the northwestern portion of Carver Creek Watershed. The Hydes Lake Subwatershed is located within the western portion of Carver Creek Watershed. Miller Lake has the largest direct drainage area of all lakes included in this TMDL. The Winkler Lake Subwatershed is southeast of Hydes Lake, but still within the western end of Carver Creek Watershed. Winkler Lake outlets to Carver Creek and eventually drains to Miller Lake, the last significant body of water for Carver Creek before emptying into the Minnesota River.

Table 2.2 Lake characteristics of the Carver Creek Lakes.

Parameter	**Goose Lake**	**Hydes Lake**	**Miller Lake**	**Winkler Lake**
Surface Area (ac)	333	216	141	73
Average Depth (ft)	4.5	8	7	2 (est.)
Maximum Depth (ft)	10	18	14	3 (est.)
Volume (ac-ft)	1,443	1,788	1,038	137
Residence Time (days)	182 - 256	109 - 186	15 - 37	15 - 27
Littoral Area (%)	100	76	100	100
Direct Watershed (excluding lake)(ac)	2,028	839*	14,645	3,118**
Lake Area:Direct Watershed	1:7	1:4	1:104	1:43

*Includes Subwatershed H2
**Includes Subwatersheds “inlets” 1, 2, and 3

2.1.1 Goose Lake

Goose Lake has a direct watershed of 2,001 acres, excluding the lake. The indirect watersheds are made up of three shallow lake/wetlands that flow intermittently into Goose Lake via the tributaries (Figure 2.2). Goose Lake discharges into a series of wetlands before entering Lake Waconia which then discharges into Carver Creek before flowing southeast into the Minnesota River.

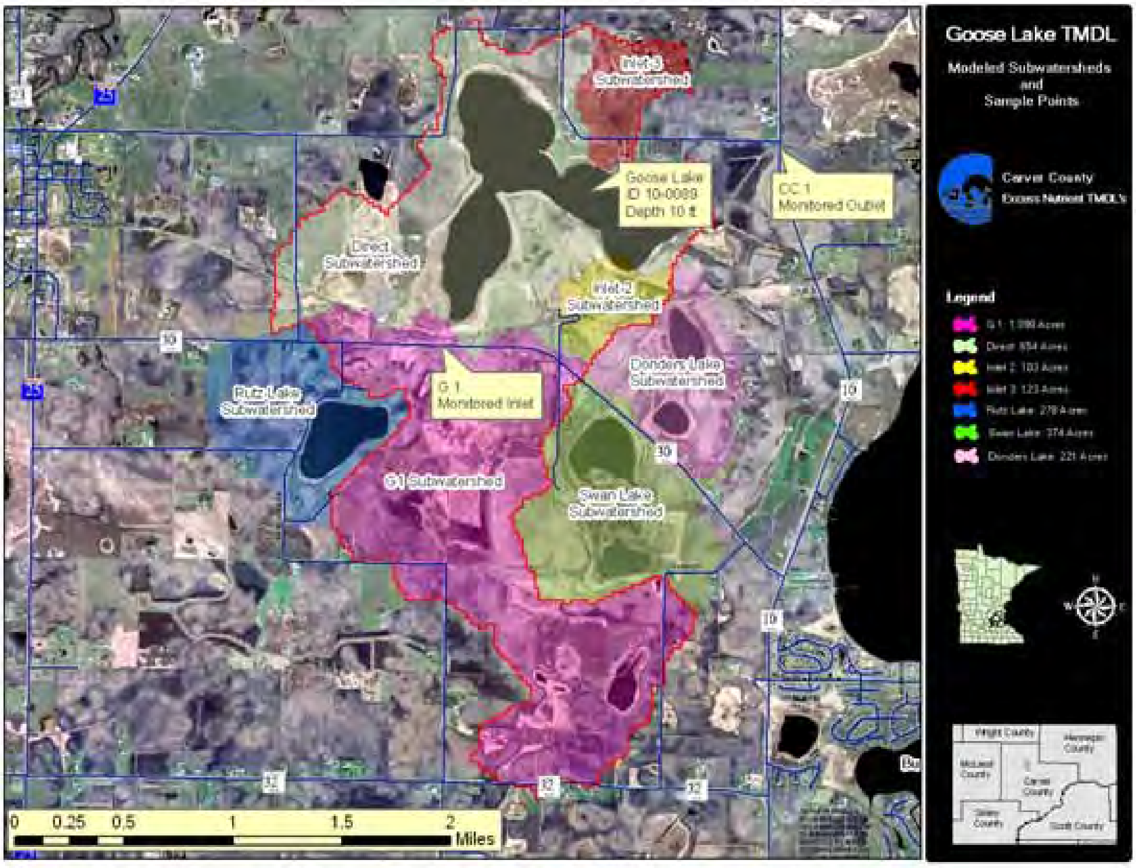


Figure 2.2 Map of Goose Lake watershed and sub-watersheds.

2.1.2 Hydes Lake

Hydes Lake has a direct watershed of 839 acres, excluding the lake and an indirect watershed from Patterson Lake, a shallow lake/wetland that is located less than one mile away, which is 2,292 acres. Only one major inlet flows intermittently into Hydes Lake from Patterson Lake (Figure 2.3).

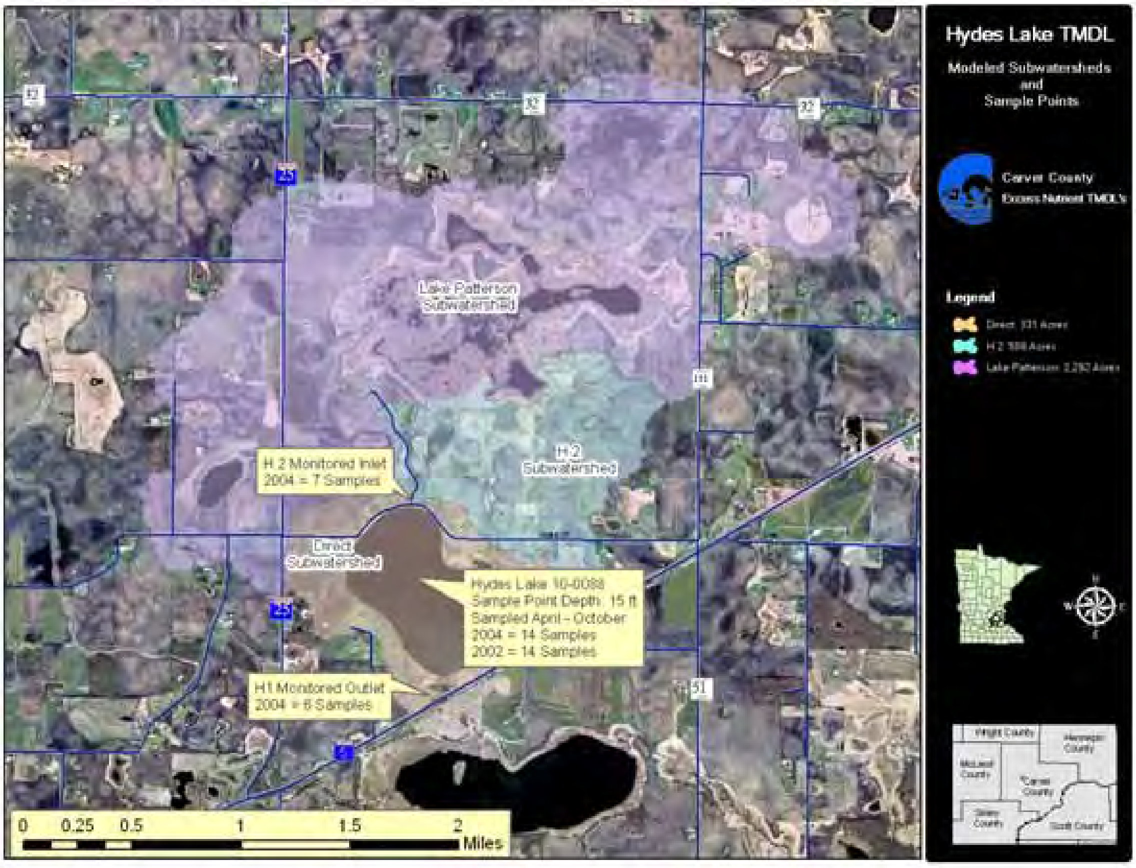


Figure 2.3 Hydes Lake watershed with Patterson Lake watershed to the north.

2.1.3 Miller Lake

Miller Lake has a direct watershed of 14,654 acres, excluding the lake (Figure 2.4). The lake area to direct watershed area ratio is 1:104, indicating that the direct watershed has the potential to contribute extremely high nutrient loads to the lake. The Miller Lake direct watershed contains one major inlet, Carver Creek, which drains a majority of the watershed (14,260 acres). Miller Lake has another much smaller, intermittent, low-flow inlet draining a small area to the west of the lake. Ultimately, four lakes drain directly to Miller Lake via the tributaries of Carver Creek (Burandt, Benton, Winkler, and Reitz).

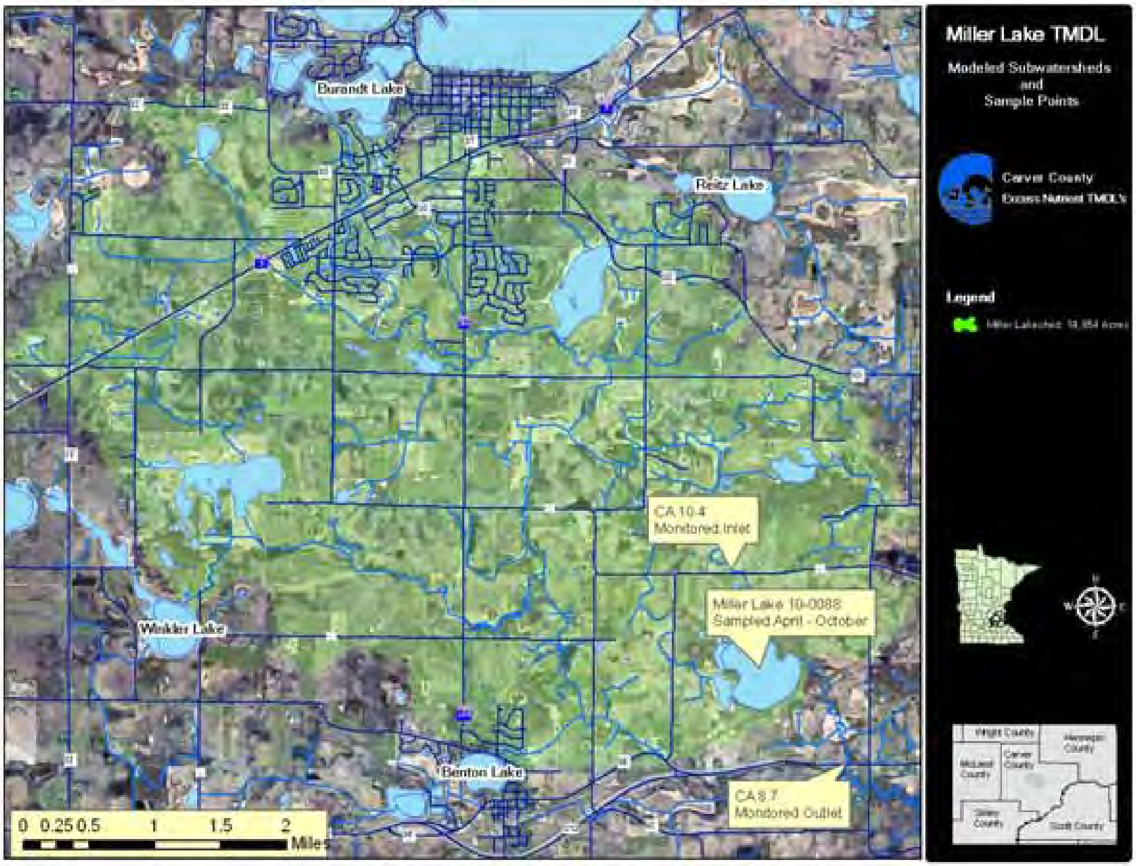


Figure 2.4 Miller Lake watershed and sampling points.

2.1.4 Winkler Lake

Winkler Lake has a direct watershed of 3,118 acres, excluding the lake (Figure 2.5). Within this area there are three inlets (drainage ditches) entering from the NW, SW and E parts of the lake. The northwest inlet flows in from Rice Lake, a public ditch to the southwest discharges treated wastewater from Bongards' wastewater treatment plant into Winkler Lake, and a small wetland drains in from the east. Rice Lake drains to Winkler Lake via the northwest sub-watershed. This indirect drainage into Winkler Lake is roughly 4,580 acres in size and contains both Rice Lake and its subwatersheds.

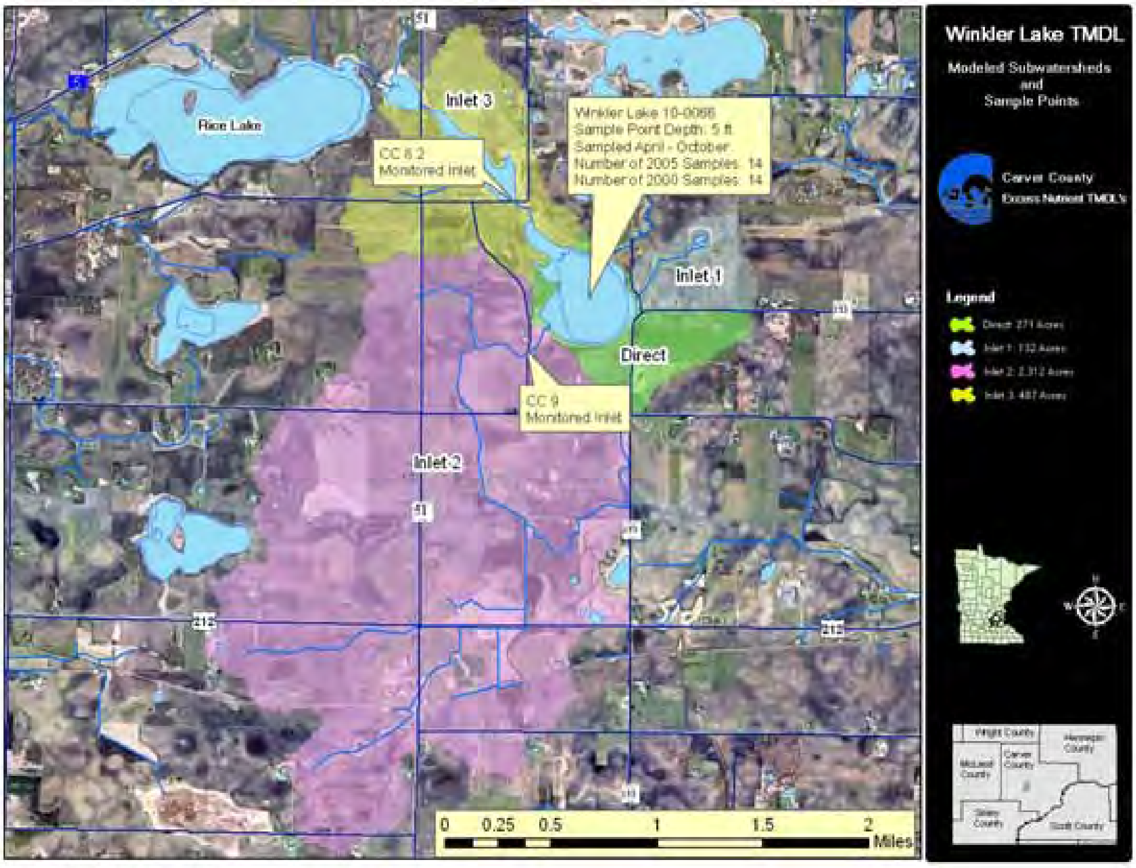


Figure 2.5 Winkler Lake watershed, subwatershed, and sampling points.

2.2 Land Use

Land use percentages are similar for the four direct watersheds compared to Carver Creek Watershed. Agriculture is the major land usage for the entire area ranging from 54 percent in Goose Lake to 74 percent in Winkler Lake. 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.

2.2.1 Goose Lake

Land use in the direct watershed is primarily tilled agriculture (Figure 2.6, Table 2.3). There are approximately 41 homes in the direct watershed with subsurface sewage treatment systems (SSTS). A GIS review showed that 13 of those 41 SSTS had no permits on file. According to the 2000 feedlot inventory data, three feedlots exist in the direct watershed with 148 animal units. 2020 Land use projections indicate that there will be minimal to no change (Table 2.4).

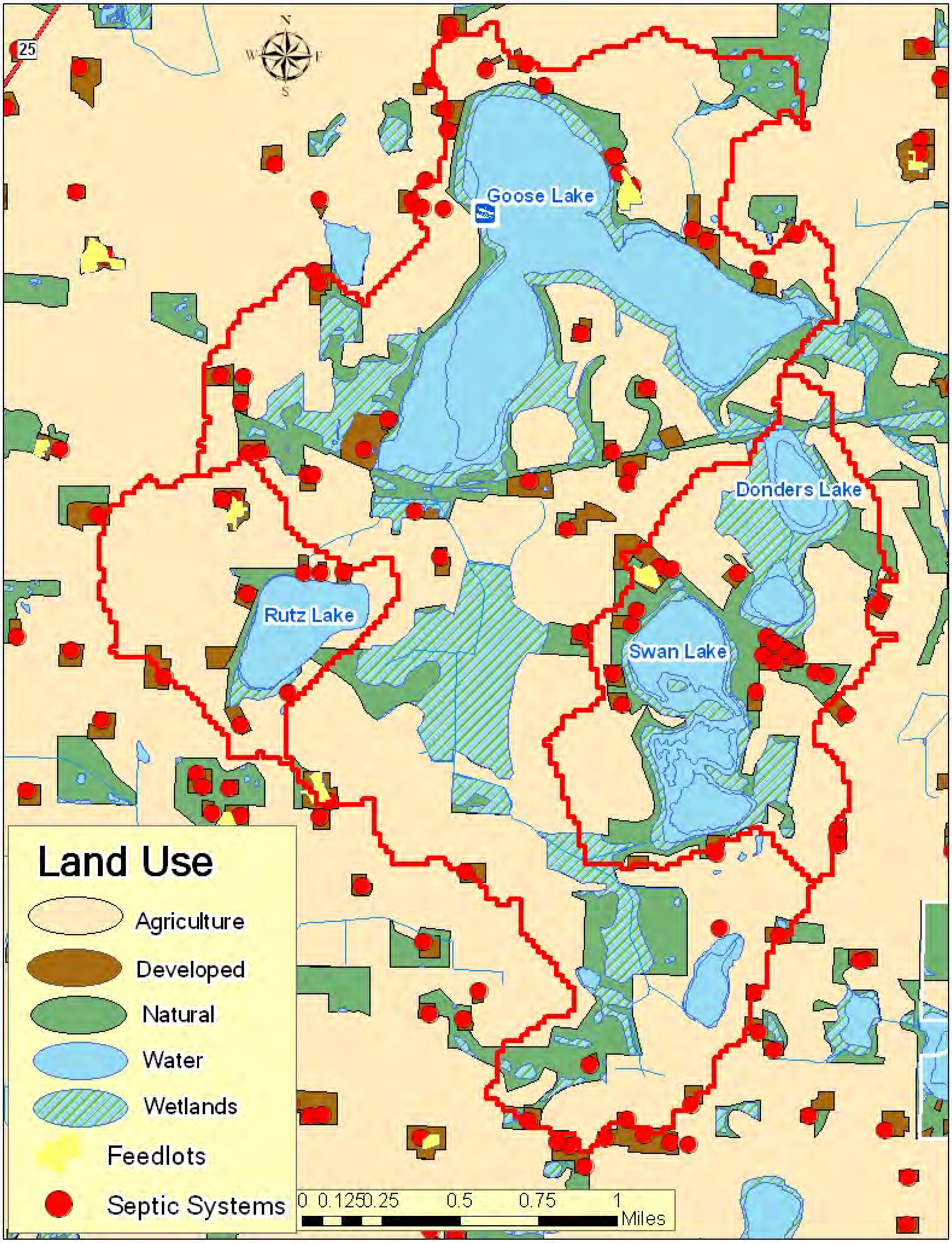


Figure 2.6 Goose Lake Watershed 2005 Land Use.

Land use surrounding lakes in the indirect watershed that flow into Goose Lake ultimately impact its water quality. As such, a GIS review was conducted to determine land use characteristics in these areas. During this review, it was determined that three separate subwatersheds ultimately drain to Goose Lake: Rutz lake, Swan lake and Donders Lake. Nearly 50 percent of the indirect watersheds are in agricultural conditions and to this point there are no plans for future development (Table 2.4). In addition there are approximately 34 homes within the three indirect watersheds collectively, all with on-site SSTS. Two homes with SSTS did not have permits on file. According to the feedlot inventories done in 2000, five feedlots containing approximately 1057 animal units are located within the indirect watersheds.

Table 2.3 Goose Lake Watershed 2005 Land Use.

Land use	**Goose Lake Direct**		**Rutz Lake**		**Swan Lake**		**Donders Lake**	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	1,250	54%	225	67%	166	40%	284	42%
Developed	117	5%	25	8%	20	5%	31	5%
Forest/Grassland	255	11%	21	6%	59	14%	92	14%
Wetland	327	14%	6	2%	68	17%	138	20%
Water	362	16%	57	17%	97	24%	128	19%
Total	**2,311**	**100%**	**335**	**100%**	**411**	**100%**	**673**	**100%**

Table 2.4 Goose Lake Watershed 2020 Land Use.

Land use	**Goose Lake Direct**		**Rutz Lake**		**Swan Lake**		**Donders Lake**	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	1,373	59%	245	73%	196	48%	301	45%
Developed	64	3%	20	6%	20	5%	30	4%
Forest/Grassland	262	11%	60	18%	45	11%	82	12%
Wetland	309	13%	7	2%	113	28%	183	27%
Water	303	13%	3	1%	37	9%	78	12%
Total	**2,311**	**100%**	**335**	**100%**	**411**	**100%**	**673**	**100%**

2.2.2 Hydes Lake

Current land use in the direct watershed is primarily tilled agriculture. There are approximately 28 homes existing in the watershed, all with on-site SSTSs. Nineteen of the homes are on the lake front (within 300 feet of the shoreline). One feedlot exists in the watershed containing approximately 47 animal units. In looking at land use in 2020, agricultural land uses will increase slightly. It should be noted that wetlands show a decrease, but this land use study did not take into account mitigation for lost wetland acres. (Figure 2.7, Table 2.5, Table 2.6).

Table 2.5 2005 land use in the Hydes Lake watershed.

Land Use	**Hydes Lake**	
	Acres	Percent
Agriculture	562	53%
Developed	64	6%
Forest/Grassland	79	8%
Wetland	128	12%
Water	220	21%
Total	**1,053**	**100%**

Table 2.6 2020 land use in the Hydes Lake watershed.

Land Use	**Hydes Lake**	
	Acres	Percent
Agriculture	628	60%
Developed	45	4%
Forest/Grassland	80	8%
Wetland	82	8%
Water	219	21%
Total	**1,054**	**100%**

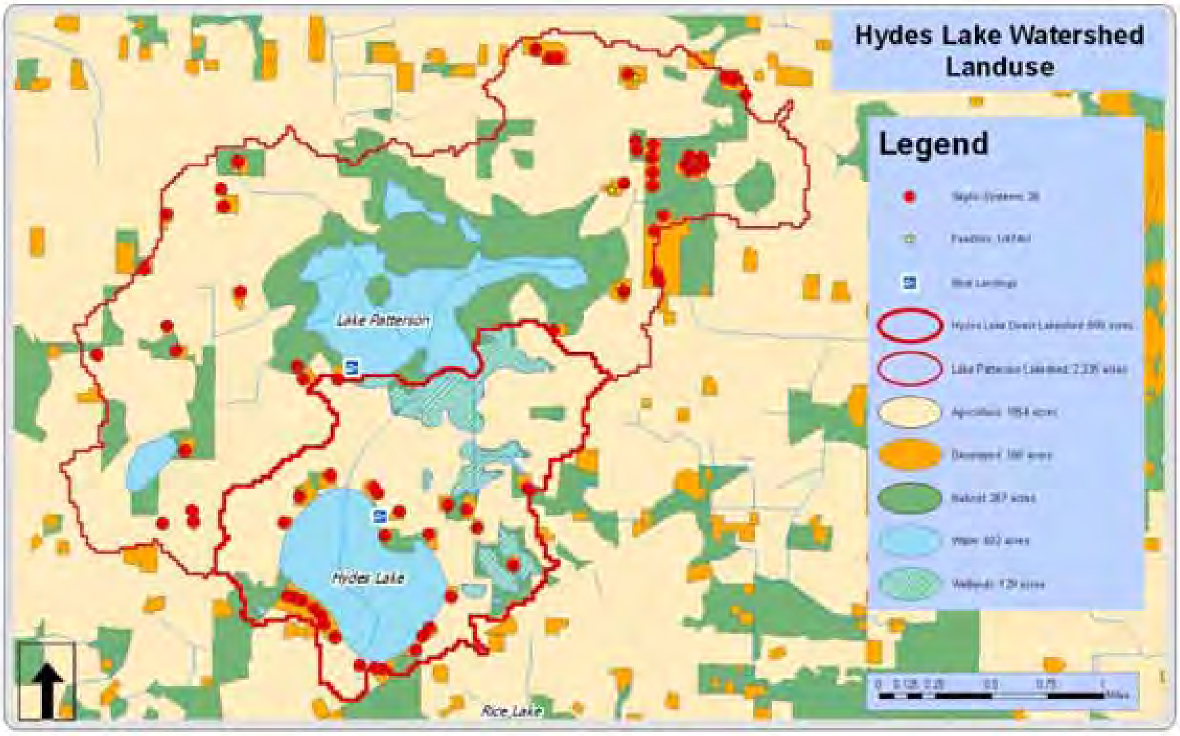


Figure 2.7 Hydes Lake 2005 land use.

2.2.3 Miller Lake

Current land use in the watershed is primarily tilled agriculture (Figure 2.8, Table 2.7, Table 2.8). The city of Waconia is partially within the direct watershed boundaries. Approximately 5,500 property parcels exist in the direct watershed; however, the land surrounding Miller Lake is minimally developed with only one home located within 300 feet of the lake. Currently 29 feedlots exist in the watershed containing approximately 2,279 animal units. None of the existing feedlots are regulated under the National Pollutant Discharge Elimination Permit System (NPDES) permit system. 2020 Comprehensive Plans indicate that there will be an increase in development reducing both the percent wetland and natural areas. As in previous sections, the reduction in wetlands should not be a point of concern due to the lack of accounting for mitigation in this study.

Table 2.7 Miller Lake Watershed 2005 Land Use.

Land Use	**Miller Lake**	
	Acres	Percent
Agriculture	8,806	60%
Developed	1,774	12%
Forest/Grassland	2,553	17%
Wetland	1,512	10%
Water	143	1%
Total	**14,788**	**100%**

Table 2.8 Miller Lake Watershed 2020 Land Use.

Land Use	**Miller Lake**	
	Acres	Percent
Agriculture	9,445	64%
Developed	2,094	14%
Forest/Grassland	2,108	14%
Wetland	992	7%
Water	153	1%
Total	**14,792**	**100%**

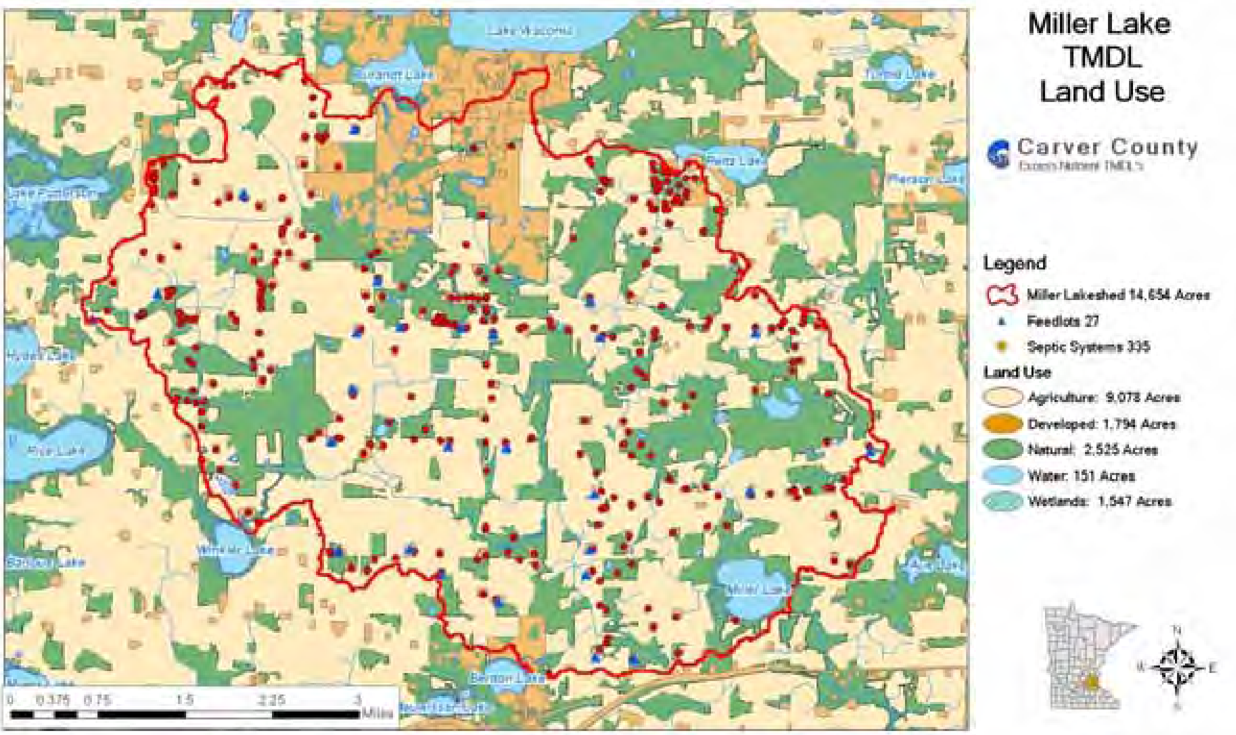


Figure 2.8 Miller Lake 2005 land use.

