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Sent by email only

April 29, 2019

Municipality of East Ferris
390 Highway 94
Corbeil, ON P0H 1K0

Attention: Mr. Jason Trottier, Chief Administrative Officer

Re: Lakeshore capacity assessments: Trout Lake, Turtle Lake and Lake Talon

Dear Mr. Trottier,

The Ministry of Natural Resources and Forestry worked with the Ministry of Environment, Conservation and Parks to undertake lakeshore capacity assessments to help inform discussions and decisions related to the Algonquin Treaty negotiation process.

The lakeshore capacity assessments for Trout Lake, Turtle Lake and Lake Talon are attached. These assessments are also being shared with the other municipalities where these lakes are located and the North Bay-Mattawa Conservation Authority.

General questions on municipal planning matters can be directed to Caitlin Carmichael, A/ Planner, Ministry of Municipal Affairs and Housing via email at caitlin.carmichael@ontario.ca and by phone to 705-564-6845.

Technical questions on the results for these lakeshore capacity assessments can be directed to the North Bay, Ministry of the Environment, Conservation and Parks general inquiry line at 705-497-6865.

Sincerely,

Daraleigh Irving
Senior Policy Advisor

Encl.: Lakeshore capacity assessments: Trout Lake, Turtle Lake and Lake Talon

cc

Caitlin Carmichael, A/ Planner, Ministry of Municipal Affairs and Housing
Angela Whiteley, Northern Region, Ministry of Environment, Conservation and Parks
Victor Castro, Eastern Region, Ministry of Environment, Conservation and Parks
Julie Robinson, North Bay District, Ministry of Natural Resources and Forestry

LAKESHORE CAPACITY ASSESSMENT: LAKE TALON

Introduction

Lake Talon

Lake Talon is located on the Precambrian Shield approximately 24 km east of North Bay, Ontario. The lake is situated in the Township of Bonfield, the Township of Calvin, and an unorganized portion of the District of Nipissing (geographic Townships of Bonfield, Calvin, Orlig, and Phelps). The lake is 1415 hectares in area and has four basins: Basin 1 (Kaibuskong Bay) is 21 meters in depth, Basin 2 (southeast arm) is 46 meters in depth, Basin 3 (northwest arm) is 60 meters in depth, and Basin 4 (Rice Bay) is 27 meters in depth (**Figure 1**).

The lake catchment is primarily forested and contains numerous wetlands and streams, along with cleared areas for roadways and hydro corridors. Lake Talon has experienced a moderate amount of shoreline development, having nearly 300 residences, campgrounds and trailer parks, and 76 vacant lots of record within the 300 meter shoreline buffer. The remaining shoreline property is Crown Land (**Figure 2**).

Lake Talon lies within the Upper Ottawa – Kipawa watershed. The Jocko, Mattawa, and Amable du Fond Rivers flow through the watershed to Lac La Cave. Turtle Lake, Otter Lake, Cahill Lake, Magee Lake, and Sheedy Lake are the main inflows into Lake Talon. Smaller streams and wetlands also feed all four basins of the lake. Lake Talon outflows to the Mattawa River at the southeast end of the lake.

Lake Talon supports a naturally reproducing Lake Trout population and is designated as a Natural Lake Trout Lake by the Ontario Ministry of Natural Resources and Forestry (MNRF). The lake was also stocked with 1500-2000 Lake Trout yearlings in 2012-2013. The lake also contains many cold and warm water species such as Burbot, Lake Whitefish, Walleye, Yellow Perch, Largemouth Bass, Smallmouth Bass, Pumpkinseed, Muskellunge, Northern Pike, White Sucker, and Rock Bass (OMNR 2012).

Development and Lake Trout

Lake Trout typically occupy deep, cold, well oxygenated lakes. As the thermocline deepens during the summer months, Lake Trout will generally move to deeper waters, making use of warmer, shallower areas during nocturnal foraging. Studies have shown that the survival, growth and reproduction of Lake Trout are impaired in lakes where the dissolved oxygen concentration drops below 7 mg/L (Evans 2005, Evans 2007).

The amount of dissolved oxygen in the water column is influenced by many factors including: temperature, wind, ice conditions, lake morphometry, photosynthetic production, respiratory consumption, and photo-oxidation of dissolved organic carbon (DOC). Dissolved oxygen concentrations typically decrease with depth through the hypolimnion because with thermal stratification, the hypolimnion is effectively isolated from atmospheric and epilimnetic oxygen supplies. The isolation persists from the time that stratification is established in the spring and summer until the fall turnover, when

stratification breaks down and mixing resumes. Oxygen depletion in the hypolimnion due to algal decomposition results in a loss of well oxygenated cold water habitat that is vital to the growth and survival of Lake Trout (OMOE et al. 2010).

Phosphorus is a limiting nutrient that controls the growth of aquatic plants and algae (Wetzel 2001). When the supply of phosphorus is high (>0.02 mg/L), it may promote excess growth of algae and aquatic plants. Throughout the growing season, algae and plant matter die, decompose, and settle to the bottom of lakes, consuming oxygen in the hypolimnion. A major source of anthropogenic phosphorus to inland lakes is from septic systems (OMOE et al. 2010). Additional sources of phosphorus to lake environments include stormwater runoff, agricultural runoff, fertilizers, shoreline clearing and associated soil erosion. By implementing controls on shoreline development, the degree of phosphorus enrichment and resulting impacts to sensitive lake systems can be mitigated.

To help protect lakes from excessive phosphorus loading and resulting oxygen depletion, the Ontario Ministry of the Environment and Climate Change (MOECC) uses several tools to assess the capacity of a lake to support development. This is collectively known as Lakeshore Capacity Assessment.

Lakeshore Capacity Assessment

Lakeshore Capacity Assessment is used as a planning tool to establish shoreline development limits on Precambrian Shield lakes in order to control phosphorus loading to inland lake environments. The Lakeshore Capacity Assessment Handbook takes a watershed approach and defines shoreline development as being within 300 meters of a lake or any permanently flowing tributary of the lake and includes lakes upstream in the watershed. The goals of lakeshore capacity assessment are to help maintain the quality of water in recreational inland lakes and to protect coldwater fish habitat by keeping changes in the nutrient status of inland lakes within acceptable limits. Phosphorus and dissolved oxygen are commonly used indicators of water quality.

Dissolved Oxygen

The Provincial Water Quality Objectives (PWQOs) set acceptable concentrations of dissolved oxygen (DO) for lakes in Ontario (OMOE 1994). For cold water biota, acceptable DO concentrations are between 5 and 8 mg/L (depending on water temperature). For warm water biota, the acceptable DO concentrations are between 4 and 7 mg/L, depending on temperature. For waters where sensitive biological communities such as Lake Trout exist, or where additional physical or chemical stressors are operating, more stringent criteria may be required.

In Ontario, 7 mg/L (expressed as a Mean Volume Weighted Hypolimnetic Dissolved Oxygen concentration (MVWHDO)) has been adopted as the water quality criterion to protect Lake Trout lakes. This is reflected in the Lakeshore Capacity Assessment Handbook (LCAH) (OMOE et al. 2010), which is used to inform development decisions on lakes situated on the Precambrian Shield. Specifically, the LCAH recommends:

“There will be no new municipal land use planning approvals for new or more intense residential, commercial or industrial development within 300m of lake trout lakes where the mean volume-weighted hypolimnetic dissolved oxygen has been measured to be at or below 7 mg/L. This recommendation also applies to lakes where water quality modeling has determined that the development of existing vacant lots, with development approvals, would reduce the MVWHDO to 7 mg/L or less. The preservation of an average of at least 7 mg/L dissolved oxygen in the hypolimnion of Ontario’s Lake Trout lakes will help to sustain the province’s Lake Trout resources”.

For the purpose of managing Lake Trout populations, MNRF recommends that a lake or basin of a lake be classified as ‘at capacity’ when the MVWHDO value is less than or equal to 7.0 mg/L (OMNR 2009). This value must represent the average of at least 3 dissolved oxygen profiles taken during the target period (August 15-September 15) of separate years.

For lakes that have MVWHDO values above 7.0 mg/L, the Lakeshore Capacity Model (LCM) can be used to predict how much development the lake can support without causing the MVWHDO to drop below the criteria. The LCM takes into account phosphorus in atmospheric deposition, natural inputs from the watershed, and anthropogenic inputs associated with development. The results of the LCM are used to predict the resulting MVWHDO through the use of a steady state model for hypolimnetic dissolved oxygen (Molot et al. 1992).

Phosphorus

Historically, management decisions relating to phosphorus have relied on an Interim Provincial Water Quality Objective (PWQO) (OMOE 1994). The Interim PWQO states:

“To avoid nuisance algae growth in lakes, average total phosphorus concentrations over the ice-free period should not exceed 20 µg/L. A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration of < 10 µg/L. This applies to all lakes naturally below this value”.

A new PWQO establishes lake-specific objectives for lakes on the Precambrian Shield based on the background phosphorus concentration of the lake (OMOE et al. 2010). The Lakeshore Capacity Model is used to determine the natural (pre-development) background concentration of total phosphorus (TP). The objective is then established as the natural background concentration of phosphorus plus 50%, to a maximum of 20 µg/L. Where the phosphorus concentrations in a lake exceed this value, the lake may be considered to be ‘at capacity’ with respect to phosphorus load.

Where the measured TP concentration within a lake is less than the natural background concentration plus 50%, the Lakeshore Capacity Model can be used to predict how much new development the lake can sustain without causing TP concentrations to exceed the objective.

This report presents an assessment of the potential development capacity of Lake Talon based on the lake's dissolved oxygen regime. A discussion of supplementary water quality information is also provided.



Figure 1. Bathymetry of Lake Talon, Townships of Bonfield, Calvin, and an unorganized portion of the District of Nipissing (geographic townships of Bonfield, Calvin, Orlig, and Phelps). Contour intervals are measured in feet. Each basin is identified by their number in bold red text.

LOCATION	
District.....	Nipissing
Township.....	Bonfield, Calvin, unorganized
Geographic Township.....	Bonfield, Calvin, Orlig, Phelps
Watershed.....	Upper Ottawa River
Zone.....	17T
Easting.....	652874
Northing.....	5127703
Topographic Sheet.....	North Bay 31 L/6

MORPHOMETRY	
Surface Area (ha).....	1415
Catchment Area (ha).....	47532
Shoreline Length (km).....	39.2
Maximum Depth (m).....	60
Total Volume (m ³).....	1.78x10 ⁸

SHORELINE DEVELOPMENT (2013)*	
Residences	
Permanent.....	72
Seasonal.....	215
Vacant Lots of Record.....	73
Commercial Establishments.....	4
Shoreline Crown Land (%).....	56

*development counts inferred from 2013 & 2014
MPAC data and examination of aerial imagery

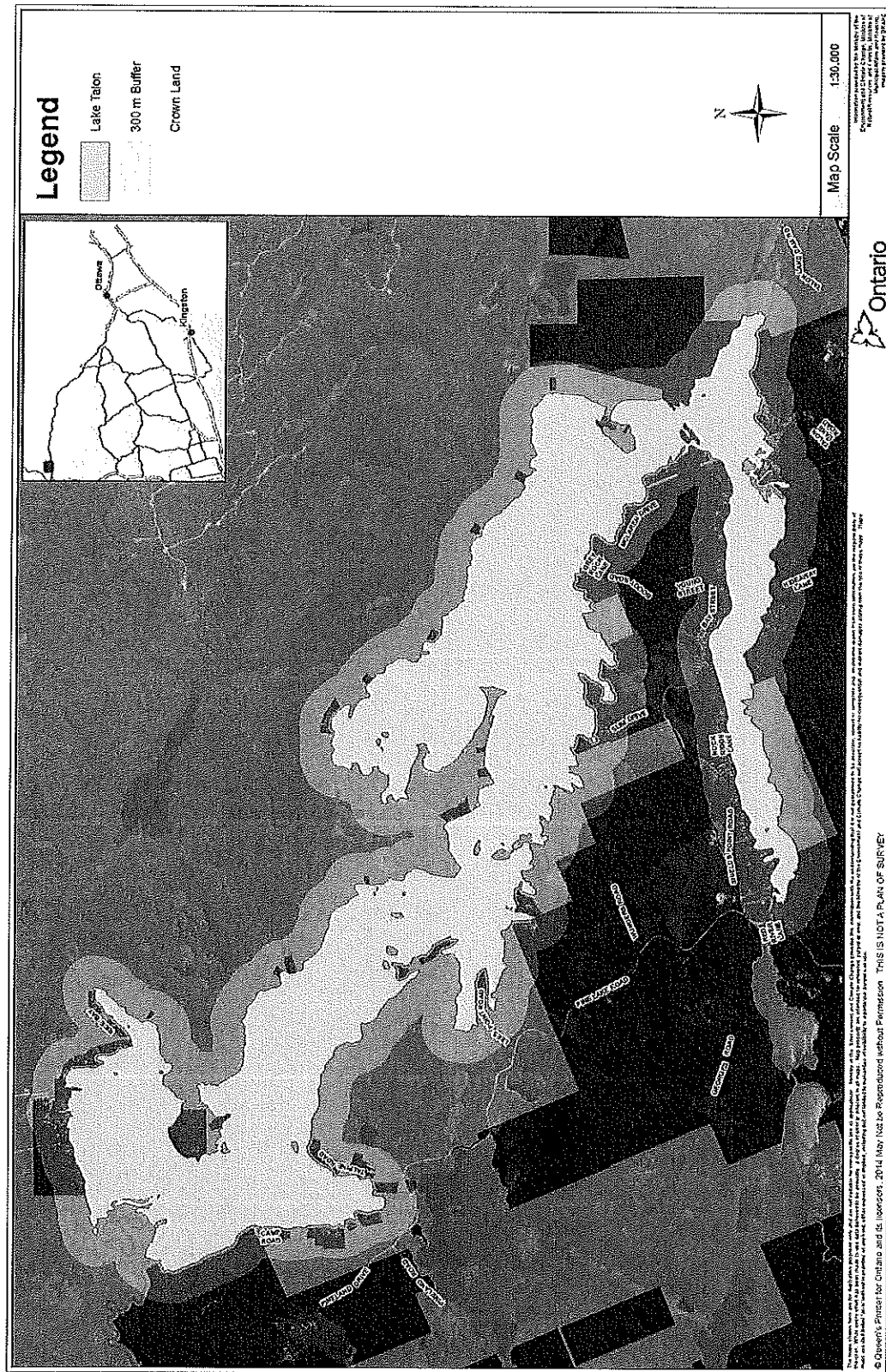


Figure 2. Lake Talon, Townships of Bonfield, Calvin, and an unorganized portion of the District of Nipissing (geographic Townships of Bonfield, Calvin, Orlig, and Phelps). The green highlighted area represents a 300 meter buffer along the shoreline and grey areas are Crown land.

Methods

Data

Lake Talon was sampled annually by the MOECC as part of their Recreational Lakes Program from 1985 to 1995. The most recent water quality information for Lake Talon was also collected by the MOECC (2011, 2013-2015). The recent MOECC water quality data includes water chemistry and Secchi depth measurements (**Appendix 1**) and dissolved oxygen and temperature data (**Appendix 2**).

For the purposes of this Lakeshore Capacity Assessment, only the most recent data were used to characterize the lake (2011, 2013-2015). These data are the most relevant to current conditions and were obtained using more reliable and consistent field and laboratory methods compared to earlier data. This assessment used four years of end-of-summer dissolved oxygen data.

Mean Volume Weighted Hypolimnetic Dissolved Oxygen Calculation

The DO regime for Lake Talon was characterized based on DO and temperature profiles collected during or near the standard sampling window (August 15 through September 15) between 2011 and 2015.

All profiles (temperature and DO) were collected using a YSI meter that was calibrated prior to each field survey. Measurements of DO and temperature were collected at one meter intervals. The upper limit of the hypolimnion was identified as the lower depth of the first 1 meter depth interval with a temperature change of less than 1 °C.

The oxygen content for a given one meter frustum (stratum) was determined by averaging the DO concentration of the top and bottom of the stratum. The MVWHDO was determined by summing the values for each stratum and dividing by the total volume of the hypolimnion. Calculations were done using the following formula (OMNR 2009):

$$MVWHDO = \frac{\sum_{s=1}^n V_s * DO_s}{n}$$

where:

MVWHDO is Mean Volume Weighted Hypolimnetic Dissolved Oxygen (mg/L);

V_s is the volume fraction of stratum s ;

DO_s is the dissolved oxygen concentration (mg/L) in stratum s ; and

n is the number of strata in the hypolimnion.

Results and Discussion

Phosphorus and Water Clarity

Recent spring phosphorus data from Lake Talon includes 2004-2008 and 2013-2015 samples from the Lake Partner Program (sampled by volunteers and the MOECC). The LPP uses a low level phosphorus method with duplicate samples to quantify phosphorus concentrations.

The recent spring phosphorus data indicates that Basins 2, 3 and 4 are typically oligotrophic (<10 µg phosphorous per litre), while Basin 1 ranges between mesotrophic (10-20 µg phosphorous per litre) to eutrophic (>20 µg phosphorous per litre) depending on the sample year.

Spring turnover total phosphorus concentrations (TP_{so}) in the euphotic zone range from 13.9 µg/L to 22.1 µg/L in Basin 1, 5.4 µg/L to 13.8 µg/L in Basin 2, 8.8 µg/L to 10.5 µg/L in Basin 3, and 8.6 µg/L to 11.2 µg/L in Basin 4. The average spring turnover phosphorus concentrations for each basin are shown in **Table 1**. All samples represent an average of duplicates except for the May 25, 2006 sample for Basin 2 that omits a bad split duplicate.

Table 1. Summary of Spring Turnover Total Phosphorus (TP_{so}) Concentrations (µg/L) in Lake Talon (2004-2008, 2013-2015).

Date	TP _{so} (µg/L)			
	Basin 1	Basin 2	Basin 3	Basin 4
09-May-04	---	9.06	---	---
25-May-05	---	5.44	---	---
25-May-06	22.10	8.40	---	---
29-Apr-07	20.57	9.16	---	---
12-May-08	19.34	7.96	---	---
22-May-13	13.90	6.80	10.50	8.60
26-May-14	14.50	---	9.80	---
19-May-15	16.2	13.8	8.8	11.2
Average	17.8	8.7	9.7	9.9

Secchi depth is a measure of water clarity. This can be influenced by zooplankton biomass, algae biomass, turbidity, dissolved organic carbon, and suspended particulate matter. The average Secchi depths measured by the MOECC were 2.3 meters in Basin 1, 3.7 meters in Basin 2, 3.9 meters in Basin 3, and 4.0 meters in Basin 4; indicating moderate water clarity in Basin 1 and good water clarity in Basins 2, 3, and 4.