2.2.4 Winkler Lake

The 3,198-acre watershed surrounding Winkler Lake is and has been since European settlement predominantly agricultural (Figure 2.9, Table 2.9, Table 2.10). Looking at future land use (2020), a slight increase in agriculture will occur. There are currently 69 homes in the direct watershed all with on-site septic systems. In addition, there are 11 feedlots in the watershed containing approximately 1,373 animal units.

Table 2.9 Winkler Lake Direct Watershed 2005 Land Use.

Land Use	**Winkler Lake**	
	Acres	Percent
Agriculture	2,366	74%
Developed	204	6%
Forest/Grassland	289	9%
Wetland	266	8%
Water	73	2%
Total	**3,198**	**100%**

Table 2.10 Winkler Lake Direct Watershed 2020 Land Use.

Land Use	**Winkler Lake**	
	Acres	Percent
Agriculture	2,506	78%
Developed	87	3%
Forest/Grassland	267	8%
Wetland	266	8%
Water	73	2%
Total	**3,201**	**100%**

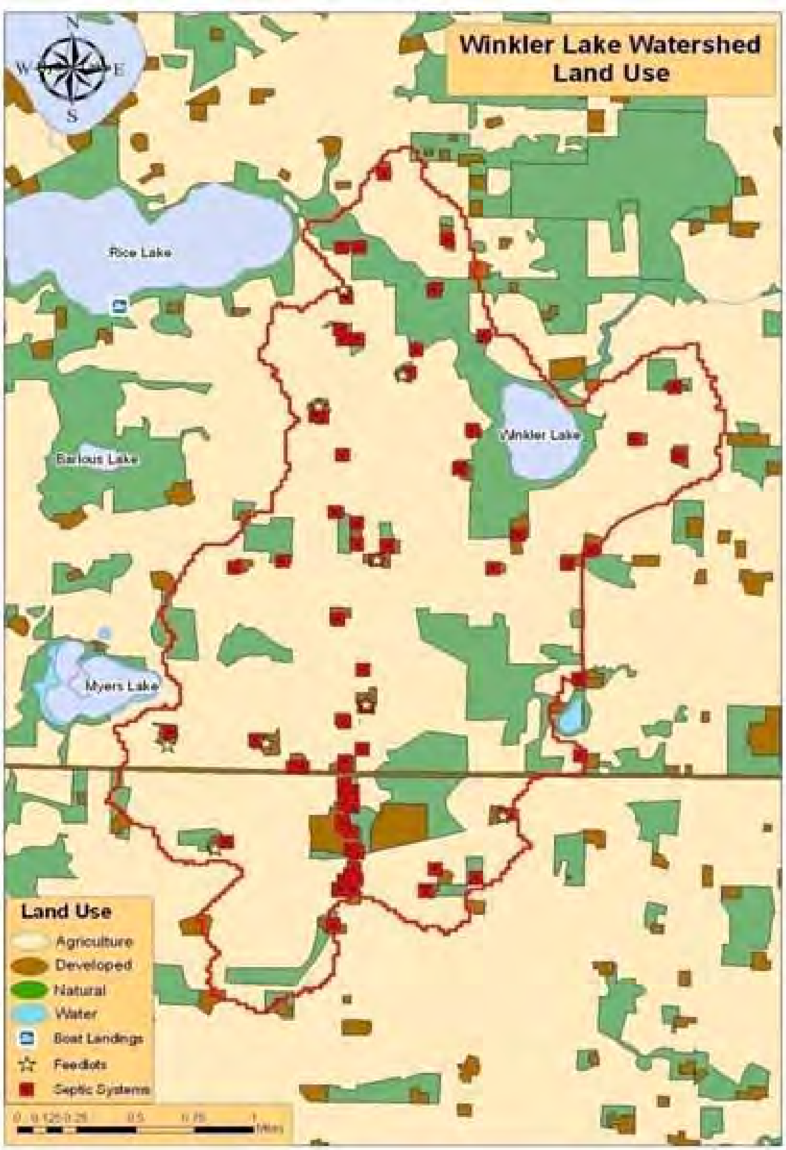


Figure 2.9 Winkler Lake 2005 land use.

2.3 Fish Populations and Fish Health

A general understanding of a lake's fishery is useful as it can have a significant influence on water quality. Fish species presence is summarized in Table 2.11. Hydes Lake has the most expansive survey history of all lakes within this TMDL report. Four full surveys were conducted between 1980 and 2001. During this time, a shift has been evident because of the increase in rough fish (carp and black bullhead) biomass. Winkler Lake has not been surveyed by the DNR and the indication of only one species (carp) is based on reporting by County Staff, and thus it is not an all-inclusive list for the lake.

Diversity of fish species is greatest within Goose Lake, which has ten species identified within previous fish surveys. Both Miller and Hydes Lake have the second most diversity, each with eight species identified. Carp has been reported in all lakes, a rough fish that can tolerate poorer water quality. Both abundance and biomass estimates from fish surveys show, in general, that carp has been increasing over the years, as well as another rough fish, black bullhead.

Goose Lake have evidence of past fish kills within the lake, mainly winterkills. As many as 10 winterkills have been identified in Goose Lake. 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. 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 2.11 Fish species present within Carver Creek Lakes (1980 – 2006).

	GOOSE	HYDES	MILLER	WINKLER
Bigmouth buffalo			X	
Black bullhead	X	X	X	
Black crappie		X	X	
Bluegill	X	X	X	
Carp	X	X	X	X
Channel catfish	X			
Crappie	X			
Green sunfish	X			
Largemouth bass	X	X		
Northern pike	X	X	X	
Pumpkinseed sunfish	X			
Walleye		X		
White sucker			X	
Yellow perch	X	X	X	

2.4 Aquatic Plants

Native aquatic plants benefit lake ecosystems by 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 water milfoil 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 all lakes during the 2005 monitoring season. These surveys were conducted once in the spring and once in the fall. Curlyleaf pondweed was found to be in Hydes and Miller Lakes and Eurasian water milfoil was found in Miller Lake. Aquatic plant diversity was low in all lakes sampled. More detailed aquatic sampling reports are available from the county.

2.5 Shoreline and Habitat 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 a Trimble GPS unit and ArcPad program. Staff circumnavigated the lake, mapping and recording shoreline type such as natural vegetation, sand beach, turf grass to shoreline, pasture, and/or retaining wall (Table 2.12 and Table 2.13). Results from this survey indicate that nearly 90 percent of all shorelines have "natural vegetation" for all four lakes. Hydes Lake has the least amount, in percentage, of "natural vegetation", with only 74 percent. In linear length, Goose Lake has almost 4.4 miles of shoreline in a "natural" condition.

Table 2.12 Percentage of shoreline habitats around Goose, Hydes, Miller, and Winkler Lakes.

Lake	Shoreline %						Total
	Natural Vegetation	Lawn	Retaining Wall	Pasture	Sand Shore	Agriculture	
Goose Lake	89.61%	6.42%		1.73%	0.24%	2.00%	41.48%
Hydes Lake	73.76%	26.24%	3.89%				21.17%
Miller Lake	100.00%						17.31%
Winkler Lake	100.00%						11.01%
Total	89.58%	8.78%	0.82%	0.72%	0.10%	0.83%	100.00%

Table 2.13 Linear Length of shoreline habitats around Goose, Hydes, Miller, and Winkler Lakes.

Lake	Miles of Shoreline						Total
	Natural Vegetation	Lawn	Retaining Wall	Pasture	Sand Shore	Agriculture	
Goose Lake	4.39	0.31		0.08	0.01	0.10	4.89
Hydes Lake	1.84	0.66	0.10				2.60
Miller Lake	2.04						2.04
Winkler Lake	1.30						1.30
Total	9.57	0.97	0.10	0.08	0.01	0.10	10.83

3.0 Assessment of Water Quality Data

3.1 Data Sources and Methodology

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 groundwater 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.
Goose, Hydes, and Miller have been given a high priority and have been monitored by both volunteer and county staff annually since 1999.

Carver County follows the monitoring techniques set up by the Metropolitan Council Environmental Services 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 (TKN). 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

Carver Creek Lakes are also periodically monitored by the volunteer program CAMP, which is operated by the Metropolitan Council Environmental Services (MCES). Citizen volunteers collect a water sample to be submitted to the Met Council for analysis of total phosphorous, 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.

3.1.3 Minnesota Pollution Control Agency

The Carver Creek Lakes have been monitored periodically by the Minnesota Pollution Control Agency (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. However, this program relies on citizens to only collect a Secchi disk reading.

3.2 Phosphorus, Chlorophyll-a, and Secchi Depth

3.2.1 Goose Lake

Monitoring conducted over the past ten years has depicted in-lake conditions as hypereutrophic (Table 3.1). In fact, TP has remained at levels nearly three times that used to list the lake as impaired (40 µg/L; prior to State rule adoption of the shallow lake standard of 60 µg/L). Figure 3.1 and 3.2 show nutrient variation during the monitored period and yearly seasonal variation. No hypolimnetic samples have been collected because the lake does not stratify.

Table 3.1 Growing season (June 1 – September 30) mean lake water quality for Goose Lake.

Year	TP Concentration (µg/L) (n)	Chlorophyll-a Concentration (µg/L) (n)	Secchi disk transparency (meters) (n)	TKN (mg/L) (n)
1979	159 (4)	N/A	0.7 (10)	2.3 (4)
1980	142 (2)	N/A	0.6 (9)	2.9 (2)
1995	120 (7)	40 (N/A)	0.5 (7)	2.7 (7)
1996	N/A	N/A	1.0 (4)	N/A
1997	164 (9)	68 (N/A)	0.4 (9)	2.4 (9)
1998	116 (9)	47 (9)	1.3 (9)	2.3 (9)
1999	173 (10)	64 (13)	0.4 (9)	3.1 (10)
2000	216 (7)	81 (11)	0.3 (7)	3.1 (7)
2001	125 (9)	60 (4)	0.7 (9)	3.0 (9)
2002	110 (9)	34 (9)	0.5 (9)	2.4 (9)
2003	176 (8)	95 (8)	0.3 (9)	2.8 (8)
2004	134 (9)	53 (9)	0.4 (9)	2.2 (9)
2005	114 (14)	94 (14)	0.4 (14)	2.1 (14)
2006	111 (12)	94 (14)	0.4 (14)	3.1 (14)
2007	103 (13)	134 (13)	0.4 (12)	4.4 (13)
10 yr avg.	138	76	0.5	2.9

n is the number of samples collected each season

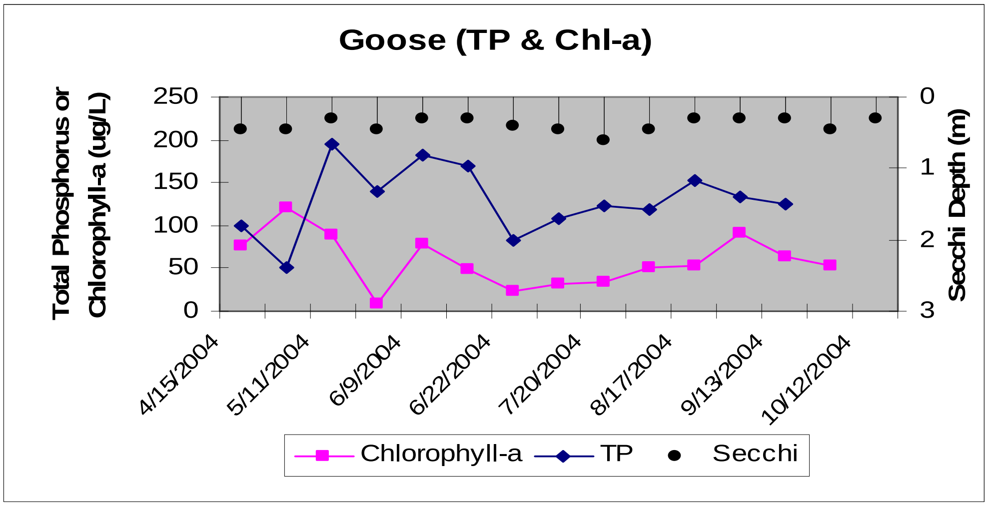


Figure 3.1 2004 TP, chlorophyll-a, and Secchi depth for Goose Lake.

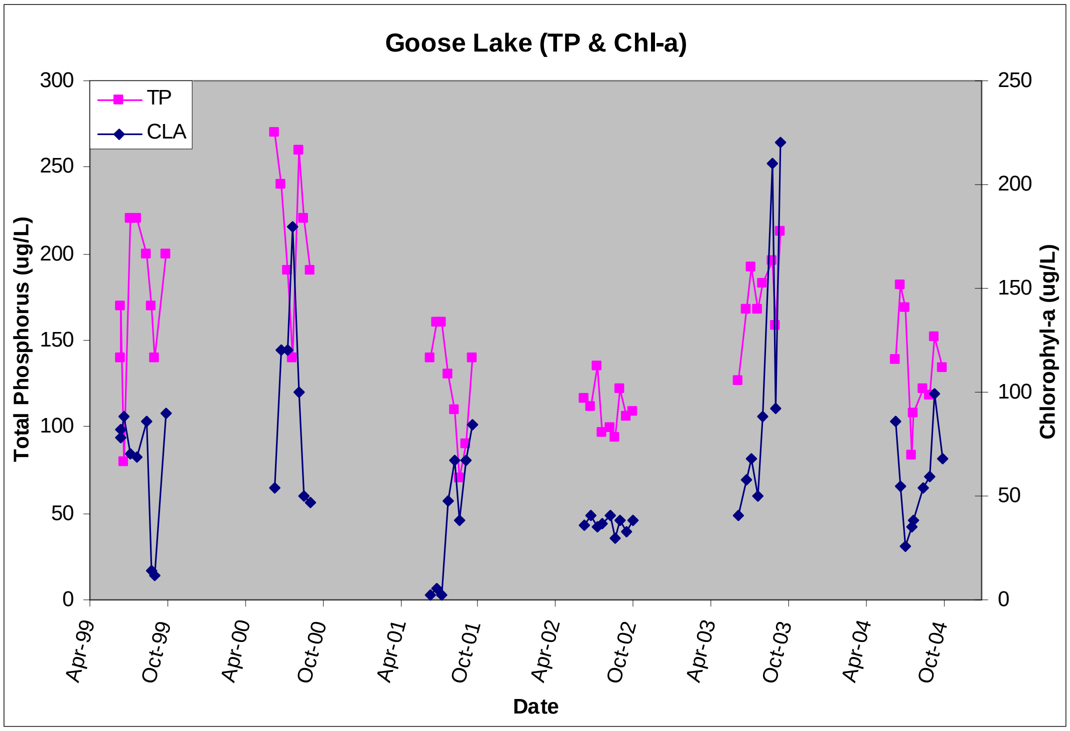
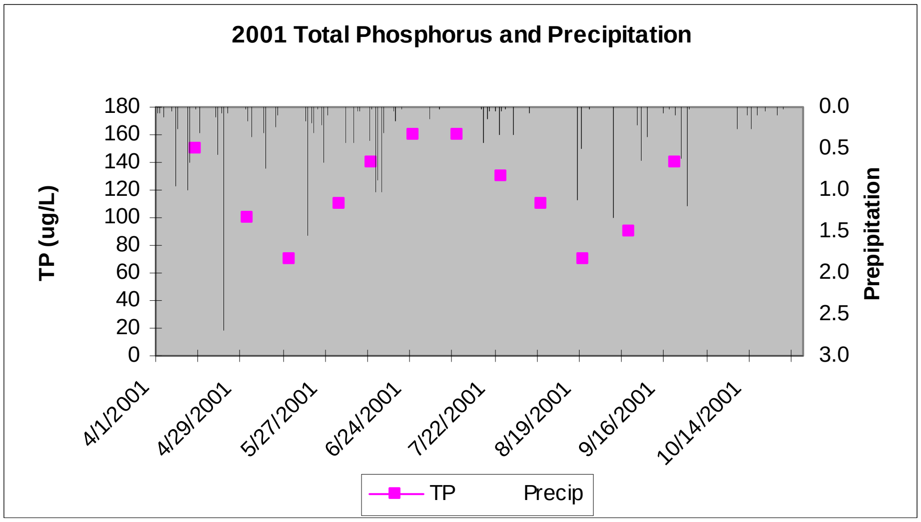


Figure 3.2 Goose Lake phosphorus and chlorophyll-a summer results from 1999 to 2004.

Chlorophyll-a concentrations generally track TP concentrations and increase throughout the spring and early summer. If the lake was nitrogen limited, increases in chlorophyll-a levels likely would not be in response to a rise in phosphorus levels. TP does show response to precipitation on a daily basis, typical of a lake that is affected by external pollution (Figure 3.3). However, evaluating yearly seasonal TP trends provides indications of internal phosphorus cycling.



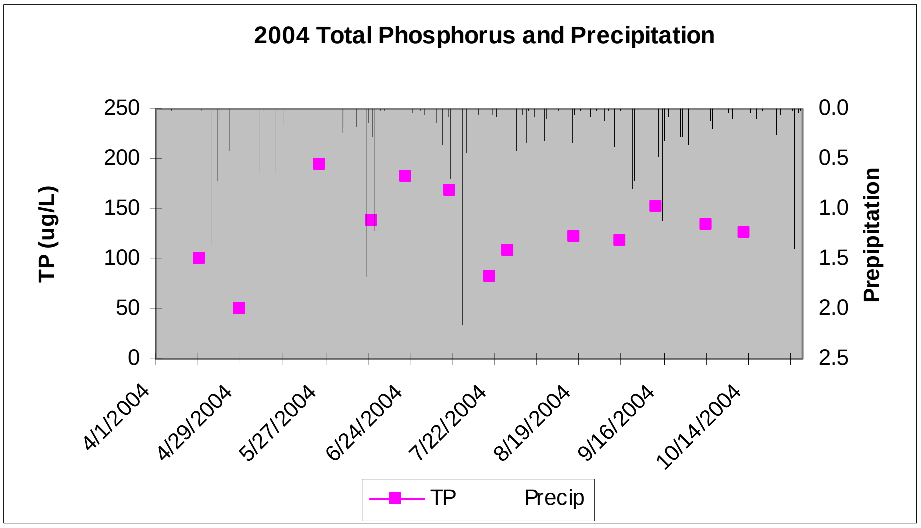


Figure 3.3 Goose Lake TP response to daily precipitation in 2001 and 2004.

Increases in TP over each growing season suggest that internal loads of phosphorus play a role in water quality since inflow is naturally low during this period (Welch & Cooke 1995). Thus, it is likely that Goose Lake water quality is affected by both internal and external phosphorus sources.

Monitoring data for Goose Lake suggests that the lake is and has historically been a highly productive system. Goose Lake is hypereutrophic with both internal and external phosphorus sources contributing to the overall nutrient load. The benthic environment in Goose Lake periodically becomes anoxic resulting in the incidence of phosphorus release from the sediments.

3.2.2 Hydes Lake

Monitoring conducted over the past ten years has depicted in-lake conditions which are highly eutrophic (Table 3.2). As seen in the Hydes Lake water quality data, Secchi depth is not always reduced by increases in TP or chlorophyll-a, which could be due to the algae species present. TP has ranged from 456 µg/L in 1979 to 84 µg/L in 2003. Figure 3.4 shows typical TP response to precipitation.

Table 3.2 Growing season (June 1 – September 30) mean lake water quality for Hydes Lake.

Year	TP Concentration (µg/L)/(n)	Chlorophyll-a Concentration (µg/L)/(n)	Secchi disk transparency (meters)/(n)	TKN (mg/L)/(n)
1979	456 (3)	N/A	N/A	3.4 (3)
1985	294 (3)	90 (N/A)	0.8 (4)	2.7 (7)
1991	200 (12)	75 (N/A)	0.8 (12)	2.3 (15)
1993	216 (9)	30 (N/A)	1.9 (9)	1.8 (9)
1995	362 (8)	138 (N/A)	0.6 (2)	2.9 (2)
1996	222 (8)	51 (N/A)	1.6 (8)	1.8 (7)

1997	326 (7)	52 (N/A)	1.0 (14)	2.3 (7)
1999	146 (11)	22 (N/A)	1.6 (11)	2.1 (11)
2000	174 (7)	28 (7)	1.5 (7)	2.1 (7)
2001	184 (9)	25 (9)	3.5 (9)	2.4 (9)
2002	106 (13)	33 (13)	0.5(9)	2.1 (13)
2003	84 (14)	39 (14)	1.1 (14)	1.7 (14)
2004	131 (14)	51 (14)	1.0 (14)	2.0 (14)
2005	155 (14)	63 (14)	2.1 (14)	2.3 (14)
2006	182 (14)	90 (14)	1.6 (14)	2.3 (14)
2007	155 (13)	53 (13)	1.4 (13)	2.5 (13)
10 yr avg.	164	46	1.5	2.2

n is the number of samples collected each season

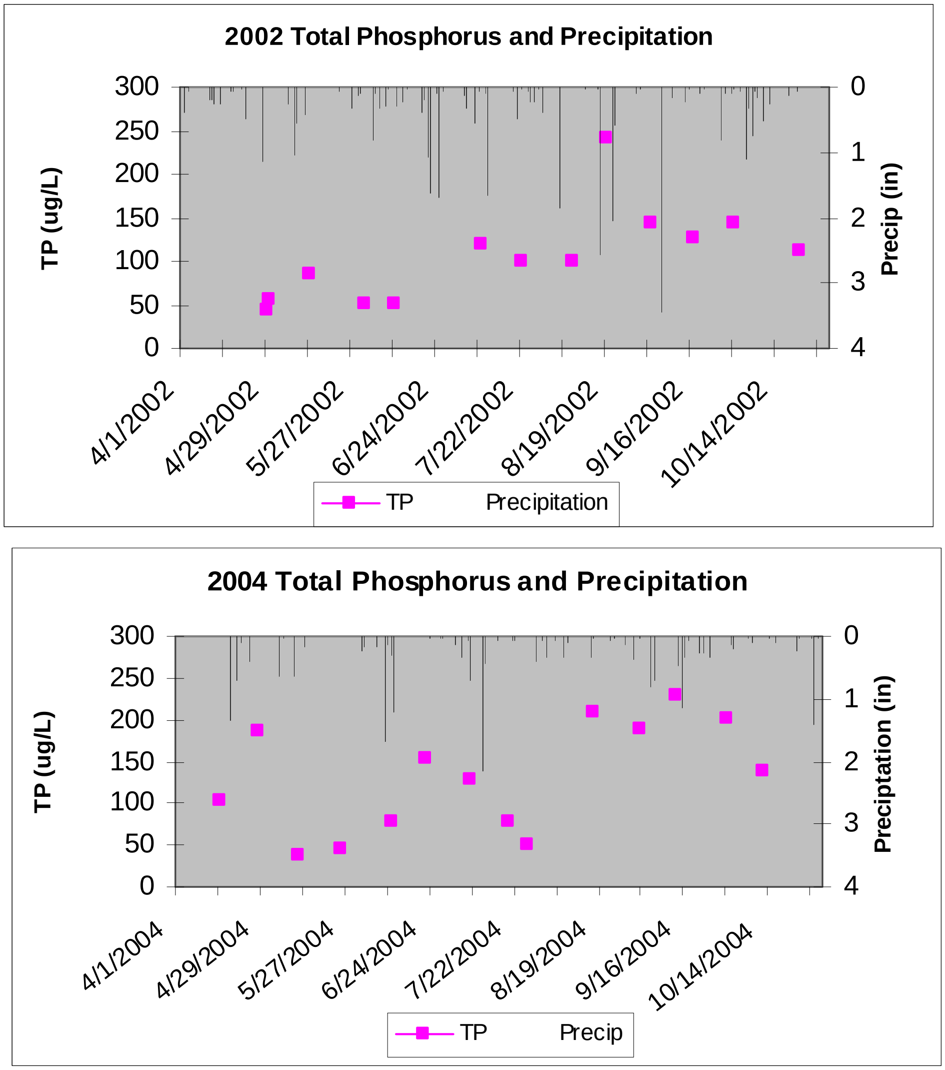


Figure 3.4 Hydes Lake TP and daily precipitation for summer 2002 and 2004.

In 2004 TP increased in mid-June and again in mid-July following precipitation events. These incidences point to increased phosphorus in the water column due to runoff from surrounding land. However, external loading is not the only contributor to water quality. When in-lake TP versus precipitation plots were examined from previous years, it was determined that TP did not always increase following rain events (Figure 3.5). High phosphorus levels witnessed during dry conditions can be attributed to internal loading. Internal loading in the lake is caused by curlyleaf pondweed senescence in the early growing season and phosphorus release from anoxic sediments due to wind mixing, boat prop disturbance and rough fish rooting during the growing season.

Research indicates that increases in TP in shallow lakes during the summer growing season are typical. Inflow is naturally low during this period and the increase in phosphorus can be attributed to internal loading (Welch & Cooke 1995). Increases in Secchi depth coinciding with increases in TP and chlorophyll-a are due to the specific algae species present in the lake, which if the lake had algae species similar to other lakes within the Carver Creek Watershed would have responded with a decrease in Secchi disk readings. The dominant algae species in the lake is Aphanizomenon, a species which forms pods in the water column, thereby leaving the water itself clear.

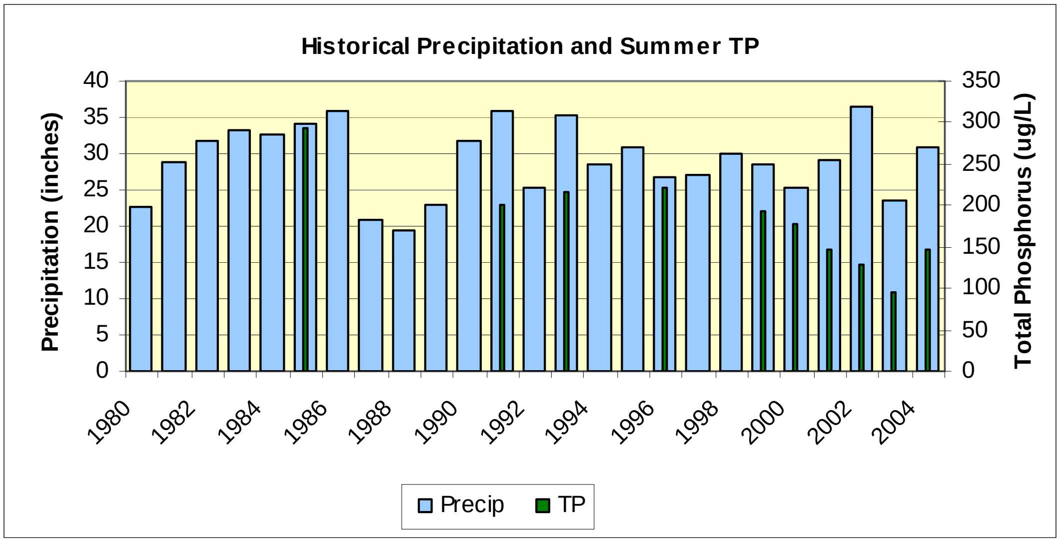
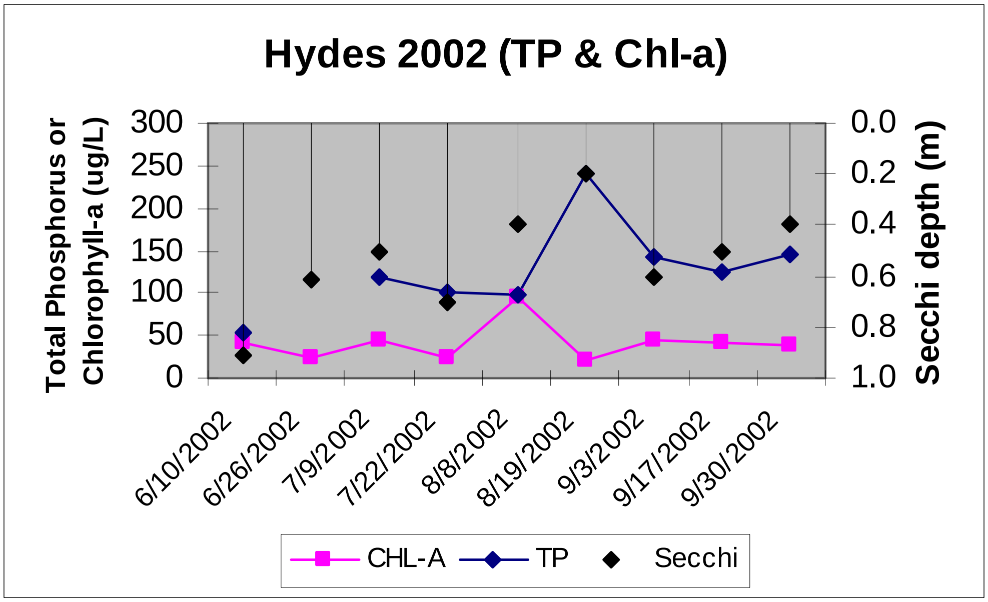


Figure 3.5 In-lake TP and annual precipitation for Hydes Lake.



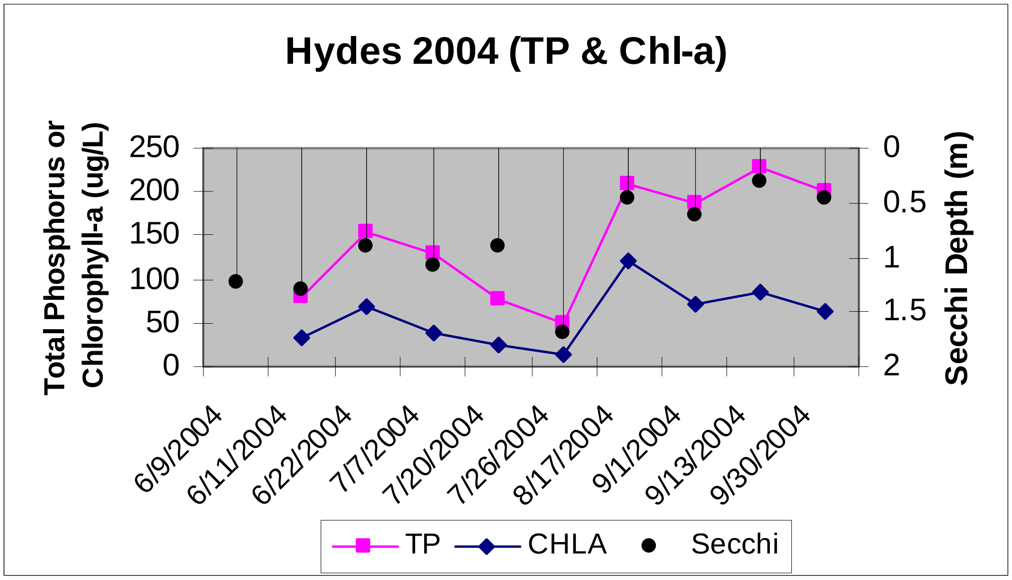


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Figure 3.6 2002 and 2004 summer TP, chlorophyll-a, and Secchi depth for Hydes Lake.

Water quality in Hydes Lake is that of a eutrophic system. Evidence suggests internal sources effect water quality. Land uses within the agriculturally dominated watershed contribute nutrient rich sediment runoff into the major tributary, which ends up accumulating in the lake.

3.2.3 Miller Lake

The watershed which includes Miller Lake has been heavily studied since the early 1990s. Data has been collected throughout the watershed and at the inlet (CA 10.4) and

outlet (CA 8.7) to Miller Lake. Monitoring has continued to show that the tributary, Carver Creek (CA 10.4), is laden with excess sediment and phosphorus.
By comparing the two sites and having data from multiple years and continuous flow, we can estimate the effects of upstream land use management to the lake. To this point Miller Lake acts as a large sediment pond for the entire watershed. In fact, it has been measured that in years of heavy rainfall, there is nearly one inch of sediment deposited to the lake bottom.

Table 3.3 Miller Lake TP and total suspended solids removal.

Miller Lake Removal				
Year	TP (pounds)	TSS (pounds)	% TP	% TSS
1997	22890	14423440	50	80
1998	15279	6311783	51	72
1999	39112	59725389	73	83
2000	1284	625982	38	82
2001	1454	108602	8	21
2002	2047	3246719	7	51
2003	6404	6490773	38	74
2004	4376	4213422	-21	-56
2005	6444	28372511	18	61

Furthermore, data collected from CA 10.4 and CA 8.7 from 1997-2005 shows that the lake has reduced the total suspended solids (TSS) and TP at the outflow by an average of 52 percent and 29 percent respectively (Table 3.3). It is clear that the major tributary (CA 10.4) is dramatically impacting Miller Lake and that the portion of the watershed above the lake is a major contributor of TSS and TP.

Monitoring conducted over the past ten years has depicted in-lake conditions as highly eutrophic to hypereutrophic. TP has ranged from 150 µg/L in 2005 to over 460 µg/L in 2001 (Table 3.4). Figure 3.7 shows nutrient variation from year to year. Figure 3.8 shows typical TP response to precipitation. Figure 3.9 shows summer TP, chlorophyll-a, and Secchi depth for Miller Lake.

Table 3.4 Growing season (June 1 – September 30) lake water quality for Miller Lake.

Year	TP Concentration (µg/L)/(n)	Chlorophyll-a Concentration (µg/L)/(n)	Secchi disk transparency (meters)/(n)	TKN (mg/L)/(n)
1994	193 (N/A)	19 (N/A)	1.2 (N/A)	1.9 (N/A)
1995	362 (8)	138 (N/A)	0.6 (2)	2.9 (2)
1997	326 (7)	52 (N/A)	1.0 (14)	2.3 (7)
1999	149 (12)	65 (12)	1.0 (12)	2.3 (12)
2000	403 (13)	48 (13)	0.8 (13)	2.3 (13)
2001	462 (13)	37 (13)	1.4 (13)	2.9 (13)
2002	298 (13)	28 (13)	1.2 (13)	N/A

2003	213 (14)	63 (14)	0.6 (14)	1.9 (14)
2004	184 (14)	49 (14)	0.7 (14)	1.9 (14)
2005	152 (14)	50 (14)	0.7 (14)	2.0 (14)
2006	172 (12)	89 (12)	0.7 (12)	2.7 (12)
2007	226 (13)	78 (13)	0.6 (12)	2.8 (13)
10 yr avg.	259	56	0.9	2.3

n is the number of samples collected each season

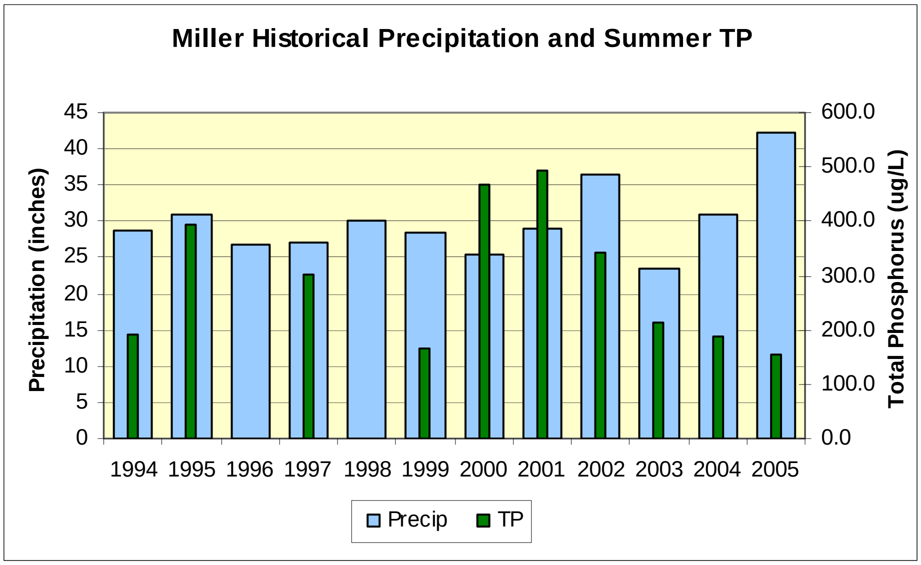
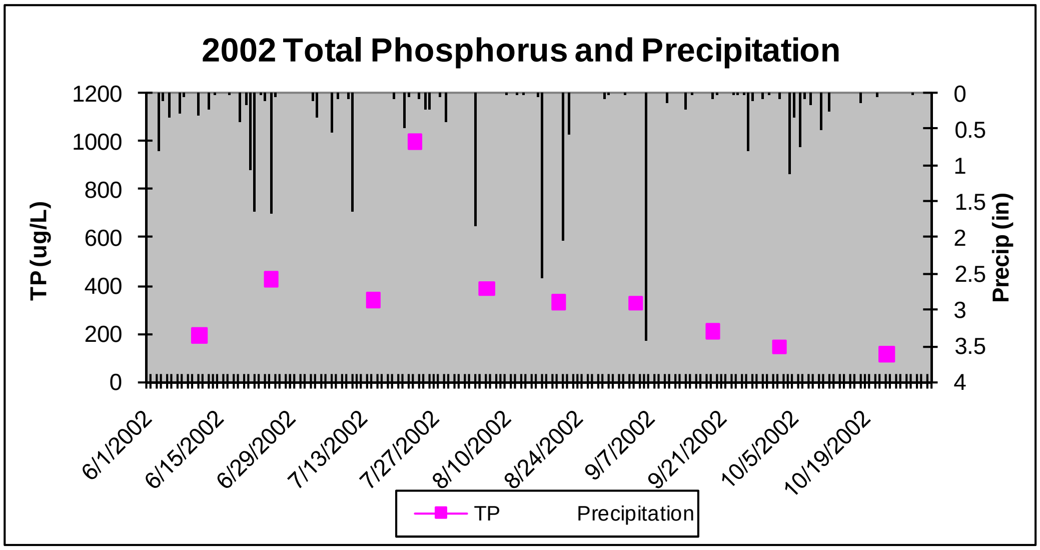


Figure 3.7 Miller Lake historical precipitation and summer TP.



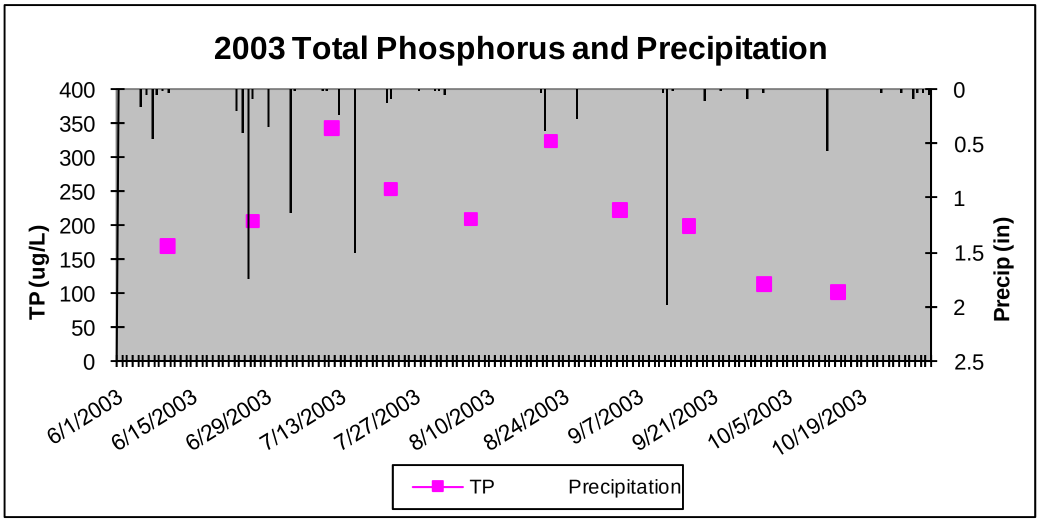
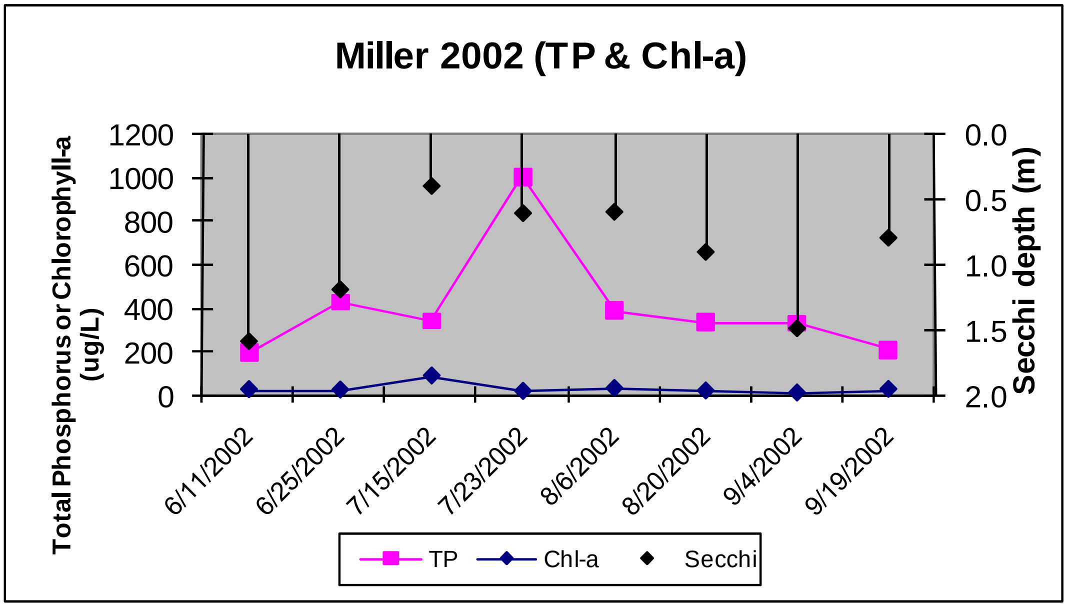


Figure 3.8 Miller Lake TP and daily precipitation for 2002 and 2003.

External loading due to runoff can be seen following precipitation events in June and July of 2003 (5.53inches); TP increased from 169 µg/L to 344 µg/L (Figure 3.8). Chlorophyll-a production decreased following the event, likely due to an increase in TSS which would have limited the light needed for algal survival.

In response to the large sediment load accumulating in the lake bottom, internal loading likely influences the water quality of Miller Lake. The large sediment loads carried into and removed from Miller Lake contain high nutrient levels. The nutrients can be released by sediments during periods of anoxia, during rooting by rough fish, curlyleaf pondweed senescence, and wind driven events. Research indicates that increases in TP in shallow lakes during the summer growing season are typical. Inflow is naturally low during this period and the increase in phosphorus can be attributed to internal loading (Welch & Cooke 1995).



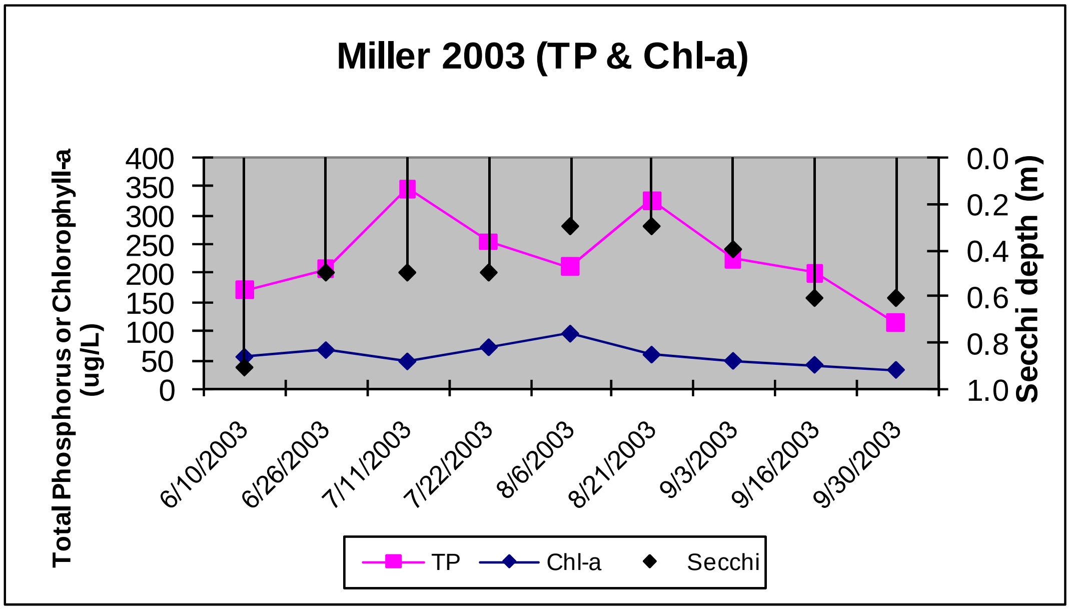


Figure 3.9 2002 and 2003 Summer TP, chlorophyll-a, and Secchi depth for Miller Lake.

Water quality in Miller Lake is that of a highly eutrophic to hypereutrophic system. Evidence suggests external sources dominate water quality. Land uses within the agriculturally dominated watershed contribute nutrient rich sediment runoff into the major tributary, which ends up accumulating in the lake. Internal loading also influences water quality, however at this point it is difficult to distinguish just how large a role it plays.

3.2.4 Winkler Lake

Analysis of in-lake conditions depicts Winkler Lake as a highly eutrophic to hyper-eutrophic system. TP has remained above 170 µg/L for the last ten years (Table 3.5). Figure 3.10 show typical nutrient variation from the 2003 and 2005 summer seasons, and Figure 3.11 shows within-year TP response to precipitation in Winkler Lake. While TP has shown a slight response to precipitation, it decreased following a large rain event (4.6”) in October of 2005.

Table 3.5 Growing season (June 1 – September 30) mean lake water quality in Winkler Lake.

Year	TP Concentration (µg/L)(n)	Chlorophyll-a Concentration (µg/L)(n)	Secchi disk transparency (meters)(n)	TKN (mg/L)(n)
1976	2580 (1)	160 (1)	0.2 (1)	4.7 (1)
1994	488 (1)	7 (1)	1.0 (1)	2.1 (1)
1995	869 (2)	78 (2)	0.5 (2)	4.7 (3)
1999	173 (6)	55 (6)	0.4 (6)	1.8 (6)
2000	1193 (4)	291 (4)	0.3 (4)	8.1 (4)
2001	297 (6)	56 (6)	0.5 (6)	2.0 (6)
2003	471 (9)	96 (9)	0.4 (9)	4.0 (9)

2005	281 (10)	67 (10)	0.6 (9)	3.2 (10)
2007	381 (13)	31 (13)	0.5 (12)	2.4 (13)
10 yr avg.	466	99	0.5	3.6

n is the number of samples collected each season

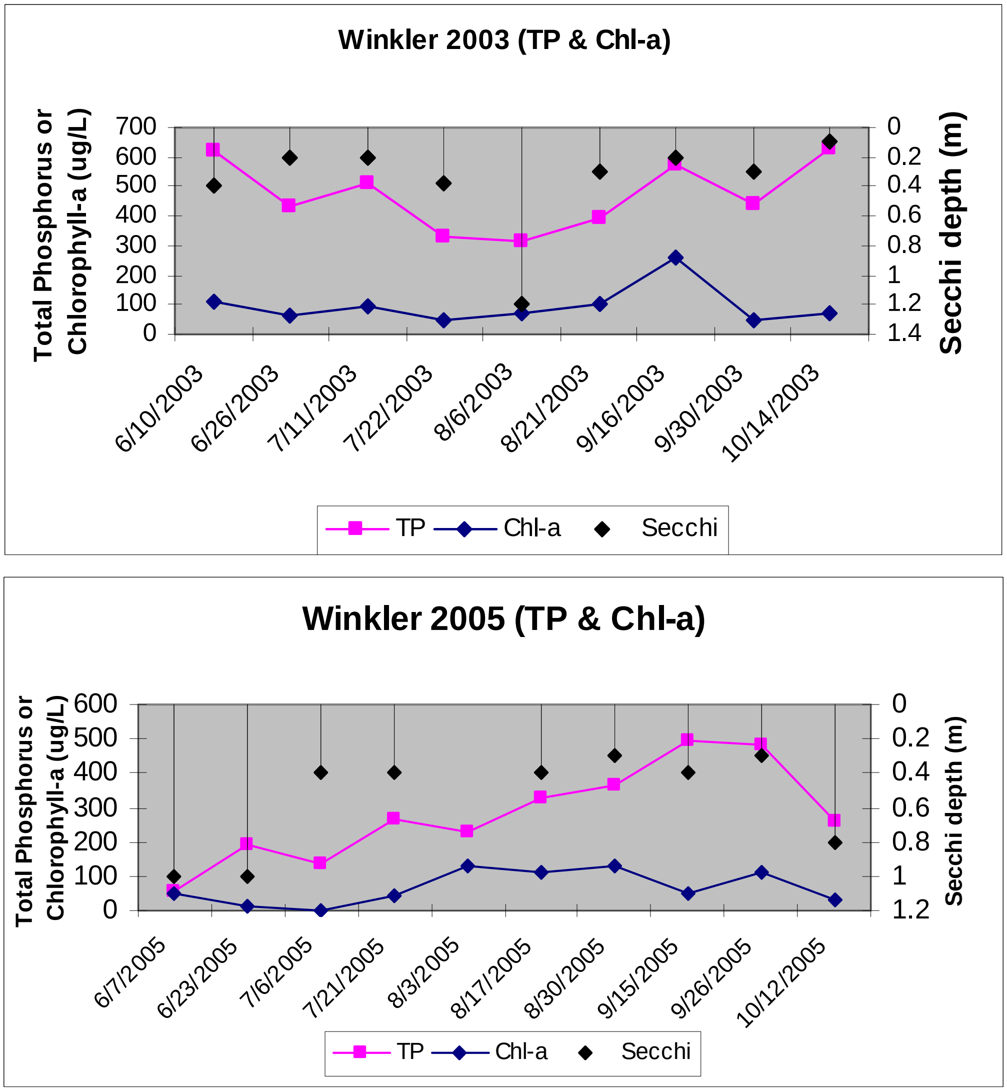


Figure 3.10 2003 and 2005 summer TP, chlorophyll-a, and Secchi depth for Winkler Lake.

Typically in a lake with high external loading, TP would increase following a precipitation event. The phosphorus responses show a steady increase typical in shallow lakes during the summer growing season. Inflow is naturally lower during this period and the increase in phosphorus can be attributed to internal loading (Welch & Cooke 1995). In addition to high phosphorus levels, over the last ten years TKN has remained above 2.0 mg/L, the threshold marking a negative response in water quality (MPCA 2005).

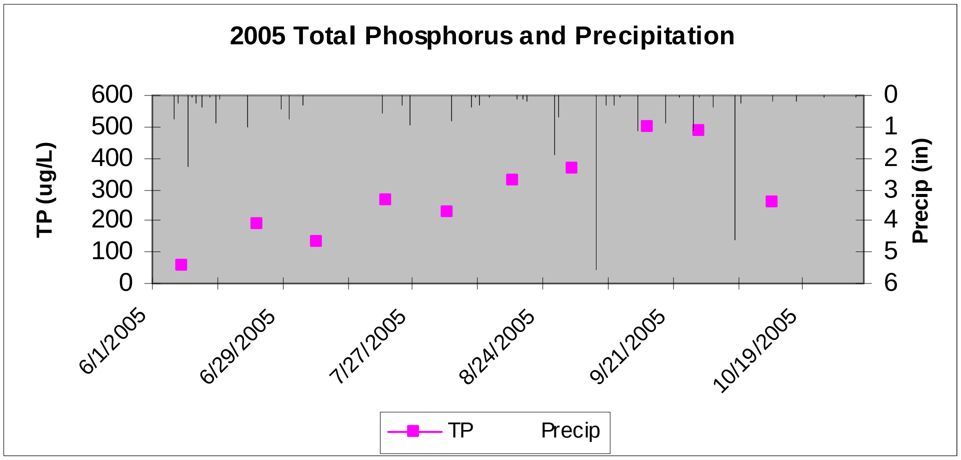


Figure 3.11 TP and daily precipitation during Winkler's 2005 summer growing season.

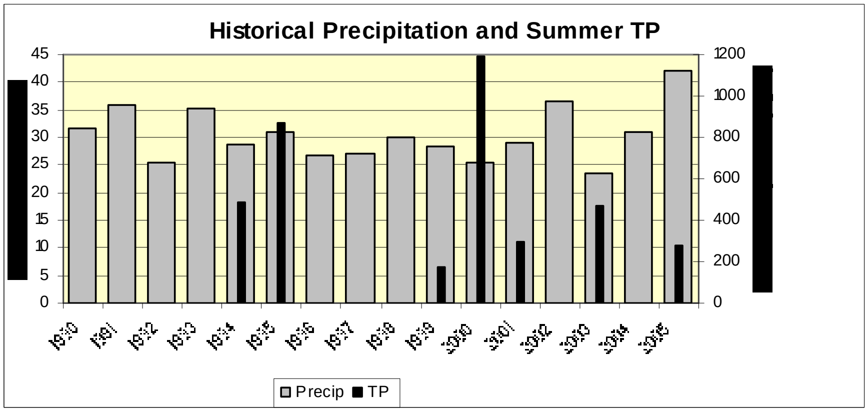


Figure 3.12 In lake TP and annual precipitation for Winkler Lake.

Changes in TP from year to year are shown in Figure 3.12. During years of below average precipitation (2000) TP increased while years of average to above average precipitation (2005) did not result in increased phosphorus.

In a somewhat unusual occurrence, during the 2005 monitoring season there were several instances where the Secchi disk could be seen at the lake's bottom. A filamentous algae mat was noted on the lake bottom, which may account for the unusual water clarity in 2005 relative to other years.

4.0 Phosphorus Source Assessment

4.1 Introduction

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

4.2 Point Sources

There is one point source in the Carver Creek watershed. Bongards' Creamery, Inc. is currently permitted to discharge into the south inlet (CC9) of Winkler Lake (Figure 2.5). Bongards' Creamery currently has a wastewater pond discharge (NPDES # MN0002135 – SD002).

A NPDES Phase II permit for small municipal separate storm sewer systems (MS4) has been issued to Waconia, a member city in the watershed. EPA requires that stormwater discharges regulated under NPDES be allocated into the wasteload allocation or point source portion of the TMDL. Although these sources of phosphorus in the watershed are nonpoint in nature, they are allocated in the wasteload allocation in this TMDL. However, the discussion of the sources maintains the nonpoint source nature of phosphorus.

Knowledge of the lakes tells us that high levels of phosphorus are likely present in the lake sediments due to historical land use, point source discharges, and surrounding inflows. There is inadequate understanding of the longevity and mechanisms of internal loading resulting from diverted effluent, as is the case with the Waconia Sewage Treatment Plant. Internal loading in some lakes following the diversion of external loading is expected to last over 30 years (Welch & Cooke 1995).

4.2.1 Winkler Lake

Bongards' Creamery, Inc. is currently permitted to discharge into the south inlet (CC9) of Winkler Lake. Bongards' Creamery has three discharges including two non-contact cooling water discharges (NPDES # MN0002135 – SD001 & SD003) and one wastewater pond discharge (NPDES # MN0002135 – SD002). Table 4.1 provides the TP data measured in the discharges in recent years as obtained from the MPCA.

The wastewater pond discharge (SD002) is regulated under NPDES and is only permitted to discharge for short durations during the year. Typically, discharging of the ponds should occur from April 1 through June 15 and September 15 through December 15. The maximum daily discharge allowed is 1.87 MGD. Phosphorus limits were 3.0 mg/L prior to the fall of 2004 but were reduced to 1.0 mg/L thereafter. An upgraded WWTP was designed to meet the lower phosphorus requirements which consisted of the addition of alum and/or ferric sulfate added continuously at the outfall which is followed by a sand filter to reduce the TP content in the discharge. The non-contact cooling water sites discharge year-round and do not have to meet any standards; however they are monitored monthly for both flow and TP. No chemicals are added to the non-contact cooling water and neither site should contribute to phosphorus loading except for what may be present in groundwater. As of April of 2006, one non-contact cooling water stream is in a state of no discharge, thus reducing the amount of phosphorus that is discharging due to non-contact cooling water.

Table 4.1 Bongards' Creamery TP load from 2002 to 2008 (MPCA data).

Year	SD001 (cooling water)		SD002[1] (process wastewater)		SD003 (cooling water)	
	Avg Flow (mgd)	TP Load (kg/yr)	Avg Flow (mgd)	TP Load (kg/yr)	Avg Flow (mgd)	TP Load (kg/yr)
2008*	0	0	0.039	21	0.021	5
2007	0	0	0.11	90	0.03	8
2006	0.025	6.6	0.063	68	0.011	3
2005	0.245	53	0.758	174	0.161	40
2004	0.282	115	0.753	253	0.05	42
2003	0.403	198	1.35	291	0.232	64
2002	0.492	145	1.44	291	0.123	25

[1] PCA permit allows for maximum 1 mg/L TP as of January 2004, prior to this the standard was 3 mg/L. At the 1-mg/L limit, the permitted TP load is 481 kg/yr at a flow of 0.756 mgd, and 1272 kg/yr at a flow of 2 mgd (mgd = millions of gallons per day).

*2008 had reports up to the month of October.

Due to the close proximity of Bongards' Creamery to Winkler Lake, and the fact that the discharge is to a ditch system, we assume that essentially the entire load from the plant reaches the lake. In addition, there are no wetlands or basins to intervene between the discharge and the lake.

Effluent discharge from Bongards' Creamery appears to have been a significant source of phosphorus to Winkler Lake prior to 2004. Wastewater discharged from the creamery is now required to meet a 1.0 mg/L total phosphorus effluent limit. New data collected from 2006 to 2008 show that non-contact cooling water does not contribute a large portion of total phosphorus to Winkler Lake with an average of roughly 5 kg per year during that time frame. This TMDL establishes a total phosphorus loading cap for all discharges from the creamery.

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 water bodies. 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. With a portion of the City of Waconia discharging to Carver Creek, stormwater runoff from developed land uses affects Miller Lake.

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 on-site 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 Carver Creek watershed.

5.0 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 load allocations, responses, and reductions goals. The models used throughout the process included a Reckhow-Simpson spreadsheet and the BATHTUB V6.1 (Walker 1999) model.

The major inflows to the lakes were monitored for flow and phosphorus loading; however, for unmonitored subwatersheds, the Reckhow-Simpson model was used to develop runoff volumes and phosphorus loads. This model relies on phosphorus export and runoff coefficients based on land uses to estimate phosphorus loading and runoff. Development of runoff and export coefficients is described in Section 6.3. Outputs from the Reckhow-Simpson model were then utilized as inputs to the BATHTUB model.

BATHTUB is a publicly available model 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. It 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 phosphorus 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 phosphorus model that accounts for water and phosphorus 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 phosphorus sedimentation and retention in the lake sediments. BATHTUB allows choice among several different mass-balance phosphorus models. For deep lakes in Minnesota, the option of the Canfield-Bachmann lake formulation has proven to be appropriate in most cases. For shallow Minnesota lakes, other options have often been more useful. 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 MPCA 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 Carver Creek Lake watershed area. For Carver Creek 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

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 assuming average watershed slopes of less than two percent (Ward And Elliott 1995). Runoff coefficients used are presented in Table 5.2.

Table 5.2 Runoff Coefficients to estimate runoff from Carver Creek Watershed.

Land Use	Watershed Runoff Coefficients			
	Goose	Hydes	Miller	Winkler
Developed	0.27	0.25	0.22	0.22
Forest/Grassland	0.09	0.07	0.07	0.07
Water	0	0	0	0
Agriculture	0.25	0.25	0.25	0.25
Wetland	0	0	0	0

Runoff coefficients were developed by applying literature values to the entire 55,076 acre Carver Creek watershed, and then adjusting the values to better predict monitored annual runoff volumes. Actual watershed runoff was monitored at Carver Creek site CA 1.7, which is monitored continuously by the Metropolitan Council Environmental Services Watershed Outlet Monitoring Program (WOMP). Predicted and monitored annual runoff volumes are presented in Table 5.3. Monitored runoff was very low in 2000 due to low precipitation (25.39 inches) and the timing of precipitation events. Most of the precipitation occurred mid-summer at which time vegetation was present and absorbed the majority of rainfall. Most years had a runoff difference of less than 20 percent and were deemed to be reasonable to apply to the Carver Creek watershed.

Table 5.3 Predicted and monitored annual runoff for the Carver Creek watershed.

	1998	1999	2000	2001	2002	2003	2004	2005
Predicted Runoff (ac-ft)	25,632	24,234	21,650	24,822	31,047	20,064	26,400	35,976
Monitored Runoff (ac-ft)	26,680	23,190	3,772	28,451	38,155	17,489	20,695	28,704
Percent Difference	-4%	4%	83%	-15%	-23%	13%	22%	20%

The five calendar years 2001 – 2005 included two average-precipitation years, 2001 and 2004. One of these two years was used to determine the TMDL for each lake (Table 5.4). For implementation planning, each lake and its watershed were also modeled for a wet year (either 2002 or 2005) and a dry year (2003).