Alkalinity, pH and Hardness

Total alkalinity in Lake Talon is low and ranged from 7.26 mg/L to 21.9 mg/L in Basin 1, 8.8 mg/L to 12.2 mg/L in Basin 2, 7.8 mg/L to 14.2 mg/L in Basin 3, and 9.9 mg/L to 13.4 mg/L in Basin 4. This indicates that the lake contains low levels of calcium carbonate ions and is moderately sensitivity to acidification. The pH range in the euphotic zone was 7.26 to 7.61 in Basin 1, 7.37 to 7.55 in Basin 2, 7.10 to 7.52 in Basin 3, and 7.35 to 7.56 in Basin 4.

The hardness level of a waterbody is a function of the concentration of the various dissolved salts (most commonly calcium and magnesium ions) and is usually associated with the surficial geology in the watershed. In Lake Talon, the water is soft, ranging from 19 mg/L to 28 mg/L in Basin 1, 15 mg/L to 24 mg/L in Basin 2, 13 mg/L to 19 mg/L in Basin 3, and 15 mg/L to 18 mg/L in Basin 4. Low calcium concentrations in Lake Talon likely contribute to the low alkalinity values (**Appendix 1**).

Dissolved Organic Carbon

Lakes with high dissolved organic carbon (DOC) concentrations may have naturally high background phosphorus concentrations (OMOE et al. 2010). High levels of DOC may occur naturally in lakes with large areas of wetlands in their catchments. In Lake Talon, DOC concentrations in the euphotic zone are moderate and ranged from 5.7 mg/L to 7.0 mg/L in Basin 1, 4.6 mg/L to 5.0 mg/L in Basin 2, 4.6 mg/L to 5.7 mg/L in Basin 3, and 4.2 mg/L to 4.7 mg/L in Basin 4 (**Appendix 1**).

Nitrogen (Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen)

In surface waters, nitrogen may exist as nitrate, nitrite, ammonia or ammonium. The chemical form of nitrogen, which varies with oxygen concentration and pH, has a strong influence on the level of toxicity to fish. Both un-ionized ammonia (NH_3), and to a lesser extent nitrate, are known to be toxic to aquatic life. Un-ionized ammonia may accumulate to toxic levels in the hypolimnion under low oxygen conditions.

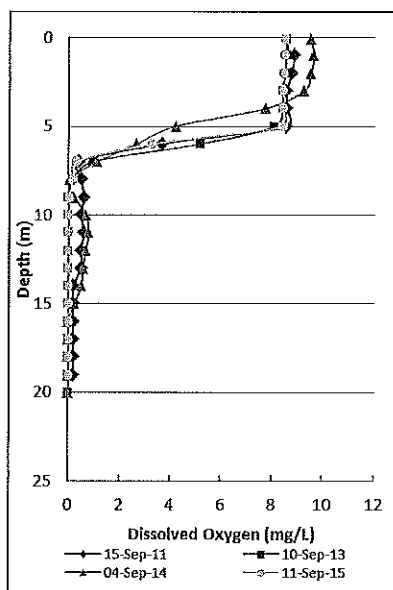
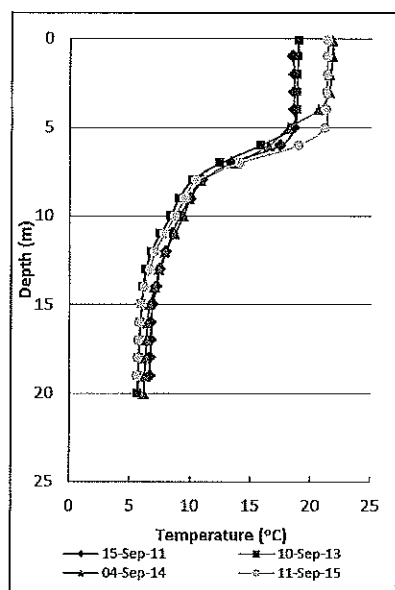
In Lake Talon, total ammonia concentrations were low. Total ammonia in the euphotic zone ranged from 0.009 mg/L to 0.089 mg/L in Basin 1, 0.041 mg/L to 0.044 mg/L in Basin 2, 0.006 mg/L to 0.048 mg/L in Basin 3, and 0.042 mg/L to 0.056 mg/L in Basin 4 (**Appendix 1**). Similarly, total ammonia at a meter off bottom ranged from 0.005 mg/L to 0.140 mg/L in Basin 1, 0.028 mg/L to 0.037 mg/L in Basin 2, 0.005 mg/L to 0.037 mg/L in Basin 3, and 0.026 mg/L to 0.054 in Basin 4 (**Appendix 1**). Under the conditions observed in the hypolimnion (temperature $<15^\circ\text{C}$ and pH <7.5 in all basins), this equates to 0.001 mg/L, 0.0003 mg/L, 0.0003 mg/L, and 0.0005 mg/L of un-ionized ammonia respectively. The Canadian Water Quality Guideline for un-ionized ammonia is 0.019 mg/L and the PWQO for un-ionized ammonia is 0.020 mg/L. Both water quality criteria are established for the protection of aquatic life (CCME 2010, OMOE 1994).

Nitrate concentrations were also low in Lake Talon: 0.01 mg/L to 0.226 mg/L in Basin 1, 0.022 mg/L to 0.266 mg/L in Basin 2, 0.033 mg/L to 0.258 mg/L in Basin 3, and 0.035 mg/L to 0.242 mg/L in Basin 4 (**Appendix 1**). These concentrations are well below the Canadian Water Quality Guideline of 3.00 mg/L nitrate-nitrogen (CCME 2012). Nitrite concentrations in Lake Talon range from 0.001 mg/L to 0.008 mg/L in Basin 1 and 0.001 mg/L to 0.003 mg/L in Basins 2, 3, and 4 (**Appendix 1**). There is no PWQO for either nitrate or nitrite.

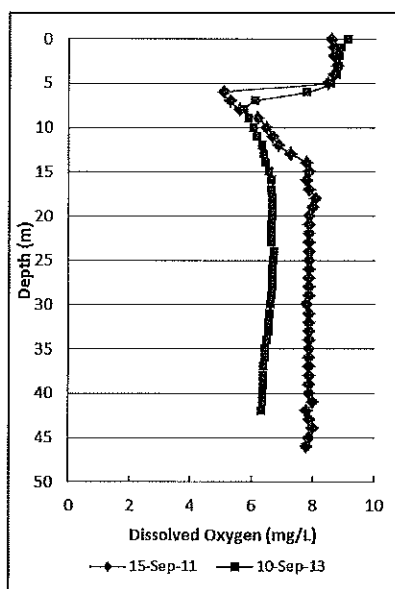
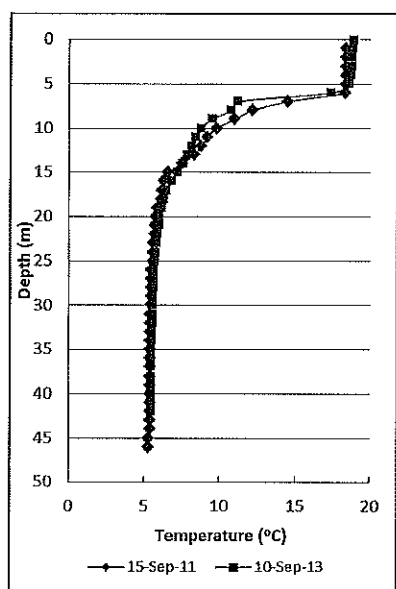
Dissolved Oxygen and Temperature

For Lake Talon, four dissolved oxygen and temperature profiles were available for Basins 1 and 3, and two profiles for Basins 2 and 4. Profiles were collected within the sampling window of August 15th to September 15th (**Figure 3**). All four basins of Lake Talon thermally stratify and the dissolved oxygen profiles typically display a negative heterograde pattern, with the exception of Basin 1. The top of the hypolimnion ranges between 9 to 10 meters in Basin 1, 10 to 11 meters in Basin 2, 9 to 11 meters in Basin 3, and 9 to 10 meters in Basin 4. Oxygen concentrations in the hypolimnion suggest that the lake bottom is anoxic in Basin 1 and oxic in Basins 2, 3 and 4. Raw dissolved oxygen and temperature data can be found in **Appendix 2**.

A



B



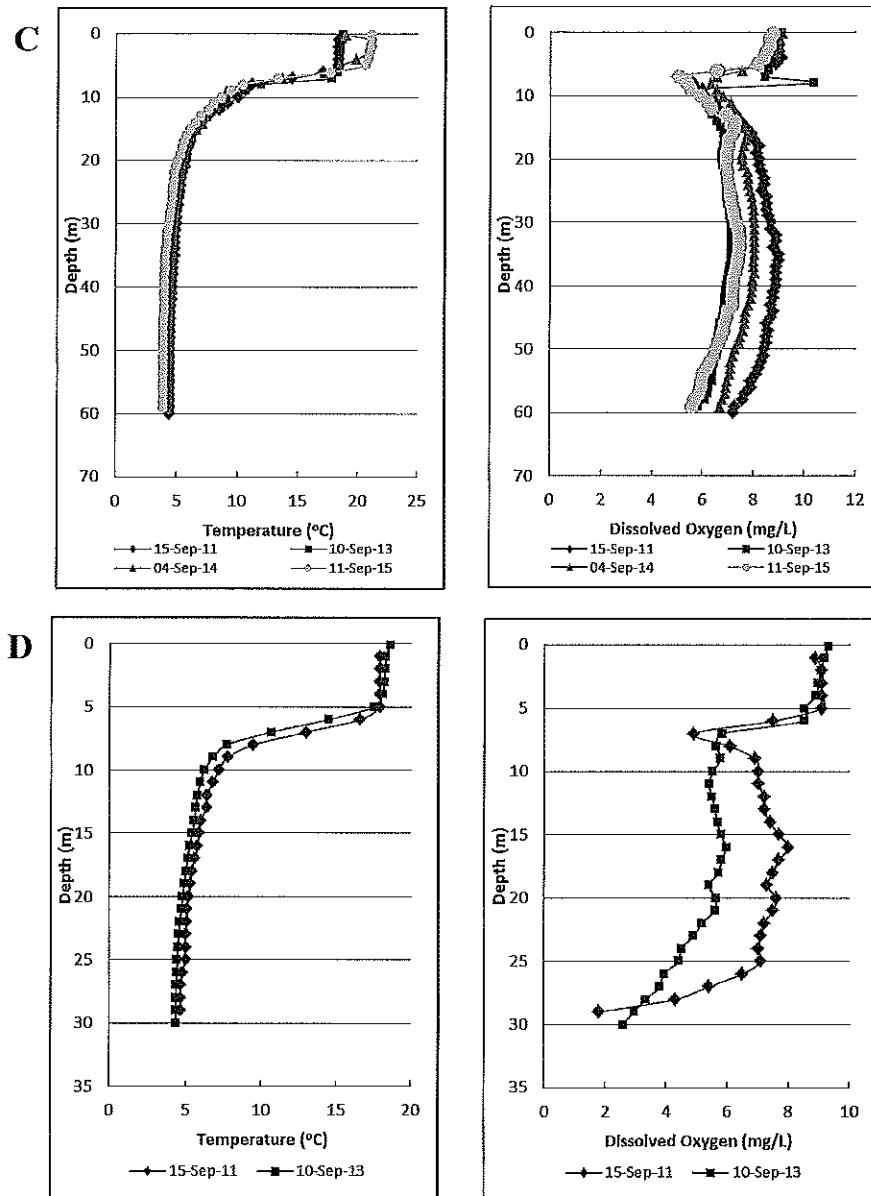


Figure 3. Temperature and dissolved oxygen profiles collected from the deepest point in the four basins of Lake Talon (2011, 2013-2015); A = Basin 1, B = Basin 2, C = Basin 3, D = Basin 4.

MVWHDO

Dissolved oxygen and temperature profiles were collected for the four basins in Lake Talon. However, unlike Basin 1 and Basin 4, Basins 2 and 3 are contiguous and morphometrically not isolated from each other. MNR (2009) suggests that a lake has independent basins if they are “separated by submerged sills that are higher than the top of the hypolimnion and maximum depth of a basin is >13 m.” There is no obvious sill between Basin 2 and Basin 3; Lake Trout populations would move freely between these interconnected basins, and for this reason Basins 2

and 3 were considered one contiguous basin. The depth of the sill between Basin 1 and Basin 2 (<1.5 meters) is less than the average hypolimnetic depth for Basin 1 and Basin 2, indicating that Basin 1 is a discrete and independent basin for the purposes of modeling lake trout habitat. Similarly, the depth of the sill between Basin 3 and Basin 4 (<6.1 meters) is less than the average hypolimnetic depth for Basin 3 and Basin 4, making it another discrete basin.

Lake Talon should be modelled as a three basin lake, however, discrete frustum data was only available for Basin 1; frustum data for Basins 2, 3, and 4 are combined. As a result, Lake Talon was modelled as a two-basin lake system; the dissolved oxygen and temperature profiles from both the deep hole in Kaibuskong Bay (Basin 1) and the deepest hole in the Main Basin (Basin 3) were used in the calculation of MVWHDO.

Four dissolved oxygen and temperature profiles collected between 2011 and 2015 were examined for Kaibuskong Bay and the Main Basin of Lake Talon. The MVWHDO was below 7 mg/L for each profile examined from Kaibuskong Bay. The MVWHDO was above 7 mg/L for two of the four profiles examined from the Main Basin but the long-term average was very close to the 7 mg/L criterion (**Table 2**). Based on the observed MVWHDO, Lakeshore Capacity Modelling was not required to assess the capacity status of Kaibuskong Bay or the Main Basin of Lake Talon.

Table 2. Summary of Mean Volume Weighted Hypolimnetic Dissolved Oxygen for Kaibuskong Bay (Basin 1) and the Main Basin (Basins 2, 3 and 4) of Lake Talon (2011, 2013-2015).

Date	MVWHDO (mg/L)	
	Basin 1	Basin 3
15-Sep-11	0.38	7.58
10-Sep-13	0.00	6.73
04-Sep-14	0.42	7.52
11-Sep-15	0.01	6.75
Average	0.20	7.15

Lake Talon Development Capacity Summary

Lake Talon is managed by the OMNR as a naturally reproducing Lake Trout Lake. For modelling purposes, the lake was divided into two separate basins: Kaibuskong Bay (Basin 1) and the Main Basin (Basins 2, 3 and 4).

Kaibuskong Bay

Kaibuskong Bay is a relatively small basin (~140 hectares). The basin has experienced extensive shoreline development over the years: 35 permanent residences, 29 seasonal residences, one marina and campground, and over 30 vacant lots of record. One large shoreline Crown land parcel and several small island Crown land parcels exist along the southern portion of the Bay. Lake Nosbonsing, situated upstream of Kaibuskong Bay, is also highly developed and is likely contributing to the degraded water quality.

Phosphorus concentrations in Kaibuskong Bay are relatively high (ice-free TP average = 18.4 µg/L, ice-free TP range = 12.45 µg/L to 28.0 µg/L) and may result in undesirable water quality problems such as algae blooms or excessive weed growth. In fact, blue-green algae blooms have been reported in Kaibuskong Bay in the past (Baytoday.ca 2012).

Water quality data collected by the MOECC show that the MVWHDO values for Kaibuskong Bay are consistently below the 7 mg/L criterion, with a long-term average of 0.20 mg/L. Based on this information, Kaibuskong Bay is considered to be an 'at capacity' Lake Trout Basin.

Given this finding, municipal land use planning approvals and Crown Land disposition decisions around Kaibuskong Bay, including tributaries of the lake and upstream lakes, should not result in a net increase in phosphorus loading to the lake, impacts to habitat, or reductions to lakeshore carrying capacity.

Main Basin

The Main Basin is a large basin (~1276 hectares). The basin has experienced some development within the 300 meter shoreline buffer: 37 permanent residences, 186 seasonal residences, three resorts, and over 40 vacant lots of record. A majority of the northern shoreline is Crown owned, along with numerous parcels that are scattered along the southern shoreline.

Phosphorus concentrations in the Main Basin are relatively low (ice-free TP average = 8.19 µg/L, ice-free TP range = 5.44 µg/L to 10.50 µg/L) and are not anticipated to result in undesirable water quality problems such as algae blooms or excessive weed growth.

Water quality data collected by the MOECC show that the MVWHDO values for the Main Basin are very close to the 7 mg/L criterion, with a long-term average of 7.14 mg/L. Considering the number of existing vacant lots of record (73), it is concluded that the Main Basin is also an 'at capacity' Lake Trout Basin.

Given this finding, municipal land use planning approvals and Crown Land disposition decisions around the Main Basin, including tributaries of the lake and upstream lakes, should not result in a net increase in phosphorus loading to the lake, impacts to habitat, or reductions to lakeshore carrying capacity.

*Prepared By: Eastern Region Technical Support Section
Date: December 7, 2017*

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Appendix 1a.

Water Chemistry Summary for Basin 1 (Kaibuskong Bay) of Lake Talon from the MOECC Lake Monitoring Program (2011, 2013, 2014).