Table 5.4 Wet, dry, and average annual precipitation amount and year for Goose, Hydes, Miller, and Winkler Lakes.

Lake	Wet		Average		Dry	
	Year	Amount (in)	Year	Amount (in)	Year	Amount (in)
Goose	2002	36.41	2004	30.96	2003	23.53
Hydes	2002	36.41	2004	30.96	2003	23.53
Miller	2002	36.41	2004	30.96	2003	23.53
Winkler	2005	42.18	2001	29.11	2003	23.53

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 5.5. 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 (Table 5.5) were applied to the watershed land use to estimate watershed phosphorus loads. Phosphorus export coefficients were based upon literature values that best represented conditions in the Carver Creek Lakes watershed (EPA 1980). Runoff TP concentrations were computed from runoff depths calculated using runoff coefficients outline in Section 5.3.1 and the resulting land use phosphorus loads derived from export values (Table 5.6). When considering loading rates for the developed areas, it was assumed that no BMPs were in place within the watershed.

Table 5.5 Phosphorus export coefficients by land use for all lakes.

Loading Rates (kg/ha/yr)	Low	Average	High
Developed	0.3	0.4	0.6
Forest/Grassland	0.01	0.04	0.08
Agriculture	0.2	0.5	1.0
Septic (kg/capita)	0.7	1.5	3.0
Wetland	0	0	0

Table 5.6 Runoff phosphorus concentrations for each lake.

TP Concentration (µg/L)	Developed			Forest/Grassland			Agriculture		
	Low	Average	High	Low	Average	High	Low	Average	High
Goose	125.2	200.3	300.4	15.0	60.1	120.2	108.2	270.4	540.8
Hydes	135.2	216.3	324.5	19.3	77.3	154.5	108.2	270.4	540.8
Miller	153.6	245.8	368.7	19.3	77.3	154.5	108.2	270.4	540.8
Winkler	153.6	245.8	368.7	19.3	77.3	154.5	108.2	270.4	540.8
Average	141.9	227.1	340.6	18.2	73.0	145.9	108.2	270.4	540.8

Based on average precipitation (29.11 inches).

5.3.3 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.

5.3.4 Atmospheric Load

Atmospheric loading rates were set at a rate of 20 mg/m^2/yr based on conversations with the MPCA and literature values (Bruce Wilson personal communication).

5.3.5 Septic System Load

Failing or nonconforming septic systems can be an important source of phosphorus to surface waters. 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 percent 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 phosphorus retention lower 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.

5.4 Phosphorus Budget Components

5.4.1 Goose Lake

5.4.1.1 Internal Load

Using the process outlined in Section 5.3.3, the final internal loading terms were entered at 0.5 mg/m^2/day and 0.7 mg/m^2/day for 2001 and 2004, respectively.

An equation utilizing anoxic factor and release rates developed by Gertrud Nurnberg was used to add confidence to the internal load calculated above. Since Goose Lake demonstrates periods of DO stratification where the sediments experience periods of low oxygen or anoxic conditions, we were able to estimate internal loading using an anoxic factor predictive equation and estimate release rates for hypereutrophic lakes (Nurnberg 1987).

5.4.1.2 Atmospheric Load

Using rates determined in Section 5.3.4, the atmospheric loading for Goose Lake is set at 27 kg/yr.

5.4.1.3 Upstream lakes

Because Donders, Rutz, and Swan Lakes flow into Goose Lake, nutrients from the three lakes will end up in Goose Lake. This potential exchange has been included in the

BATHTUB model. To effectively determine phosphorus loading from these water bodies, independent BATHTUB models were set up and calibrated in a similar fashion to Goose Lake. Outputs from the models were then entered into the Goose Lake model as tributaries (Table 5.7).

Limited monitoring was available for Rutz and Swan Lakes and no data was available for Donders Lake. Tributary input data was calculated using methods outlined in Sections 5.3.1 and 5.3.2. To improve the confidence of the models additional monitoring should occur as part of the implementation plan.

Table 5.7 BATHTUB model outputs for contributing water bodies to Goose Lake.

Year	Lake	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)
2004	Rutz	1.13	300	0.21
	Donders	0.89	517	0.11
	Swan	1.51	380	0.17
2001	Rutz	1.13	319	0.20
	Donders	0.89	550	0.10
	Swan	1.51	404	0.16

5.4.1.4 Tributary or Watershed Load

The tributary load from the watershed was developed using monitored data and the Reckhow-Simpson model as described in Section 5.3. For the monitored inlet, G1, the flow weighted-mean concentration calculated from the five samples collected in 2004 (300 µg/L) was used to calibrate the inflow concentration. This concentration was within 7 percent of the Reckhow-Simpson model calculated concentrations for the 2004 modeled year. Based upon this, the Reckhow-Simpson model concentrations were used for all inlets. Also, the Reckhow-Simpson model was utilized to estimate the flow (Table 5.8).

Table 5.8 BATHTUB model inputs for Goose Lake tributaries.

	Direct		G1		Inlet 2		Inlet 3	
Component	2001	2004	2001	2004	2001	2004	2001	2004
Flow (hm^3/yr)	0.7	0.8	1.00	1.37	0.90	0.11	0.08	0.09
TP Concentration (µg/L)	372	349	341	320	359	338	271	255
TP Load (kg/yr)	126	129	198	199	22	20	22	20

5.4.1.5 Septic System Load

A total of 75 septic systems are located within the Goose Lake Watershed. Table 5.9 outlines the BATHTUB septic system inputs. Septic systems within the Swan, Rutz, and Donders Subwatersheds were not included within the Goose Lake BATHTUB model due to the inclusion into each lake's individual BATHTUB models that were used to determine outflow and loadings.

Table 5.9 Septic system BATHTUB model inputs for Goose Lake.

Component	Direct		G1		Inlet 2		Inlet 3	
	2001	2004	2001	2004	2001	2004	2001	2004
Flow (hm^3/yr)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TP Concentration (µg/L)	554		378		76		25	
TP Load (kg/yr)	5.5	5.5	3.8	3.8	0.8	0.8	0.3	0.3

5.4.2 Hydes Lake

5.4.2.1 Internal Load

Using the process outlined in Section 5.3.3, the final internal loading terms were entered at 0.01 mg/m^2/day for both 2004 and 2002.

5.4.2.2 Atmospheric Load

Atmospheric loading rates were determined to contribute 17.5 kg/yr of phosphorus to Hydes Lake for each modeled year.

5.4.2.3 Upstream Lakes

Patterson Lake drains directly to Hydes Lake through a 0.6 mile segment of Carver Creek. Consequently, water and nutrients flow out of Patterson and into Hydes Lake (Table 5.10). As such, the inflow has been included in the BATHTUB modeling using techniques outlined in Section 5.3. To improve the confidence of the models, additional monitoring may occur in Patterson Lake as part of the implementation of the TMDL.

Table 5.10 BATHTUB model outputs for contributing water bodies to Goose Lake.

Year	Lake	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)
2004	Patterson	9.5	310	1.23
2002	Patterson	9.5	263	1.45

5.4.2.4 Tributary or Watershed Load

Table 5.11 outlines the inputs used within the BATHTUB model for both the 2001 and 2005 modeled years. These values are calculated using methods as described in Section 5.3.

Table 5.11 BATHTUB model inputs for Hydes Lake.

Year	Watershed	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)
2004	H2	2.1	321.5	0.30
	Direct	2.2	488.6	0.22
2002	H2	2.1	273.3	0.35
	Direct	2.2	415.5	0.26

5.4.2.5 Septic System Load

28 septic systems are located within the Hydes Lake Watershed. Table 5.12 outlines the septic system BATHTUB model inputs.

Table 5.12 Septic system BATHTUB model inputs for Hydes Lake.

Component	Direct		H2	
	2002	**2004**	**2001**	**2004**
Flow (hm^3/yr)	0.1	<0.1	0.1	<0.1
TP Concentration (µg/L)	275		75.1	
TP Load (kg/yr)	27.5	2.8	7.5	0.8

5.4.3 Miller Lake

5.4.3.1 Internal Load

Using the process outlined in Section 5.3.3, internal loading was determined to be 52 $mg/m^2/day$ for the 2002 model and 0.5 $mg/m^2/day$ for the 2004 model.

5.4.3.2 Atmospheric Load

Atmospheric loading rates for both 2002 and 2004 were set at a rate of 20 $kg/km^2/yr$ and determined to contribute 11.4 kg/yr to the TP in Miller Lake.

5.4.3.3 Upstream Lake Load

Reitz, Burandt, Winkler and Benton Lakes drain directly into Carver Creek and therefore eventually into Miller Lake. Consequently, water which may be transporting nutrients flows out of the lakes and into Miller Lake (Table 5.13). As such, the inflow has been included in the BATHTUB modeling using techniques outlined in Section 5.3 and stream monitoring data collected at CA 10_4 (see Appendix A).

Table 5.13 BATHTUB model outputs for contributing water bodies to Miller Lake.

Year	Lake	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)
2004	Burandt	43.6	239.1	4.1
	Winkler	49.2	256.7	7.2
	Reitz	14.7	294.5	1.9
	Benton	9.1	244.1	1.3
2002	Burandt	43.6	203.5	4.8
	Winkler	49.2	218.3	8.4
	Reitz	14.7	250.4	2.3
	Benton	9.1	207.6	1.5

5.4.3.4 Tributary or Watershed Load

Table 5.14 outlines the inputs used within the BATHTUB model for both the 2002 and 2004 modeled years. These values are calculated using methods as described in Section 5.3.

Table 5.14 BATHTUB model inputs for Miller Lake.

Year	Watershed	Watershed Area (km^2)	P Concentration (µg/L)	Flow (hm^3/yr)
2004	CA 10.4	57.7	287	8.58
	D1	1.2	293	0.18
	D2	0.4	324	0.04
2002	CA 10.4	57.7	244	10.09
	D1	1.2	223	0.21
	D2	0.4	275	0.05

5.4.3.5 Septic System Load

There are a total of 334 septic systems within Miller Lake direct watershed. Homes within the Waconia and Cologne city boundaries are connected to city sewage disposal infrastructure. Table 5.15 outlines the septic system BATHTUB model inputs

Table 5.15 Septic system BATHTUB model inputs for Miller Lake.

	CA 10.4		D1		D2	
Component	2002	2003	2002	2003	2002	2003
Flow (hm^3/yr)	0.1	0.1	0.1	0.1	0.1	0.1
TP Concentration (µg/L)	4093		37.5		50.1	
TP Load (kg/yr)	409.3	409.3	3.8	3.8	5.0	5.0

5.4.4 Winkler Lake

5.4.4.1 Internal Load

Using the process outlined in Section 5.3.3, the final internal loading terms were entered as 5 $mg/m^2/day$ for 2001 and 13 $mg/m^2/day$ for 2005.

5.4.4.2 Atmospheric Load

Atmospheric loading rates were set at 20 $kg/km^2/yr$ and determined to contribute approximately 6 kg/yr to Winkler Lake.

5.4.4.3 Upstream Lake Load

Rice Lake drains directly to Winkler Lake via inlet CC8 and has been accounted for by utilizing monitored data at stream station CC8 and Reckhow-Simpson Models. Table 5.16 outlines the upstream lake loads to Winkler Lake.

Table 5.16 BATHTUB model outputs for contributing water bodies to Winkler Lake.

Year	Lake	Watershed Area (km^2)	P Concentration (µg/L)	Outflow (hm^3/yr)
2005	Rice	18.5	222	3.7
	Barlous	3.8	207	0.7
	Hydes	9.1	222	2.4
2001	Rice	18.5	321	2.6
	Barlous	3.8	300	0.5
	Hydes	9.1	321	1.6

5.4.4.4 Tributary or Watershed Load

Table 5.17 outlines the inputs used within the BATHTUB model for both the 2001 and 2005 modeled years. These values are calculated using methods as described in Section 5.3.

Table 5.17 BATHTUB model inputs for Winkler Lake.

Year	Watershed	Watershed Area (km^2)	P Concentration (µg/L)	Flow (hm^3/yr)
2001	Inlet 1	0.5	294	0.09
	Inlet 2 (CC9)	9.3	313	1.49
	Inlet 3 (CC8)	2.0	356	0.27
	Direct	1.1	410	0.12
2005	Inlet 1	0.5	203	0.13
	Inlet 2 (CC9)	9.3	216	2.13
	Inlet 3 (CC8)	2.0	246	0.39
	Direct	1.1	283	0.17

5.4.4.5 Septic System Load

There are a total of 63 septic systems within the Winkler Lake Watershed. For BATHTUB modeling purposes, methods outlined in Section 5.3.5 were used to calculate loads within all subwatersheds. Table 5.18 outlines the septic system BATHTUB model inputs.

Table 5.18 Septic system BATHTUB model inputs for Winkler Lake.

	Inlet 1		Inlet 2 (CC9)		Inlet 3 (CC8)		Direct	
Component	2001	2005	2001	2005	2001	2005	2001	2005
Flow (hm^3/yr)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TP Concentration (µg/L)	12.5		613.3		863.6		25.0	
TP Load (kg/yr)	1.3	1.3	61.3	61.3	86.4	86.4	2.5	2.5

5.4.4.6 Industrial Load

Bongards' Creamery, Inc. is currently permitted to discharge into the south inlet (CC9) of Winkler Lake. Bongards' is the only industrial discharge within the watersheds of the four lakes. See Section 5.2.2 for description of Bongards' discharge.

5.5 Model Validation and Benchmark Phosphorus Budgets

5.5.1 Model Validation

5.5.1.1 Goose Lake

BATHTUB model results from 2001 (average year) and 2004 (wet year) are presented as the predicted and observed values and a coefficient of variation (standard error of the mean) in Table 5.19. The focus of the phosphorus budget development will focus on 2004, where the monitoring data set was most complete and precipitation was average.

Table 5.19 Observed and predicted in-lake water quality for Goose Lake in 2001 and 2004 (June – September).

Year	Variable	Predicted		Observed	
		Mean	CV	Mean	CV
2004	TP (µg/L)	129.2	0.34	134.0	0.23
	Chlorophyll-a (µg/L)	59.5	0.35	53.0	0.42
	Secchi Depth (meters)	0.4	0.19	0.4	0.25
2001	TP (µg/L)	123.0	0.34	125.0	0.28
	Chlorophyll-a (µg/L)	81.6	0.38	60.3	0.29
	Secchi Depth (meters)	0.6	0.29	1.0	0.74

There is acceptable agreement among predicted and observed TP in both years. The overestimation of chlorophyll-a in 2001 may be due to the fact that water clarity in Goose Lake is often influenced by turbidity caused by suspended sediments and not algae itself.

5.5.1.2 Hydes Lake

Model results from 2002 (wet year) and 2004 (average year) are presented as the predicted and observed values and a coefficient of variation. The model represents reasonable agreement with a slight under prediction for TP in both years (Table 5.20).

Table 5.20 Observed and predicted in-lake water quality for Hydes Lake in 2002 and 2004 (June – September).

Year	Variable	Predicted		Observed	
		Mean	CV	Mean	CV
2004	TP (µg/L)	145.3	0.26	146.0	0.46
	Chlorophyll-a (µg/L)	67.1	0.29	57.8	0.59
	Secchi Depth (meters)	0.8	0.25	0.9	0.49
2002	TP (µg/L)	132.2	0.23	129.0	0.43
	Chlorophyll-a (µg/L)	50.0	0.31	42.0	0.52
	Secchi Depth (meters)	0.5	0.18	0.5	0.37

Chlorophyll-a concentrations were slightly over predicted in both modeled years. Secchi depth was in reasonable agreement in 2004 and exact for 2002. Slight differences can be attributed to numerous factors including sampling frequency and high populations of planktivores which graze zooplankton to the point where they are unable to control algae. In addition, algal species present include Aphanizomenon which forms clusters while the water itself remains clear, therefore increasing Secchi depths.

5.5.1.3 Miller Lake

Model results from the 2002 and 2003 are presented in Table 5.21 as the predicted and observed values and a coefficient of variation. The model represents reasonable agreement in 2002 and 2003. As mentioned in section 3.3 the modeled years were chosen based on similarities in monitored and Canfield-Bachman modeled phosphorus loads. The overestimation of chlorophyll-a in 2001 may be due to the fact that water clarity in Miller Lake is often influenced by turbidity caused by suspended sediments and not algae itself.

Table 5.21 Observed and predicted in-lake water quality for Miller Lake in 2002 and 2003 (June – September).

Year	Variable	Predicted		Observed	
		Mean	CV	Mean	CV
2002	TP (µg/L)	397.5	0.17	398.0	0.73
	Chlorophyll-a (µg/L)	52.1	0.28	28.8	0.93
	Secchi Depth (meters)	0.7	0.19	0.9	0.41
2004	TP (µg/L)	198.8	0.15	197.0	0.42
	Chlorophyll-a (µg/L)	44.1	0.29	56.0	0.37
	Secchi Depth (meters)	0.6	0.17	0.7	0.32

5.5.1.4 Winkler Lake

Model results from the 2001 and 2005 are presented in Table 5.22 as the predicted and observed values and a coefficient of variation. The model represents reasonable agreement in 2001 and 2005.

Table 5.22 Observed and predicted in-lake water quality for Winkler Lake in 2001 and 2005 (June – September).

Year	Variable	Predicted		Observed	
		Mean	CV	Mean	CV
2005	TP (µg/L)	282.0	0.10	283	0.53
	Chlorophyll-a (µg/L)	81.9	0.27	71	0.71
	Secchi Depth (meters)	0.8	0.28	0.5	0.56
2001	TP (µg/L)	298.2	0.12	297	0.46
	Chlorophyll-a (µg/L)	56.7	0.27	57	0.83
	Secchi Depth (meters)	0.5	0.18	0.5	0.34

Chlorophyll-a concentrations were over-predicted for both modeled years. Secchi depth was slightly over-predicted both years. The differences here can be attributed to the unique processes within shallow lakes.

5.5.2 Benchmark Phosphorus Budgets

One of the key aspects of developing TMDLs is an estimate of the nutrient budget for the current loading to the water body. Monitoring data and modeling were used to estimate the current sources of phosphorus to the Carver Creek 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 so the net effect on the water or nutrient budgets is very small.

5.5.2.1 Goose Lake

The G1 inlet, combined with inflow from Rutz Lake and Swan Lake, make up the upper half of the Goose Lake watershed. Collectively, the three subwatersheds account for nearly 35 percent of the TP load (Table 5.23). They have the largest potential to continue to degrade water quality in Goose Lake, particularly during spring when there is constant flow from all channels. Runoff from direct inflow accounts for 14 percent of external phosphorus loading, the second highest external load. Based on estimates, phosphorus loading from septic systems appears to be low, and accounted for approximately 1 percent of the loading. Finally, internal load estimates were based on a rate of 0.5 mg/m^2/yr which translates to 37 percent of the TP load.

Table 5.23 Summary of current TP and water budget for Goose Lake based on 2004 data and BATHTUB modeling.

Subwatershed	**Area km^2**	**Water Inflow hm^3/yr**	**TP Load kg/yr**	**Percent of Total Load**
G1	4.4	0.6	199	21%
Inlet 2	0.4	0.1	20	2%
Inlet 3	0.5	0.1	20	2%
Rutz Lake	1.4	0.2	63	7%
Swan Lake	1.5	0.2	65	7%
Direct inflow	0.9	0.4	129	14%
Donders	0.9	0.1	57	6%
Septic Systems	--	<0.1	7	1%
Atmospheric Deposition	1.4	1.1	27	2%
Total External		**2.8**	**587**	**63%**
Total Internal			**345**	**37%**
TOTAL P LOADING			**932**	**100%**

5.5.2.2 Hydes Lake

The H2 inlet along with the Patterson Lake subwatershed represents a potentially large external source of nutrients to Hydes Lake, accounting for approximately 79 percent of the phosphorus load in an average year (Table 5.24). Nutrient loading from Patterson Lake is relatively unclear however, which means that additional in-lake monitoring is needed. If Patterson Lake is low in nutrients, there is a possibility that nutrient loading occurs within the portion of the inlet (H2) between the two lakes. This portion of the subwatershed is primarily agricultural. An additional 18 percent of the nutrient load is accounted for in the direct watershed runoff. Internal loads represented 0.5 percent of the load. Septic systems represent a relatively small proportion of the load (0.5 percent).

Table 5.24 Summary of current TP and water budget for Hydes Lake based on 2004 data and BATHTUB modeling.

Subwatershed	Area km^2	Water Inflow hm^3/yr	Estimated External TP Load kg/yr	Percent Contributions
H2 (including Patterson Lake)	2.1	0.3	97	16%
D1 (Direct)	2.2	0.2	108	18%
Patterson Lake	9.5	1.2	381	63%
Septic systems	--	0.02	4	0.5%
Atmospheric Deposition	0.9	0.7	17	3%
Total External		**2.4**	**585**	**99%**
Total Internal			**3**	**0.5%**
TOTAL P LOADING			**588**	**100%**

5.5.2.3 Miller Lake

2004 modeling results show that the majority of nutrient loading into Miller Lake occurs from the major inlet, CA 10.4 (Table 5.25). Additionally, some animal units are maintained in the watershed. Reckhow-Simpson predicted septic system phosphorus loading rates account for approximately 6 percent of the overall phosphorus load.

Table 5.25 Summary of current TP and water budget for Miller Lake based on 2004 data and BATHTUB modeling.

Subwatershed	Area km^2	Water Inflow hm^3/yr	Estimated TP Load kg/yr	Percent of total Load
CA 10.4 (inlet 1)	57.7	8.6	2,463	37%
D1 (inlet2)	1.2	0.2	53	0.8%
D2 (direct inflow)	0.4	0.01	13	0.2%
Burandt Sub	43.6	4.1	974	14%
Winkler Sub	49.2	7.2	1,835	27%
Reitz Sub	14.7	1.9	565	8%
Benton Sub	9.1	1.3	312	5%
Septic systems		<0.1	418	6%
Atmospheric Deposition	0.6	0.3	11	0.2%
Total External		**23.2**	**6,646**	**98%**
Total Internal			**104**	**2%**
TOTAL P LOADING			**6,750**	**100%**

5.5.2.4 Winkler Lake

The two major inlets, CC8 and CC9, contribute the majority of water flowing into Winkler Lake; therefore the water quality of the two inlets greatly influences the conditions within Winkler Lake. The CC8 inlet flows into the lake from a series of lakes which themselves have very high nutrients (Rice and Hydes Lakes), which is broken out into the Rice Subwatershed and Hydes Subwatershed in Table 5.26. With the addition of these upstream lakes, CC8 contributes 51percent of the total load to Winkler Lake. The measured concentration in this inlet is similar to Rice Lake. CC9 contributes the second highest loading; the majority of the watershed here is drained agricultural land, in addition to the point source that drains into the ditch. Internal loading accounts for a major portion of the available phosphorus. Over the years, excess nutrients (from both point and non-point sources) have built up in the lake's sediments and are now easily re-suspended by wind mixing and rough fish activity. Although in this model it appears that septic systems are a minor source, failing septic systems near any surface water contribute to phosphorus loads. Table 5.26 summarizes model outputs for Winkler Lake.

Table 5.26 Summary of current TP and water budget for Winkler Lake based on 2005 data and BATHTUB modeling.

Subwatershed	**Area km^2**	**Water Inflow hm^3/yr**	**Estimated External TP Load kg/yr**	**Percent of Total Load**
Inlet CC9	9.3	1.5	467	17%
Inlet CC8	2.0	0.3	96	3%
Direct	1.1	0.1	49	2%
Inlet 1	0.5	0.1	27	0.9%
Rice Subwatershed	18.5	2.6	822	29%
Hydes Subwatershed	12.8	1.6	524	19%
Barlous Subwatershed	3.8	0.5	144	5%
Septic systems	--	<0.1	151	5%
Atmospheric Deposition	0.3	0.3	6	0.2%
Total External		**6.6**	**2,284**	**81%**
Total Internal			**530**	**19%**
TOTAL P LOADING			**2,814**	**100%**

6.0 TMDL Allocations

TMDL = WLA + LA + MOS + RC

Where:

TMDL = Total Maximum Daily Load
WLA = Wasteload Allocation (for permitted sources)
LA = Load Allocation (for nonpermitted 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 four lakes was determined by fitting the lake's phosphorus load to the appropriate (shallow or deep) 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 (such as Goose, Miller, and Winkler) 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.

The above points, though stated for shallow lakes, also apply in large part to Hydes Lake, due to its large littoral area.

An additional conservative assumption applies to Winkler Lake and relates to loading to it from Bongards’ Creamery. Its wastewater pond discharge is limited to two discharge periods: March 1 to June 15 and September 15 to December 31. Thus, the facility’s ponds are not discharging during much of the summer critical period each year.

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. For the City of Waconia and Laketown Township, regulated MS4s, future growth was accounted for in their WLAs by basing their allocations for stormwater contribution on their developed land area projections for 2030. 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. Permitted loads for Bongards’ Creamery have been established by the MPCA and meet both the goals of this TMDL and future growth needs of the creamery.

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 set to the benchmark phosphorus budgets (Section 5.3.4) as this is not a load that can be reduced. The atmospheric loading rate was assumed to be 20 kg/km^2/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, as well as WLAs for MS4 area loading were done as follows:

1) Using the total loading capacity (TMDL) as determined per Section 6.1.1 subtracted the following loads:
    a. any WLAs for wastewater facilities and construction/industrial stormwater
    b. upstream lake loading (at their respective water quality standard)
    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) Separated regulated MS4 community area loading out of the direct watershed loading. Regulated MS4 loading was determined using 2020 Land Use GIS

shapefiles using only designated “developed” land use areas within defined 2030 municipal boundaries (i.e., those areas projected to contribute to a stormwater conveyance; specifically, single family, multi-family, commercial and public/industrial).

6) Multiplied the following loads by the calculated ratio in step 4:
    a. non-MS4 area loading (from step 5)
    b. MS4 area loading (from step 5)
    c. internal loading (from step 3)

The resulting loads are the non-MS4 area LA, the MS4 area WLA 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)

The process for determining WLAs for regulated MS4 areas was described above in Section 6.2.1. The City of Waconia (permit number MS400232) and Laketown Township (permit number MS400142) are partly within the Miller Lake watershed and each is assigned a WLA.

As development occurs within the watershed, the Census Bureau-defined Urban Area may expand. If this occurs, it may be necessary to transfer WLA from one MS4 to another. For example, a segment of state-owned highway may come under permit coverage as the Urban Area expands. In the event that additional stormwater discharges come under permit coverage within the watershed, WLA will be transferred to these new entities based on the process used to set wasteload allocations in the TMDL. MS4s will be notified and will have an opportunity to comment on the reallocation. If and when areas within the watershed designated as LA are developed (urbanized) or become part of the Urban Area and thus fall under an NPDES regulated MS4 framework, the TMDL will be re-opened and load will be transferred from the LA to the WLA as appropriate.

6.2.2.2 Municipal and Industrial Wastewater Discharges

One NPDES-permitted facility discharges wastewater within a direct watershed covered by the TMDL (Table 6.1). The WLAs for this facility are further discussed in Section 6.3 under Winkler Lake.

Table 6.1 NPDES-permitted wastewater facilities with currently permitted loads.

Permit	Facility	Lake	Permitted TP Load	
			kg/yr	kg/day
MN0002135	Bongards' Creamery	Winkler	150.59	0.4

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 Four 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 four lakes in the following sections.

6.3.1 Goose Lake TMDL

The Goose Lake TMDL is set for a shallow lake in the NCHF ecoregion of Minnesota with a standard of 60 µg/L phosphorus as a final goal. The selected average precipitation year for the Goose Lake TMDL is 2004. Table 6.2 presents the TMDL and its components, which are discussed in the following subsections.

Note that it suspected that illicit direct-discharge septic systems impact Goose Lake. Such systems must reach a 100 percent reduction. As such, there is no WLA for these discharges.

Table 6.2 TMDL allocations for Goose Lake. Allowable loads to meet the NCHF shallow lake standard of 60 µg/L. MOS is implicit and RC is zero.

Load Units	TMDL	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA Non-MS4	LA Upstream Lakes
kg/yr	270	0.27	27	111	103	29
kg/day	0.74	0.0007	0.07	0.30	0.28	0.08

In Table 6.2, the "upstream lakes" load represents the phosphorus discharging from Rutz, Swan, and Donders Lakes. Rutz is listed as impaired and Swan and Donders are suspected to be, based on observation and limited data. TMDLs have not yet been done for these lakes. Therefore, for Goose Lake's future TMDL condition, the upstream lakes are assumed to meet their respective water quality standards. This is the most reasonable way to account for the upstream lakes' effects on Goose Lake under future conditions. It also implies that Goose 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 Goose Lake. Atmospheric loading is set at 27 kilograms per year (kg/yr). Internal loading has been established to be 111 kg/yr and the non-MS4 loading is limited to 103 kg/yr. Upstream lakes have an allocation of 29 kg/yr.

6.3.1.2 Wasteload Allocations

Construction and Industrial stormwater within the watershed have an assigned WLA of 0.27 kg/yr, per the methodology described in Section 6.2.2.3. No MS4s are designated, nor are there any NPDES permitted wastewater facilities located within the watershed boundaries of Goose 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 Goose Lake meeting the Secchi depth requirement of greater than 1 meter (Table 6.3). 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 6.3 BATHTUB modeling of TMDL Loads for Goose Lake.

Results	Goose Lake
TP Concentration	60
Chlorophyll-a Concentration	45
Secchi Depth	1.3

6.3.1.4 Modeled Historic Loads

Using the Canfield-Bachmann equation, historic loads and load reductions were calculated for each monitored year (Figure 6.1). Goose Lake requires a 58 to 86 percent reduction to meet the proposed water quality standard of a summer average of

60 µg/L TP. Over the past ten years the lowest allowable load on an annual basis was 233 kilograms phosphorus and the maximum allowable load was 294 kilograms of phosphorus.