Parameter	21-Jul-11		15-Sep-11		10-Sep-13		26-May-14	04-Sep-14	
	Euphotic	MOB	Euphotic	MOB	Euphotic	MOB	Euphotic	Euphotic	MOB
Secchi Disk (m)	2.7		2.0		2.5		2.0	2.5	
Total Phosphorus	0.017	0.036	0.016	0.060	0.013	0.153	0.070	0.012	0.014
Ammonia- Nitrogen	0.043	0.032	0.062	0.046	0.054	0.140	0.089	0.009	0.005
Nitrite-Nitrogen	0.004	0.004	0.003	0.008	0.001	0.008	0.005	0.001	0.001
Nitrate- Nitrogen	0.01	0.226	0.053	0.196	0.091	0.112	0.054	0.02	0.151
Total Kjeldahl Nitrogen	0.47	0.32	0.45	0.38	0.32	0.60	0.12	0.30	0.30
Dissolved Organic Carbon	7.0	5.3	6.2	5.4	5.9	6.5	5.7	6.3	5.6
Dissolved Inorganic Carbon	4.4	4.0	4.8	4.5	4.9	5.6	3.6	4.8	5.1
pH	7.62	7.24	7.62	7.35	7.55	7.24	12.4	7.51	6.98
Total Alkalinity	16.4	14.0	21.9	16.7	17.8	17.8	7.26	21.6	15.9
Conductivity (uS/cm)	71	69	77	73	74	76	63	73	68
Calcium	6.09	4.72	6.86	6.57	6.67	6.46	5.18	6.13	5.54
Magnesium	2.61	1.9	2.62	2.05	1.94	1.78	1.52	1.85	1.61
Hardness	26	20	28	25	25	23	19	23	20
Total Suspended Solids	1.8	1.7	2.3	3.8	1.6	4.8	2.1	2.5	1.3
Total Dissolved Solids	46.0	45.0	50.0	47.0	48.0	51.0	41.0	47.0	44.0

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

Appendix 1b. Water Chemistry Summary for Basin 2 (Southeast Arm) of Lake Talon from the MOECC Lake Monitoring Program (2011, 2013, 2014).

Parameter	21-Jul-11		15-Sep-11		10-Sep-13	
	Euphotic	MOB	Euphotic	MOB	Euphotic	MOB
Secchi Disk (m)	3.5		4.0		3.5	
Total Phosphorus	<i>0.003</i>	<i>0.006</i>	<i>0.006</i>	<i>0.006</i>	0.010	0.012
Ammonia- Nitrogen	0.043	0.037	0.044	0.034	0.041	0.028
Nitrite-Nitrogen	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.002</i>	<i>0.001</i>
Nitrate- Nitrogen	<i>0.022</i>	0.198	0.056	0.231	<i>0.089</i>	0.266
Total Kjeldahl Nitrogen	0.25	0.25	0.24	0.20	0.22	0.28
Dissolved Organic Carbon	5.0	4.6	4.5	4.4	5.0	4.8
Dissolved Inorganic Carbon	3.1	2.8	2.9	2.2	3.2	2.5
pH	7.55	7.18	7.45	7.26	7.37	6.94
Total Alkalinity	10.7	9.7	12.2	10.3	12.0	8.8
Conductivity (uS/cm)	54	54	58	54	57	52
Calcium	4.37	3.83	7.14	4.22	4.8	4.17
Magnesium	1.86	1.24	1.48	1.56	1.29	1.1
Hardness	19	15	24	17	17	15
Total Suspended Solids	<i>1.6</i>	<i>0.5</i>	<i>0.8</i>	<i>1.4</i>	<i>0.5</i>	<i>0.5</i>
Total Dissolved Solids	35.0	35.0	37.0	35.0	202	147

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

Appendix 1c.

Water Chemistry Summary for Basin 3 (Northwest Arm) of Lake Talon from the MOECC Lake Monitoring Program (2011, 2013, 2014).

Parameter	21-Jul-11		15-Sep-11		10-Sep-13		26-May-14	04-Sep-14	
	Euphotic	MOB	Euphotic	MOB	Euphotic	MOB	Euphotic	Euphotic	MOB
Secchi Disk (m)	3.5		4.5		N/A		3.4	4.0	
Total Phosphorus	<i>0.006</i>	0.010	<i>0.005</i>	<i>0.008</i>	0.010	0.012	0.024	0.009	0.010
Ammonia- Nitrogen	0.048	0.037	0.040	0.033	0.035	0.032	0.048	<i>0.006</i>	<i>0.005</i>
Nitrite-Nitrogen	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.003</i>	<i>0.002</i>	<i>0.002</i>	<i>0.003</i>	<i>0.001</i>	<i>0.001</i>
Nitrate- Nitrogen	<i>0.045</i>	0.197	0.084	0.217	<i>0.087</i>	0.258	0.121	<i>0.033</i>	0.234
Total Kjeldahl Nitrogen	0.29	0.25	0.24	0.23	0.23	0.30	0.19	0.28	0.27
Dissolved Organic Carbon	5.0	5.0	4.6	4.8	5.1	5.0	5.2	5.7	5.0
Dissolved Inorganic Carbon	3.4	2.5	3.1	2.1	3.4	2.6	2.2	3.2	2.7
pH	7.52	7.09	7.46	7.19	7.42	6.99	7.10	7.37	6.76
Total Alkalinity	12.0	8.1	12.8	8.4	13.1	8.9	7.8	14.2	8.6
Conductivity (uS/cm)	57	50	59.0	50.0	59	53	50	61	50
Calcium	4.51	3.44	5.08	3.61	5.04	4.19	3.8	4.88	3.61
Magnesium	1.4	1.12	1.65	1.2	1.35	1.09	1.05	1.35	1.02
Hardness	17	13	19	14	18	15	14	18	13
Total Suspended Solids	1.2	1.5	1.6	1.2	0.6	0.7	3.4	1.3	1.3
Total Dissolved Solids	37.0	32.0	38.0	33.0	107.0	197.0	33.0	40.0	33.0

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

Appendix 1d.

Water Chemistry Summary for Basin 4 (Rice Bay) of Lake Talon
from the MOECC Lake Monitoring Program (2011, 2013, 2014).

Parameter	21-Jul-11		15-Sep-11		10-Sep-13	
	Euphotic	MOB	Euphotic	MOB	Euphotic	MOB
Secchi Disk (m)	3.3		5.0		3.75	
Total Phosphorus	<i>0.004</i>	<i>0.009</i>	<i>0.006</i>	<i>0.008</i>	0.009	0.011
Ammonia- Nitrogen	0.043	0.026	0.042	0.029	0.056	0.054
Nitrite-Nitrogen	<i>0.003</i>	<i>0.002</i>	<i>0.003</i>	<i>0.003</i>	<i>0.002</i>	<i>0.001</i>
Nitrate- Nitrogen	<i>0.035</i>	0.166	0.079	0.187	0.103	0.242
Total Kjeldahl Nitrogen	0.27	0.23	0.23	0.21	0.19	0.25
Dissolved Organic Carbon	4.7	3.9	4.2	3.9	4.5	4.2
Dissolved Inorganic Carbon	3.3	3.1	3.1	2.9	3.4	3.2
pH	7.56	7.16	7.44	7.27	7.35	6.97
Total Alkalinity	11.8	9.9	13.0	10.4	13.4	11.6
Conductivity (uS/cm)	54	47	56	48	56	52
Calcium	3.96	3.73	4.57	4.18	4.89	4.62
Magnesium	1.41	1.36	1.58	1.45	1.35	1.23
Hardness	16	15	18	16	18	17
Total Suspended Solids	<i>1.0</i>	<i>2.5</i>	<i>1.4</i>	3.0	<i>0.6</i>	<i>0.8</i>
Total Dissolved Solids	<i>35.0</i>	<i>30.0</i>	<i>36.0</i>	<i>31.0</i>	82.0	443.0

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

Appendix 2a.

Summary of dissolved oxygen and temperature data from Basin 1 (Kaibuskong Bay) of Lake Talon in 2011, 2013-2015. The maximum depth of Basin 1 is approximately 20 meters.

Measured Depth (m)	15-Sep-11		10-Sep-13		04-Sep-14		11-Sep-15	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.1			18.98	8.60	21.83	9.53	21.4	8.55
1	18.50	8.90	18.94	8.58	21.79	9.65	21.38	8.53
2	18.60	8.80	18.88	8.54	21.63	9.54	21.35	8.49
3	18.60	8.60	18.85	8.43	21.51	9.27	21.3	8.45
4	18.60	8.60	18.83	8.44	20.65	7.77	21.29	8.44
5	18.60	8.60	18.50	8.12	18.15	4.23	21.17	8.46
6	17.50	3.70	15.89	5.21	16.56	2.67	19.01	3.29
7	13.40	0.40	12.52	0.94	13.83	1.13	14.15	0.29
8	11.00	0.50	10.15	0.16	10.88	0.07	10.5	0.18
9	10.00	0.60	9.06	0.00	9.98	0.23	9.54	0.04
10	9.10	0.50	8.39	0.00	9.43	0.68	8.73	0.00
11	8.50	0.60	7.52	0.00	8.70	0.79	7.87	0.00
12	8.00	0.50	6.77	0.00	7.96	0.68	7.1	0.00
13	7.50	0.50	6.36	0.00	7.45	0.57	6.68	0.00
14	7.20	0.20	6.13	0.00	7.07	0.51	6.18	0.00
15	6.90	0.20	6.02	0.00	6.68	0.25	5.97	0.00
16	6.80	0.20	5.91	0.00	6.48	0.00	5.82	0.00
17	6.80	0.20	5.82	0.00	6.43	0.00	5.78	0.00
18	6.70	0.20	5.77	0.00	6.34	0.00	5.73	0.00
19	6.70	0.20	5.71	0.00	6.26	0.00	5.62	0.00
20			5.68	0.00	6.19	0.00		

Appendix 2b.

Summary of dissolved oxygen and temperature data from Basin 2 (Northeast Arm) of Lake Talon in 2011 and 2013. The maximum depth of Basin 2 is approximately 46 meters.

Measured Depth (m)	15-Sep-11		10-Sep-13	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.5		8.6	18.9	9.15
1	18.4	8.7	18.83	8.92
2	18.4	8.7	18.78	8.87
3	18.4	8.8	18.76	8.84
4	18.4	8.7	18.75	8.77
5	18.4	8.5	18.61	8.58
6	18.3	5.1	17.42	7.81
7	14.5	5.3	11.18	6.13
8	12.2	5.6	10.75	5.75
9	11	6.2	9.51	5.89
10	9.8	6.5	8.78	6.06
11	9.2	6.7	8.45	6.18
12	8.8	6.9	8.16	6.36
13	8.3	7.3	7.85	6.42
14	7.5	7.8	7.54	6.48
15	6.6	7.9	7.2	6.59
16	6.3	7.8	6.84	6.67
17	6.2	7.9	6.44	6.68
18	6.1	8.1	6.3	6.7
19	5.9	8	6.16	6.71
20	5.8	7.9	6.02	6.69
21	5.7	7.9	5.99	6.67
22	5.7	7.9	5.91	6.68
23	5.6	7.9	5.82	6.68
24	5.6	7.9	5.77	6.74
25	5.6	7.9	5.71	6.72
26	5.5	7.9	5.67	6.71
27	5.5	7.9	5.65	6.71
28	5.5	7.9	5.63	6.69
29	5.5	7.9	5.61	6.66
30	5.5	7.8	5.61	6.63
31	5.4	7.9	5.61	6.62
32	5.4	7.9	5.58	6.59
33	5.4	7.9	5.57	6.58
34	5.4	7.9	5.52	6.53
35	5.4	7.9	5.5	6.48
36	5.4	7.9	5.49	6.46
37	5.4	7.9	5.49	6.42
38	5.4	7.9	5.49	6.41
39	5.4	7.9	5.49	6.4
40	5.4	7.9	5.49	6.37
41	5.4	8	5.49	6.37
42	5.4	7.8	5.49	6.35
43	5.4	7.9		
44	5.4	8		
45	5.3	7.9		
46	5.3	7.8		

Appendix 2c.

Summary of dissolved oxygen and temperature data from Basin 3 (Northwest Arm) of Lake Talon in 2011, 2013-2015. The maximum depth of Basin 3 is approximately 60 meters.

Measured Depth (m)	15-Sep-11		10-Sep-13		04-Sep-14		11-Sep-15	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.5			18.79	9.08	19.01	9.12	21.15	8.74
1	18.40	8.80	18.71	8.88	21.11	9.03	21.17	8.62
2	18.40	9.00	18.55	8.78	20.97	8.99	21.14	8.63
3	18.40	9.00	18.50	8.68	20.86	8.85	21.03	8.48
4	18.40	9.10	18.39	8.67	19.85	8.46	20.89	8.38
5	18.40	8.90	18.33	8.66	18.50	8.09	20.69	8.15
6	17.10	6.70	18.28	8.59	17.25	7.56	17.76	6.53
7	14.50	5.00	17.85	8.45	13.73	6.57	13.36	5.07
8	11.20	5.60	11.88	10.35	10.48	6.33	10.38	5.38
9	10.60	6.00	10.59	5.69	9.10	6.57	9.47	5.52
10	10.00	6.10	9.12	5.93	8.62	6.80	8.68	5.91
11	9.20	6.50	8.66	6.22	8.05	7.10	7.98	6.19
12	8.50	6.60	7.92	6.42	7.76	7.21	7.59	6.34
13	7.60	7.30	7.51	6.35	7.35	7.25	6.96	6.90
14	7.00	7.50	6.90	6.57	7.08	7.33	6.46	7.24
15	6.60	7.70	6.54	6.71	6.57	7.59	6.04	7.22
16	6.10	7.90	6.23	6.84	6.13	7.75	5.78	7.17
17	6.10	8.00	6.03	6.87	5.93	7.68	5.58	7.01
18	5.90	8.20	5.91	6.82	5.80	7.62	5.44	7.01
19	5.80	8.10	5.77	6.78	5.69	7.55	5.3	6.93
20	5.70	8.20	5.61	6.75	5.60	7.56	5.07	6.95
21	5.60	8.20	5.46	6.80	5.47	7.60	4.91	6.92
22	5.40	8.30	5.36	6.88	5.43	7.75	4.77	6.97
23	5.30	8.40	5.26	6.90	5.34	7.78	4.74	6.98
24	5.30	8.40	5.23	6.94	5.29	7.81	4.69	7.01
25	5.20	8.30	5.21	6.93	5.17	7.87	4.65	7.08
26	5.10	8.50	5.13	6.94	5.04	7.93	4.6	7.10
27	5.10	8.50	5.08	6.98	4.95	7.97	4.52	7.13
28	5.00	8.50	4.97	7.08	4.93	7.99	4.45	7.23
29	5.00	8.60	4.89	7.09	4.92	7.99	4.4	7.25
30	5.00	8.70	4.86	7.12	4.89	8.02	4.3	7.33
31	4.90	8.70	4.82	7.13	4.86	8.03	4.24	7.42
32	4.80	8.90	4.76	7.14	4.84	8.02	4.21	7.46
33	4.80	8.90	4.67	7.12	4.79	8.02	4.17	7.47
34	4.80	8.80	4.63	7.12	4.75	8.03	4.13	7.46
35	4.80	9.00	4.59	7.11	4.73	8.03	4.06	7.43
36	4.70	9.00	4.58	7.12	4.71	8.01	4.04	7.39
37	4.70	8.90	4.56	7.09	4.67	7.99	4.01	7.34
38	4.70	8.90	4.53	7.03	4.64	8.02	3.98	7.28
39	4.60	8.90	4.51	6.98	4.63	7.98	3.98	7.23
40	4.60	8.90	4.49	6.94	4.59	7.96	3.96	7.22
41	4.60	8.80	4.48	6.90	4.57	7.95	3.95	7.19
42	4.60	8.80	4.46	6.87	4.54	7.89	3.94	7.17
43	4.50	8.70	4.45	6.86	4.53	7.81	3.94	7.17
44	4.50	8.80	4.44	6.84	4.51	7.71	3.93	6.99
45	4.50	8.70	4.43	6.80	4.50	7.65	3.91	6.94
46	4.50	8.50	4.42	6.70	4.49	7.65	3.91	6.88
47	4.50	8.60	4.41	6.67	4.49	7.58	3.9	6.83
48	4.50	8.50	4.41	6.65	4.48	7.49	3.88	6.72
49	4.40	8.50	4.40	6.58	4.47	7.44	3.88	6.63
50	4.40	8.40	4.40	6.55	4.47	7.27	3.88	6.52
51	4.40	8.40	4.39	6.49	4.47	7.20	3.88	6.45
52	4.40	8.30	4.40	6.47	4.47	7.11	3.88	6.28
53	4.40	8.20	4.40	6.43	4.47	7.10	3.87	6.14
54	4.40	8.10	4.39	6.40	4.47	7.09	3.88	5.99
55	4.40	7.90	4.39	6.38	4.46	6.97	3.87	5.95
56	4.40	7.90	4.38	6.27	4.46	6.94	3.87	5.90
57	4.40	7.70	4.38	6.22	4.46	6.91	3.88	5.86
58	4.4	7.6	4.38	6.13	4.46	6.82	3.87	5.69
59	4.4	7.3	4.37	5.86	4.46	6.71	3.87	5.56
60	4.4	7.2						

Appendix 2d.

Summary of dissolved oxygen and temperature data from Basin 4 (Rice Bay) of Lake Talon in 2011 and 2013. The maximum depth of Basin 4 is approximately 30 meters.

Measured Depth (m)	15-Sep-11		10-Sep-13	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.5			18.62	9.32
1	17.9	8.9	18.32	9.17
2	17.9	9.1	18.24	9.05
3	17.9	9.1	18.21	8.97
4	17.9	9.1	18.07	8.9
5	17.9	9.1	17.52	8.53
6	16.6	7.5	14.49	8.51
7	13	4.9	10.67	5.83
8	9.5	6.1	7.72	5.65
9	7.8	6.9	6.83	5.79
10	7.2	7	6.21	5.54
11	6.8	7	5.95	5.42
12	6.4	7.2	5.77	5.51
13	6.4	7.2	5.67	5.6
14	6	7.4	5.56	5.69
15	5.9	7.7	5.43	5.8
16	5.8	8	5.25	5.97
17	5.6	7.7	5.13	5.81
18	5.4	7.5	5.02	5.74
19	5.3	7.3	4.92	5.41
20	5.2	7.6	4.79	5.63
21	5.1	7.5	4.72	5.6
22	5.1	7.2	4.63	5.18
23	5	7.1	4.55	4.91
24	5	7	4.49	4.49
25	5	7.1	4.46	4.42
26	4.8	6.5	4.43	3.92
27	4.7	5.4	4.4	3.8
28	4.7	4.3	4.38	3.33
29	4.7	1.8	4.36	2.95
30			4.36	2.58

LAKESHORE CAPACITY ASSESSMENT: TURTLE LAKE

Introduction

Turtle Lake

Turtle Lake is located on the Precambrian Shield approximately 15 km east of North Bay, Ontario. The lake lies within the Township of Bonfield and an unorganized portion of the District of Nipissing (geographic Townships of Bonfield and Phelps).

The lake is 257 hectares in area and has one main basin 56 meters in depth (**Figure 1**). The catchment is primarily forest and wetlands with several tributary streams, along with some cleared area for roadways. Turtle Lake has only one seasonal residence and two vacant lots of record within the 300 meter shoreline buffer; the remaining shoreline is Crown Land (**Figure 2**).

Turtle Lake lies within the Upper Ottawa – Kipawa watershed. The Jocko, Mattawa, and Amable du Fond Rivers flow through the watershed to Lac La Cave. Trout Lake, Loren Lake, Barse Lake, and Pine Lake are the main inflows into Turtle Lake. Several streams and wetlands also feed the lake. Turtle Lake's outflow is the Mattawa River to the north.

Turtle Lake supports a naturally reproducing Lake Trout population and is designated as a Natural Lake Trout lake by the Ontario Ministry of Natural Resources and Forestry (MNRF). The lake is also stocked annually with 2000-2500 Lake Trout yearlings. Besides Lake Trout, the lake contains many cold and warm water species such as Yellow Perch, Walleye, Largemouth Bass, Smallmouth Bass, Muskellunge, Northern Pike, White Sucker, and Rock Bass (OMNR 2012).

Development and Lake Trout

Lake Trout typically occupy deep, cold, well oxygenated lakes. As the thermocline deepens during the summer months, Lake Trout will generally move to deeper waters, making use of warmer, shallower areas during nocturnal foraging. Studies have shown that the survival, growth and reproduction of Lake Trout are impaired in lakes where the dissolved oxygen concentration drops below 7 mg/L (Evans 2005, Evans 2007).

The amount of dissolved oxygen in the water column is influenced many factors including: temperature, wind, ice conditions, lake morphometry, photosynthetic production, respiratory consumption, and photo-oxidation of dissolved organic carbon (DOC). Dissolved oxygen concentrations typically decrease with depth through the hypolimnion because with thermal stratification, the hypolimnion is effectively isolated from atmospheric and epilimnetic oxygen supplies. The isolation persists from the time that stratification is established in the spring and summer until the fall turnover, when stratification breaks down and mixing resumes. Oxygen depletion in the hypolimnion due to algal decomposition results in a loss of well oxygenated cold water habitat that is vital to the growth and survival of Lake Trout (OMOE et al. 2010).

Phosphorus is a limiting nutrient that controls the growth of aquatic plants and algae (Wetzel 2001). When the supply of phosphorus is high (>0.02 mg/L), it may promote excess growth of algae and aquatic plants. Throughout the growing season, algae and plant matter die, decompose, and settle to the bottom of lakes, consuming oxygen in the hypolimnion. A major source of anthropogenic phosphorus to inland lakes is from septic systems (OMOE et al. 2010). Additional sources of phosphorus to lake environments include stormwater runoff, agricultural runoff, fertilizers, shoreline clearing and associated soil erosion. By implementing controls on shoreline development, the degree of phosphorus enrichment and resulting impacts to sensitive lake systems can be mitigated.

To help protect lakes from excessive phosphorus loading and resulting oxygen depletion, the Ontario Ministry of the Environment and Climate Change (MOECC) uses several tools to assess the capacity of a lake to support development. This is collectively known as Lakeshore Capacity Assessment.

Lakeshore Capacity Assessment

Lakeshore Capacity Assessment is used as a planning tool to establish shoreline development limits on Precambrian Shield lakes in order to control phosphorus loading to inland lake environments. The Lake Capacity Assessment Handbook takes a watershed approach and defines shoreline development as being within 300 meters of a lake or any permanently flowing tributary of the lake and includes lakes upstream in the water watershed. The goals of lakeshore capacity assessment are to help maintain the quality of water in recreational inland lakes and to protect coldwater fish habitat by keeping changes in the nutrient status of inland lakes within acceptable limits. Phosphorus and dissolved oxygen are commonly used indicators of water quality.

Dissolved Oxygen

The Provincial Water Quality Objectives (PWQOs) set acceptable concentrations of dissolved oxygen (DO) for lakes in Ontario (OMOE 1994). For cold water biota, acceptable DO concentrations are between 5 and 8 mg/L (depending on water temperature). For warm water biota, the acceptable DO concentrations are between 4 and 7 mg/L, depending on temperature. For waters where sensitive biological communities such as Lake Trout exist, or where additional physical or chemical stressors are operating, more stringent criteria may be required.

In Ontario, 7 mg/L (expressed as a Mean Volume Weighted Hypolimnetic Dissolved Oxygen concentration (MVWHDO)) has been adopted as the water quality criterion to protect Lake Trout lakes. This is reflected in the Lakeshore Capacity Assessment Handbook (LCAH) (OMOE et al. 2010), which is used to inform development decisions on lakes situated on the Precambrian Shield. Specifically, the LCAH recommends:

“There will be no new municipal land use planning approvals for new or more intense residential, commercial or industrial development within 300m of lake trout lakes where the mean volume-weighted hypolimnetic dissolved oxygen has been measured to be at or below 7 mg/L. This recommendation also applies to lakes where water quality modeling has

determined that the development of existing vacant lots, with development approvals, would reduce the MVWHDO to 7 mg/L or less. The preservation of an average of at least 7 mg/L dissolved oxygen in the hypolimnion of Ontario's Lake Trout lakes will help to sustain the province's Lake Trout resources".

For the purpose of managing Lake Trout populations, MNRF recommends that a lake or basin of a lake be classified as 'at capacity' when the MVWHDO value is less than or equal to 7.0 mg/L (OMNR 2009). This value must represent the average of at least 3 dissolved oxygen profiles taken during the target period (August 15-September 15) of separate years.

For lakes that have MVWHDO values above 7.0 mg/L, the Lakeshore Capacity Model (LCM) can be used to predict how much development the lake can support without causing the MVWHDO to drop below the criteria. The LCM takes into account phosphorus in atmospheric deposition, natural inputs from the watershed, and anthropogenic inputs associated with development. The results of the LCM are used to predict the resulting MVWHDO through the use of a steady state model for hypolimnetic dissolved oxygen (Molot et al. 1992).

Phosphorus

Historically, management decisions relating to phosphorus have relied on an Interim Provincial Water Quality Objective (PWQO) (OMOE 1994). The Interim PWQO states:

"To avoid nuisance algae growth in lakes, average total phosphorus concentrations over the ice-free period should not exceed 20 µg/L. A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration of < 10 µg/L. This applies to all lakes naturally below this value."

A new PWQO establishes lake-specific objectives for lakes on the Precambrian Shield based on the background phosphorus concentration of the lake (OMOE et al. 2010). The Lakeshore Capacity Model is used to determine the natural (pre-development) background concentration of total phosphorus (TP). The objective is then established as the natural background concentration of phosphorus plus 50%, to a maximum of 20 µg/L. When the measured phosphorus concentrations in a lake exceed this value, the lake may be considered to be 'at capacity' with respect to phosphorus load.

Where the measured TP concentration within a lake is less than the natural background concentration plus 50%, the Lakeshore Capacity Model can be used to predict how much new development the lake can sustain without causing TP concentrations to exceed the objective.

This report presents an assessment of the potential development capacity of Turtle Lake based on the lake's dissolved oxygen regime. A discussion of supplementary water quality information is also provided.

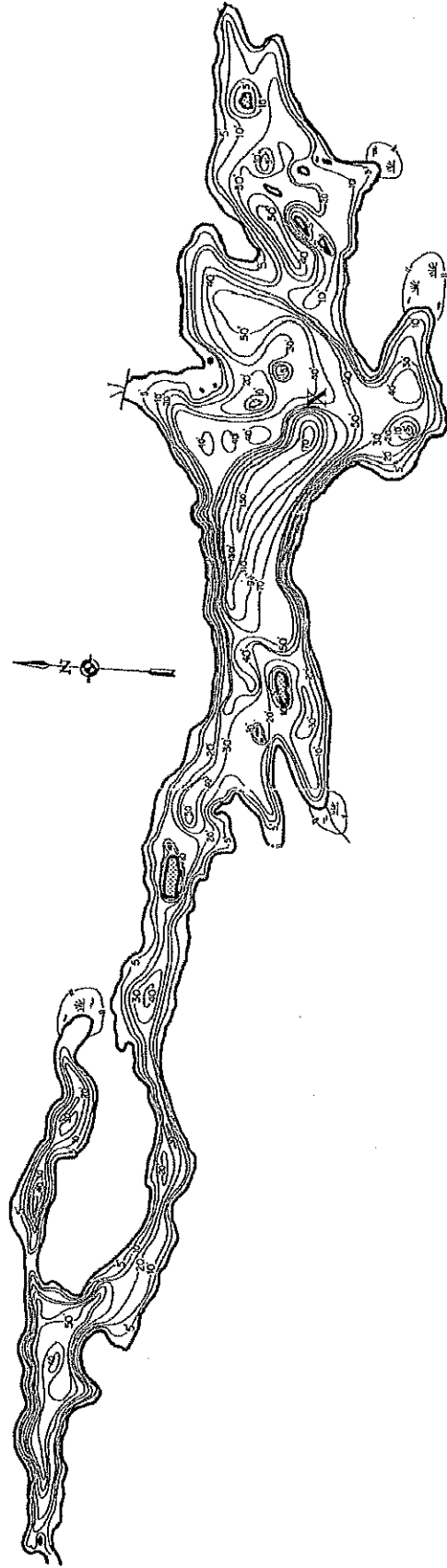


Figure 1. Bathymetry of Turtle Lake, Townships of Bonfield and an unorganized portion of the District of Nipissing (geographic townships of Bonfield and Phelps). Contour intervals are measured in feet. The deep hole is identified by an 'x'.

LOCATION		MORPHOMETRY		SHORELINE DEVELOPMENT (2014)*	
District.....	Nipissing	Surface Area (ha).....	257	Residences	
Township.....	Bonfield, unorganized	Catchment Area (ha).....	2158	Permanent.....	
Geographic Township.....	Bonfield, Phelps	Shoreline Length (km).....	29.0	Seasonal.....	
Watershed.....	Upper Ottawa River	Maximum Depth (m).....	56	Vacant Lots of Record.....	
Zone.....	17T	Total Volume (m ³).....	2.52x10 ⁷	Commercial Establishments.....	
Easting.....	640911			Shoreline Crown Land (%).....	
Northing.....	5129140				
Topographic Sheet.....	North Bay 31 L/6				

*development counts inferred from 2014 MPAC data and examination of aerial imagery

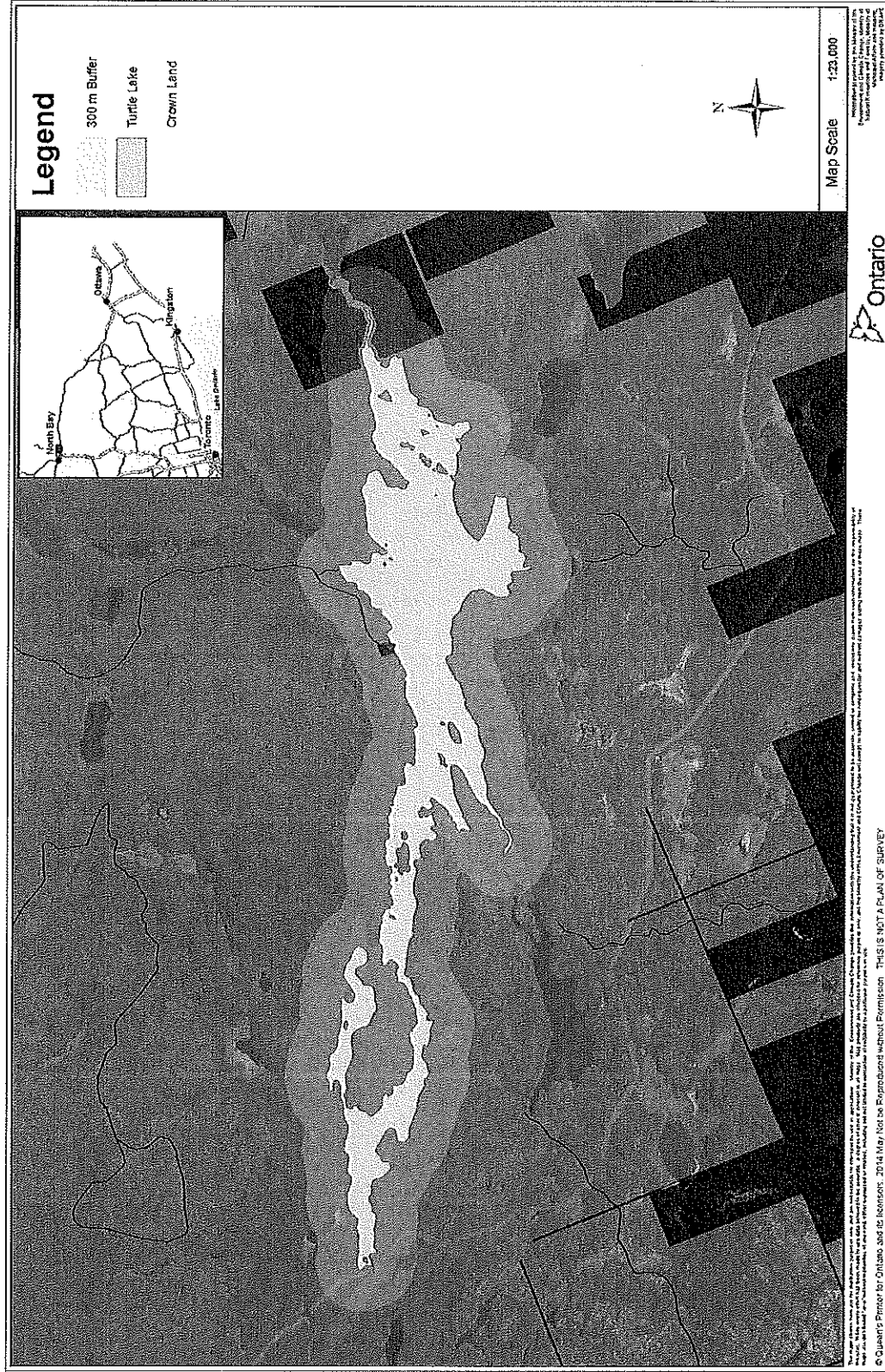


Figure 2. Turtle Lake, Townships of Bonfield and an unorganized portion of the District of Nipissing (geographic Townships of Bonfield and Phelps). The green highlighted area represents a 300 meter buffer along the shoreline and grey areas are Crown land.

Methods

Data

Limited water quality information exists for Turtle Lake. Historically, the lake was sampled by MNRF in 1972, 1991, 1994, and 1996. The most recent water quality information for Turtle Lake was collected by the North Bay-Mattawa Conservation Authority (2003-2006) and the MOECC (spring 2014, fall 2014, fall 2015). The MOECC water quality data includes water chemistry and Secchi depth measurements (**Appendix 1**) and dissolved oxygen and temperature data (**Appendix 2**).

For the purposes of this Lakeshore Capacity Assessment, only the most recent data were used to characterize the lake. These data are the most relevant to current conditions and were obtained using more reliable and consistent field and laboratory methods compared to historic data. This assessment used four years of end-of-summer dissolved oxygen data.

Mean Volume Weighted Hypolimnetic Dissolved Oxygen Calculation

The DO regime for Turtle Lake was characterized based on DO and temperature profiles collected during or near the standard sampling window (August 15 through September 15) between 1994 and 2015.

All profiles (temperature and DO) were collected using a YSI meter which were fully calibrated prior to each field survey. Measurements of DO and temperature were collected at one meter intervals through the water column. The upper limit of the hypolimnion was identified as the lower depth of the first 1 meter depth interval with a temperature change of less than 1 °C.

The oxygen content for a given one meter frustum (stratum) was determined by averaging the DO concentration of the top and bottom of the stratum. The MVWHDO was determined by summing the values for each stratum and dividing by the total volume of the hypolimnion. Calculations were done using the following formula (OMNR 2009):

$$MVWHDO = \sum_{s=1}^n V_s * DO_s$$

where:

MVWHDO is Mean Volume Weighted Hypolimnetic Dissolved Oxygen (mg/L);

V_s is the volume fraction of stratum s ;

DO_s is the dissolved oxygen concentration (mg/L) in stratum s ; and

n is the number of strata in the hypolimnion.

Results and Discussion

Phosphorus and Water Clarity

Recent spring phosphorus data from Turtle Lake includes 2004-2006 and 2014-2015 samples from the Lake Partner Program (sampled by the North Bay-Mattawa Conservation Authority and the MOECC). The LPP uses a low level phosphorus method with duplicate samples to quantify phosphorus concentrations.

This recent spring phosphorus data indicates that Turtle Lake is oligotrophic (<10 µg phosphorous per litre). Spring turnover total phosphorus concentrations (TP_{so}) in the euphotic zone range from 4.03 to 8.51 µg/L. There were 13 TP_{so} measurements used to determine the average spring turnover phosphorus concentration of 5.31 µg/L (**Table 1**). All samples represent an average of duplicates except for the May 12, 2004 sample that omits a bad split duplicate.

Table 1. Summary of Spring Turnover Total Phosphorus (TP_{so}) Concentrations (µg/L) in Turtle Lake (2004-2006, 2014-2015).

Date	TP _{so} (µg/L)
12-May-04	5.24
13-May-04	4.54
19-May-04	5.61
27-May-04	6.02
06-May-05	8.51
09-May-05	5.17
13-May-05	4.03
16-May-05	4.66
24-May-05	4.69
26-May-05	4.54
30-May-06	6.86
29-May-14	4.80
26-May-15	4.40
Average	5.31

Secchi depth is a measure of water clarity. This can be influenced by zooplankton biomass, algae biomass, turbidity, dissolved organic carbon, and suspended particulate matter. The average Secchi depth measured by the MOECC is 4.6 meters (2014), indicating excellent water clarity in Turtle Lake.

Alkalinity, pH and Hardness

Total alkalinity in Turtle Lake is low and ranged from 8.8 to 11.7 mg/L. This indicates the lake has low levels of calcium carbonate ions and is therefore moderately sensitivity to acidification. The range in pH in the euphotic zone was 7.23 to 7.40.

The hardness level of a waterbody is a function of the concentration of the various dissolved salts (most commonly calcium and magnesium ions) and is usually associated with the surficial geology in the watershed. In Turtle Lake, the water is soft, ranging from 15 to 17 mg/L. Low calcium concentrations in Turtle Lake (4.18 to 4.59 mg/L) likely contribute to the low alkalinity values (**Appendix 1**).