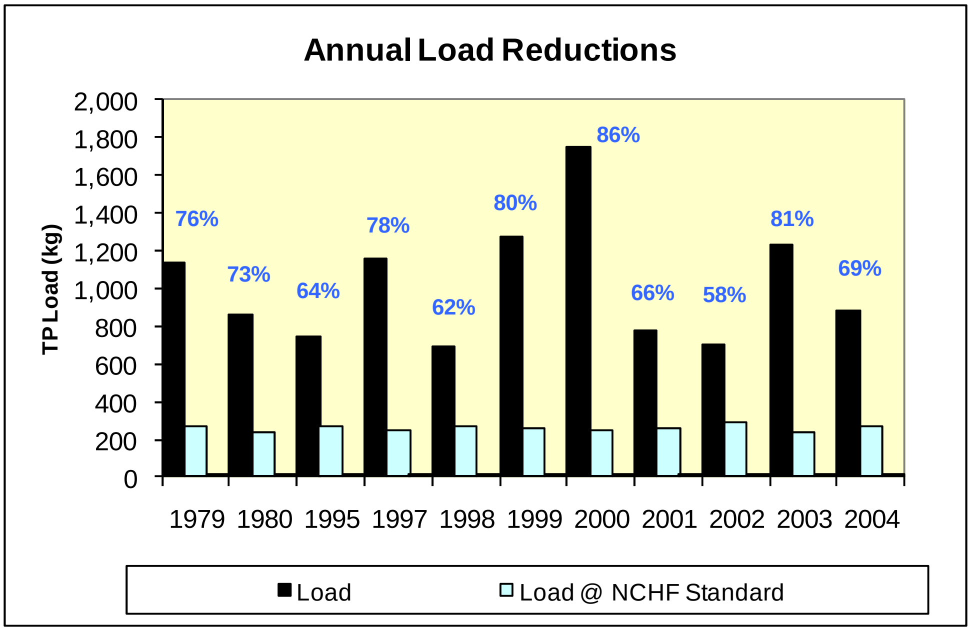


Figure 6.1 Predicted annual loads for monitored conditions and for the 60 µg/L TP standard for NCHF shallow lakes. Percentages represent the necessary reduction to meet the standard.

6.3.2 Hydes Lake TMDL

The Hydes Lake TMDL is set for a deep lake in the NCHF ecoregion of Minnesota with a standard of 40 µg/L phosphorus as a final goal. The selected average precipitation year for the Hydes Lake TMDL is 2004. Table 6.4 presents the TMDL and its components, which are discussed in the following subsections.

Note that it suspected that illicit direct-discharge septic systems impact Hydes Lake. Such systems must reach a 100 percent reduction. As such, there is no WLA for these discharges.

Table 6.4 TMDL allocations for Hydes Lake. Allowable loads to meet the NCHF deep lake standard of 40 µg/L. MOS is implicit and RC is zero.

Load Units	TMDL	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA Non-MS4	LA Upstream Lakes
kg/yr	197	0.20	17	76	29	74
kg/day	0.54	0.0005	0.05	0.21	0.08	0.20

In Table 6.4, the “upstream lakes” load represents the phosphorus discharging from Lake Patterson. This lake is suspected to be impaired based on observation and limited data and a TMDL has not yet been done. Therefore, for Hydes Lake’s future TMDL condition, the upstream lake is assumed to meet its water quality standard. This is the most reasonable way to account for the upstream lakes' effects on Hydes Lake under future conditions. It also implies that Hydes Lake's TMDL does not affect the TMDL of the upstream lake.

6.3.2.1 Load Allocations

Section 6.2.1 outlines the methodology used to determine establishing Load Allocations for Hydes Lake. Atmospheric loading is set at 17 kg/yr. Internal loading has been established to be 76 kg/yr and the non-MS4 loading is limited to 29 kg/yr. Upstream lakes have an allocation of 74 kg/yr.

6.3.2.2 Wasteload Allocations

Construction and Industrial stormwater within the watershed have an assigned WLA of 0.20 kg/yr, per the methodology described in Section 6.2.2.3. No MS4s are designated nor are there any NPDES permitted wastewater facilities located within the watershed boundaries of Hydes Lake.

6.3.2.3 Load Response

In addition to meeting a phosphorus limit of 40 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 Hydes Lake meeting the Secchi depth requirement of greater than 1 meter (Table 6.5). Chlorophyll-a concentrations are still above the State Standards of 14 µg/L. To view BATHTUB inputs and results for this model, see Appendix C.

Table 6.5 BATHTUB modeling of TMDL Loads for Hydes Lake.

Results	Hydes Lake
TP Concentration	40
Chlorophyll-a Concentration	24
Secchi Depth	2.3

6.3.2.4 Modeled Historic Loads

Historical loads over the last ten years were estimated for those years with monitoring data using an inverted Canfield-Bachmann model. The model was run for average runoff conditions in each monitored year, although precipitation varies from year to year.

Using the Canfield-Bachmann equation, historic loads and load reductions were calculated for each of the basins (Figure 6.2). Hydes Lake requires a 73 to 94 percent reduction to meet the proposed water quality standard of a summer average of 40 µg/L TP. Over the past ten years the lowest allowable load on an annual basis was 172 kilograms phosphorus and the maximum allowable load was 214 kilograms of phosphorus.

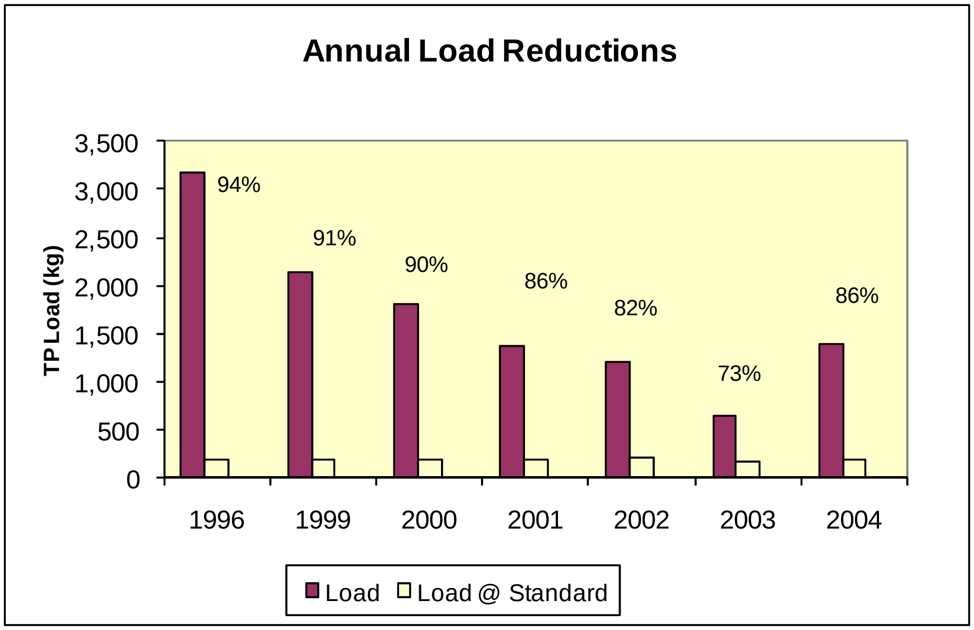


Figure 6.2 Hydes Lake predicted annual loads for monitored conditions and predicted loads at the standard NCHF deep lake standard of 40 µg/L TP. Percentages represent the necessary reduction to meet the standard.

6.3.3 Miller Lake TMDL

The Miller Lake TMDL is set for a shallow lake in the NCHF ecoregion of Minnesota with a standard of 60 µg/L phosphorus as a final goal. The selected average precipitation year for the Miller Lake TMDL is 2004. Table 6.6 presents the TMDL and its components, which are discussed in the following subsections.

Note that it is suspected that illicit direct-discharge septic systems impact Miller Lake. Such systems must reach a 100 percent reduction. As such, there is no WLA for these discharges.

Table 6.6 TMDL allocations for Miller Lake. Allowable loads to meet the NCHF shallow lake standard of 60 µg/L. MOS is implicit and Reserve Capacity is zero.

Load Units	TMDL	WLA Laketown Township	WLA Waconia	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA Non-MS4	LA Upstream Lakes
kg/yr	1,738	1	47	1.74	11	530	402	745
kg/day	3.08	0.002	0.13	0.0048	0.03	1.45	1.10	2.04

In Table 6.6, the "upstream lakes" load represents the phosphorus discharging from Benton, Winkler, Burandt, and Reitz Lakes. These four lakes area currently impaired; however, each has its own TMDL, either previously completed or in progress. Therefore, for Miller Lake's future TMDL condition, the upstream lakes are assumed to meet their respective water quality standards. This is the most reasonable way to account for the upstream lakes' effects on Miller Lake under future conditions. It also implies that Miller Lake's TMDL does not affect the TMDLs of the upstream lakes.

6.3.3.1 Load Allocations

Section 6.2.1 outlines the methodology used to determine establishing Load Allocations for Miller Lake. Atmospheric loading is set at 11 kg/yr. Internal loading has been established to be 530 kg/yr and the non-MS4 loading is limited to 402 kg/yr. Upstream lakes contribute 745 kg/yr to Miller Lake and have been allocated this amount.

6.3.3.2 Wasteload Allocations

As stated in Section 6.2.2, two permitted MS4s are located within the Miller Lake Watershed. The City of Waconia and Laketown Township have WLAs of 47 kg/yr and 1 kg/yr, respectively. These allocations were based upon land use acreages that are classified as "Developed" within the Carver County 2020 Land Use shapefile. These acreages were 1,489 acres for the City of Waconia and 22 acres for Laketown Township.

No NPDES permitted wastewater facilities are located within Miller Lake watershed.

Construction and Industrial stormwater within the watershed have an assigned WLA of 1.74 kg/yr, per the methodology described in Section 6.2.2.3.

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 Miller Lake meeting the Secchi Depth requirement of greater than 1 meter (Table 6.7). 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 6.7 BATHTUB modeling of TMDL Loads for Miller Lake.

Results	Miller Lake
TP Concentration	60
Chlorophyll-a Concentration	32
Secchi Depth	1.8

6.3.3.4 Modeled Historic Loads

Using the Canfield-Bachmann equation, historic loads and load reductions were calculated for each monitored year (Figure 6.3). Miller Lake requires a 65 to 91 percent reduction to meet the proposed water quality standard of a summer average of 60 µg/L TP. Over the monitored years the lowest allowable load on an annual basis was 1,367 kilograms phosphorus and the maximum allowable load was 2,290 kilograms of phosphorus.

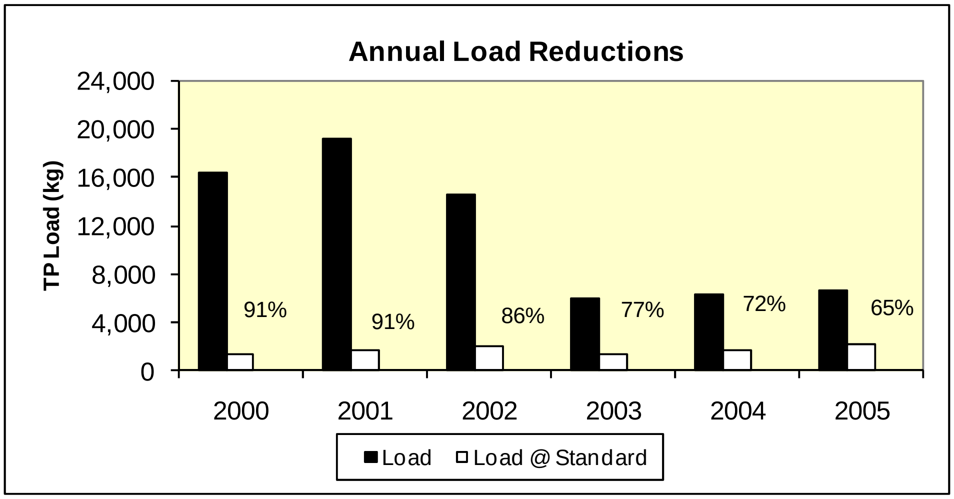


Figure 6.3 Miller Lake predicted annual loads for monitored conditions and predicted loads at the standard NCHF shallow lake standard of 60 µg/L TP. Percentages represent the necessary reduction to meet the standard.

6.3.4 Winkler Lake

The Winkler Lake TMDL is set for a shallow lake in the NCHF ecoregion of Minnesota with a standard of 60 µg/L phosphorus as a final goal. The selected average precipitation year for the Winkler Lake TMDL is 2001. Table 6.8 presents the TMDL and its components, which are discussed in the following subsections.

Note that it suspected that illicit direct-discharge septic systems impact Winkler Lake. Such systems must reach a 100 percent reduction. As such, there is no WLA for these discharges.

Table 6.8 TMDL allocations for Winkler Lake. Allowable loads to meet the NCHF shallow lake standard of 60 µg/L. MOS is implicit and RC is zero.

Load Units	TMDL	WLA Bongards' Creamery	WLA Construction/ Industrial	LA Atmospheric	LA Internal	LA Non-MS4	LA Upstream Lakes
kg/yr	643	150.59	0.64	6	162	43	281
kg/day	1.76	0.41	0.0018	0.02	0.45	0.12	0.77

In Table 6.8, the "upstream lakes" load represents the phosphorus discharging from Barlous, Hydes, and Rice Lakes. Hydes is listed as impaired (and is part of this project) and the other two lakes are suspected of being impaired based on observation and limited (and as such TMDLs have not yet been done). Therefore, for Winkler Lake's future TMDL condition, the upstream lakes are assumed to meet their respective water quality standards. This is the most reasonable way to account for the upstream lakes' effects on Winkler Lake under future conditions. It also implies that Winkler Lake's TMDL does not affect the TMDLs of the upstream lakes.

6.3.4.1 Load Allocations

Section 6.2.1 outlines the methodology used to determine establishing Load Allocations for Winkler Lake. Atmospheric loading is set at 6 kg/yr. Internal loading has been established to be 162 kg/yr and the non-MS4 loading is limited to 43 kg/yr. Upstream lakes have an allocation of 281 kg/yr.

6.3.4.2 Wasteload Allocations

No MS4s are designated within the Winkler Lake watershed.

Bongards' Creamery discharges in the Winkler Lake watershed and is currently covered under an NPDES permit (MN0002135). The current NPDES permit limits the discharge of total phosphorus loading at 150.59 kg/yr, which is protective of Winkler Lake water quality and as such this limit was used within the TMDL.

Construction and Industrial stormwater within the watershed have an assigned WLA of 0.64 kg/yr, per the methodology described in Section 6.2.2.3.

6.3.4.3 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 Winkler Lake meeting the Secchi Depth requirement of greater than 1 meter (Table 6.9). 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 6.9 BATHTUB modeling of TMDL Loads for Winkler Lake.

Results	Winkler Lake
TP Concentration	60
Chlorophyll-a Concentration	47
Secchi Depth	1.3

6.3.4.4 Modeled Historic Loads

Winkler Lake requires reductions between 68 and 97 percent to meet the NCHF proposed water quality standard of summer average of 60 µg/L TP (Figure 6.4). Over the monitored years the lowest allowable load was 412 kilograms of phosphorus and the maximum allowable load was 761 kilograms of phosphorus. The variation in loading between years is due to the variability in precipitation from year to year.

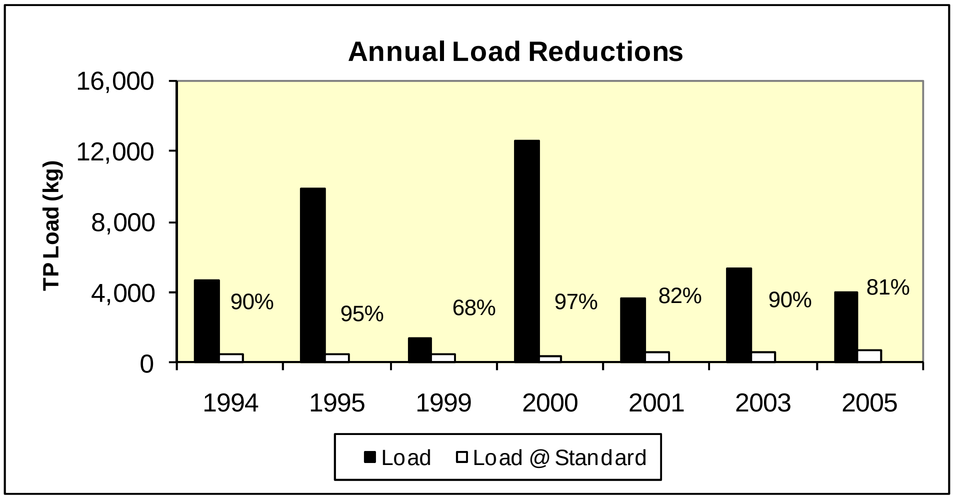


Figure 6.4 Winkler Lake predicted annual loads for the summer growing season (June 1-September 30) and for the 60 µg/L TP standard for NCHF shallow lakes. Percentages represent the necessary reduction to meet the standard.

7.0 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 will aid 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 Carver Creek Lake TMDL have been given various opportunities to provide input through public surveys, public meetings, and personal meetings. 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.

During the public comment period the Minnesota Corn Growers Association requested that the following statement be included: "Lake water quality has likely been influenced by 150 years of development, including construction of roads, businesses (including farms) and homes, sewage and septic systems, and increasing population."

General results from open houses and surveys conducted are described below.

7.3.1 Goose Lake

An open house was held on September 1, 2005, for landowners within the Goose Lake watershed. Prior to that, 132 surveys were sent to landowners inquiring about lake uses and perceptions. Fourteen surveys were returned and of those 81 percent were lakeshore owners. Eleven people attended the meeting and filled out surveys. The following is a summary of the user survey and comments received during the meeting:

- Sources attendees were concerned about were geese, curlyleaf pondweed, feedlots, agricultural and lawn run off, and rough fish.
- The public was very supportive of the process and would like to know what we need from them. They would like to see Goose Lake attain a swimmable status again.
- Some landowners were interested in the dredging and channelization of the water courses that, prior to disturbance, did not allow other watersheds to flow into Goose Lake (Rutz and Swan Lakes).
- The public was very concerned about feedlots and manure management.
- 50 percent of lake users indicated that their uses of the lake are interfered with by aquatic plants and/or algae.
- 43 percent of surveyors indicate that their perception of the lake is currently "no swimming, boating ok" while 21 percent perceive the lake to be unusable.

7.3.2 Hydes Lake

An open house was held on September 1st, 2005 for landowners within the Hydes Lake watershed. Previous to the meeting, landowners were sent surveys inquiring upon lake uses and perceptions. Although 107 invitations were sent out, 18 people attended the meeting and completed surveys, with 72 percent of those being lakeshore owners. The following is a summary of the user survey and comments received during the meeting:

- Sources attendees were concerned about were affects of geese, curlyleaf pondweed, feedlots and rough fish.
- Landowners were very supportive but asked "How much money are we as property owners on the lake going to have to pay?" They are concerned that lake property owners would be expected to come up with large sums of money.
- Attendees were hopeful that in the future "their" lake would be swimmable once again.
- Uses of the lake at this point were indicated to be swimming, boating, waterskiing, hunting and wildlife observation.

- 72 percent of users believe that their use of the lake is interfered with by aquatic plants and/or algae.
- Additional management practices brought up were alum treatments and dredging.

7.3.3 Miller Lake

A user perception survey was sent out to landowners inquiring upon lake uses and perceptions in July of 2006. Due to the high volume of homes within the direct watershed and lack of public access on the lake only landowners within one mile of the lake were sent surveys. Seventy five surveys were sent out and 13 surveys were returned. Of the surveys returned, one was a lakeshore owner. Many of the comments were incorporated throughout the TMDL. Below is a list of general comments, concerns respondents had for the lake and thoughts on what may be causing excess nutrients in the lake.

- Should add a public access/boat landing as most of the lake is isolated from general public.
- Tile lines form agriculture/ farms dump nutrients, pesticides and silt into the lake.
- Runoff form fertilizer used in nearby yards contributes to nutrient loading.
- Carp may be causing increased nutrients.

During the public comment period the Minnesota Corn Growers Association requested that the following statement be included: “Urban runoff from the City of Waconia, along with “legacy” phosphorus from decades of sewage discharge, are large potential sources of excess phosphorus.”

7.3.4 Winkler Lake

A user perception survey was sent out to landowners inquiring upon lake uses and perceptions in October of 2008. Surveys were sent to homeowners within a one mile radius of the lakeshore. Fifty five surveys were sent out and five were returned. Out of all the surveys, only one was a lakeshore owner. Below is a general list of comments and concerns that homeowners had about the lake.

- Observation of the wildlife around the lake was the most important aspect for recreational use.
- Runoff from adjacent fields is seen as a deterrent to water quality of Winkler Lake.
- Residents within the direct watershed feel that Bongards’ Creamery have had a negative impact to Winkler Lake due to discharges from production.

8.0 Implementation

8.1 Introduction

Carver County, through their Water Management Plan, has embraced a basin wide goal for protecting water quality in the Carver Creek watershed. 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 BMPs on their land.

This section broadly addresses the course that Carver County will take to incorporate actions and strategies to achieve the TMDL goals set forth within this document. An Implementation Plan that will lay out specific goals, actions and strategies will be published within one year of the final EPA approval of this TMDL. Any action items pertinent to this TMDL that are not included in the Carver County Water Plan will be identified and amended to the Implementation Plan.

8.2 Carver County Water Management Plan

To respond to the County's established goals for Natural Resource Management, the Carver County Water Management Plan describes the set of issues requiring implementation action. MN Rule 8410 describes a list of required plan elements. Carver County has determined the following issues to be of higher priority. Items not covered in this plan will be addressed as necessary to accomplish the higher priority goals. Each issue is summarized in the Carver County 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 Carver County will rely largely on its current Water Management Plan which identifies the Carver SWCD as the local agency for implementing BMPs. It will list suggested BMPs to be applied in the watershed and the order of importance for which they should 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 reductions that would occur from each strategy. Because of this, an iterative management approach will be applied to the monitoring strategy after implementation of the BMPs.

8.4 SWAT Modeling

Although the modeling conducted for this TMDL estimates pollutant sources, we have determined that each lake is much more complex than the models chosen can handle. The MCES is in the process of developing a SWAT model for the Carver Creek watershed for a Turbidity TMDL. As part of the Implementation Plan for the Carver Creek Lakes, we are asking that phosphorus be added to the SWAT model development. This model is much more complex than what was used here and will allow us to better differentiate phosphorus sources. Thus, we will go on with the implementation of BMPs to reduce external loads, however, at the completion of SWAT modeling, we will be able to predict source loads more precisely, thus improving our ability to effectively locate BMPs, increasing the effectiveness of reducing TP.

Upon the implementation of external BMPs, and following the completion of a detailed source analysis from SWAT, internal sources will be targeted as seen fit through the use of adaptive management.

8.5 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.

As a number of lakes flow into each other (Hydes Lake to Winkler Lake via Rice Lake) improvements in the water quality of upstream lakes are taken into account for the water quality of downstream lakes. Due to this, higher priority will be given to those lakes that are upstream.

Total costs to implement this TMDL, which encompasses internal and external load reduction strategies for Goose, Hydes, Miller, and Winkler Lakes has been estimated between $2,698,000 to $4,256,000. Individual strategies and costs associated with them are broken out in the following sections.

8.5.1 External Load Reduction Strategies

8.5.1.1 Bongards Creamery

Bongards' Creamery has seen a reduction in effluent discharges in recent years due to a shift of certain production lines to another city in Minnesota. Due to this, the NPDES permit for the site changed in 2007. Current limits are considered to be both protective of water quality and adequate for its future needs.

8.5.1.2 Landowner Practices

Runoff from urban 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: $450,000 to $800,000
Goose Lake: $50,000 to $150,000
Hydes Lake: $100,000 to $150,000
Miller Lake: $250,000 to $350,000
Winkler Lake: $50,000 to $150,000

8.5.1.4 Stormwater Management

Urban stormwater is a small proportion of nutrient loads within the Carver Creek Watershed. However, in the case of elimination of agricultural and natural areas and construction of residential areas, the potential for urban runoff contributing to nutrient loads would greatly increase. Construction activity in growth areas can deliver phosphorus laden sediment if not controlled properly. In the incidence of unforeseen development, the requirements set forth in the County Water Management Plan and rules should ensure that anticipated increases in urban stormwater runoff do not contribute to nutrient loading.

Goals:

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

Cost for Implementation: $175,000 to $300,000
Goose Lake: $15,000 to $25,000
Hydes Lake: $5,000 to $15,000
Miller Lake: $150,000 to $250,000
Winkler Lake: $5,000 to $10,000

8.5.1.5 Feedlots

Feedlots without runoff controls may contribute to nutrient loading during wet conditions. Surface water concerns include contamination by open lot runoff into a water body, ditch or open tile inlet. Rules addressing proper feedlot management are included in the water management plan and will be addressed here. In order to address this pollution, the County will rely on goals and policies set forth in the County Water Management Plan. Properly managed feedlots will assist in meeting nutrient standards during wet conditions.

Goals:

- Proper management of feedlots to insure that water 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: $185,000 to $260,000
Goose Lake: $35,000 to $55,000
Hydes Lake: $45,000 to $60,000
Miller Lake: $60,000 to $80,000
Winkler Lake: $45,000 to $65,000

8.5.1.6 SSTS

Failing and/or direct discharge septic systems are potentially contributing nutrients to all lakes within the Carver Creek Watershed. These failing and improperly maintained SSTS present a substantial threat to the quality of surface and groundwater resources within Carver County. Actions to ensure that direct discharge systems are eliminated have been taken as part of the Carver and Bevens Fecal Coliform TMDL Implementation Plan. Should any non-conforming systems remain at the time TMDL implementation, action will be taken to ensure of their elimination.

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: $210,000 to $275,000
Goose Lake: $30,000 to $40,000
Hydes Lake: $30,000 to $40,000
Miller Lake: $100,000 to $120,000
Winkler Lake: $50,000 to $75,000

8.5.1.7 Agricultural BMPs

Agricultural land is the major land use within the Carver Creek 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: $950,000 to $1,600,000
Goose Lake: $150,000 to $200,000
Hydes Lake: $150,000 to $200,000
Miller Lake: $500,000 to $1,000,000
Winkler Lake: $150,000 to $200,000

8.5.2 Internal Load Reduction Strategies

8.5.2.1 Aquatic Plant Management

Macrophyte surveys and monitoring efforts throughout the four lakes listed within this TMDL have shown a wide range of aquatic plant communities. Plant diversity in Goose, Hydes, Miller, and Winkler Lakes are low. Curlyleaf pondweed is present in Hydes, and Miller Lakes. Curlyleaf grows under the ice but dies back during late June or early July, releasing nutrients to the water column in summer, possibly leading to algal blooms. For these reasons, it is of importance to control populations of curlyleaf pondweed and establish a native aquatic plant community. Eurasian watermilfoil is present in Miller Lake. While Eurasian watermilfoil, which out-competes native plants, is the current dominant aquatic plant, curlyleaf pondweed can quickly take its place if given the chance.

Aquatic plants stabilize banks and sediment, oxygenate water, protect small fish, create spawning habitats, act as refuges for zooplankton and serve as food sources for water fowl and wildlife. For these reasons, it is of importance to restore native aquatic plant populations within each 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: $200,000 to $245,000
Goose Lake: $70,000 to $80,000
Hydes Lake: $40,000 to $50,000
Miller Lake: $60,000 to $70,000
Winkler Lake: $30,000 to $45,000

8.5.2.2 Rough Fish Management

Species such as black bullhead and carp increase the mixing of sediments releasing phosphorus into the water column, and reducing the clarity of water, thereby minimizing the amount of light filtering to aquatic macrophytes. Each lake has either a high population of rough fish or has seen an increase in recent years of rough fish populations. Implementation plans must include the management of rough fish species by following management practices set forth below.

Goals:

- Investigate partnership with U of M in research of effective carp removal methods.
- Stocking of pan fish to assist in reducing carp reproduction through predation of carp eggs.
- Increased surveys to monitor the results of management efforts.
- Installation of fish barriers paired with intensified efforts for removal of carp and black bullheads

Cost for Implementation: $160,000 to $220,000
Goose Lake: $50,000 to $60,000
Hydes Lake: $40,000 to $55,000
Miller Lake: $40,000 to $55,000
Winkler Lake: $30,000 to $50,000

8.5.2.3 Alum Treatments

Aluminum sulfate (alum) is a chemical addition that forms a non-toxic precipitate with phosphorus. It removes phosphorus from the lake system so that is not available for algal growth and forms a barrier between lake sediments and the water to restrict phosphorus release from the sediments.

Goals:

- Evaluate whether Alum is a viable option to reduce internal phosphorus loading
- Establish treatment area, dosing amounts and costs needed to treat the lake

Cost for Implementation: $200,000 to $300,000
Hydes Lake: $100,000 to $150,000
Miller Lake: $100,000 to $150,000

8.5.2.4 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 causing release of phosphorus from disturbed sediments. No wake 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: $8,000 to $16,000
Goose Lake: $2,000 to $4,000
Hydes Lake: $2,000 to $4,000
Miller Lake: $2,000 to $4,000
Winkler Lake: $2,000 to $4,000

8.5.2.5 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: $160,000 to $240,000
Goose Lake: $70,000 to $100,000
Miller Lake: $50,000 to $75,000
Winkler Lake: $40,000 to $65,000

9.0 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 percent 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 within the Carver Creek 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 groundwater.

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 NPDES Phase II Stormwater Permits

The Stormwater Program for MS4s is designed to reduce the amount of sediment and pollution that enters surface and groundwater from storm sewer systems to the maximum extent practicable. Stormwater discharges associated with MS4s are regulated through the use of NPDES permits which are legal documents. Through this permit, the owner or operator is required to develop a Stormwater Pollution Prevention Program (SWPPP) that incorporates BMPs applicable to their MS4. Applicable MS4s in this project are Waconia and Laketown Township.

Under the stormwater program, MS4s are required to develop and implement a SWPPP. The SWPPP must cover six minimum control measures:

- Public education and outreach;

- Public participation/involvement;
- Illicit discharge, detection and elimination;
- Construction site runoff control;
- Post-construction site runoff control; and
- Pollution prevention/good housekeeping.

The MS4 must identify BMPs and measurable goals associated with each minimum control measure. An annual report on the implementation of the SWPPP must be submitted each year.

Additionally, stormwater permits for construction sites greater than one acre and any industrial site on EPA's list of mandatory industrial facilities, per the Standard industrial code, are required.