Dissolved Organic Carbon

Lakes with high dissolved organic carbon (DOC) concentrations may have naturally high background phosphorus concentrations (OMOE et al. 2010). High levels of DOC may occur naturally in lakes with large areas of wetlands in their catchments. In Turtle Lake, DOC concentrations are moderate and ranged from 4.2 to 4.8 mg/L in the euphotic zone (**Appendix 1**).

Nitrogen (Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen)

In surface waters, nitrogen may exist as nitrate, nitrite, ammonia or ammonium. The chemical form of nitrogen, which varies with oxygen concentration and pH, has a strong influence on the level of toxicity to fish. Both un-ionized ammonia (NH_3), and to a lesser extent nitrate, are known to be toxic to aquatic life. Un-ionized ammonia may accumulate to toxic levels in the hypolimnion under low oxygen conditions.

In Turtle Lake, total ammonia concentrations were low. Total ammonia ranged from 0.005 mg/L to 0.048 mg/L in the euphotic zone and 0.005 mg/L at a meter off bottom (MOB) (**Appendix 1**). Under the conditions observed in the hypolimnion (temperature $<10^\circ\text{C}$ and $\text{pH} < 7$), this equates to 0.00008 mg/L of un-ionized ammonia. The Canadian Water Quality Guideline for un-ionized ammonia is 0.019 mg/L and the PWQO for un-ionized ammonia is 0.020 mg/L. Both water quality criteria are established for the protection of aquatic life (CCME 2010, OMOE 1994).

Similarly, nitrate concentrations were relatively low in Turtle Lake (0.03 mg/L to 0.086 mg/L euphotic, 0.20 mg/L MOB) (**Appendix 1**). This is well below the Canadian Water Quality Guideline of 3.00 mg/L nitrate-nitrogen (CCME 2012). Nitrite concentrations in Turtle Lake range from 0.001 to 0.002 mg/L in surface samples and 0.001 mg/L in the MOB sample (**Appendix 1**). There is no PWQO for either nitrate or nitrite.

Dissolved Oxygen and Temperature

Four dissolved oxygen and temperature profiles were available for Turtle Lake. Profiles were collected within the sampling window of August 15th to September 15th (**Figure 3**). Turtle Lake thermally stratifies and the dissolved oxygen profiles display typical negative heterograde patterns. The top of the hypolimnion ranges between 10 to 11 meters. Oxygen concentrations in the hypolimnion suggest that the lake bottom is oxic. Raw dissolved oxygen and temperature data can be found in **Appendix 2**.

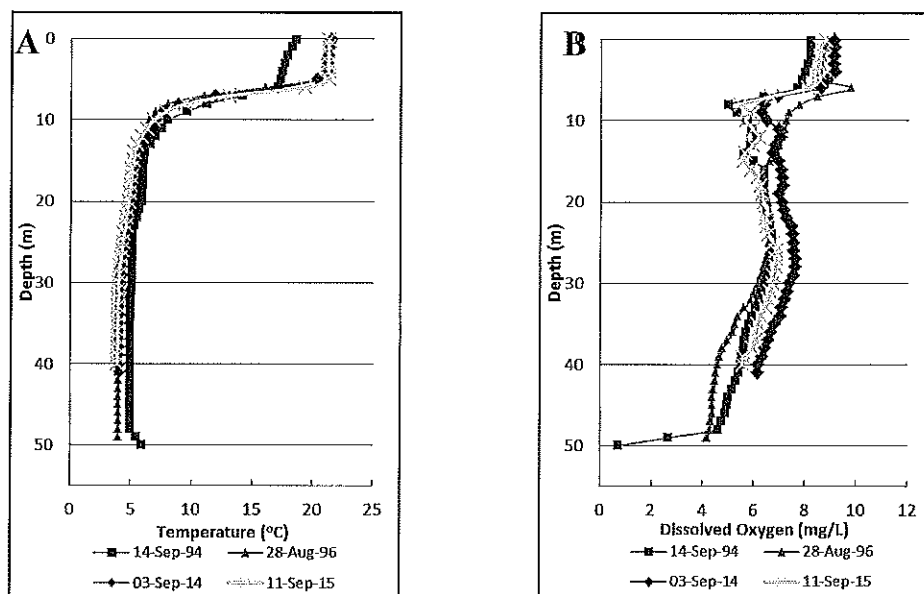


Figure 3. Temperature (A) and dissolved oxygen (B) profiles collected from the deepest point in Turtle Lake (1994, 1996, 2014, 2015).

MVWHDO

Four dissolved oxygen and temperature profiles, collected between 1994 and 2015, were examined for Turtle Lake. All profiles were collected over the deepest point on the lake (**Figure 1**).

As shown in Table 2, the MVWHDO was below 7 mg/L for each profile examined and the average MVWHDO for Turtle Lake is 6.32 mg/L. Based on the observed MVWHDO, Lakeshore Capacity Modelling is not required to assess the capacity status of Turtle Lake since measured values do not currently meet the provincial objective of 7.0 mg/L.

Table 2. Summary of Mean Volume Weighted Hypolimnetic Dissolved Oxygen for Turtle Lake (1994, 1996, 2014, 2015).

Date	MVWHDO (mg/L)
19-Sep-94	6.09
28-Aug-96	6.54
03-Sep-14	6.76
11-Sep-15	5.88
Average	6.32

Turtle Lake Development Capacity Summary

Turtle Lake is managed by MNRF as a naturally reproducing Lake Trout Lake. Water quality data collected by the MOECC and MNRF show that MVWHDO values are consistently below the 7 mg/L criterion, within a long-term average of 6.32 mg/L. Based on this information, Turtle Lake is considered to be 'at capacity'.

Given this finding, municipal land use planning approvals and Crown Land disposition decisions around Turtle Lake, including tributaries of the lake and upstream lakes, should not result in a net increase in phosphorus loading to the lake, impacts to habitat, or reductions to lakeshore carrying capacity.

*Prepared By: Eastern Region Technical Support Section
Date: December 7, 2017*

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Appendix 1.Water Chemistry Summary for Turtle Lake from the MOECC
Lake Monitoring Program (2014).

Parameter	29-May-14	03-Sep-14	
	Euphotic	Euphotic	MOB
Secchi Disk (m)	5.2	4.0	
Total Phosphorus	0.32	0.005	0.006
Ammonia- Nitrogen	0.048	0.005	0.005
Nitrite-Nitrogen	<i>0.002</i>	0.001	0.001
Nitrate- Nitrogen	<i>0.086</i>	0.03	0.20
Total Kjeldahl Nitrogen	0.42	0.23	0.25
Dissolved Organic Carbon	4.6	4.8	4.2
Dissolved Inorganic Carbon	2.4	3.2	4.1
pH	7.23	7.40	6.95
Total Alkalinity	8.8	11.7	11.7
Conductivity (uS/cm)	71	82.0	76.0
Calcium	4.18	4.59	4.35
Magnesium	1.21	1.34	1.29
Hardness	15	17	16
Total Suspended Solids	0.9	0.5	0.5
Total Dissolved Solids	46.0	53.0	50.0

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

MOB = meter off bottom

Appendix 2.

Summary of Dissolved Oxygen and Temperature Data from Turtle Lake in 1994, 1996, 2014, and 2015. The maximum depth of Turtle Lake is approximately 52 meters.

Measured Depth (m)	14-Sep-94		28-Aug-96		03-Sep-14		11-Sep-15	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.1	18.60	8.20	21.50	8.90	21.52	9.14	21.29	8.8
1	18.25	8.20	21.25	8.80	21.48	9.16	21.28	8.58
2	17.90	8.20	21.00	8.70	21.29	9.14	21.28	8.59
3	17.70	8.10	21.00	8.65	21.25	9.14	21.28	8.55
4	17.50	8.00	21.00	8.60	21.20	9.17	21.28	8.52
5	17.30	7.85	20.50	8.60	20.36	8.86	21.28	8.55
6	17.10	7.70	16.00	9.80	17.09	8.62	19.34	8.09
7	14.15	6.35	11.00	8.50	11.91	6.91	13.06	6.66
8	11.20	5.00	8.00	7.80	8.95	6.39	9.48	5.47
9	9.60	5.35	7.00	7.40	7.75	6.30	7.88	5.86
10	8.00	5.70	6.50	7.30	7.07	6.50	6.88	5.66
11	7.50	5.90	6.50	7.20	6.82	6.97	6.31	5.94
12	7.00	6.10	6.50	7.10	6.33	7.03	5.86	6.2
13	6.55	5.85	6.25	7.00	6.05	6.83	5.5	5.96
14	6.10	5.60	6.00	6.90	5.91	6.75	5.29	5.64
15	6.05	6.00	5.75	6.65	5.77	6.99	5.18	5.61
16	6.00	6.40	5.50	6.40	5.67	7.07	5.08	5.88
17	6.00	6.40	5.25	6.40	5.60	7.10	5.02	6.12
18	6.00	6.40	5.00	6.40	5.50	7.13	4.95	6.24
19	5.95	6.40	5.00	6.50	5.41	6.98	4.9	6.31
20	5.90	6.40	5.00	6.60	5.25	7.10	4.8	6.38
21	5.70	6.50	5.00	6.60	5.12	7.17	4.68	6.53
22	5.50	6.60	5.00	6.60	4.97	7.29	4.61	6.46
23	5.30	6.65	4.75	6.60	4.81	7.48	4.58	6.49
24	5.10	6.70	4.50	6.60	4.70	7.52	4.43	6.57
25	5.10	6.70	4.50	6.60	4.65	7.57	4.33	6.78
26	5.10	6.70	4.50	6.60	4.55	7.57	4.25	6.86
27	5.10	6.60	4.25	6.50	4.41	7.61	4.18	6.88
28	5.10	6.50	4.00	6.40	4.38	7.62	4.08	6.86
29	5.10	6.45	4.00	6.30	4.31	7.57	4.02	6.77
30	5.10	6.40	4.00	6.20	4.27	7.38	4	6.73
31	5.05	6.30	4.00	6.05	4.25	7.33	4	6.64
32	5.00	6.20	4.00	5.90	4.23	7.23	3.98	6.56
33	5.00	6.05	4.00	5.65	4.21	7.09	3.94	6.47
34	5.00	5.90	4.00	5.40	4.19	7.04	3.95	6.24
35	5.00	5.80	4.00	5.30	4.17	6.79	3.94	6.15
36	5.00	5.70	4.00	5.20	4.14	6.68	3.93	6.1
37	5.00	5.65	4.00	5.00	4.14	6.58	3.94	6.08
38	5.00	5.60	4.00	4.80	4.10	6.44	3.92	5.95
39	5.00	5.55	4.00	4.70	4.09	6.32	3.88	5.61
40	5.00	5.50	4.00	4.60	4.09	6.15	3.87	5.58
41	5.00	5.40	4.00	4.55	4.09	6.15		
42	5.00	5.30	4.00	4.50				
43	5.00	5.15	4.00	4.45				
44	5.00	5.00	4.00	4.40				
45	5.00	4.95	4.00	4.40				
46	5.00	4.90	4.00	4.40				
47	5.00	4.75	4.00	4.35				
48	5.00	4.60	4.00	4.30				
49	5.45	2.65	4.00	4.20				
50	5.90	0.70						
51								
52								

Note: Red values indicate interpolated data.

LAKE CAPACITY ASSESSMENT: TROUT LAKE

Introduction

Trout Lake

Trout Lake is located on the Precambrian Shield in the District of Nipissing. The lake has an area of 1,887 hectares and is comprised of two basins: Four Mile Bay (north) is 27 meters in depth and Trout Lake (Main Basin – south) is 63 meters in depth (**Figure 1**). The catchment is primarily forested with many wetlands and streams. The lake provides drinking water to the City of North Bay, situated on the western shoreline. Both lake basins have experienced extensive permanent and seasonal shoreline development within the 300 meter buffer due to its close proximity to the City. The remaining shoreline property is Crown owned (**Figure 2**).

Trout Lake lies within the Upper Ottawa – Kipawa watershed. The Jocko, Mattawa, and Amable du Fond Rivers flow through the watershed to Lac La Cave. Four Mile Lake is the main inflow into Trout Lake, flowing into Four Mile Bay which is connected to Trout Lake (Main Basin). Many small streams and wetlands also feed both basins of the lake. Trout Lake's outflow is the Mattawa River which flows southeast to Turtle Lake.

Both basins of Trout Lake support a naturally reproducing Lake Trout population and the lake is designated as a Natural Lake Trout Lake by the Ministry of Natural Resources and Forestry (MNRF) (OMNRF 2015). The lake's fish community is diverse with many cold and warm water species such as Lake Trout, Rainbow Trout, Walleye, Brook Trout, Largemouth Bass, Smallmouth Bass, Muskellunge, White Sucker, and Rock Bass (OMNR 2012).

The Official Plans for both the City of North Bay and the Township of East Ferris include water quality objectives for Trout Lake. Both Official Plans also have policies limiting the number of new shoreline lots. These development restrictions effectively impose a development freeze on the lake (City of North Bay 2012, Township of East Ferris 1999).

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Lake Trout typically occupy deep, cold, well oxygenated lakes. As the thermocline deepens during the summer months, Lake Trout will generally move to deeper waters, making use of warmer, shallower areas during nocturnal foraging. Studies have shown that the survival, growth and reproduction of Lake Trout are impaired in lakes where the dissolved oxygen concentration drops below 7 mg/L (Evans 2005, Evans 2007).

The amount of dissolved oxygen in the water column is influenced by many factors including: temperature, wind, ice conditions, lake morphometry, photosynthetic production, respiratory consumption, and photo-oxidation of dissolved organic carbon (DOC). Dissolved oxygen concentrations typically decrease with depth through the hypolimnion. This is because, with thermal stratification, the hypolimnion is effectively isolated from atmospheric and epilimnetic oxygen supplies. The isolation persists from the time that stratification is established in the spring and summer until the fall turnover,

when stratification breaks down and mixing resumes. Oxygen depletion in the hypolimnion due to algal decomposition results in a loss of well oxygenated cold-water habitat that is vital to the growth and survival of Lake Trout (OMOE et al. 2010). In some oligotrophic lakes, dissolved oxygen concentrations will remain high with increasing depth through the hypolimnion. This type of oxygen profile (orthograde) tends to occur in lakes with large hypolimnions and low levels of phosphorus (Wetzel 2001).

Phosphorus is a limiting nutrient that controls the growth of aquatic plants and algae (Wetzel 2001). When the supply of phosphorus is high (>0.02 mg/L), it may promote excess growth of algae and aquatic plants. Throughout the growing season, algae and plant matter die, decompose, and settle to the bottom of lakes, consuming oxygen in the hypolimnion. A major source of anthropogenic phosphorus to inland lakes is from septic systems (OMOE et al. 2010). Additional sources of phosphorus to lake environments include stormwater runoff, agricultural runoff, fertilizers, shoreline clearing and associated soil erosion. By implementing controls on shoreline development, the degree of phosphorus enrichment and resulting impacts to sensitive lake systems can be mitigated.

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Lakeshore Capacity Assessment is used as a planning tool to establish shoreline development limits on Precambrian Shield lakes in order to control phosphorus loading to inland lake environments. The Lake Capacity Assessment Handbook (2010) takes a watershed approach and defines shoreline development as being within 300 meters of a lake or any permanently flowing tributary of the lake and includes lakes upstream in the watershed. The goals of lakeshore capacity assessment are to help maintain the quality of water in recreational inland lakes and to protect coldwater fish habitat by keeping changes in the nutrient status of inland lakes within acceptable limits. Phosphorus and dissolved oxygen are commonly used indicators of water quality.

Dissolved Oxygen

The Provincial Water Quality Objectives (PWQOs) set acceptable concentrations of dissolved oxygen (DO) for lakes in Ontario (OMOE 1994). For cold water biota, acceptable DO concentrations are between 5 and 8 mg/L (depending on water temperature). For warm water biota, the acceptable DO concentrations are between 4 and 7 mg/L, depending on temperature. For waters where sensitive biological communities such as Lake Trout exist, or where additional physical or chemical stressors are operating, more stringent criteria may be required.

In Ontario, 7 mg/L (expressed as a Mean Volume Weighted Hypolimnetic Dissolved Oxygen concentration (MVWHDO)) has been adopted as the water quality criterion to protect Lake Trout lakes. This is reflected in the Lakeshore Capacity Assessment

Handbook (LCAH) (OMOE et al. 2010), which is used to inform development decisions on lakes situated on the Precambrian Shield. Specifically, the LCAH recommends:

“There will be no new municipal land use planning approvals for new or more intense residential, commercial or industrial development within 300m of lake trout lakes where the mean volume-weighted hypolimnetic dissolved oxygen has been measured to be at or below 7 mg/L. This recommendation also applies to lakes where water quality modeling has determined that the development of existing vacant lots, with development approvals, would reduce the MVWHDO to 7 mg/L or less. The preservation of an average of at least 7 mg/L dissolved oxygen in the hypolimnion of Ontario’s Lake Trout lakes will help to sustain the province’s Lake Trout resources”.

For the purpose of managing Lake Trout populations, MNRF recommends that a lake or basin of a lake be classified as ‘at capacity’ when the MVWHDO value is less than or equal to 7.0 mg/L (OMNR 2009). This value must represent the average of at least 3 dissolved oxygen profiles taken during the target period (August 15-September 15) of separate years.

For lakes that have MVWHDO values above 7.0 mg/L, the Lakeshore Capacity Model (LCM) can be used to predict how much development the lake can support without causing the MVWHDO to drop below the criteria. The LCM takes into account phosphorus in atmospheric deposition, natural inputs from the watershed, and anthropogenic inputs associated with development. The results of the LCM are used to predict the resulting MVWHDO through the use of a steady state model for hypolimnetic dissolved oxygen (Molot et al. 1992).

Phosphorus

Historically, management decisions relating to phosphorus have relied on an Interim Provincial Water Quality Objective (PWQO) (OMOE 1994). The Interim PWQO states:

“To avoid nuisance algae growth in lakes, average total phosphorus concentrations over the ice-free period should not exceed 20 µg/L. A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration of < 10 µg/L. This applies to all lakes naturally below this value”.

A new PWQO establishes lake-specific objectives for lakes on the Precambrian Shield based on the background phosphorus concentration of the lake (OMOE et al. 2010). The Lakeshore Capacity Model is used to determine the natural (pre-development) background concentration of total phosphorus (TP). The objective is then established as the natural background concentration of phosphorus plus 50%, to a maximum of 20 µg/L. When the phosphorus concentration within the lake exceeds this value, the lake may be considered to be ‘at capacity’ with respect to phosphorus load.

Where the measured TP concentration within a lake is less than the natural background concentration plus 50%, the Lakeshore Capacity Model can be used to predict how much

new development the lake can sustain without causing TP concentrations to exceed the objective.

This report presents an assessment of the potential development capacity of Trout Lake based on the lake's phosphorus levels and dissolved oxygen regime. A discussion of supplementary water quality information is also provided.



Figure 1. Bathymetry of Trout Lake, City of North Bay and Corporation of the Municipality of East Ferris (geographic townships of Widdifield and Ferris). Depth strata are measured in meters. The deep holes in Four Mile Bay (north) and Trout Lake Main Basin (south) are indicated by an 'x'.

LOCATION

District.....Nipissing
 Township.....City of North Bay, East Ferris
 Geographic Township.....Widdifield, Ferris
 Watershed.....Upper Ottawa - Kipawa
 Zone.....17T
 Easting.....633993
 Northing.....5130403
 Topographic Sheet.....North Bay 31 L/6

MORPHOMETRY

Surface Area (ha).....1887
 Catchment Area (ha).....10201
 Shoreline Length (km).....71.6
 Maximum Depth (m).....63.0
 Total Volume (m³).....3.3x10⁸

SHORELINE DEVELOPMENT (2013)*

Residences
 Permanent.....760
 Seasonal.....259
 Vacant Lots of Record.....172
 Shoreline Crown Land (%).....1.67

*development counts inferred from 2013 Municipal Property Assessment Corporation (MPAC) data and examination of aerial imagery



Figure 2. Trout Lake, City of North Bay and Corporation of the Municipality of East Ferris (geographic Townships of Widdifield and Ferris). The green highlighted area represents a 300 meter buffer along the shoreline and grey areas are Crown Land.

Methods

Data

Trout Lake was sampled annually by the MOECC between 1984 to 1996 as part of their Recreational Lakes Program. The most recent water quality information for Trout Lake was collected by the North Bay-Mattawa Conservation Authority (NBMCA) (2004-2007) and the MOECC (2010, 2012, 2013, 2015). The MOECC water quality data includes water chemistry and Secchi depth measurements (**Appendix 1**) and dissolved oxygen and temperature data (**Appendix 2**).

For the purposes of this Lakeshore Capacity Assessment, historical and recent data were used to characterize the lake. This assessment used 5 to 8 years of end-of-summer dissolved oxygen data and 8 years of spring phosphorus data.

Mean Volume Weighted Hypolimnetic Dissolved Oxygen Calculation

The DO regime for Trout Lake was characterized using DO and temperature profiles collected during or near the target sampling window (August 15 through September 15) between 1987 and 2015.

All profiles (temperature and DO) were collected using a YSI meter and these meters were fully calibrated prior to each survey. Values for DO and temperature were considered at one meter depth intervals. The upper limit of the hypolimnion was identified as the lower depth of the first 1 meter depth interval with a temperature change less than 1 °C.

The oxygen content for a given one meter frustum (stratum) was determined by averaging the DO concentration of the top and bottom of the stratum. The MVWHDO was determined by summing the values for each stratum and dividing by the total volume of the hypolimnion. Calculations were done using the following formula (OMNR 2009):

$$MVWHDO = \sum_{s=1}^n V_s * DO_s$$

where:

MVWHDO is the Mean Volume Weighted Hypolimnetic Dissolved Oxygen (mg/L);

V_s is the volume fraction of stratum s ;

DO_s is the dissolved oxygen concentration (mg/L) in stratum s ; and

n is the number of strata in the hypolimnion.

Lakeshore Capacity Model

The Lakeshore Capacity Model (LCM) (MOE 2010) was used to assess the development capacity of Trout Lake. The LCM is a steady-state mass balance model that calculates a phosphorus budget for a lake based on natural and anthropogenic phosphorus loads, lake morphometry, and watershed hydrology (Paterson et al. 2006). The LCM is used to predict a phosphorus concentration of a lake which can then be compared to measured values for model

validation. If predicted phosphorus concentrations are within acceptable levels of measured values, the LCM can be used as a planning tool to estimate changes in lake phosphorus concentrations resulting from proposed development applications, conversions of seasonal cottages to permanent homes, or other land use activities that may increase or decrease phosphorus loadings to the lake. A separate oxygen model (Molot et al. 1992) is used to predict changes to hypolimnetic oxygen based on predicted changes in phosphorus concentrations.

The LCM uses input data from a variety of sources such as topographic maps, geological maps, provincial datasets for wetlands, forested areas, and watershed boundaries. Field visits are often used to verify sub-catchment areas and confirm drainage patterns, particularly if concerns are raised regarding the accuracy of any data set. For example, at the southeast end of Trout Lake field work was completed to confirm the flow directions of tributary streams and identify the drainage divide between Trout Lake and the Mattawa River. This work confirmed that the watershed mapping produced using MNRF's Ontario Flow Assessment Tool 3 (OFAT 3) was accurate.

MOECC and MNRF lake files are an important source of bathymetric data, water quality data, and fishery inventories. Shoreline development is an important input parameter and obtaining accurate development counts around a lake can often be challenging. Information can be obtained from the assessment rolls of municipalities, lake associations, aerial imagery or direct field counts. At a cost, the Municipal Property Assessment Corporation (MPAC) can provide assessment data that identify waterfront lots and second-tier development. For Trout Lake, MPAC data provided the main source of development counts. This was supplemented by aerial imagery taken in 2009.

Results and Discussion

Trout Lake Outflow Point

In 1994 the Ministry of the Environment and Energy recognized the outlet of Trout Lake as the line corresponding to Universal Transverse Mercator (UTM) 634,000 metres east (grid zone 18T) (**Figure 3**).

This location is a natural constriction at the east end of Trout Lake. The reach between this location and the Narrows (inlet to Turtle Lake) is more riverine than lacustrine, has a very shallow morphometry (<2 metres) and is considered a flowing system (the Mattawa River). The Ministry of Natural Resources and Forestry, in their publication Data Capture Specification for Hydrographic Features, also identify this location as the outflow of Trout Lake and this reach as the Mattawa River (MNRF 2011).

For the purposes of modelling Trout Lake and delineating the catchment area, UTM 634,000 meters east was used to define the outlet of Trout Lake and the beginning of the Mattawa River. OFAT 3 was used to create a watershed boundary for Trout Lake from this outlet location, and provincial datasets were overlaid over the watershed boundary to calculate model input parameters such as percent wetland, percent forest, and a 300 metre influence area.

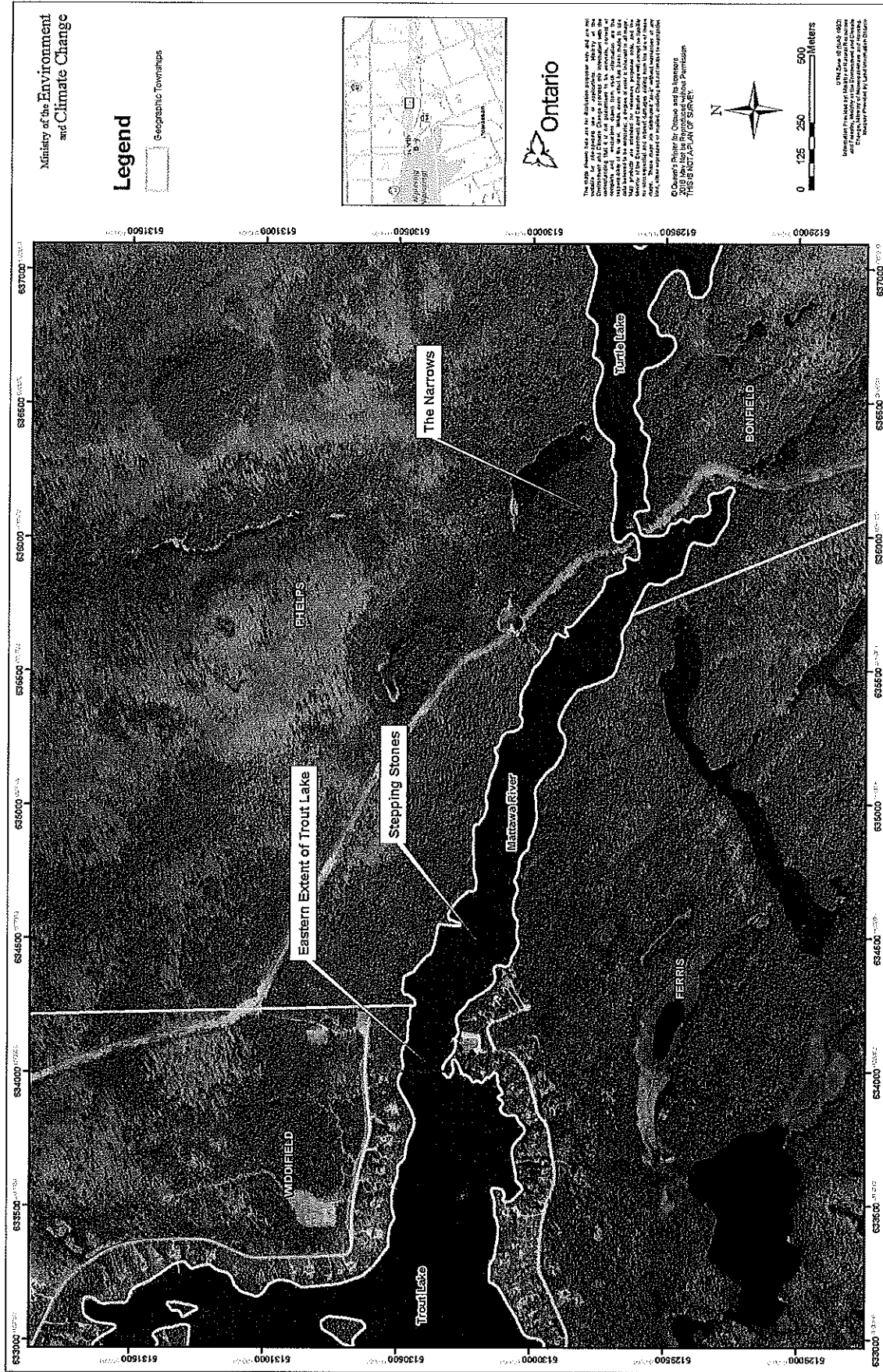


Figure 3. The outflow of Trout Lake is located at UTM easting line 634,000 meters.

Phosphorus and Water Clarity

Recent spring phosphorus data from Trout Lake includes 2004-2007, 2010, 2012, 2013 and 2015 samples from the Lake Partner Program (sampled by NBMCA and MOECC). The LPP uses a low level phosphorus detection method with duplicate samples to quantify phosphorus concentrations.

The recent spring phosphorus data indicates that both basins of Trout Lake are oligotrophic (<10 µg phosphorous per litre). Spring turnover total phosphorus concentrations (TP_{so}) in the euphotic zone range from 4.04 µg/L to 8.88 µg/L in Four Mile Bay and 2.80 µg/L to 8.00 µg/L in Trout Lake (Main Basin). The average spring turnover phosphorus concentrations for Four Mile Bay and Trout Lake (Main Basin) are 5.88 µg/L and 4.19 µg/L respectively (**Table 1**).

Table 1. Summary of annual average spring turnover total phosphorus (TP_{so}) concentrations (µg/L) in Trout Lake (2004-2007, 2010, 2012, 2013, 2015).

Year	Annual Average TP _{so} (µg/L)	
	Four Mile Bay	Trout Lake (Main Basin)
2004	6.85	4.76
2005	5.29	3.63
2006	6.53	5.60
2007	4.57	3.46
2010	5.56	3.36
2012	4.60	2.90
2013	8.45	5.00
2015	5.70	4.43
Average	5.88	4.19

Secchi depth is a measure of water clarity which can be influenced by zooplankton biomass, algae biomass, turbidity, dissolved organic carbon, and suspended particulate matter. The average Secchi depths measured by the LPP (2002-2012) are 5.1 meters in Four Mile Bay and 5.8 meters in Trout Lake (Main Basin) which are indicative of excellent water clarity in both basins.

Alkalinity, pH and Hardness

Total alkalinity in Trout Lake is low and ranged from 7.0 to 8.0 mg/L in Four Mile Bay and 13.4 to 13.8 mg/L in Trout Lake (Main Basin). This indicates the lake has low levels of calcium carbonate ions and is therefore moderately sensitivity to acidification. The range in pH in the euphotic zone was 6.83 to 7.20 in Four Mile Bay and 7.24 to 7.52 in Trout Lake (Main Basin).

The hardness level of a waterbody is a function of the concentration of various dissolved salts (most commonly calcium and magnesium ions) and is usually associated with the surficial geology in the watershed. The hardness concentrations in Trout Lake (11 to 19 mg/L) indicate that it is a fairly dilute water body (**Appendix 1**).

Dissolved Organic Carbon

Lakes with high dissolved organic carbon (DOC) concentrations may have naturally high background phosphorus concentrations (OMOE et al. 2010). High levels of DOC may occur naturally in lakes with large areas of wetlands in their catchments. In Trout Lake, DOC concentrations are low to moderate and ranged from 3.3 to 5.3 mg/L in the euphotic zone (**Appendix 1**).

Nitrogen (Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen)

In surface waters, nitrogen may exist as nitrate, nitrite, ammonia or ammonium. The chemical form of nitrogen, which varies with oxygen concentration and pH, has a strong influence on the level of toxicity to fish. Both un-ionized ammonia (NH_3), and to a lesser extent nitrate, are known to be toxic to aquatic life. Un-ionized ammonia may accumulate to toxic levels in the hypolimnion under low oxygen conditions.

In Four Mile Bay, total ammonia concentrations were 0.011 mg/L in the euphotic zone and 0.005 mg/L at a meter off bottom (MOB); in the main basin of Trout Lake concentrations were 0.009 mg/L in the euphotic zone and 0.005 mg/L at MOB (**Appendix 1**). Under the conditions observed in the hypolimnion (temperature $<10^\circ\text{C}$ and $\text{pH} < 7.5$), this equates to 0.00003 mg/L of un-ionized ammonia which is very low. The Canadian Water Quality Guideline for un-ionized ammonia is 0.019 mg/L and the PWQO for un-ionized ammonia is 0.020 mg/L. Both water quality criteria are established for the protection of aquatic life (CCME 2010, OMOE 1994).

Similarly, nitrate concentrations were relatively low in Trout Lake (0.031 to 0.202 mg/L in Four Mile Bay, 0.033 to 0.194 mg/L in Trout Lake (Main Basin)) (**Appendix 1**). This is well below the Canadian Water Quality Guideline of 3.00 mg/L nitrate-nitrogen (CCME 2012). Nitrite concentrations in Trout Lake were 0.001 mg/L in surface samples and 0.001 mg/L in the MOB samples (**Appendix 1**). There is no PWQO for either nitrate or nitrite.

Dissolved Oxygen and Temperature

Five and eight dissolved oxygen and temperature profiles were available for Four Mile Bay and Trout Lake (Main Basin) respectively. Profiles were collected within the sampling window of August 15th to September 15th (**Figure 4**). Both basins of Trout Lake thermally stratify and the dissolved oxygen profiles display clinograde, positive heterograde, and negative heterograde patterns depending on the year sampled. The top of the hypolimnion ranged between 10 to 12 meters in Four Mile Bay and 11 to 15 meters in Trout Lake (Main Basin). Oxygen concentrations in the hypolimnion suggest the lake bottom is oxic in both basins. Raw dissolved oxygen and temperature data can be found in **Appendix 2**.

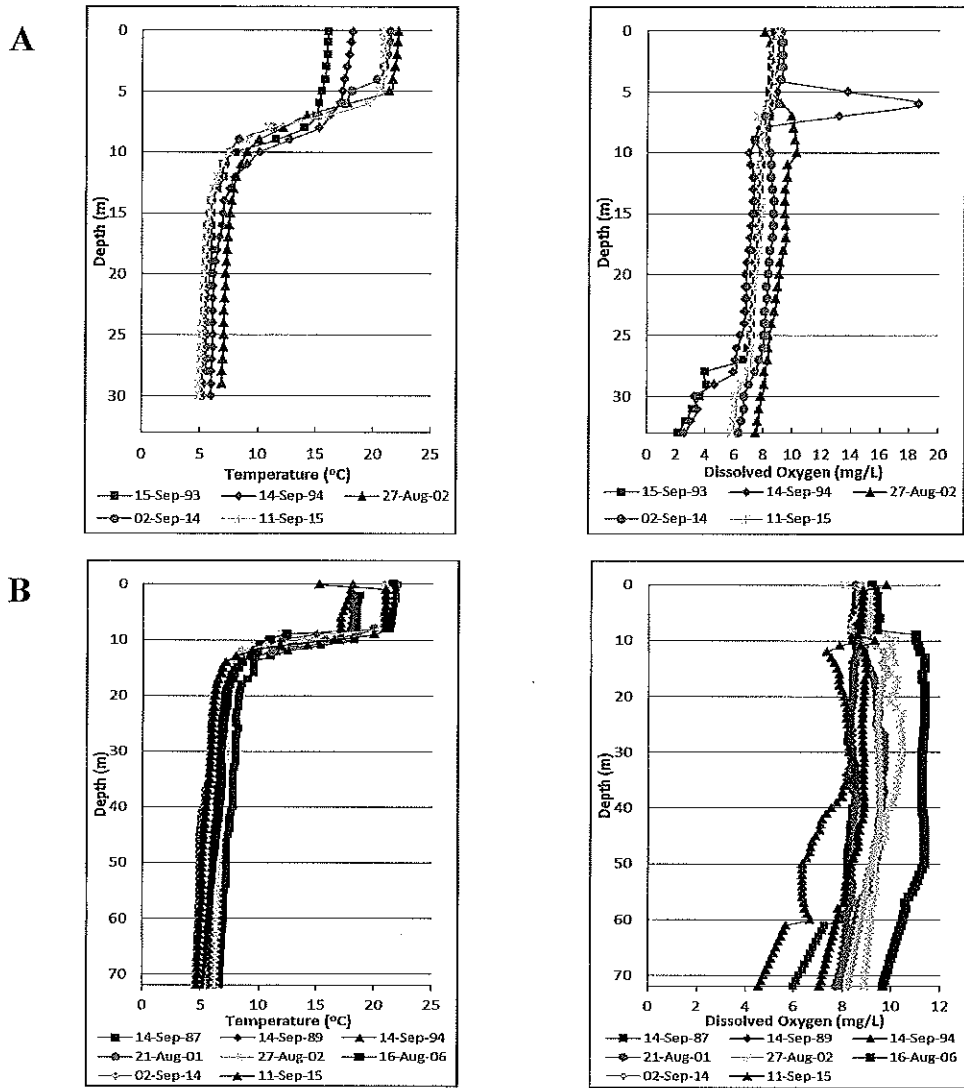


Figure 4. Temperature and dissolved oxygen profiles collected from the deepest point in the two basins of Trout Lake; A = Four Mile Bay, B = Trout Lake (Main Basin).