9.3.3 NPDES Permits for Municipal and Industrial Wastewater

The MPCA issues NPDES permits for any discharge into waters of the state. These permits have both general and specific limits on pollutants that are based on water quality standards. Permits regulate discharges with the goals of 1) protecting public health and aquatic life, and 2) assuring that every facility treats wastewater. One such permit is held by a facility within the Winkler Lake direct watershed: MN0002135 (Bongards' Creamery).

9.3.4 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.

9.3.5 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 and Sibley 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.

10.0 Monitoring

Monitoring will continue for all Carver Creek 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 Carver Creek Lakes.

Lake	Priority	Frequency	Schedule	
Goose	High	Bi-Weekly	Annually	April - October
Hydes	High	Bi-Weekly	Annually	April - October
Miller	High	Bi-Weekly	Annually	April - October
Winkler	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 Goose Lake

Additional monitoring may include sampling of inlets not monitored during the initial TMDL study to further refine loading estimates, sampling in the individual bays of Goose Lake to determine interaction within the lake between each bay, or additional in-lake sampling of Donders, Rutz and Swan Lakes to refine loading estimates exiting these lakes.

10.2 Hydes Lake

Additional monitoring may include more detailed monitoring at the inlet and outlet to refine loading estimates and monitoring of Patterson Lake to identify its role in nutrient loading to Hydes Lake.

10.3 Miller Lake

Additional areas that may need to be monitored include inlets not monitored during the initial TMDL study and/or sediment samples to further account for internal loading. Furthermore, assessment of the stormwater discharge may be monitored to better grasp the nutrient loads caused by runoff from surrounding land.

10.4 Winkler Lake

Additional areas that may need to be monitored include the short, ditched lake inlet not monitored during the initial TMDL study, sediment core samples to further account for internal loading, land use change monitoring and an assessment of the current fish community will be considered to aid in determining existing rough fish populations.

11.0 Literature Cited

Bailey, R.G. 2004. Identifying ecoregion boundaries. Environmental Management Volume 34, Suppl. 1, pages S14-S26.

Borman S., R. Korth and J. Temte. 1997. Through the Looking Glass, A Field Guide to Aquatic Plants.

Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society.

Carver County and Wenck Associates, Inc. 2005. Carver County Bacteria TMDL. Report to the MPCA.

Conroy, Tom 2005. Shallow Lakes Case History: Lake Christina. Shallow Lakes: Hope for Minnesota's Troubled Waters. DNR

Cooke G.D. and E.B. Welch. 1995. Internal Phosphorus Loading in Shallow Lakes: Importance and Control. Lake and Reservoir Management 11(3): 273-281.

Cooke G.D., P. Lombardo and C. Burandt. 2001. Shallow and Deep Lakes: Determining Successful Management Options. Lakeline, spring issue.

Environmental Protection Agency 2008. EPA fact sheet, Pointer No. 6 EPA841-F-96-004F http://www.epa.gov/nps/facts/point6.htm

Environmental Protection Agency 1980. Modeling phosphorus loading and lake response under uncertainty: Amanula and compilation of export coefficients. USEPA, Washington, D.C., 1980, EPA 440-5-80-011.

EPA Web. http://www.epa.gov/owow/NPS/MMGI/Chapter7/ch7-2a.html

Fandrei, G., S. Heiskary, and S. McCollar. 1988. Descriptive characteristics of the seven ecoregions in Minnesota. Minnesota Pollution Control Agency, Division of Water Quality, Program Development Section, St. Paul, Minnesota.

Heiskary, S.A. and C. B. Wilson, 2005. Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria 3d ed. Minnesota Pollution Control Agency, September, 2005.

Hondzo, M. and H.G. Stefan. 1993. Lake water temperature simulation model. ASCE J. Hyd. Div. **119:** 1251-1273.

James, W. F., Barko, J. W., and Eakin, H. L. 2001. "Direct and indirect impacts of submersed aquatic vegetation on the nutrient budget of an urban oxbow lake," APCRP Technical Notes Collection (ERDC TN-APCRP-EA-02), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/aqua

Kreider J.C. and J. C. Panuska. 2003. Wisconsin Lake Modeling Suite. Program Documentation and User's Manual. Version 3.3 for Windows. Wisconsin Department of Natural Resources. October 2003.

McCollor and Heiskary 1993 referenced on page 20

Metropolitan Council Small lakes 2005 from page 71

MPCA 2005. Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria, 3rd Edition. September 2005.

MPCA, 2005. MPCA Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment 305(b) and 303(d) List. http://www.pca.state.mn.us/publications/wq-iw1-06.pdf

MPCA 2006. Lake TMDL Protocols and Submittal Requirements Draft report 9/18/06.

MPCA 2006, MPCA Guidance Manual for Small Municipal Separate Storm Sewer Systems (MS4's), March 2006.

MPCA 2007. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment. October 2007.

MPCA and Anoka Conservation District, 2005. Draft Typo and Martin Lakes Total Maximum Daily Load (TMDL) for excess nutrients. MPCA Report.

MPCA, 2005. Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria. 3rd Ed. September 2005.

MPCA, 2005. Runoff Reductions with Incorporated Manure – A Literature Review. http://www.pca.state.mn.us/index.php/topics/feedlots/feedlot-nutrient-and-manure-management.html

Mulla, D.J., A.S. Birr, G. Randall, J. Moncrief, M. Schmitt, Asekely, and E. Kerre 2001. Impacts of animal agriculture on water quality. Technical Work Paper prepared for the Environmental Quality Board of Minnesota.

NCSU Web, http://www.water.ncsu.edu/watershedss/dss/wetland/aqlife/septic.html

Nurnberg, G.K. 1987 A comparison of internal phosphorus loads in lakes with anoxic hypolimnia: laboratory incubations versus hypolimnetic phosphorus accumulation. Limnology and Oceanography 32: 1160-1164.

Reckhow, Kenneth H., Beaulac, Michael N., Simpson, Jonathan T., June 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. Department of Resource Development, Michigan State University.

Scheffer, M. 1998. Ecology of Shallow Lakes. Population and Community Biology Series.

Walker, W. W., 1999. Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. USACE Report w-96-2. http://wwwalker.net/bathtub/, Walker 1999 (October 30, 2002).

Ward, Andy D. and Elliot, William J. 1995. Environmental Hydrology.

Wenck Associates Inc. 1998. Lakes Nokomis and Hiawatha Diagnostic Feasibility Study – Internal Phosphorus Load Estimates. Internal Technical Memorandum.

WOW Web 2008. Water on the Web (from http://waterontheweb.org/under/lakeecology/18_ecoregions.html)

Appendix A Tributary Monitoring

Water quality parameters such as temperature, transparency, and 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.

A.1 Goose Lake

Water quality was monitored via grab samples at the primary inlet and outlet (G1 and CC1 – Figure A.1) in 2004. The remaining two inlets were not monitored because of the low flow conditions through much of the sampling season. It was decided by the MPCA and Carver County staff at the beginning of the TMDL process not to monitor all of the inlets as the non-monitored, low-flow inlet information could be accurately estimated by the models used to develop the TMDL.

Figure A.1 Goose Lake subwatersheds and sampling points.

Flow measurement was difficult due to minimal or no flow during much of the growing season. Captured flow was compared to modeled flow and it was determined that modeled flow accurately depicted flow at the G1 site.

The G1 inlet accounts for inflow from Rutz Lake watershed, Swan Lake watershed, and the remaining 1,099 acres of land that drain directly to Goose Lake. As such, a rather large portion of the land contributing to the inflow of Goose Lake is captured here. Samples at G1 were targeted at an array of flow conditions ranging from base to high flows. The most significant flow into Goose Lake via G1 occurs during spring high flow events. Due to minimal flow conditions during the 2004 sampling season only five samples were collected. Therefore it is difficult to determine trends between the inlet and Goose Lake water quality. Data does indicate that the inlet has high TP concentrations (320 µg/L average; range 48-990 µg/L) which increased throughout the summer growing season (Table A.1). Similar trends are seen in Goose Lake. In addition, inlet phosphorus concentrations appear to increase in response to precipitation events. While there are high phosphorus concentrations in the G1 inlet over the entire summer season, the most water exchange occurs during spring high flows. Upon implementation, an automated sampler with a continuous flow record device will be installed at the inlet and data will be used to refine models.

Table A.1 Goose Lake inlet (G1) monitored phosphorus concentrations and flow.

	TP	DP	OP		Flow
Date	ug/L	ug/L	ug/L	Date	CFS
4/12/2004	~48	<5	59	7/7/2004	1.614
5/27/2004	158	146	139	7/22/2004	0
6/7/2004	234	152	206	9/7/2004	0
7/9/2004	170	107	120		
7/22/2004	990	295	342		

The Goose Lake outlet (CC1) was monitored similarly to the inlet with a range of flows targeted. Samples were collected from the inlet and outlet at the same time. The outlet was sampled an additional three times as well. TP concentrations ranged from 72-434 µg/L (average 252µg/L) (Table A.2). Water quality results from the outlet were compared with that of the BATHTUB model outputs in calibration.

Table A.2 Goose Lake outlet (CC1) monitored phosphorus concentrations and flow.

	TP	DP	OP		Flow
Date	ug/L	ug/L	ug/L	Date	CFS
4/12/2004	72	26	53	4/12/2004	0.04
5/27/2004	434	348	442	5/27/2004	5.40
6/7/2004	184	~6	~47	6/7/2004	8.58
7/9/2004	198	34	~40	7/7/2004	7.46
7/22/2004	181	~8	~22	7/9/2004	4.00
8/19/2004	318	43	83	7/22/2004	5.22
9/16/2004	376	139	157	8/19/2004	0.09
				9/16/2004	0.57

A.2 Hydes Lake

Water quality was monitored via grab samples in 2004 at the primary inlet and outlet (H2, H1; Figure A.2). Flow was also monitored but stage was not monitored continuously to develop a daily discharge record. In addition, flow measurement was difficult due to low flow conditions during much of the growing season. When low to no flow conditions were observed at the inlet, no grab sample was taken. Base and high flows were targeted however due to low flow only seven samples were taken at H2 and six samples taken at H1. The results of tributary monitoring are integrated into BATHTUB models.

Samples at H2 were targeted at an array of flow conditions ranging from base to high flows. The most significant flow into Hydes Lake via H2 occurs during the summer rain events. Seven samples were collected during the 2004 monitoring season. Data does indicate that the inlet has an average TP concentration that is below the 50th percentile for the predicted NCHF ecoregion stream concentration of 100 µg/L (99 µg/L average; range 55 – 131 µg/L)(Table A.3).

Table A.3 Hydes Lake inlet (H2) monitored phosphorus concentrations and flow.

	TP	DP	OP		Flow
Date	ug/L	ug/L	ug/L	Date	CFS
4/12/2004	56	27	~45	4/12/2004	0.02
5/27/2004	118	133	154	5/27/2004	4.59
6/7/2004	131	105	151	6/7/2004	8.35
7/9/2004	101	49	87	7/7/2004	6.65
7/22/2004	110	64	86	7/9/2004	4.91
8/19/2004	55	24	~34	7/22/2004	5.14
9/16/2004	124	25	~44	7/23/2004	4.09
				8/19/2004	1.09

Hydes Lake outlet (H1) was monitored similarly to the inlet with a range of flows targeted. Samples were collected from the inlet and outlet at the same time. Unfortunately, the September 16th sample that was taken at the inlet was not taken at the outlet. TP concentrations ranged from 48 – 217 µg/L (average 128 µg/L)(Table A.4). Comparisons between the inlet and the outlet concentrations show the influence that Hydes Lake has on water quality discharging, especially during the late summer season. Water quality results from the outlet were compared with that of the BATHTUB model outputs in calibration.

Table A.4 Hydes Lake outlet (H1) monitored phosphorus concentrations and flow.

	TP	DP	OP		Flow
Date	ug/L	ug/L	ug/L	Date	CFS
4/12/2004	~48	<5	~15	4/12/2004	0.00
5/27/2004	120	73	153	5/27/2004	0.27
6/7/2004	58	<5	67	6/27/2004	6.04
7/9/2004	147	15	50	6/7/2004	5.75
7/22/2004	180	<5	~32	7/9/2004	4.96
8/19/2004	217	75	99	7/22/2004	4.24
				8/19/2004	0.30

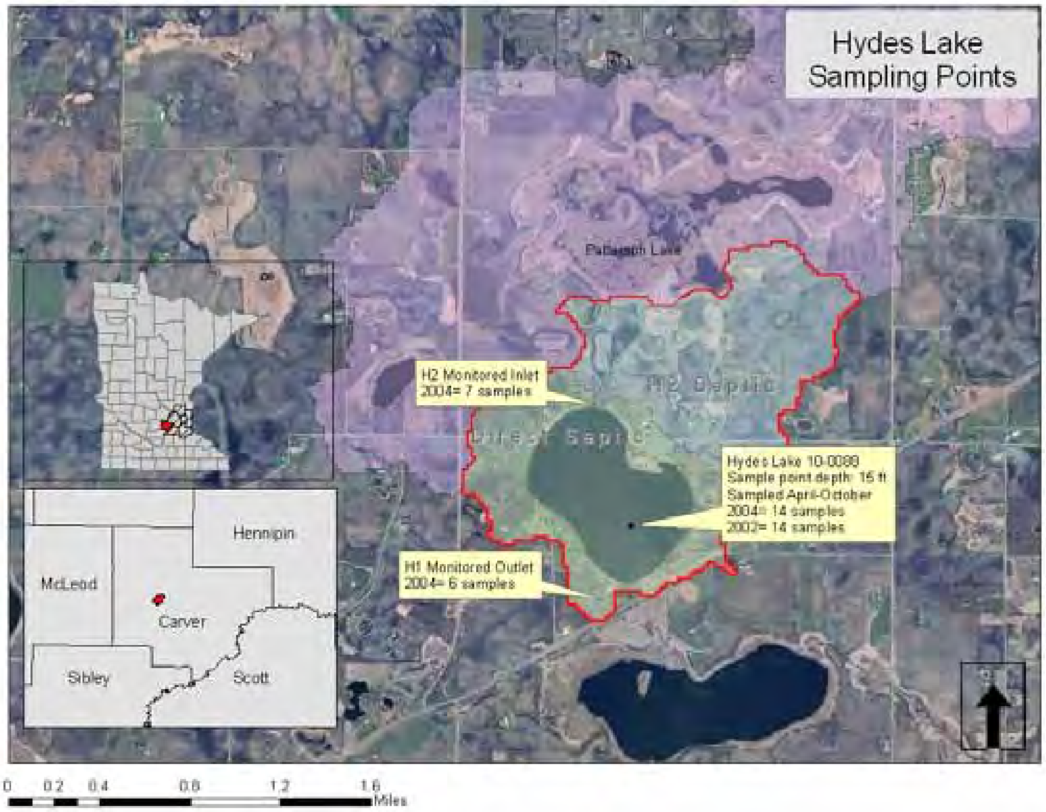


Figure A.2 Hydes Lake subwatersheds and sampling points.

A.3 Miller Lake

Water quality and flow have been monitored using automatic sampling and continuous flow equipment since 1998 at the primary inlet (CA 10.4) and outlet (CA 8.7) (Figure A.3) to Miller Lake. In addition, grab samples have been collected at both of these sites since 1998. Water quality was not monitored at the west inlet (D1) of the lake as it typically has low to no flow. Automated, composite samples were collected at high-flow events each year while base flow grab samples were collected bi-weekly during base and low-flow.

The 2003 sampling year was targeted for this study. Miller Lake inlet (CA 10.4) was sampled a total of twelve times during the monitoring season. A total of twelve samples were taken throughout 2003, of those only eleven had all three phosphorus parameters. Both the range and average TP concentrations at CA 10.4 were above the 75th percentile for expected NCHF ecoregion stream TP concentrations (430 µg/L average; range of 106-1360 µg/L)(Table A.5). Composite samples were collected at this site as well. Concentrations for these two samples were significantly higher than grab samples. This discrepancy can be attributed to difference in sampling procedures.

Table A.5 Miller Lake inlet (CA 10.4) monitored phosphorus concentrations.

		TP	DP	OP		Flow (est)
Date	Sample Type	ug/L	ug/L	ug/L	Date	CFS
3/25/2003	Grab	281	70	86	3/25/2003	34.7
4/21/2003	Grab	399	38	~48	4/21/2003	51.6
5/9/2003	Grab	332	7	~14	5/9/2003	23.8
5/9/2003	Composite	1360	42	58	5/14/2003	62.6
5/17/2003	Composite	822	31	497	5/20/2003	52.3
6/2/2003	Grab	106	23	~17	6/2/2003	37.0
6/19/2003	Grab	329	129	126	6/19/2003	19.0
7/2/2003	Grab	217	89	99	7/2/2003	14.0
7/17/2003	Grab	233	23	206	7/17/2003	5.6
8/1/2003	Grab	238	52	70	8/1/2003	0.5
9/12/2003	Grab	417	93	114	9/12/2003	0.5
12/1/2003	Grab		~5		12/1/2003	0.5

Eleven samples were taken at Miller Lake outlet (CA 8.7), of which ten had lab results for all three phosphorus parameters. TP concentrations ranged from 119 µg/L to 351 µg/L and an average concentration of 234 µg/L (Table A.6). Comparisons between the inlet and outlet results indicate Miller Lake acting like a settling pond with lower TP concentrations exiting the lake. The results of monitoring are integrated in the computer modeling exercises.

Table A.6 Miller Lake outlet (CA 8.7) monitored phosphorus concentrations and flow.

		TP	DP	OP		Flow (est)
Date	Sample Type	ug/L	ug/L	ug/L	Date	CFS
3/25/2003	Grab	280	129	136	3/25/2003	68.8
4/21/2003	Grab	204	5	~25	4/21/2003	111.8
5/9/2003	Grab	240	5	~40	5/9/2003	62.9
5/10/2003	Composite	299	13	~38	5/14/2003	127.3
5/19/2003	Grab	202	10	~16	5/19/2003	106.4
6/2/2003	Grab	234	8	~35	6/2/2003	74.6
6/19/2003	Grab	127	12	~33	6/19/2003	41.5
7/2/2003	Grab	119	~6	~29	7/2/2003	33.7
7/17/2003	Grab	285	59	105	7/17/2003	12.8
8/1/2003	Grab	351	91	108	8/1/2003	2.5
12/1/2003	Grab		10		12/1/2003	0.5

Figure A.3 Miller Lake watershed and sampling points.

A.4 Winkler Lake

Water quality and flow were monitored in 2005 at the inlet CC8.2 (Figure A.4). Flow was also monitored in 2006. Site CC9 was monitored in 2004 through 2007 for both water quality and flow. The extent of monitoring at site CC9 has to do with its inclusion in the Carver Creek Turbidity TMDL to be completed in 2009. A total of 7 samples in 2004, 10 samples in 2005, and 7 samples in 2006 were collected, targeting both base and high flows at site CC9. Ten samples targeting both base and high flows were taken at site CC8.2. The results of tributary monitoring are integrated in the computer modeling exercises.

Sampling lab results for Winkler Lake inlet CC 8.2 are summarized in Table A.7. The average TP concentration was 248 µg/L which is above the 75th percentile for expected NCHF ecoregion stream TP concentrations. The range was between 76 µg/L and 394 µg/L. Concentrations increased during the summer months, which might be an indication of the influence of Rice Lake that drains to Winkler Lake via CC 8.2.

Table A.7 Winkler Lake inlet (CC 8.2) monitored phosphorus concentrations and flow.

	TP	DP	OP		Flow
Date	ug/L	ug/L	ug/L	Date	CFS
4/13/2005	161	80	116	4/13/2005	11.43
4/20/2005	118	61	107	4/22/2005	19.58
5/5/2005	76	27	55	4/27/2005	12.01
6/1/2005	207	137	154	5/5/2005	7.87
6/14/2005	219	176	212	5/27/2005	13.34
6/28/2005	254	171	182	6/15/2005	16.21
7/13/2005	334	223	284	7/14/2005	3.52
8/10/2005	394	187	219	8/15/2005	0.67
9/20/2005	361	249	271	9/13/2005	1.84
10/6/2005	351	240	281	9/20/2005	0.68

Phosphorus lab results for the Winkler Lake inlet CC 9 ranged from 153 µg/L to 1260 µg/L during the 2005 monitoring season. An average of 406 µg/L was well above the 75th percentile of the expected NCHF ecoregion stream TP concentration (Table A.8).

Table A.8 Winkler Lake inlet (CC 9) monitored phosphorus concentrations and flow.

	TP	DP	OP		Flow
Date	ug/L	ug/L	ug/L	Date	CFS
4/11/2005	330	204	262	4/20/2005	2.85
4/20/2005	181	107	155	4/27/2005	3.10
5/5/2005	318	33	133	5/5/2005	0.64
6/1/2005	316	266	310	5/27/2005	4.35
6/14/2005	153	126	187	6/3/2005	1.95
6/28/2005	235	143	178	6/16/2005	1.91
7/13/2005	314	263	308	7/14/2005	0.80
8/10/2005	1260	960	842	9/13/2005	1.88
9/20/2005	500	327	369	9/20/2005	0.62
10/6/2005	450	263	297		

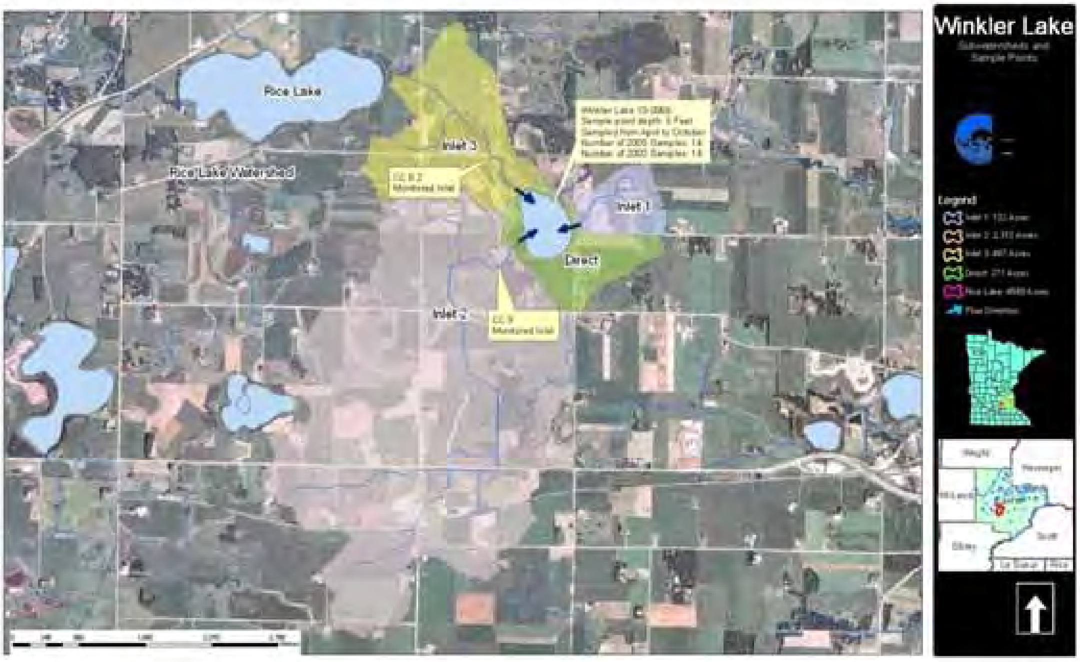


Figure A.4 Winkler Lake subwatersheds and sampling points.

Appendix B BATHTUB Benchmark Models

B.1 Goose Lake

B.1.1 2001 Inputs

B.1.2 2001 Mass Balance

goose2001

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Goose\Models\goose01_12-07.btb**

Description:

Global Variables	**Mean**	**CV**
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.74	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

													Internal Loads (mg/m2-day)					
		Outflow		**Area**	**Depth**	**Length**	**Mixed Depth (m)**		**Hypol Depth**		**Non-Algal Turb (m^{-1})**		**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	Goose	0	1	1.35	1.5	3.5	1.3	0.12	0	0	0.53	0.2	0	0	0.5	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	125	0	3020	0	60	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	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	Donders	1	1	0.89	0.1	0.1	0	0	549.6	0.2	0	0	0	0	0	0
2	Swan Trib	1	1	1.51	0.16	0.1	0	0	404	0.2	0	0	0	0	0	0
3	Rutz trib	1	1	1.13	0.2	0.1	0	0	319.3	0.2	0	0	0	0	0	0
4	G1	1	1	4.45	0.58	0	0	0	340.7	0	0	0	0	0	0	0
5	Inlet 2	1	1	0.42	0.06	0	0	0	359	0	0	0	0	0	0	0
6	Inlet 3	1	1	0.5	0.08	0	0	0	271.1	0	0	0	0	0	0	0
7	inlet1 septic	1	3	0	0.01	0	0	0	378	0	0	0	0	0	0	0
8	Inlet2 septic	1	3	0	0.01	0	0	0	75.6	0	0	0	0	0	0	0
9	inlet3 septic	1	3	0	0.01	0	0	0	25.2	0	0	0	0	0	0	0
10	Direct	1	1	2.65	0.34	0	0	0	371.5	0	0	0	0	0	0	0
11	direct septic	1	3	0	0.01	0	0	0	554	0	0	0	0	0	0	0

goose 2001
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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	Donders	0.9	0.1	1.00E-04	0.10	0.11
2	1	1	Swan Trib	1.5	0.2	2.56E-04	0.10	0.11
3	1	1	Rutz trib	1.1	0.2	4.00E-04	0.10	0.18
4	1	1	G1	4.4	0.6	0.00E+00	0.00	0.13
5	1	1	Inlet 2	0.4	0.1	0.00E+00	0.00	0.14
6	1	1	Inlet 3	0.5	0.1	0.00E+00	0.00	0.16
7	3	1	inlet1 septic		0.0	0.00E+00	0.00	
8	3	1	Inlet2 septic		0.0	0.00E+00	0.00	
9	3	1	inlet3 septic		0.0	0.00E+00	0.00	
10	1	1	Direct	2.7	0.3	0.00E+00	0.00	0.13
11	3	1	direct septic		0.0	0.00E+00	0.00	
PRECIPITATION				1.4	1.0	3.99E-02	0.20	0.74
TRIBUTARY INFLOW				11.5	1.5	7.56E-04	0.02	0.13
POINT-SOURCE INFLOW					0.0	0.00E+00	0.00	
***TOTAL INFLOW				12.9	2.6	4.07E-02	0.08	0.20
ADVECTIVE OUTFLOW				12.9	1.6	1.21E-01	0.22	0.13
***TOTAL OUTFLOW				12.9	1.6	1.21E-01	0.22	0.13
***EVAPORATION					0.9	8.04E-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	Donders	55.0	6.6%	1.51E+02	20.2%	0.22	549.6	61.8
2	1	1	Swan Trib	64.6	7.7%	2.09E+02	28.0%	0.22	404.0	42.8
3	1	1	Rutz trib	63.9	7.7%	2.04E+02	27.3%	0.22	319.3	56.5
4	1	1	G1	197.6	23.7%	0.00E+00		0.00	340.7	44.4
5	1	1	Inlet 2	21.5	2.6%	0.00E+00		0.00	359.0	51.3
6	1	1	Inlet 3	21.7	2.6%	0.00E+00		0.00	271.1	43.4
7	3	1	inlet1 septic	3.8	0.5%	0.00E+00		0.00	378.0	
8	3	1	Inlet2 septic	0.8	0.1%	0.00E+00		0.00	75.6	
9	3	1	inlet3 septic	0.3	0.0%	0.00E+00		0.00	25.2	
10	1	1	Direct	126.3	15.1%	0.00E+00		0.00	371.5	47.7
11	3	1	direct septic	5.5	0.7%	0.00E+00		0.00	554.0	
PRECIPITATION				27.0	3.2%	1.82E+02	24.4%	0.50	27.0	20.0
INTERNAL LOAD				246.5	29.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				550.6	66.0%	5.64E+02	75.6%	0.04	362.2	47.7
POINT-SOURCE INFLOW				10.3	1.2%	0.00E+00		0.00	258.2	
***TOTAL INFLOW				834.5	100.0%	7.46E+02	100.0%	0.03	326.1	64.7
ADVECTIVE OUTFLOW				198.5	23.8%	5.52E+03		0.37	123.0	15.4
***TOTAL OUTFLOW				198.5	23.8%	5.52E+03		0.37	123.0	15.4
***RETENTION				636.0	76.2%	5.98E+03		0.12		

Overflow Rate (m/yr)	1.2	Nutrient Resid. Time (yrs)	0.2984
Hydraulic Resid. Time (yrs)	1.2546	Turnover Ratio	3.4
Reservoir Conc (mg/m3)	123	Retention Coef.	0.762

B.1.3 2001 Predicted vs. Observed

goose 2001

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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Goose**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	123.0	0.34	85.3%	125.0		85.7%
TOTAL N MG/M3	3020.0		95.8%	3020.0		95.8%
C.NUTRIENT MG/M3	109.4	0.27	91.9%	110.8		92.2%
CHL-A MG/M3	81.6	0.38	99.8%	60.0		99.2%
SECCHI M	0.6	0.29	20.0%	0.7		28.4%
ORGANIC N MG/M3	2056.4	0.36	99.8%			
TP-ORTHO-P MG/M3	153.6	0.39	95.7%			
ANTILOG PC-1	3569.6	0.58	98.0%	2022.6		94.6%
ANTILOG PC-2	18.7	0.13	97.9%	16.2		96.1%
(N - 150) / P	23.3	0.35	67.9%	23.0		67.1%
INORGANIC N / P	963.6	0.77	100.0%			
TURBIDITY 1/M	0.5	0.20	43.7%	0.5	0.20	43.7%
ZMIX * TURBIDITY	0.7	0.23	2.5%	0.7	0.23	2.5%
ZMIX / SECCHI	2.3	0.30	10.2%	1.9	0.12	5.3%
CHL-A * SECCHI	46.5	0.16	98.4%	42.0		97.7%
CHL-A / TOTAL P	0.7	0.27	97.2%	0.5		92.0%
FREQ(CHL-a>10) %	99.9	0.00	99.8%	99.5		99.2%
FREQ(CHL-a>20) %	97.5	0.04	99.8%	92.8		99.2%
FREQ(CHL-a>30) %	90.4	0.11	99.8%	79.0		99.2%
FREQ(CHL-a>40) %	79.9	0.21	99.8%	63.5		99.2%
FREQ(CHL-a>50) %	68.4	0.32	99.8%	49.4		99.2%
FREQ(CHL-a>60) %	57.3	0.42	99.8%	37.8		99.2%
CARLSON TSI-P	73.5	0.07	85.3%	73.8		85.7%
CARLSON TSI-CHLA	73.8	0.05	99.8%	70.8		99.2%
CARLSON TSI-SEC	68.1	0.06	80.0%	65.1		71.6%