MVWHDO

Dissolved oxygen and temperature profiles have been collected for both basins of Trout Lake. MNRF (2009) suggests that a lake has discrete basins if they are “separated by submerged sills that are higher than the top of the hypolimnion and maximum depth of a basin is >13 m.” The sill depth between the two Trout Lake basins (< 6 meters) is always less than the average hypolimnetic depth for Four Mile Bay or Trout Lake, and the maximum depth for both basins is >13 meters. Therefore, for the purposes of calculating MVWHDO, Trout Lake is considered a dual-basin lake.

As with other dual or multi-basin Lake Trout lakes, dissolved oxygen and temperature profiles from the deepest hole in each basin is considered in the calculation of MVWHDO.

The average MVWHDO in Four Mile Bay was calculated using five dissolved oxygen and temperature profiles collected between 1993 and 2015. Eight profiles, collected between 1987 and 2015, were used for Trout Lake (Main Basin). As shown in **Table 2**, the MVWHDO was above 7 mg/L for each profile examined except for the 1994 profile from Four Mile Bay. The long-term MVWHDO averages were 8.03 mg/L and 9.15 mg/L for Four Mile Bay and Trout Lake (Main Basin) respectively.

Table 2. Summary of Mean Volume Weighted Hypolimnetic Dissolved Oxygen for Four Mile Bay and Trout Lake Proper of Trout Lake.

Date	MVWHDO (mg/L)	
	Four Mile Bay	Trout Lake (Main)
14-Sep-87	---	8.77
14-Sep-89	---	8.36
15-Sep-93	7.94	---
14-Sep-94	6.94	7.78
21-Aug-01	---	9.25
27-Aug-02	9.30	10.07
16-Aug-06	---	11.12
02-Sep-14	8.40	9.18
11-Sep-15	7.59	8.69
Average	8.03	9.15

Phosphorus and Oxygen Models

The Lakeshore Capacity Model was used to determine residual development capacity for Trout Lake as the average MVWHDO is > 7 mg/L in both basins.

The phosphorus model for Trout Lake is provided in **Appendix 2**. Trout Lake is considered a second order lake; it is fed by one lake greater than 25 hectares in size (Four Mile Lake) as well as several wetlands, streams, and ponds. The catchment of Trout Lake (Main Basin) is located within the Precambrian Shield. The catchment for Four Mile Bay has approximately 11% cleared land and 5% wetland, while the catchment for Trout Lake (Main Basin) has approximately 21% cleared land and 11% wetland. All waterbodies in the watershed less than 25 hectares in size are assumed to be forested, and are not modeled independently (MOECC 2010). Recent monitoring data indicate that Four Mile Bay and Trout Lake (Main Basin) are oxic at a meter off bottom and thermally stratify during the ice-free period.

The phosphorus model over-predicts measured spring overturn concentrations for both Four Mile Bay and Trout Lake (Main Basin) by greater than 20%, indicating that the model does not predict within acceptable ranges for either basin of this lake (**Table 3**). Therefore, the number of allowable residences to reach capacity based on the background + 50% phosphorus objective cannot be determined by the model and in turn, the dissolved oxygen model cannot be employed.

Table 3. Summary of phosphorus model predictions for Trout Lake.

Phosphorus Concentration (µg/L)	Four Mile Bay		Trout Lake (Main Basin)	
	Predicted	Average Measured	Predicted	Average Measured
TP _{so}	10.66	5.88	11.42	4.19
TP _{lake}	10.02	N/A	10.77	N/A
TP _{background}	5.19	N/A	5.51	N/A
TP _{background} + 50%	7.79	N/A	8.26	N/A

There are several reasons that may explain the over-prediction of measured TP. They include a lag time in the movement of phosphorus from septic systems to lakes due to watershed soils that favour retention; significant groundwater inputs to the lake; the lake being erroneously modeled as anoxic; measured phosphorus data are of poor quality; or the lake falling outside of the calibration and test range of the model.

When the LCM does not predict phosphorus concentrations within acceptable limits, the Lakeshore Capacity Assessment Handbook (MOE 2010) recommends that the Interim PWQO for phosphorus be followed as a guideline. For lakes that are naturally below 10 µg/L phosphorus, such as Trout Lake, the Interim PWQO recommends using 10 µg/L as an upper threshold. We are of the opinion that because the long-term measured phosphorus concentrations in Trout Lake are so low (i.e. < 4 µg/L), the Interim PWQO is not adequately protective of water quality in Trout Lake. Therefore we do not recommend its use.

The Official Plans (OP's) for the City of North Bay and the Township of East Ferris already include water quality objectives for total phosphorus and dissolved oxygen. These policies recommend maintaining a measured average long term ice-free phosphorus concentration below 7 µg/L combined with a late summer volume weighted dissolved oxygen measure of 8 mg/L. Both these water quality objectives are more stringent than the PWQO's. The OP policies for both municipalities have been in place for many years and effectively impose a development cap on new lots.

Trout Lake Development Capacity Summary

Trout Lake is managed by the MNRF as a naturally reproducing Lake Trout lake. It is a relatively large waterbody that has experienced extensive shoreline development due to its proximity to the City of North Bay. Trout Lake is the source of drinking water for the City of North Bay and for numerous individual private water supplies. Its excellent water quality supports many recreational activities and a strong fishery.

The phosphorus model does not predict within acceptable limits for Four Mile Bay or Trout Lake (Main Basin), as it over-predicts the spring overturn concentrations by greater than 20% of measured values. As such the model cannot be used as a planning tool to predict a background concentration (in order to set a background plus 50% objective), and therefore it cannot be used to estimate an upper limit for development.

The City of North Bay and the Township of East Ferris OP's already have policies for Trout Lake which restrict the development of new lots based on water quality objectives for phosphorus and hypolimnetic dissolved oxygen. Given the importance of this lake as a drinking water source for the City, and the at-capacity status of the downstream Lake Trout lakes (Turtle Lake and Talon Lake), the ministry supports the approach taken by the municipalities to limit new development. In the future, the Ministry may be open to considering a very limited release of new development lots for Trout Lake. The decision to allow or not allow new shoreline development lots will be based on a rigorous review of the long-term measured water quality data and a detailed statistical analysis of trends by the ministry.

*Prepared By: Eastern Region Technical Support Section
Date: February 7, 2018*

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Appendix 1a.**Water Chemistry Summary for Four Mile Bay from the MOECC Lake Monitoring Program (2014).**

Parameter	03-Sep-14	
	Euphotic	MOB
Secchi Disk (m)	4.0	
Total Phosphorus	0.005	0.008
Ammonia- Nitrogen	<i>0.011</i>	0.005
Nitrite-Nitrogen	0.001	0.001
Nitrate- Nitrogen	<i>0.031</i>	0.202
Total Kjeldahl Nitrogen	0.24	0.23
Dissolved Organic Carbon	5.0	4.3
Dissolved Inorganic Carbon	1.9	2.1
pH	7.20	6.83
Total Alkalinity	8.0	7.0
Conductivity (uS/cm)	53.0	51.0
Calcium	3.2	3.19
Magnesium	0.838	0.824
Hardness	11.0	11.0
Total Suspended Solids	<i>1.2</i>	0.5
Total Dissolved Solids	35.0	33.0

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

MOB = meter off bottom

Appendix 1b.

Water Chemistry Summary for Trout Lake (Main Basin) from the MOECC Lake Monitoring Program (2014).

Parameter	03-Sep-14	
	Euphotic	MOB
Secchi Disk (m)	4.0	
Total Phosphorus	0.005	0.005
Ammonia- Nitrogen	<i>0.009</i>	0.005
Nitrite-Nitrogen	0.001	0.001
Nitrate- Nitrogen	<i>0.033</i>	0.194
Total Kjeldahl Nitrogen	0.18	0.25
Dissolved Organic Carbon	3.9	3.3
Dissolved Inorganic Carbon	3.4	3.7
pH	7.52	7.24
Total Alkalinity	13.4	13.8
Conductivity (uS/cm)	98.0	99.0
Calcium	5.43	5.32
Magnesium	1.43	1.46
Hardness	19.0	19.0
Total Suspended Solids	<i>0.9</i>	<i>0.5</i>
Total Dissolved Solids	64.0	64.0

Notes:

Results given in italics indicate a measurable trace amount which should be interpreted with caution

Shaded cells indicate the method detection limit (MDL) (i.e. the true value could not be reliably detected and is less than or equal to MDL)

All units in mg/L unless otherwise stated

MOB = meter off bottom

Appendix 2a.

Summary of dissolved oxygen and temperature data from Four Mile Bay in 1993, 1994, 2002, 2014, and 2015.

Measured Depth (m)	15-Sep-93		14-Sep-94		27-Aug-02		02-Sep-14		11-Sep-15	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.1	16.1	8.7	18.2	9	22.2	8.1	21.47	9.18	20.84	9.04
1	16	8.6	<i>18.05</i>	9	22.1	8.5	21.41	9.3	20.98	8.79
2	16	8.6	17.9	9	22	8.6	21.27	9.3	20.98	8.8
3	15.9	8.5	17.7	<i>8.95</i>	21.9	8.7	20.97	9.3	20.94	8.74
4	15.8	8.5	17.5	8.9	<i>21.65</i>	8.6	20.37	9.19	20.85	8.69
5	15.5	8.4	17.3	<i>13.8</i>	21.4	8.5	18.13	8.86	20.61	8.61
6	15.3	8.4	17.1	18.7	17.8	<i>9.25</i>	17.41	9.02	19.41	8.28
7	15	8.4	16.2	<i>13.25</i>	14.2	10	15.27	8.1	15.88	7.65
8	14	8.2	15.3	7.8	<i>12.1</i>	<i>10.1</i>	11.26	8.15	10.91	7.99
9	11.5	7.4	12.7	<i>7.4</i>	10	10.2	8.36	8.17	8.92	8.01
10	8	7.9	10.1	7	9	10.3	7.57	8.45	7.43	8.04
11	7	7.8	<i>9.05</i>	<i>7.15</i>	8.5	9.7	7.15	8.47	6.92	7.77
12	7	7.7	8	7.3	8.1	9.7	6.77	8.47	6.5	7.82
13	6.5	7.7	<i>7.55</i>	7.3	7.9	9.5	6.39	8.61	6.2	7.75
14	6	7.6	7.1	7.3	<i>7.75</i>	9.5	5.99	8.7	5.95	7.87
15	6	7.6	7	<i>7.25</i>	7.6	9.5	5.85	8.67	5.82	7.91
16	6	7.7	6.9	7.2	7.5	<i>9.55</i>	5.72	8.64	5.61	7.77
17	6	7.6	6.7	<i>7.1</i>	7.4	9.6	5.69	8.63	5.55	7.72
18	6	7.4	6.5	7	<i>7.35</i>	9.4	5.65	8.44	5.52	7.7
19	6	7.4	<i>6.35</i>	6.9	7.3	9.2	5.6	8.37	5.46	7.51
20	5.8	7.3	6.2	6.8	<i>7.25</i>	<i>9.1</i>	5.54	8.34	5.4	7.44
21	5.8	7.2	<i>6.15</i>	6.8	7.2	9	5.52	8.23	5.33	7.36
22	5.5	7.2	6.1	6.8	<i>7.15</i>	8.9	5.49	8.24	5.28	7.31
23	5.5	7.1	6.1	<i>6.75</i>	7.1	8.8	5.46	8.1	5.26	7.23
24	5.5	7.1	6.1	6.7	<i>7.1</i>	8.6	5.43	8.1	5.2	7.19
25	5.5	7.1	6.1	<i>6.45</i>	7.1	8.4	5.39	8.02	5.16	7.2
26	5.5	6.9	6.1	6.2	<i>7.05</i>	<i>8.35</i>	5.36	7.97	5.12	7.2
27	5.5	6.6	<i>6.05</i>	6.1	7	8.3	5.32	7.7	5.09	7.13
28	5.5	4	6	6	6.9	8.1	5.26	7.41	5.06	6.99
29			6	<i>4.65</i>	6.9	8.1	5.23	6.96	4.99	6.56
30			6	3.3			5.22	6.65	4.97	6.11

Notes:

Red/Italic text indicates interpolated value.

Appendix 2b. Summary of dissolved oxygen and temperature data from Trout Lake (Main Basin) in 1987, 1989, 1994, 2001, 2006, 2014, and 2015.

Measured Depth (m)	14-Sep-87		14-Sep-89		14-Sep-94		21-Aug-01		27-Aug-02		16-Aug-06		02-Sep-14		11-Sep-15	
	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0.1					18.1	8.6	22	8.5	21.4	8.1	21.7	9.2	20.88	8.8	15.25	9.83
1					18	8.6	21.8	8.7	21.4	8.9	21.6	9.3	21.24	9.14	21.03	8.86
2	18.80	8.50	18.1	9.0	17.9	8.6	21.8	8.7	21.45	8.85	21.5	9.4	21.22	9.16	21.04	8.85
3	18.65	8.50	18.1	8.95	17.7	8.55	21.8	8.7	21.5	8.8	21.5	9.4	21.17	9.17	21.01	8.81
4	18.50	8.50	18.1	8.9	17.5	8.5	21.65	8.8	21.45	8.75	21.5	9.4	21.1	9.17	21	8.82
5	18.50	8.50	18.1	8.9	17.3	8.45	21.5	8.9	21.4	8.7	21.5	9.4	20.91	9.2	20.96	8.79
6	18.50	8.50	18.1	8.9	17.1	8.4	21.5	8.9	21.4	8.5	21.4	9.5	20.78	9.17	20.96	8.76
7	18.50	8.50	18.05	8.85	17.1	8.4	21.5	8.9	21.4	8.3	21.4	9.4	20.73	9.17	20.96	8.75
8	18.50	8.50	18.0	8.8	17.1	8.4	20	8.95	21.1	8.3	21.3	9.4	20.56	9.14	20.92	8.77
9	18.40	8.45	15	8.8	17.05	8.4	18.5	9	12	9.8	12.4	11	18.52	9	20.02	8.63
10	18.30	8.40	12.0	8.8	17	8.4	15.75	8.95	10.9	10.2	10.9	11	13.8	9.06	16.58	9.35
11	15.40	8.50	10.75	8.75	14.25	7.9	13	8.9	9.6	10	10.1	11.1	10.58	9.33	11.85	8.75
12	12.50	8.60	9.5	8.7	11.5	7.4	11.1	8.85	8.5	10.1	9.8	11.2	8.55	9.72	9.38	8.94
13	11.00	8.55	8.75	8.55	9.75	7.55	9.2	8.8	8.4	10.1	9.4	11.4	8.1	9.81	7.99	9
14	9.50	8.50	8.0	8.4	8	7.7	8.1	8.95	8.1	10.2	8.5	11.4	7.5	9.68	7.18	9
15	9.50	8.45	7.6	8.45	7.75	7.8	7	9.1	8	9.7	8.2	11.4	7.24	9.8	6.88	8.89
16	9.50	8.40	7.2	8.5	7.5	7.9	6.9	9.2	7.65	10	7.9	11.3	6.98	9.91	6.86	9.02
17	9.00	8.40	7.1	8.5	7.3	7.9	6.8	9.3	7.7	10.3	7.7	11.3	6.8	9.67	6.51	8.93
18	8.50	8.40	7.0	8.5	7.1	7.9	6.65	9.35	7.65	10.25	7.4	11.4	6.66	9.65	6.38	8.92
19	8.40	8.40	7	8.5	7.1	8	6.5	9.4	7.6	10.2	7.3	11.4	6.43	9.61	6.25	8.92
20	8.30	8.40	7.0	8.5	7.1	8.1	6.5	9.4	7.5	10.1	7.2	11.4	6.37	9.58	6.21	8.89
21	8.25	8.35	6.9	8.45	7.05	8.15	6.5	9.4	7.4	10	7.2	11.4	6.32	9.55	6.16	8.86
22	8.20	8.30	6.8	8.4	7	8.2	6.3	9.45	7.35	10.25	7.2	11.4	6.22	9.53	6.12	8.84
23	8.10	8.30	6.7	8.35	7	8.2	6.1	9.5	7.3	10.5	7.1	11.4	6.18	9.49	6.07	8.87
24	8.00	8.30	6.6	8.3	7	8.2	6.05	9.45	7.25	10.45	7	11.4	6.15	9.49	6.04	8.84
25	8.10	8.30	6.6	8.35	7	8.25	6	9.4	7.2	10.4	6.95	11.4	6.13	9.48	6.02	8.83
26	8.20	8.30	6.6	8.4	7	8.3	6	9.55	7.2	10.45	6.9	11.4	6.11	9.48	6	8.84
27	8.10	8.25	6.6	8.4	6.95	8.3	6	9.7	7.2	10.5	6.85	11.4	6.09	9.49	5.98	8.86
28	8.00	8.20	6.6	8.4	6.9	8.3	6	9.7	7.2	10.5	6.8	11.3	6.07	9.5	5.93	8.84
29	8.00	8.30	6.5	8.4	6.9	8.3	6	9.7	7.2	10.5	6.75	11.3	6.04	9.51	5.9	8.87
30	8.00	8.40	6.4	8.4	6.9	8.3	6	9.7	7.15	10.5	6.7	11.3	6.02	9.51	5.88	8.89
31	8.00	8.40	6.3	8.4	6.85	8.45	6	9.7	7.1	10.5	6.72	11.3	5.98	9.54	5.86	8.92
32	8.00	8.40	6.2	8.4	6.8	8.8	5.95	9.7	7.1	10.45	6.74	11.3	5.96	9.54	5.84	8.91
33	7.90	8.50	6.15	8.3	6.65	8.55	5.9	9.7	7.1	10.4	6.76	11.3	5.93	9.53	5.82	8.9
34	7.80	8.60	6.1	8.2	6.5	8.5	5.9	9.65	7.1	10.35	6.78	11.3	5.91	9.57	5.77	8.88
35	7.80	8.55	6.05	8.25	6.35	8.3	5.9	9.6	7.1	10.3	6.8	11.3	5.9	9.59	5.74	8.88
36	7.80	8.50	6.0	8.3	6.2	8.1	5.7	9.65	7.05	10.3	6.76	11.3	5.87	9.59	5.71	8.89
37	7.80	8.55	6	8.45	6.15	8.05	5.5	9.7	7	10.3	6.72	11.3	5.86	9.58	5.63	8.9
38	7.80	8.80	6.0	8.6	6.1	8	5.5	9.65	6.95	10.2	6.68	11.3	5.79	9.59	5.56	8.91
39	7.80	8.50	6	8.6	6.05	7.8	5.5	9.6	6.9	10.1	6.64	11.3	5.79	9.58	5.51	8.94
40	7.80	8.40	6.0	8.6	6	7.8	5.35	9.6	6.85	9.95	6.8	11.3	5.77	9.59	5.47	8.92
41	7.65	8.40	6	8.55	5.95	7.4	5.2	9.6	6.8	9.8	6.54	11.32	5.74	9.58	5.43	8.88
42	7.50	8.40	6.0	8.5	5.9	7.2	5.15	9.55	6.75	9.8	6.48	11.34	5.69	9.57	5.39	8.84
43	7.50	8.35	6	8.55	5.9	7.15	5.1	9.5	6.7	9.8	6.42	11.36	5.6	9.54	5.36	8.75
44	7.50	8.30	6.0	8.6	5.9	7.1	5.05	9.55	6.7	9.8	6.36	11.38	5.57	9.51	5.35	8.73
45	7.35	8.30	5.95	8.6	5.9	6.95	5	9.6	6.7	9.8	6.3	11.4	5.53	9.46	5.3	8.66
46	7.20	8.30	5.9	8.6	5.9	6.8	5	9.55	6.65	9.7	6.24	11.4	5.51	9.42	5.25	8.69
47	7.20	8.25	5.9	8.55	5.9	6.75	5	9.5	6.6	9.6	6.18	11.4	5.46	9.33	5.22	8.68
48	7.20	8.20	5.9	8.5	5.9	6.7	5	9.45	6.6	9.5	6.12	11.4	5.44	9.32	5.2	8.58
49	7.20	8.20	5.9	8.45	5.9	6.55	5	9.4	6.8	9.4	6.06	11.4	5.44	9.26	5.14	8.48
50	7.20	8.20	5.9	8.4	5.9	6.4	5	9.35	6.6	9.4	6	11.4	5.43	9.24	5.11	8.35
51	7.20	8.20	5.9	8.4	5.9	6.4	5	9.3	6.6	9.4	5.96	11.3	5.4	9.18	5.1	8.29
52	7.20	8.20	5.9	8.4	5.9	6.4	5	9.2	6.55	9.4	5.92	11.2	5.4	9.11	5.1	8.27
53	7.20	8.30	5.85	8.4	5.9	6.4	5	9.1	6.5	9.4	5.88	11.1	5.37	9.02	5.09	8.2
54	7.20	8.40	5.8	8.4	5.9	6.4	5	9.1	6.5	9.4	5.84	11	5.28	9.04	5.08	8.18
55	7.10	8.30	5.75	8.4	5.9	6.4	5	9.1	6.5	9.4	5.8	10.9	5.24	8.99	5.08	8.18
56	7.00	8.20	5.7	8.4	5.9	6.4	5	8.85	6.5	9.35	5.75	10.75	5.21	8.95	5.08	8.15
57	7.00	8.25	5.65	8.35	5.9	6.45	5	8.6	6.5	9.3	5.7	10.6	5.18	8.91	5.08	8.12
58	7.00	8.30	5.6	8.3	5.9	6.5	4.92	8.73	6.5	9.25	5.63	10.65	5.14	8.86	5.08	7.88
59	7.00	8.20	5.6	8.25	5.9	6.6	4.91	8.66	6.5	9.2	5.58	10.58	5.11	8.82	4.97	7.89
60	7.00	8.10	5.6	8.2	5.9	6.7	4.90	8.59	6.45	9.2	5.52	10.51	5.08	8.78	4.95	7.83
61	6.93	7.29	5.55	8.20	5.90	5.70	4.89	8.52	6.4	9.2	5.47	10.44	5.04	8.74	4.93	7.77
62	6.90	7.17	5.52	8.18	5.90	5.60	4.88	8.45	6.4	9.2	5.42	10.37	5.01	8.69	4.91	7.71
63	6.88	7.08	5.48	8.15	5.90	5.49	4.87	8.38	6.39	9.14	5.37	10.30	4.98	8.65	4.88	7.65
64	6.85	6.94	5.45	8.13	5.90	5.39	4.86	8.31	6.37	9.12	5.32	10.23	4.94	8.61	4.86	7.59
65	6.83	6.82	5.42	8.10	5.90	5.29	4.84	8.24	6.35	9.09	5.27	10.16	4.91	8.56	4.84	7.53
66	6.80	6.70	5.39	8.08	5.90	5.18	4.83	8.17	6.34	9.07	5.22	10.09	4.88	8.52	4.82	7.47
67	6.78	6.68	5.36	8.05	5.90	5.08	4.82	8.10	6.32	9.05	5.17	10.02	4.84	8.48	4.80	7.41
68	6.75	6.46	5.33	8.03	5.90	4.98	4.81	8.04	6.31	9.02	5.12	9.95	4.81	8.43	4.77	7.35
69	6.73	6.35	5.30	8.00	5.90	4.87	4.80	7.97	6.29	9.00	5.06	9.88	4.78	8.39	4.75	7.29
70	6.70	6.23	5.27	7.98	5.90	4.77	4.79	7.90	6.27	8.98	5.01	9.82	4.74	8.35	4.73	7.23
71	6.68	6.11	5.24	7.95	5.90	4.67	4.78	7.83	6.26	8.95	4.96	9.75	4.71	8.31	4.71	7.17
72	6.65	5.99	5.21	7.93	5.90	4.58	4.77	7.76	6.24	8.93	4.91	9.68	4.68	8.26	4.68	7.11

Notes:

Red/italic text indicates interpolated and/or extrapolated value.

Appendix 2: Lakeshore Capacity Model for Trout Lake.

Lakeshore Capacity Model - Info on Version 4.0 (updated November 2011)

1. This model has been updated to reflect the Ontario Ministry of the Environment's Lakeshore Capacity Assessment Handbook released in July 2010.
2. Unless otherwise specified, coefficients are derived from Paterson et al. (2006).
3. The model is calibrated to predict the whole lake ice-free mean total phosphorus concentration of the lake. This is reflected in the final output value TPlake.
4. Lakes that are smaller than 25 ha are not modeled, unless they have significant shoreline development. The surface and catchment area of lakes <25 ha are added to the catchment area of the larger downstream lake.
5. Vacant lots of record refers to lots that are designated as residential, but have not yet been cleared for development. The model assumes that these lots will eventually be developed into extended seasonal cottages, unless otherwise specified. Vacant lots of record are used when calculating future anthropogenic load.
6. Current development is inferred based on examination of topographic maps, aerial photographs, and municipal datasets. Land use schedules used where available.
7. All runoff coefficients determined based on decimal degree coordinates obtained from GeoPortal and converted to degrees/minutes/seconds.
8. Lake stats (catchment, wetlands etc) have been obtained from GIS.
9. Relationships between spreadsheets have been established with respect to lake flow schematics for the Brule Lake Watershed (lakes >25 ha).
10. A lake is considered anoxic where the average late summer DO (August 15 -September 15) is less than 1mg/L at 1 meter off bottom. Where no DO data is available, lakes with a maximum depth of less than 12 m (or average depth of < 4m) are assumed to become anoxic at 1 meter off bottom during the late summer critical period. Where no depth information is available, small lakes < 35 ha are assumed to be anoxic.

Lakeshore Capacity Model – Coefficients

Anthropogenic Supply

<u>Shoreline Development Type</u>	<u>Usage</u>	<u>Units</u>
Permanent	2.56	capita years/yr
Extended Seasonal	1.27	capita years/yr
Seasonal	0.69	capita years/yr
Resort	1.18	capita years/yr
Trailer Parks	0.69	capita years/yr
Youth Camps	0.125	kg/capita/yr
Campgrounds/Tent trailers/RV parks	0.37	capita years/yr
Vacant Lots of Record	1.27	capita years/yr
Per lot TP load	0.04	kg/lot/yr
Per capita load	0.66	kg/capita/yr

Intensive Land Use

Crop agriculture	30	mg/m ² /yr
Urbanization	50	mg/m ² /yr
Golf course	14	mg/m ² /yr (Winter et al. 2006)

Natural Supply

P in Precipitation/Atmospheric Dep.	16.7	mg/m ² /yr
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Watershed Descriptors

Default Wetland	15	%
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Forested Watersheds

< 15% cleared land	5.5	mg/m ² /yr
≥ 15% cleared land	9.8	mg/m ² /yr

Wetland Export Equation

Natural P load from catchment = $Ad * (0.47 * \% \text{ wetland area} + 3.82)$

Slope	0.47
Constant	3.82

Sedimentation

Retention coefficient (R_p) = $v / (v + q_s)$

Anoxic	7.2	m/yr
Oxic	12.4	m/yr

Relationship between Spring Overturn and Mixed Whole Lake TP (based on long-term mean; Clark et al. 2010)

$TP_{lake} = 0.992 * TP_{so} - 0.563$

Slope	0.992
Constant	-0.563

Lakeshore Capacity Model – Inputs

Lake	Lat	Long	Runoff (m) from Database	Surface area, Ao (ha)	Catchment area, Ad (ha)	% Wetland	% Cleared	Years of spring TP sampling	No. of TP samples	Avg. Measured TPso (µg/L)	Hypolimnetic DO (mg/L)	Anoxic?	LT Lake?	Max Depth (m)	Mean Depth (m)	Hydrologic Flow
Four Mile Lake (west)	46 23 08	79 23 11	0.512	48.3	122	12.9	21.49	4	6	6.94	< 1 mg/L	Y	N	8.60	2.70	To Four Mile Lake (east)
Four Mile Lake (east)	46 22 46	79 22 25	0.500	34.76	145.68	3.59	12.41	5	7	8.75	< 1 mg/L	Y	N	5.10	2.70	To Four Mile Bay
Four Mile Bay	46 19 26	79 16 20	0.501	324.66	4289.04	4.81	11.01	8	23	5.88	> 1 mg/L	N	Y	27.00	N/A	To Trout Lake
Trout Lake	46 18 50	79 15 35	0.481	1562.25	5912.39	10.88	21.00	8	60	4.19	> 1 mg/L	N	Y	63.00	16.90	TARGET

Lakeshore Capacity Model - Anthropogenic Inputs

Lake	Lat	Long	Permanent	Extended Seasonal	Seasonal	Resort	Trailer Parks	Youth Camps	Campgrounds/ Tent trailers/ RV parks	Vacant Lots of Record	Other (e.g., agriculture, urbanization, golf course)
Four Mile Lake (west)	46 23 08	79 23 11	22		3					6	
Four Mile Lake (east)	46 22 46	79 22 25	20		6					7	
Four Mile Bay	46 19 26	79 16 20	142		73					22	
Trout Lake	46 18 50	79 15 35	618		186				20	150	

Lakeshore Capacity Model

Four Mile Lake (west)

Anthropogenic Supply			Sedimentation	
<u>Shoreline Development Type</u>	<u>Number</u>	<u>Usage (capita years/yr)</u>	Is the lake anoxic?	Y
Permanent	22	2.56	Settling velocity (v)	7.2 m/yr
Extended Seasonal	0	1.27	In lake retention (Rp)	0.80
Seasonal	3	0.69		
Resort	0	1.18		
Trailer Parks	0	0.69		
Youth Camps	0	0.125		
Campgrounds/Tent trailers/RV parks	0	0.37		
Vacant Lots of Record	6	1.27		
Retention by soil (Rs) (0-1)	0			
Catchment			Monitoring Data	
			Years of spring TP data	4
			Average Measured TPso	6.94 µg/L
			Measured vs. Predicted TPso	150.7 %
			Is the model applicable?	over
			Over or under predicted?	
Upstream Lakes			Modeling Results	
			TPlake	16.69 µg/L
			TPout	15.96 µg/L
			TPso	17.39 µg/L
			TPfuture	17.96 µg/L
Hydrological Flow			Phosphorus Thresholds	
Mean annual runoff	0.512	m/yr	TPbk	7.18 µg/L
Lake outflow discharge (Q)	873735	m3/yr	TPbk+40	10.05 µg/L
Areal water loading rate (qs)	1.81	m/yr	TPbk+50	10.77 µg/L
Inflow 1		m3/yr	TPbk+60	11.49 µg/L
Natural Loading			*if TPbk+40% < TPlake < TPbk+60% cell is orange	
Atmospheric Load	8.06	kg/yr	*if TPlake > TPbk+60% cell is red	
Runoff Load	21.79	kg/yr	No. of allowable residences to reach capacity:	
Upstream Loading			# Permanent OR	N/A
Background Upstream Load 1		kg/yr	# Extended seasonal OR	N/A
Current Total Upstream Load 1		kg/yr	# Seasonal cottages OR	N/A
Future Upstream Load 1		kg/yr	Loads	
Anthropogenic Loading			Natural Load w/no development	29.85 kg/yr
Current Anthropogenic Load	39.54	kg/yr	Background + 50% Load	44.78 kg/yr
Future Anthropogenic Load	44.81	kg/yr	Current Load	69.39 kg/yr
Areal Load Rate			Future Load	74.66 kg/yr
Current Total Areal Loading Rate (LT)	143.81	mg/m2/yr	Outflow Loads	
Future Total Areal Loading Rate (LFT)	154.73	mg/m2/yr	Background Outflow Load	6.00 kg/yr
			Current Outflow Load	13.94 kg/yr
			Future Outflow Load	15.00 kg/yr

Lakeshore Capacity Model Four Mile Lake (east)

Anthropogenic Supply			Sedimentation	
<u>Shoreline Development Type</u>	<u>Number</u>	<u>Usage (capita years/yr)</u>	Is the lake anoxic?	Y
Permanent	20	2.56	Settling velocity (v)	7.2 m/yr
Extended Seasonal	0	1.27	In lake retention (Rp)	0.58
Seasonal	6	0.69		
Resort	0	1.18		
Trailer Parks	0	0.69		
Youth Camps	0	0.125	Monitoring Data	
Campgrounds/Tent trailers/RV parks	0	0.37	Years of spring TP data	5
Vacant Lots of Record	7	1.27	Average Measured TPso	8.75 µg/L
			Measured vs. Predicted TPso	90.4 %
			Is the model applicable?	
			Over or under predicted?	over
Catchment			Modeling Results	
Lake Area (Ao)	34.8	ha	TPlake	15.97 µg/L
Catchment Area (Ad)	145.7	ha	TPout	15.27 µg/L
Wetland	3.6	%	TPso	16.66 µg/L
Cleared	12.4	%	TPfuture	17.73 µg/L
Hydrological Flow			Phosphorus Thresholds	
Mean annual runoff	0.500	m/yr	TPbk	4.85 µg/L
Lake outflow discharge (Q)	1775954	m3/yr	TPbk+40	6.79 µg/L
Areal water loading rate (qs)	5.11	m/yr	TPbk+50	7.27 µg/L
Inflow 1	873735	m3/yr	TPbk+60	7.76 µg/L
Natural Loading			*If TPbk+40% < TPlake < TPbk+60% cell is orange	
Atmospheric Load	5.81	kg/yr	*If TPlake > TPbk+60% cell is red	
Runoff Load	8.02	kg/yr	No. of allowable residences to reach capacity:	
Upstream Loading			# Permanent OR	N/A
Background Upstream Load 1	6.00	kg/yr	# Extended seasonal OR	N/A
Current Total Upstream Load 1	13.94	kg/yr	# Seasonal cottages OR	N/A
Future Upstream Load 1	15.00	kg/yr	Loads	
Anthropogenic Loading			Natural Load w/no development	19.83 kg/yr
Current Anthropogenic Load	37.56	kg/yr	Background + 50% Load	29.74 kg/yr
Future Anthropogenic Load	43.71	kg/yr	Current Load	65.34 kg/yr
Areal Load Rate			Future Load	72.54 kg/yr
Current Total Areal Loading Rate (LT)	187.95	mg/m2/yr	Outflow Loads	
Future Total Areal Loading Rate (LFT)	208.68	mg/m2/yr	Background Outflow Load	8.23 kg/yr
			Current Outflow Load	27.12 kg/yr
			Future Outflow Load	30.11 kg/yr

Lakeshore Capacity Model - Summary Results

Lake	Model Predictions (µg/L)										Measured vs. Predicted TPso (%)	Model applicable?	Over or under predicted?	TPlake vs. TPbk+50%	Over capacity?	Available Capacity			Loads (kg/yr)			
	TP out	TP lake	TP so	TP future	TP bk	TP bk+40%	TP bk+50%	TP bk+60%	Measured TPso (µg/L)	# Permanent OR						# Extended seasonal OR	# Seasonal cottages OR	Bk +50% P load	Current P load	Allowable P load	Future P load	
Four Mile (west)	15.96	16.69	17.39	17.96	7.18	10.05	10.77	11.49	8.94	150.71		over	5.92	N/A	N/A	N/A	N/A	44.78	69.39	-24.61	74.66	
Four Mile (east)	15.27	15.97	16.66	17.73	4.85	6.79	7.27	7.76	8.75	90.36		over	8.70	N/A	N/A	N/A	N/A	29.74	65.34	-35.60	72.54	
Four Mile Bay	9.58	10.02	10.65	10.38	5.19	7.27	7.79	8.30	5.88	81.46		over	2.23	N/A	N/A	N/A	N/A	484.88	623.91	-139.03	646.22	
Trout Lake	10.30	10.77	11.42	10.83	5.51	7.71	8.26	8.81	4.19	172.95		over	2.51	N/A	N/A	N/A	N/A	2010.21	2621.73	-511.52	2536.40	