B.1.4 2004 Input

B.1.5 2004 Mass Balance

Goose Lake 2004

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Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.79	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	Goose Lake	0	1	1.35	1.5	3.5	1.5	0.12	0	0	1.71	0.2	0	0	0.7	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	134	0	2200	0	53	0	0.4	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	G1	1	1	4.45	0.62	0.1	0	0	320.3	0.2	0	0	0	0	0	0
2	inlet 2	1	1	0.42	0.06	0.1	0	0	337.5	0.2	0	0	0	0	0	0
3	Inlet 3	1	1	0.5	0.08	0.1	0	0	254.9	0.2	0	0	0	0	0	0
4	Rutz	1	1	1.13	0.21	0	0	0	300.3	0	0	0	0	0	0	0
5	Donders	1	1	0.89	0.11	0	0	0	516.8	0	0	0	0	0	0	0
6	Direct	1	1	0.89	0.37	0	0	0	349.3	0	0	0	0	0	0	0
7	Inlet 2 Septic	1	3	0	0.01	0	0	0	76	0	0	0	0	0	0	0
8	Inlet 3 Septic	1	3	0	0.01	0	0	0	25	0	0	0	0	0	0	0
9	Direct Septic	1	3	0	0.01	0	0	0	554	0	0	0	0	0	0	0
10	Swan	1	1	1.51	0.17	0	0	0	379.8	0	0	0	0	0	0	0

Goose Lake 2004
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Overall Water & Nutrient Balances

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

Trb	Type	Seq	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	G1	4.4	0.6	3.84E-03	0.10	0.14
2	1	1	inlet 2	0.4	0.1	3.60E-05	0.10	0.14
3	1	1	Inlet 3	0.5	0.1	6.40E-05	0.10	0.16
4	1	1	Rutz	1.1	0.2	0.00E+00	0.00	0.19
5	1	1	Donders	0.9	0.1	0.00E+00	0.00	0.12
6	1	1	Direct	0.9	0.4	0.00E+00	0.00	0.42
7	3	1	Inlet 2 Septic		0.0	0.00E+00	0.00	
8	3	1	Inlet 3 Septic		0.0	0.00E+00	0.00	
9	3	1	Direct Septic		0.0	0.00E+00	0.00	
10	1	1	Swan	1.5	0.2	0.00E+00	0.00	0.11
PRECIPITATION				1.4	1.1	4.55E-02	0.20	0.79
TRIBUTARY INFLOW				9.8	1.6	3.94E-03	0.04	0.17
POINT-SOURCE INFLOW					0.0	0.00E+00	0.00	
***TOTAL INFLOW				11.1	2.7	4.94E-02	0.08	0.24
ADVECTIVE OUTFLOW				11.1	1.8	1.30E-01	0.20	0.16
***TOTAL OUTFLOW				11.1	1.8	1.30E-01	0.20	0.16
***EVAPORATION					0.9	8.04E-02	0.30	

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

Trb	Type	Seq	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	G1	198.6	21.3%	1.97E+03	89.8%	0.22	320.3	44.6
2	1	1	inlet 2	20.3	2.2%	2.05E+01	0.9%	0.22	337.5	48.2
3	1	1	Inlet 3	20.4	2.2%	2.08E+01	0.9%	0.22	254.9	40.8
4	1	1	Rutz	63.1	6.8%	0.00E+00		0.00	300.3	55.8
5	1	1	Donders	56.8	6.1%	0.00E+00		0.00	516.8	63.9
6	1	1	Direct	129.2	13.9%	0.00E+00		0.00	349.3	145.2
7	3	1	Inlet 2 Septic	0.8	0.1%	0.00E+00		0.00	76.0	
8	3	1	Inlet 3 Septic	0.3	0.0%	0.00E+00		0.00	25.0	
9	3	1	Direct Septic	5.5	0.6%	0.00E+00		0.00	554.0	
10	1	1	Swan	64.6	6.9%	0.00E+00		0.00	379.8	42.8
PRECIPITATION				27.0	2.9%	1.82E+02	8.3%	0.50	25.3	20.0
INTERNAL LOAD				345.2	37.0%	0.00E+00		0.00		
TRIBUTARY INFLOW				552.9	59.4%	2.01E+03	91.7%	0.08	341.3	56.5
POINT-SOURCE INFLOW				6.5	0.7%	0.00E+00		0.00	218.3	
***TOTAL INFLOW				931.7	100.0%	2.20E+03	100.0%	0.05	343.0	83.6
ADVECTIVE OUTFLOW				228.9	24.6%	7.10E+03		0.37	129.2	20.5
***TOTAL OUTFLOW				228.9	24.6%	7.10E+03		0.37	129.2	20.5
***RETENTION				702.8	75.4%	8.35E+03		0.13		

Overflow Rate (m/yr)	1.3	Nutrient Resid. Time (yrs)	0.2808
Hydraulic Resid. Time (yrs)	1.1431	Turnover Ratio	3.6
Reservoir Conc (mg/m3)	129	Retention Coef.	0.754

B.1.6 2004 Predicted vs. Observed

Goose Lake 2004
File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Goose Lake**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	129.2	0.34	86.5%	134.0		87.3%
TOTAL N MG/M3	2200.0		89.0%	2200.0		89.0%
C.NUTRIENT MG/M3	103.1	0.22	90.7%	105.4		91.2%
CHL-A MG/M3	59.5	0.35	99.2%	53.0		98.8%
SECCHI M	0.4	0.19	8.7%	0.4		9.6%
ORGANIC N MG/M3	1642.4	0.31	99.3%			
TP-ORTHO-P MG/M3	142.3	0.30	94.9%			
ANTILOG PC-1	3220.8	0.44	97.5%	3028.9		97.3%
ANTILOG PC-2	11.2	0.22	85.5%	9.6		77.9%
(N - 150) / P	15.9	0.34	46.0%	15.3		43.8%
INORGANIC N / P	557.6	0.91	99.8%			
TURBIDITY 1/M	1.7	0.20	88.0%	1.7	0.20	88.0%
ZMIX * TURBIDITY	2.6	0.23	39.6%	2.6	0.23	39.6%
ZMIX / SECCHI	3.9	0.21	36.5%	3.8	0.12	34.0%
CHL-A * SECCHI	22.9	0.29	87.3%	21.2		84.9%
CHL-A / TOTAL P	0.5	0.30	91.0%	0.4		86.5%
FREQ(CHL-a>10) %	99.5	0.01	99.2%	99.1		98.8%
FREQ(CHL-a>20) %	92.6	0.08	99.2%	89.7		98.8%
FREQ(CHL-a>30) %	78.7	0.20	99.2%	72.8		98.8%
FREQ(CHL-a>40) %	63.0	0.33	99.2%	55.7		98.8%
FREQ(CHL-a>50) %	48.8	0.46	99.2%	41.4		98.8%
FREQ(CHL-a>60) %	37.3	0.57	99.2%	30.5		98.8%
CARLSON TSI-P	74.3	0.07	86.5%	74.8		87.3%
CARLSON TSI-CHLA	70.7	0.05	99.2%	69.5		98.8%
CARLSON TSI-SEC	73.8	0.04	91.3%	73.2		90.4%

B.2 Hydes Lake

B.2.1 2002 Inputs

Hydes Lake 2002

File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Hydes\Models\hydes02new.btb

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.92	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	0.500	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	Hydes Lake	0	1	0.87	2.53	1	2.5	0.12	0	0	1.22	0.2	0	0	0.01	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	129	0	2425	0	42	0	0.54	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	H2 (inlet 1)	1	1	2.1	0.35	0.1	0	0	273.3	0.2	0	0	0	0	0	0
2	Direct	1	1	2.2	0.26	0.1	0	0	415.5	0.2	0	0	0	0	0	0
3	Septic H2	1	3	2.06	0.1	0	0	0	75.1	0	0	0	0	0	0	0
4	Direct Septic	1	3	2.21	0.1	0	0	0	275	0	0	0	0	0	0	0
5	Patterson	1	1	9.5	1.45	0	0	0	263.3	0	0	0	0	0	0	0

B.2.2 2002 Mass Balance

Hydes Lake 2002

File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Hydes\Models\hydes02new.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	H2 (inlet 1)	2.1	0.3	1.23E-03	0.10	0.17
2	1	1	Direct	2.2	0.3	6.76E-04	0.10	0.12
3	3	1	Septic H2	2.1	0.1	0.00E+00	0.00	0.05
4	3	1	Direct Septic	2.2	0.1	0.00E+00	0.00	0.05
5	1	1	Patterson	9.5	1.5	0.00E+00	0.00	0.15
PRECIPITATION				0.9	0.8	2.56E-02	0.20	0.92
TRIBUTARY INFLOW				13.8	2.1	1.90E-03	0.02	0.15
POINT-SOURCE INFLOW				4.3	0.2	0.00E+00	0.00	0.05
***TOTAL INFLOW				18.9	3.1	2.75E-02	0.05	0.16
ADVECTIVE OUTFLOW				18.9	2.5	6.09E-02	0.10	0.13
***TOTAL OUTFLOW				18.9	2.5	6.09E-02	0.10	0.13
***EVAPORATION					0.6	3.34E-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	H2 (inlet 1)	95.7	14.9%	4.57E+02	41.0%	0.22	273.3	45.5
2	1	1	Direct	108.0	16.9%	5.84E+02	52.3%	0.22	415.5	49.1
3	3	1	Septic H2	7.5	1.2%	0.00E+00		0.00	75.1	3.6
4	3	1	Direct Septic	27.5	4.3%	0.00E+00		0.00	275.0	12.4
5	1	1	Patterson	381.8	59.6%	0.00E+00		0.00	263.3	40.2
PRECIPITATION				17.4	2.7%	7.57E+01	6.8%	0.50	21.7	20.0
INTERNAL LOAD				3.2	0.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				585.5	91.3%	1.04E+03	93.2%	0.06	284.2	42.4
POINT-SOURCE INFLOW				35.0	5.5%	0.00E+00		0.00	175.0	8.2
***TOTAL INFLOW				641.1	100.0%	1.12E+03	100.0%	0.05	209.5	33.8
ADVECTIVE OUTFLOW				324.1	50.6%	5.51E+03		0.23	132.2	17.1
***TOTAL OUTFLOW				324.1	50.6%	5.51E+03		0.23	132.2	17.1
***RETENTION				317.0	49.4%	5.67E+03		0.24		

Overflow Rate (m/yr)	2.8	Nutrient Resid. Time (yrs)	0.4539
Hydraulic Resid. Time (yrs)	0.8979	Turnover Ratio	2.2
Reservoir Conc (mg/m3)	132	Retention Coef.	0.494

B.2.3 2002 Predicted vs. Observed

Hydes Lake 2002

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

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Hydes Lake**

	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	132.2	0.23	87.0%	129.0		86.5%
TOTAL N MG/M3	2425.0		91.6%	2425.0		91.6%
C.NUTRIENT MG/M3	108.4	0.15	91.8%	106.7		91.4%
CHL-A MG/M3	50.0	0.31	98.5%	42.0		97.4%
SECCHI M	0.5	0.18	16.0%	0.5		18.1%
ORGANIC N MG/M3	1389.5	0.28	98.3%			
TP-ORTHO-P MG/M3	113.9	0.28	92.0%			
ANTILOG PC-1	2487.7	0.36	96.2%	1836.3		93.8%
ANTILOG PC-2	11.6	0.21	86.8%	10.4		82.0%
(N - 150) / P	17.2	0.23	50.7%	17.6		52.1%
INORGANIC N / P	56.5	2.07	74.1%			
TURBIDITY 1/M	1.2	0.20	78.5%	1.2	0.20	78.5%
ZMIX * TURBIDITY	3.1	0.23	48.3%	3.1	0.23	48.3%
ZMIX / SECCHI	4.9	0.20	52.2%	4.6	0.12	48.0%
CHL-A * SECCHI	25.4	0.26	90.1%	22.7		87.0%
CHL-A / TOTAL P	0.4	0.30	85.0%	0.3		78.8%
FREQ(CHL-a>10) %	98.9	0.01	98.5%	97.7		97.4%
FREQ(CHL-a>20) %	87.9	0.11	98.5%	81.2		97.4%
FREQ(CHL-a>30) %	69.7	0.24	98.5%	59.2		97.4%
FREQ(CHL-a>40) %	52.0	0.37	98.5%	40.8		97.4%
FREQ(CHL-a>50) %	37.9	0.49	98.5%	27.7		97.4%
FREQ(CHL-a>60) %	27.3	0.60	98.5%	18.8		97.4%
CARLSON TSI-P	74.6	0.04	87.0%	74.2		86.5%
CARLSON TSI-CHLA	69.0	0.04	98.5%	67.3		97.4%
CARLSON TSI-SEC	69.8	0.04	84.0%	68.9		81.9%

B.2.4 2004 Inputs

Hydes Lake high
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Hydes\Models\Hydes04TBB.btb
Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.79	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	0.500	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	Hydes Lake	0	1	0.87	2.53	1	2.5	0.12	0	0	0.26	0.2	0	0	0.01	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	146	0	2189	0	57.78	0	0.89	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	H2	1	1	2.1	0.3	0.1	0	0	321.5	0.2	0	0	0	0	0	0
2	Direct	1	1	2.2	0.22	0.1	0	0	488.6	0.2	0	0	0	0	0	0
3	Septic H2	1	3	2.06	0.01	0	0	0	75	0	0	0	0	0	0	0
4	Direct Septic	1	3	2.21	0.01	0	0	0	275	0	0	0	0	0	0	0
5	Patterson	1	1	9.5	1.23	0	0	0	309.6	0	0	0	0	0	0	0

B.2.5 2004 Mass Balance

Hydes Lake high

File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Hydes\Models\Hydes04TBB.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	H2	2.1	0.3	9.00E-04	0.10	0.14
2	1	1	Direct	2.2	0.2	4.84E-04	0.10	0.10
3	3	1	Septic H2	2.1	0.0	0.00E+00	0.00	0.00
4	3	1	Direct Septic	2.2	0.0	0.00E+00	0.00	0.00
5	1	1	Patterson	9.5	1.2	0.00E+00	0.00	0.13
PRECIPITATION				0.9	0.7	1.89E-02	0.20	0.79
TRIBUTARY INFLOW				13.8	1.8	1.38E-03	0.02	0.13
POINT-SOURCE INFLOW				4.3	0.0	0.00E+00	0.00	0.00
***TOTAL INFLOW				18.9	2.5	2.03E-02	0.06	0.13
ADVECTIVE OUTFLOW				18.9	1.8	5.37E-02	0.13	0.10
***TOTAL OUTFLOW				18.9	1.8	5.37E-02	0.13	0.10
***EVAPORATION					0.6	3.34E-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	H2	96.5	15.8%	4.65E+02	41.6%	0.22	321.5	45.9
2	1	1	Direct	107.5	17.7%	5.78E+02	51.6%	0.22	488.6	48.9
3	3	1	Septic H2	0.8	0.1%	0.00E+00		0.00	75.0	0.4
4	3	1	Direct Septic	2.8	0.5%	0.00E+00		0.00	275.0	1.2
5	1	1	Patterson	380.8	62.5%	0.00E+00		0.00	309.6	40.1
PRECIPITATION				17.4	2.9%	7.57E+01	6.8%	0.50	25.3	20.0
INTERNAL LOAD				3.2	0.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				584.8	96.0%	1.04E+03	93.2%	0.06	334.1	42.4
POINT-SOURCE INFLOW				3.5	0.6%	0.00E+00		0.00	175.0	0.8
***TOTAL INFLOW				608.8	100.0%	1.12E+03	100.0%	0.05	247.8	32.1
ADVECTIVE OUTFLOW				268.6	44.1%	4.92E+03		0.26	145.3	14.2
***TOTAL OUTFLOW				268.6	44.1%	4.92E+03		0.26	145.3	14.2
***RETENTION				340.2	55.9%	5.22E+03		0.21		

Overflow Rate (m/yr)	2.1	Nutrient Resid. Time (yrs)	0.5253
Hydraulic Resid. Time (yrs)	1.1909	Turnover Ratio	1.9
Reservoir Conc (mg/m3)	145	Retention Coef.	0.559

B.2.6 2004 Predicted vs. Observed

Hydes Lake high

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

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 1 Hydes Lake

	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	145.3	0.26	89.1%	146.0		89.2%
TOTAL N MG/M3	2189.0		88.9%	2189.0		88.9%
C.NUTRIENT MG/M3	110.4	0.15	92.1%	110.7		92.1%
CHL-A MG/M3	67.1	0.29	99.5%	57.8		99.1%
SECCHI M	0.8	0.25	34.0%	0.9		40.0%
ORGANIC N MG/M3	1706.2	0.29	99.4%			
TP-ORTHO-P MG/M3	121.5	0.32	93.0%			
ANTILOG PC-1	2582.2	0.42	96.4%	1560.1		92.1%
ANTILOG PC-2	19.7	0.11	98.3%	19.0		98.1%
(N - 150) / P	14.0	0.26	38.9%	14.0		38.6%
INORGANIC N / P	20.3	1.83	35.0%			
TURBIDITY 1/M	0.3	0.20	16.7%	0.3	0.20	16.7%
ZMIX * TURBIDITY	0.6	0.23	2.1%	0.6	0.23	2.1%
ZMIX / SECCHI	3.2	0.26	24.1%	2.8	0.12	18.1%
CHL-A * SECCHI	53.0	0.12	99.0%	51.4		98.9%
CHL-A / TOTAL P	0.5	0.30	91.1%	0.4		86.5%
FREQ(CHL-a>10) %	99.7	0.00	99.5%	99.4		99.1%
FREQ(CHL-a>20) %	95.0	0.05	99.5%	91.9		99.1%
FREQ(CHL-a>30) %	83.8	0.13	99.5%	77.3		99.1%
FREQ(CHL-a>40) %	70.0	0.23	99.5%	61.2		99.1%
FREQ(CHL-a>50) %	56.5	0.32	99.5%	46.9		99.1%
FREQ(CHL-a>60) %	44.8	0.41	99.5%	35.5		99.1%
CARLSON TSI-P	75.9	0.05	89.1%	76.0		89.2%
CARLSON TSI-CHLA	71.9	0.04	99.5%	70.4		99.1%
CARLSON TSI-SEC	63.4	0.06	66.0%	61.7		60.0%

B.3 Miller Lake

B.3.1 2002 Inputs

Miller Lake

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Miller\Models\miller2002.btb**

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.9	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	Miller lake	0	1	0.57	2.24	0.5	2.2	0.12	0	0	0.64	0.2	0	0	32.5	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	343	0	1700	0	23.7	0	1	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	0	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	Inlet 1 CA 10.4	1	1	57.71	10.09	0.1	0	0	262.3	0.2	0	0	0	0	0	0
2	Inlet 2 (D1)	1	1	1.2	0.21	0.1	0	0	245	0.2	0	0	0	0	0	0
3	Direct (D2)	1	1	0.39	0.05	0.1	0	0	665.4	0.2	0	0	0	0	0	0
4	CA 10.4 septic	1	3	0.01	0.1	0	0	0	4093	0	0	0	0	0	0	0
5	D1 Septic	1	3	0.01	0.1	0	0	0	37.5	0	0	0	0	0	0	0
6	D2 Septic	1	1	0.01	0.1	0	0	0	50.1	0	0	0	0	0	0	0
7	Burandt, Waconia, Goose Sub:	1	1	43.633	4.787	0	0	0	322.8	0	0	0	0	0	0	0
8	Winkler, Hydes, Patterson, Ric	1	1	49.633	8.406	0	0	0	249.2	0	0	0	0	0	0	0
9	Reitz Sub	1	1	4.204	2.258	0	0	0	278.4	0	0	0	0	0	0	0
10	Benton Sub	1	1	3.126	1.504	0	0	0	242.6	0	0	0	0	0	0	0

B.3.2 2002 Mass Balance

Miller Lake
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Miller\Models\miller2002.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	Inlet 1 CA 10.4	57.7	10.1	1.02E+00	0.10	0.17
2	1	1	Inlet 2 (D1)	1.2	0.2	4.41E-04	0.10	0.17
3	1	1	Direct (D2)	0.4	0.1	2.50E-05	0.10	0.13
4	3	1	CA 10.4 septic	0.0	0.1	0.00E+00	0.00	10.00
5	3	1	D1 Septic	0.0	0.1	0.00E+00	0.00	10.00
6	1	1	D2 Septic	0.0	0.1	0.00E+00	0.00	10.00
7	1	1	Burandt, Waconia, Goose S	43.6	4.8	0.00E+00	0.00	0.11
8	1	1	Winkler, Hydes, Patterson,	49.6	8.4	0.00E+00	0.00	0.17
9	1	1	Reitz Sub	4.2	2.3	0.00E+00	0.00	0.54
10	1	1	Benton Sub	3.1	1.5	0.00E+00	0.00	0.48
PRECIPITATION				0.6	0.5	1.05E-02	0.20	0.90
TRIBUTARY INFLOW				159.9	27.4	1.02E+00	0.04	0.17
POINT-SOURCE INFLOW				0.0	0.2	0.00E+00	0.00	10.00
***TOTAL INFLOW				160.5	28.1	1.03E+00	0.04	0.18
ADVECTIVE OUTFLOW				160.5	27.7	1.04E+00	0.04	0.17
***TOTAL OUTFLOW				160.5	27.7	1.04E+00	0.04	0.17
***EVAPORATION					0.4	1.43E-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	Inlet 1 CA 10.4	2646.6	18.2%	3.50E+05	99.9%	0.22	262.3	45.9
2	1	1	Inlet 2 (D1)	51.4	0.4%	1.32E+02	0.0%	0.22	245.0	42.9
3	1	1	Direct (D2)	33.3	0.2%	5.53E+01	0.0%	0.22	665.4	85.3
4	3	1	CA 10.4 septic	409.3	2.8%	0.00E+00		0.00	4093.0	40930.0
5	3	1	D1 Septic	3.8	0.0%	0.00E+00		0.00	37.5	375.0
6	1	1	D2 Septic	5.0	0.0%	0.00E+00		0.00	50.1	501.0
7	1	1	Burandt, Waconia, Goose S	1545.2	10.6%	0.00E+00		0.00	322.8	35.4
8	1	1	Winkler, Hydes, Patterson,	2094.8	14.4%	0.00E+00		0.00	249.2	42.2
9	1	1	Reitz Sub	628.6	4.3%	0.00E+00		0.00	278.4	149.5
10	1	1	Benton Sub	364.9	2.5%	0.00E+00		0.00	242.6	116.7
PRECIPITATION				11.4	0.1%	3.25E+01	0.0%	0.50	22.2	20.0
INTERNAL LOAD				6766.3	46.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				7369.9	50.6%	3.50E+05	100.0%	0.08	268.9	46.1
POINT-SOURCE INFLOW				413.1	2.8%	0.00E+00		0.00	2065.3	20652.5
***TOTAL INFLOW				14560.6	100.0%	3.50E+05	100.0%	0.04	517.8	90.7
ADVECTIVE OUTFLOW				9465.6	65.0%	2.33E+06		0.16	341.5	59.0
***TOTAL OUTFLOW				9465.6	65.0%	2.33E+06		0.16	341.5	59.0
***RETENTION				5095.0	35.0%	2.23E+06		0.29		

Overflow Rate (m/yr)	48.6	Nutrient Resid. Time (yrs)	0.0299
Hydraulic Resid. Time (yrs)	0.0461	Turnover Ratio	33.4
Reservoir Conc (mg/m3)	341	Retention Coef.	0.350

B.3.3 2002 Predicted vs. Observed

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

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Miller lake**

	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	341.5	0.16	98.5%	343.0		98.6%
TOTAL N MG/M3	1700.0		79.6%	1700.0		79.6%
C.NUTRIENT MG/M3	120.8	0.02	93.6%	120.9		93.6%
CHL-A MG/M3	51.5	0.28	98.6%	23.7		88.5%
SECCHI M	0.7	0.19	28.9%	1.0		46.0%
ORGANIC N MG/M3	1379.7	0.27	98.2%			
TP-ORTHO-P MG/M3	102.8	0.29	90.3%			
ANTILOG PC-1	2294.0	0.32	95.6%	600.8		75.3%
ANTILOG PC-2	14.5	0.16	93.8%	11.4		86.4%
(N - 150) / P	4.5	0.16	2.6%	4.5		2.6%
INORGANIC N / P	1.3	1.09	0.1%			
TURBIDITY 1/M	0.6	0.20	52.2%	0.6	0.20	52.2%
ZMIX * TURBIDITY	1.4	0.23	15.0%	1.4	0.23	15.0%
ZMIX / SECCHI	3.1	0.20	23.1%	2.2	0.12	9.2%
CHL-A * SECCHI	36.5	0.19	96.4%	23.7		88.3%
CHL-A / TOTAL P	0.2	0.31	34.0%	0.1		5.1%
FREQ(CHL-a>10) %	99.0	0.01	98.6%	86.0		88.5%
FREQ(CHL-a>20) %	88.8	0.09	98.6%	48.5		88.5%
FREQ(CHL-a>30) %	71.3	0.21	98.6%	24.5		88.5%
FREQ(CHL-a>40) %	53.9	0.33	98.6%	12.4		88.5%
FREQ(CHL-a>50) %	39.7	0.43	98.6%	6.5		88.5%
FREQ(CHL-a>60) %	28.9	0.53	98.6%	3.5		88.5%
CARLSON TSI-P	88.3	0.03	98.5%	88.3		98.6%
CARLSON TSI-CHLA	69.3	0.04	98.6%	61.7		88.5%
CARLSON TSI-SEC	65.0	0.04	71.1%	60.0		54.0%

B.3.4 2004 Inputs

Miller Lake

File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Miller\Models\miller2004.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	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	Miller lake	0	1	0.57	2.24	0.5	2.2	0.12	0	0	1.15	0.2	0	0	0.5	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	197	0	1856	0	56	0	0.68	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	Inlet 1 CA 10.4	1	1	57.7	8.58	0.1	0	0	287.1	0.2	0	0	0	0	0	0
2	Inlet 2 (D1)	1	1	1.2	0.18	0.1	0	0	292.6	0.2	0	0	0	0	0	0
3	Direct (D2)	1	1	0.39	0.04	0.1	0	0	323.9	0.2	0	0	0	0	0	0
4	Burandt Subwatershed	1	1	43.6	4.07	0	0	0	239.3	0	0	0	0	0	0	0
5	Winkler Subwatershed	1	1	49.2	7.15	0	0	0	256.7	0	0	0	0	0	0	0
6	Reitz Subwatershed	1	1	14.7	1.92	0	0	0	294.5	0	0	0	0	0	0	0
7	Benton Subwatershed	1	1	9.1	1.28	0	0	0	244.1	0	0	0	0	0	0	0
8	Inlet CA 10.4 Septics	1	3	0	0.1	0	0	0	4093	0	0	0	0	0	0	0
9	Inlet D1	1	3	0	0.1	0	0	0	37.5	0	0	0	0	0	0	0
10	Direct Septics	1	3	0	0.1	0	0	0	50.1	0	0	0	0	0	0	0

B.3.5 2004 Mass Balance

Miller Lake

File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Miller\Models\miller2004.btb

Overall Water & Nutrient Balances

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

Trb	Type	Seq	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	Inlet 1 CA 10.4	57.7	8.6	7.36E-01	0.10	0.15
2	1	1	Inlet 2 (D1)	1.2	0.2	3.24E-04	0.10	0.15
3	1	1	Direct (D2)	0.4	0.0	1.60E-05	0.10	0.10
4	1	1	Burandt Subwatershed	43.6	4.1	0.00E+00	0.00	0.09
5	1	1	Winkler Subwatershed	49.2	7.2	0.00E+00	0.00	0.15
6	1	1	Reitz Subwatershed	14.7	1.9	0.00E+00	0.00	0.13
7	1	1	Benton Subwatershed	9.1	1.3	0.00E+00	0.00	0.14
8	3	1	Inlet CA 10.4 Septics		0.1	0.00E+00	0.00	
9	3	1	Inlet D1		0.1	0.00E+00	0.00	
10	3	1	Direct Septics		0.1	0.00E+00	0.00	
PRECIPITATION				0.6	0.3	4.68E-03	0.20	0.60
TRIBUTARY INFLOW				175.9	23.2	7.36E-01	0.04	0.13
POINT-SOURCE INFLOW					0.3	0.00E+00	0.00	
***TOTAL INFLOW				176.5	23.9	7.41E-01	0.04	0.14
ADVECTIVE OUTFLOW				176.5	23.5	7.56E-01	0.04	0.13
***TOTAL OUTFLOW				176.5	23.5	7.56E-01	0.04	0.13
***EVAPORATION					0.4	1.43E-02	0.30	

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

Trb	Type	Seq	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	Inlet 1 CA 10.4	2463.3	36.5%	3.03E+05	99.9%	0.22	287.1	42.7
2	1	1	Inlet 2 (D1)	52.7	0.8%	1.39E+02	0.0%	0.22	292.6	43.9
3	1	1	Direct (D2)	13.0	0.2%	8.39E+00	0.0%	0.22	323.9	33.2
4	1	1	Burandt Subwatershed	974.0	14.4%	0.00E+00		0.00	239.3	22.3
5	1	1	Winkler Subwatershed	1835.4	27.2%	0.00E+00		0.00	256.7	37.3
6	1	1	Reitz Subwatershed	565.4	8.4%	0.00E+00		0.00	294.5	38.5
7	1	1	Benton Subwatershed	312.4	4.6%	0.00E+00		0.00	244.1	34.3
8	3	1	Inlet CA 10.4 Septics	409.3	6.1%	0.00E+00		0.00	4093.0	
9	3	1	Inlet D1	3.8	0.1%	0.00E+00		0.00	37.5	
10	3	1	Direct Septics	5.0	0.1%	0.00E+00		0.00	50.1	
PRECIPITATION				11.4	0.2%	3.25E+01	0.0%	0.50	33.3	20.0
INTERNAL LOAD				104.1	1.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				6216.2	92.1%	3.04E+05	100.0%	0.09	267.7	35.3
POINT-SOURCE INFLOW				418.1	6.2%	0.00E+00		0.00	1393.5	
***TOTAL INFLOW				6749.7	100.0%	3.04E+05	100.0%	0.08	282.9	38.3
ADVECTIVE OUTFLOW				4664.1	69.1%	5.38E+05		0.16	198.8	26.4
***TOTAL OUTFLOW				4664.1	69.1%	5.38E+05		0.16	198.8	26.4
***RETENTION				2085.6	30.9%	4.56E+05		0.32		

Overflow Rate (m/yr)	41.2	Nutrient Resid. Time (yrs)	0.0376
Hydraulic Resid. Time (yrs)	0.0544	Turnover Ratio	26.6
Reservoir Conc (mg/m3)	199	Retention Coef.	0.309

B.3.6 2004 Predicted vs. Observed

Miller Lake

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

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Miller lake**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	198.8	0.15	94.3%	197.0		94.2%
TOTAL N MG/M3	1856.0		83.2%	1856.0		83.2%
C.NUTRIENT MG/M3	115.6	0.05	92.9%	115.3		92.9%
CHL-A MG/M3	44.1	0.29	97.8%	56.0		99.0%
SECCHI M	0.6	0.17	18.9%	0.7		27.1%
ORGANIC N MG/M3	1249.8	0.26	97.1%			
TP-ORTHO-P MG/M3	101.7	0.26	90.1%			
ANTILOG PC-1	2228.9	0.30	95.4%	1946.3		94.3%
ANTILOG PC-2	10.9	0.21	84.2%	15.1		94.8%
(N - 150) / P	8.6	0.15	15.8%	8.7		16.1%
INORGANIC N / P	6.2	0.52	5.8%			
TURBIDITY 1/M	1.1	0.20	76.5%	1.1	0.20	76.5%
ZMIX * TURBIDITY	2.5	0.23	38.9%	2.5	0.23	38.9%
ZMIX / SECCHI	4.0	0.19	37.9%	3.2	0.12	25.2%
CHL-A * SECCHI	24.4	0.26	89.1%	38.1		96.9%
CHL-A / TOTAL P	0.2	0.31	57.8%	0.3		72.1%
FREQ(CHL-a>10) %	98.1	0.02	97.8%	99.3		99.0%
FREQ(CHL-a>20) %	83.3	0.14	97.8%	91.2		99.0%
FREQ(CHL-a>30) %	62.3	0.28	97.8%	75.7		99.0%
FREQ(CHL-a>40) %	44.0	0.41	97.8%	59.2		99.0%
FREQ(CHL-a>50) %	30.4	0.53	97.8%	44.9		99.0%
FREQ(CHL-a>60) %	21.0	0.64	97.8%	33.7		99.0%
CARLSON TSI-P	80.5	0.03	94.3%	80.3		94.2%
CARLSON TSI-CHLA	67.8	0.04	97.8%	70.1		99.0%
CARLSON TSI-SEC	68.6	0.04	81.1%	65.6		72.9%

B.4 Winkler Lake

B.4.1 2001 Inputs

B.4.2 2001 Mass Balance

winkler_monitored_data

File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Winkler\Models\Updated winkler01_monitored_data.btb**

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.74	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	Winkler	0	1	0.29	0.6	0.5	0.6	0.12	0	0	1.07	0.2	0	0	5	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	297	0	2000	0	57	0	0.52	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	0.6	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	CC9 (Inlet 2)	1	1	9.3	1.49	0.1	0	0	313	0.2	0	0	0	0	0	0
2	CC8 (Inlet 3)	1	1	2	0.27	0.1	0	0	355.8	0.2	0	0	0	0	0	0
3	Direct	1	1	1.1	0.12	0.1	0	0	410	0.2	0	0	0	0	0	0
4	Inlet 1	1	1	0.5	0.09	0	0	0	294.3	0	0	0	0	0	0	0
5	Inlet 1 Septic	1	3	0.01	0.1	0	0	0	12.5	0	0	0	0	0	0	0
6	Inlet 2 Septic	1	3	0.01	0.1	0	0	0	613.3	0	0	0	0	0	0	0
7	Inlet 3 Septic	1	3	0.01	0.1	0	0	0	863.6	0	0	0	0	0	0	0
8	Direct Septic	1	3	0.01	0.1	0	0	0	25	0	0	0	0	0	0	0
9	Rice Subwatershed	1	1	18.5	2.56	0	0	0	321	0	0	0	0	0	0	0
10	Barlous Subwatershed	1	1	3.8	0.48	0	0	0	300.3	0	0	0	0	0	0	0
11	Hydes Subwatershed	1	1	12.8	1.63	0	0	0	321.2	0	0	0	0	0	0	0

winkler_monitored_data
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Winkler\Models\Updated winkler01_monitored_data.btb

Overall Water & Nutrient Balances

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

Trb	Type	Seq	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	CC9 (Inlet 2)	9.3	1.5	2.22E-02	0.10	0.16
2	1	1	CC8 (Inlet 3)	2.0	0.3	7.29E-04	0.10	0.14
3	1	1	Direct	1.1	0.1	1.44E-04	0.10	0.11
4	1	1	Inlet 1	0.5	0.1	0.00E+00	0.00	0.18
5	3	1	Inlet 1 Septic	0.0	0.1	0.00E+00	0.00	10.00
6	3	1	Inlet 2 Septic	0.0	0.1	0.00E+00	0.00	10.00
7	3	1	Inlet 3 Septic	0.0	0.1	0.00E+00	0.00	10.00
8	3	1	Direct Septic	0.0	0.1	0.00E+00	0.00	10.00
9	1	1	Rice Subwatershed	18.5	2.6	0.00E+00	0.00	0.14
10	1	1	Barlous Subwatershed	3.8	0.5	0.00E+00	0.00	0.13
11	1	1	Hydes Subwatershed	12.8	1.6	0.00E+00	0.00	0.13
PRECIPITATION				0.3	0.2	1.84E-03	0.20	0.74
TRIBUTARY INFLOW				48.0	6.6	2.31E-02	0.02	0.14
POINT-SOURCE INFLOW				0.0	0.4	0.00E+00	0.00	10.00
***TOTAL INFLOW				48.3	7.3	2.49E-02	0.02	0.15
ADVECTIVE OUTFLOW				48.3	7.1	2.86E-02	0.02	0.15
***TOTAL OUTFLOW				48.3	7.1	2.86E-02	0.02	0.15
***EVAPORATION					0.2	3.71E-03	0.30	

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

Trb	Type	Seq	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	CC9 (Inlet 2)	466.4	16.6%	1.09E+04	94.8%	0.22	313.0	50.1
2	1	1	CC8 (Inlet 3)	96.1	3.4%	4.61E+02	4.0%	0.22	355.8	48.0
3	1	1	Direct	49.2	1.7%	1.21E+02	1.1%	0.22	410.0	44.7
4	1	1	Inlet 1	26.5	0.9%	0.00E+00		0.00	294.3	53.0
5	3	1	Inlet 1 Septic	1.3	0.0%	0.00E+00		0.00	12.5	125.0
6	3	1	Inlet 2 Septic	61.3	2.2%	0.00E+00		0.00	613.3	6133.0
7	3	1	Inlet 3 Septic	86.4	3.1%	0.00E+00		0.00	863.6	8636.0
8	3	1	Direct Septic	2.5	0.1%	0.00E+00		0.00	25.0	250.0
9	1	1	Rice Subwatershed	821.8	29.2%	0.00E+00		0.00	321.0	44.4
10	1	1	Barlous Subwatershed	144.1	5.1%	0.00E+00		0.00	300.3	37.9
11	1	1	Hydes Subwatershed	523.6	18.6%	0.00E+00		0.00	321.2	40.9
PRECIPITATION				5.8	0.2%	8.41E+00	0.1%	0.50	27.0	20.0
INTERNAL LOAD				529.6	18.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				2127.6	75.6%	1.15E+04	99.9%	0.05	320.4	44.3
POINT-SOURCE INFLOW				151.4	5.4%	0.00E+00		0.00	378.6	3786.0
***TOTAL INFLOW				2814.4	100.0%	1.15E+04	100.0%	0.04	388.0	58.2
ADVECTIVE OUTFLOW				2102.8	74.7%	6.23E+04		0.12	298.2	43.5
***TOTAL OUTFLOW				2102.8	74.7%	6.23E+04		0.12	298.2	43.5
***RETENTION				711.6	25.3%	5.75E+04		0.34		

Overflow Rate (m/yr)	24.3	Nutrient Resid. Time (yrs)	0.0184
Hydraulic Resid. Time (yrs)	0.0247	Turnover Ratio	54.2
Reservoir Conc (mg/m3)	298	Retention Coef.	0.253

B.4.3 2001 Predicted vs. Observed

winkler_monitored_data

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

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Winkler**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	298.2	0.12	97.9%	297.0		97.9%
TOTAL N MG/M3	2000.0		86.0%	2000.0		86.0%
C.NUTRIENT MG/M3	136.9	0.02	95.4%	136.8		95.3%
CHL-A MG/M3	56.7	0.27	99.0%	57.0		99.0%
SECCHI M	0.5	0.18	16.9%	0.5		16.8%
ORGANIC N MG/M3	1529.3	0.26	98.9%			
TP-ORTHO-P MG/M3	122.1	0.27	93.0%			
ANTILOG PC-1	3121.9	0.29	97.4%	2541.4		96.3%
ANTILOG PC-2	12.4	0.18	89.5%	12.4		89.5%
(N - 150) / P	6.2	0.12	6.9%	6.2		7.0%
INORGANIC N / P	2.7	0.76	0.8%			
TURBIDITY 1/M	1.1	0.20	73.9%	1.1	0.20	73.9%
ZMIX * TURBIDITY	0.6	0.23	2.0%	0.6	0.23	2.0%
ZMIX / SECCHI	1.2	0.20	0.7%	1.2	0.12	0.7%
CHL-A * SECCHI	29.5	0.22	93.3%	29.6		93.4%
CHL-A / TOTAL P	0.2	0.28	48.0%	0.2		48.7%
FREQ(CHL-a>10) %	99.4	0.01	99.0%	99.4		99.0%
FREQ(CHL-a>20) %	91.5	0.07	99.0%	91.6		99.0%
FREQ(CHL-a>30) %	76.3	0.17	99.0%	76.6		99.0%
FREQ(CHL-a>40) %	59.9	0.27	99.0%	60.3		99.0%
FREQ(CHL-a>50) %	45.7	0.37	99.0%	46.1		99.0%
FREQ(CHL-a>60) %	34.4	0.46	99.0%	34.7		99.0%
CARLSON TSI-P	86.3	0.02	97.9%	86.3		97.9%
CARLSON TSI-CHLA	70.2	0.04	99.0%	70.3		99.0%
CARLSON TSI-SEC	69.4	0.04	83.1%	69.4		83.2%

B.4.4 2005 Inputs

winkler_monitored_data
File: **S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Winkler\Models\updated winkler05_monitored_data.btb**
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	Winkler	0	1	0.29	0.6	0.5	0.6	0.12	0	0	0.01	0.2	0	0	13	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	283	0	3230	0	71	0	0.525	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	0.6	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	CC9 (Inlet 2)	1	1	9.3	2.16	0.1	0	0	216	0.2	0	0	0	0	0	0
2	CC8 (Inlet 3)	1	1	2	0.39	0.1	0	0	245.5	0.2	0	0	0	0	0	0
3	Direct	1	1	1.1	0.17	0.1	0	0	283	0.2	0	0	0	0	0	0
4	Direct septic	1	3	0.01	0.01	0	0	0	25	0	0	0	0	0	0	0
5	Inlet 1	1	1	0.5	0.13	0	0	0	203.1	0	0	0	0	0	0	0
6	Inlet 1 Septic	1	3	0.01	0.1	0	0	0	12.5	0	0	0	0	0	0	0
7	Inlet 2 Septic	1	3	0.01	0.1	0	0	0	613.3	0	0	0	0	0	0	0
8	Inlet 3 Septic	1	3	0.01	0.1	0	0	0	137.7	0	0	0	0	0	0	0
9	Rice Subwatershed	1	1	18.5	3.72	0	0	0	221.5	0	0	0	0	0	0	0
10	Hydes Subwatershed	1	1	12.8	2.36	0	0	0	221.6	0	0	0	0	0	0	0
11	Barlous Subwatershed	1	1	3.8	0.7	0	0	0	207.2	0	0	0	0	0	0	0

B.4.5 2005 Mass Balance

winkler_monitored_data
File: S:\Water\Water Monitoring\TMDL\TMDL\Lake TMDLs\Draft TMDL to MPCA\Five Lake TMDL\Individual Lakes\Winkler\Models\updated winkler05_monitored_data.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	CC9 (Inlet 2)	9.3	2.2	4.67E-02	0.10	0.23
2	1	1	CC8 (Inlet 3)	2.0	0.4	1.52E-03	0.10	0.19
3	1	1	Direct	1.1	0.2	2.89E-04	0.10	0.15
4	3	1	Direct septic	0.0	0.0	0.00E+00	0.00	1.00
5	1	1	Inlet 1	0.5	0.1	0.00E+00	0.00	0.26
6	3	1	Inlet 1 Septic	0.0	0.1	0.00E+00	0.00	10.00
7	3	1	Inlet 2 Septic	0.0	0.1	0.00E+00	0.00	10.00
8	3	1	Inlet 3 Septic	0.0	0.1	0.00E+00	0.00	10.00
9	1	1	Rice Subwatershed	18.5	3.7	0.00E+00	0.00	0.20
10	1	1	Hydes Subwatershed	12.8	2.4	0.00E+00	0.00	0.18
11	1	1	Barlous Subwatershed	3.8	0.7	0.00E+00	0.00	0.18
PRECIPITATION				0.3	0.3	4.07E-03	0.20	1.10
TRIBUTARY INFLOW				48.0	9.6	4.85E-02	0.02	0.20
POINT-SOURCE INFLOW				0.0	0.3	0.00E+00	0.00	7.75
***TOTAL INFLOW				48.3	10.3	5.25E-02	0.02	0.21
ADVECTIVE OUTFLOW				48.3	10.1	5.62E-02	0.02	0.21
***TOTAL OUTFLOW				48.3	10.1	5.62E-02	0.02	0.21
***EVAPORATION					0.2	3.71E-03	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	CC9 (Inlet 2)	466.6	13.0%	1.09E+04	94.9%	0.22	216.0	50.2
2	1	1	CC8 (Inlet 3)	95.7	2.7%	4.58E+02	4.0%	0.22	245.5	47.9
3	1	1	Direct	48.1	1.3%	1.16E+02	1.0%	0.22	283.0	43.7
4	3	1	Direct septic	0.3	0.0%	0.00E+00		0.00	25.0	25.0
5	1	1	Inlet 1	26.4	0.7%	0.00E+00		0.00	203.1	52.8
6	3	1	Inlet 1 Septic	1.3	0.0%	0.00E+00		0.00	12.5	125.0
7	3	1	Inlet 2 Septic	61.3	1.7%	0.00E+00		0.00	613.3	6133.0
8	3	1	Inlet 3 Septic	13.8	0.4%	0.00E+00		0.00	137.7	1377.0
9	1	1	Rice Subwatershed	824.0	23.0%	0.00E+00		0.00	221.5	44.5
10	1	1	Hydes Subwatershed	523.0	14.6%	0.00E+00		0.00	221.6	40.9
11	1	1	Barlous Subwatershed	145.0	4.0%	0.00E+00		0.00	207.2	38.2
PRECIPITATION				5.8	0.2%	8.41E+00	0.1%	0.50	18.2	20.0
INTERNAL LOAD				1377.0	38.4%	0.00E+00		0.00		
TRIBUTARY INFLOW				2128.8	59.3%	1.15E+04	99.9%	0.05	221.1	44.4
POINT-SOURCE INFLOW				76.6	2.1%	0.00E+00		0.00	247.1	1915.0
***TOTAL INFLOW				3588.2	100.0%	1.15E+04	100.0%	0.03	349.8	74.2
ADVECTIVE OUTFLOW				2836.0	79.0%	7.76E+04		0.10	282.0	58.7
***TOTAL OUTFLOW				2836.0	79.0%	7.76E+04		0.10	282.0	58.7
***RETENTION				752.2	21.0%	7.15E+04		0.36		

Overflow Rate (m/yr)	34.7	Nutrient Resid. Time (yrs)	0.0137
Hydraulic Resid. Time (yrs)	0.0173	Turnover Ratio	73.1
Reservoir Conc (mg/m3)	282	Retention Coef.	0.210

B.4.6 2005 Predicted vs. Observed

winkler_monitored_data

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

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **Winkler**

	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	282.0	0.10	97.6%	283.0		97.6%
TOTAL N MG/M3	3230.0		96.6%	3230.0		96.6%
C.NUTRIENT MG/M3	189.8	0.04	98.2%	190.1		98.2%
CHL-A MG/M3	81.9	0.27	99.8%	71.0		99.6%
SECCHI M	0.8	0.28	35.1%	0.5		17.1%
ORGANIC N MG/M3	2025.3	0.27	99.8%			
TP-ORTHO-P MG/M3	141.9	0.31	94.9%			
ANTILOG PC-1	4162.6	0.37	98.5%	3102.6		97.4%
ANTILOG PC-2	21.1	0.08	98.8%	14.5		93.9%
(N - 150) / P	10.9	0.10	25.8%	10.9		25.6%
INORGANIC N / P	8.6	0.36	10.6%			
TURBIDITY 1/M	0.0	0.20	0.0%	0.0	0.20	0.0%
ZMIX * TURBIDITY	0.0	0.23	0.0%	0.0	0.23	0.0%
ZMIX / SECCHI	0.7	0.29	0.1%	1.1	0.12	0.7%
CHL-A * SECCHI	66.1	0.10	99.6%	37.3		96.6%
CHL-A / TOTAL P	0.3	0.27	73.2%	0.3		65.1%
FREQ(CHL-a>10) %	99.9	0.00	99.8%	99.8		99.6%
FREQ(CHL-a>20) %	97.5	0.02	99.8%	95.8		99.6%
FREQ(CHL-a>30) %	90.5	0.08	99.8%	86.0		99.6%
FREQ(CHL-a>40) %	80.1	0.15	99.8%	73.1		99.6%
FREQ(CHL-a>50) %	68.7	0.22	99.8%	60.1		99.6%
FREQ(CHL-a>60) %	57.6	0.29	99.8%	48.5		99.6%
CARLSON TSI-P	85.5	0.02	97.6%	85.6		97.6%
CARLSON TSI-CHLA	73.8	0.04	99.8%	72.4		99.6%
CARLSON TSI-SEC	63.1	0.06	64.9%	69.3		82.9%

Appendix C BATHTUB TMDL Load Response Models

C.1 Goose Lake

C.1.1 TMDL Inputs

Goose Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Goose 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

													Internal Loads (mg/m2-day)					
		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		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	Goose Lake	0	1	1.34865	1.324842	0.5	1.3	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	1.61	0	0	0	167.61	0	0	0	0	0	0	0

C.1.2 TMDL Mass Balance

Goose Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Goose 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	1.6	0.00E+00	0.00	1.61
TRIBUTARY INFLOW				1.0	1.6	0.00E+00	0.00	1.61
***TOTAL INFLOW				2.3	1.6	0.00E+00	0.00	0.69
ADVECTIVE OUTFLOW				2.3	1.6	0.00E+00	0.00	0.69
***TOTAL OUTFLOW				2.3	1.6	0.00E+00	0.00	0.69

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	269.9	100.0%	0.00E+00		0.00	167.6	269.9
TRIBUTARY INFLOW				269.9	100.0%	0.00E+00		0.00	167.6	269.9
***TOTAL INFLOW				269.9	100.0%	0.00E+00		0.00	167.6	114.9
ADVECTIVE OUTFLOW				96.7	35.8%	7.51E+02		0.28	60.1	41.2
***TOTAL OUTFLOW				96.7	35.8%	7.51E+02		0.28	60.1	41.2
***RETENTION				173.1	64.2%	7.51E+02		0.16		

Overflow Rate (m/yr)	1.2	Nutrient Resid. Time (yrs)	0.3978
Hydraulic Resid. Time (yrs)	1.1098	Turnover Ratio	2.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.642

C.1.3 TMDL Predicted

Goose Lake TMDL

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

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Goose Lake**

Variable	**Mean**	**CV**	**Rank**
	Predicted Values--->		
TOTAL P MG/M3	60.1	0.28	59.9%
CHL-A MG/M3	45.3	0.41	98.0%
SECCHI M	1.3	0.38	60.3%
ORGANIC N MG/M3	1196.6	0.38	96.5%
TP-ORTHO-P MG/M3	78.5	0.45	84.4%
ANTILOG PC-1	860.8	0.74	83.1%
ANTILOG PC-2	21.9	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%
ZMIX / SECCHI	1.0	0.38	0.3%
CHL-A * SECCHI	59.6	0.11	99.4%
CHL-A / TOTAL P	0.8	0.26	98.3%
FREQ(CHL-a>10) %	98.3	0.03	98.0%
FREQ(CHL-a>20) %	84.4	0.19	98.0%
FREQ(CHL-a>30) %	63.9	0.39	98.0%
FREQ(CHL-a>40) %	45.7	0.58	98.0%
FREQ(CHL-a>50) %	32.0	0.74	98.0%
FREQ(CHL-a>60) %	22.3	0.89	98.0%
CARLSON TSI-P	63.2	0.07	59.9%
CARLSON TSI-CHLA	68.0	0.06	98.0%
CARLSON TSI-SEC	56.0	0.10	39.7%

C.2 Hydes Lake

C.2.1 TMDL Inputs

Hydes Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Hydes 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	Hydes Lake	0	1	0.874294	3.160491	0.5	3.1	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)	
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	1.751	0	0	0	112.28	0	0	0	0	0	0	0

C.2.2 TMDL Mass Balance

C.2.3 TMDL Predicted

Hydes Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Hydes 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	1.8	0.00E+00	0.00	1.75
TRIBUTARY INFLOW				1.0	1.8	0.00E+00	0.00	1.75
***TOTAL INFLOW				1.9	1.8	0.00E+00	0.00	0.93
ADVECTIVE OUTFLOW				1.9	1.8	0.00E+00	0.00	0.93
***TOTAL OUTFLOW				1.9	1.8	0.00E+00	0.00	0.93

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	196.6	100.0%	0.00E+00		0.00	112.3	196.6
TRIBUTARY INFLOW				196.6	100.0%	0.00E+00		0.00	112.3	196.6
***TOTAL INFLOW				196.6	100.0%	0.00E+00		0.00	112.3	104.9
ADVECTIVE OUTFLOW				70.1	35.7%	3.97E+02		0.28	40.1	37.4
***TOTAL OUTFLOW				70.1	35.7%	3.97E+02		0.28	40.1	37.4
***RETENTION				126.5	64.3%	3.97E+02		0.16		

Overflow Rate (m/yr)	2.0	Nutrient Resid. Time (yrs)	0.5630
Hydraulic Resid. Time (yrs)	1.5781	Turnover Ratio	1.8
Reservoir Conc (mg/m3)	40	Retention Coef.	0.643

Hydes Lake TMDL

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

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Hydes Lake**

Predicted Values--->

Variable	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	40.1	0.28	42.1%
CHL-A MG/M3	23.8	0.40	88.7%
SECCHI M	2.3	0.34	83.8%
ORGANIC N MG/M3	706.3	0.33	78.3%
TP-ORTHO-P MG/M3	40.2	0.45	62.1%
ANTILOG PC-1	279.4	0.69	54.0%
ANTILOG PC-2	21.9	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.2		0.1%
ZMIX / SECCHI	1.4	0.34	1.5%
CHL-A * SECCHI	54.5	0.12	99.1%
CHL-A / TOTAL P	0.6	0.26	96.0%
FREQ(CHL-a>10) %	86.2	0.16	88.7%
FREQ(CHL-a>20) %	48.9	0.53	88.7%
FREQ(CHL-a>30) %	24.8	0.82	88.7%
FREQ(CHL-a>40) %	12.6	1.06	88.7%
FREQ(CHL-a>50) %	6.6	1.25	88.7%
FREQ(CHL-a>60) %	3.6	1.42	88.7%
CARLSON TSI-P	57.4	0.07	42.1%
CARLSON TSI-CHLA	61.7	0.06	88.7%
CARLSON TSI-SEC	48.1	0.10	16.2%

C.3 Miller Lake

C.3.1 TMDL Inputs

Miller Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Miller 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	Miller Lake	0	1	0.572654	2.244576	0.5	2.2	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)	
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	23.209	0	0	0	74.87	0	0	0	0	0	0	0

C.3.2 TMDL Mass Balance

Miller Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Miller 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	23.2	0.00E+00	0.00	23.21
TRIBUTARY INFLOW				1.0	23.2	0.00E+00	0.00	23.21
***TOTAL INFLOW				1.6	23.2	0.00E+00	0.00	14.76
ADVECTIVE OUTFLOW				1.6	23.2	0.00E+00	0.00	14.76
***TOTAL OUTFLOW				1.6	23.2	0.00E+00	0.00	14.76

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	1737.7	100.0%	0.00E+00		0.00	74.9	1737.7
TRIBUTARY INFLOW				1737.7	100.0%	0.00E+00		0.00	74.9	1737.7
***TOTAL INFLOW				1737.7	100.0%	0.00E+00		0.00	74.9	1104.9
ADVECTIVE OUTFLOW				1397.2	80.4%	1.50E+04		0.09	60.2	888.4
***TOTAL OUTFLOW				1397.2	80.4%	1.50E+04		0.09	60.2	888.4
***RETENTION				340.5	19.6%	1.50E+04		0.36		

Overflow Rate (m/yr)	40.5	Nutrient Resid. Time (yrs)	0.0445
Hydraulic Resid. Time (yrs)	0.0554	Turnover Ratio	22.5
Reservoir Conc (mg/m3)	60	Retention Coef.	0.196

C.3.3 TMDL Predicted

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

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Miller Lake**
Predicted Values--->

Variable	Mean	CV	Rank
TOTAL P MG/M3	60.2	0.09	60.0%
CHL-A MG/M3	36.0	0.27	95.9%
SECCHI M	1.6	0.25	70.2%
ORGANIC N MG/M3	982.8	0.26	92.4%
TP-ORTHO-P MG/M3	61.8	0.32	77.7%
ANTILOG PC-1	570.8	0.49	74.1%
ANTILOG PC-2	22.0	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.2		0.0%
ZMIX / SECCHI	1.4	0.26	1.6%
CHL-A * SECCHI	58.1	0.11	99.3%
CHL-A / TOTAL P	0.6	0.26	96.0%
FREQ(CHL-a>10) %	96.0	0.04	95.9%
FREQ(CHL-a>20) %	73.8	0.19	95.9%
FREQ(CHL-a>30) %	49.3	0.35	95.9%
FREQ(CHL-a>40) %	31.5	0.49	95.9%
FREQ(CHL-a>50) %	20.0	0.62	95.9%
FREQ(CHL-a>60) %	12.8	0.73	95.9%
CARLSON TSI-P	63.2	0.02	60.0%
CARLSON TSI-CHLA	65.7	0.04	95.9%
CARLSON TSI-SEC	53.1	0.07	29.8%

C.4 Winkler Lake

C.4.1 TMDL Inputs

Winkler Lake TMDL

File: **C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Winkler 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	Winkler Lake	0	1	0.293625	0.576573	0.5	0.57	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	9.484	0	0	0	67.81	0	0	0	0	0	0	0

C.4.2 TMDL Mass Balance

Winkler Lake TMDL

File: C:\Documents and Settings\tsundby\Desktop\4-6-10 work\Five Lake TMDL Model Runs\Winkler 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	9.5	0.00E+00	0.00	9.48
TRIBUTARY INFLOW				1.0	9.5	0.00E+00	0.00	9.48
***TOTAL INFLOW				1.3	9.5	0.00E+00	0.00	7.33
ADVECTIVE OUTFLOW				1.3	9.5	0.00E+00	0.00	7.33
***TOTAL OUTFLOW				1.3	9.5	0.00E+00	0.00	7.33

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	643.1	100.0%	0.00E+00		0.00	67.8	643.1
TRIBUTARY INFLOW				643.1	100.0%	0.00E+00		0.00	67.8	643.1
***TOTAL INFLOW				643.1	100.0%	0.00E+00		0.00	67.8	497.1
ADVECTIVE OUTFLOW				571.1	88.8%	8.22E+02		0.05	60.2	441.5
***TOTAL OUTFLOW				571.1	88.8%	8.22E+02		0.05	60.2	441.5
***RETENTION				72.0	11.2%	8.22E+02		0.40		

Overflow Rate (m/yr)	32.3	Nutrient Resid. Time (yrs)	0.0159
Hydraulic Resid. Time (yrs)	0.0179	Turnover Ratio	63.1
Reservoir Conc (mg/m3)	60	Retention Coef.	0.112

C.4.3 TMDL Predicted

Winkler Lake TMDL

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

Predicted Values Ranked Against CE Model Development Dataset

Segment: **1** **Winkler Lake**

	Predicted Values--->		
Variable	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	60.2	0.05	60.0%
CHL-A MG/M3	45.8	0.27	98.0%
SECCHI M	1.3	0.25	59.8%
ORGANIC N MG/M3	1206.9	0.26	96.7%
TP-ORTHO-P MG/M3	79.3	0.31	84.7%
ANTILOG PC-1	876.1	0.49	83.5%
ANTILOG PC-2	21.9	0.08	99.0%
TURBIDITY 1/M	0.1		1.1%
ZMIX * TURBIDITY	0.0		0.0%
ZMIX / SECCHI	0.4	0.26	0.0%
CHL-A * SECCHI	59.7	0.10	99.4%
CHL-A / TOTAL P	0.8	0.26	98.3%
FREQ(CHL-a>10) %	98.4	0.02	98.0%
FREQ(CHL-a>20) %	84.8	0.12	98.0%
FREQ(CHL-a>30) %	64.5	0.24	98.0%
FREQ(CHL-a>40) %	46.3	0.36	98.0%
FREQ(CHL-a>50) %	32.6	0.47	98.0%
FREQ(CHL-a>60) %	22.8	0.57	98.0%
CARLSON TSI-P	63.2	0.01	60.0%
CARLSON TSI-CHLA	68.1	0.04	98.0%
CARLSON TSI-SEC	56.2	0.07	40.2%