6.0 North Bay

6.1 Introduction & Summary of Findings

This Section includes analyses of vulnerability with respect to both water quantity and water quality for the surface water intake for the City of North Bay. General methodology for water quality vulnerability assessments for surface water systems is described in Section 3 of this report. The information specific to water quality vulnerability in this Section is based primarily on the Surface Water Vulnerability and Threats Assessment for Drinking Water Source Protection for the City of North Bay, 2010a, prepared by AECOM Canada, and includes the following:

- intake characterization (including water treatment plant and raw water quality);
- intake protection zone (IPZ) delineations;
- uncertainty analysis of IPZ delineations and vulnerability scores;
- drinking water issues evaluation;
- threat identification and assessment; and
- gap analysis and recommendations

The primary purpose is to identify existing and potential activities that could negatively impact the quality of drinking water. To that end, the conclusions must summarize all circumstances that could pose either chemical or pathogenic threats based on the MOE Table of Drinking Water Threats.

Water quantity assessments were reviewed by a peer review committee as well as by the Manager of Environmental Services for the City of North Bay. Technical review of the water quality assessment was provided by a technical advisory committee, which consisted primarily of members of the Trout Lake Watershed Advisory Committee, a multi-stakeholder committee including representatives of various ministries, institutions, associations and municipalities. Local knowledge was solicited and comments received at two public meetings, one early in the process and another when the draft findings were presented. Additional peer review was not conducted because the technical challenges posed by the assessment were considered well within the expertise of the consultant. The full report is available at www.actforcleanwater.ca or directly from the North Bay-Mattawa Conservation Authority.

Based on this evaluation, there are no existing significant drinking water threats related to either chemicals or pathogens for the City of North Bay.

However, the North Bay-Mattawa Source Protection Committee (SPC) has submitted a request to the Ministry of Environment (MOE) to add, as a local threat, the transportation of hazardous substances along the rail line and highway that run through the Intake Protection Zone-1 (adjacent to Delaney Bay where the source water intake is located). The MOE decision is pending.

6.2 Water Budget and Water Quantity Stress Assessment

General principles were explained earlier in Section 2.5 Conceptual Water Budget. The methodology specified in the Technical Rules Part III describes a tiered approach whereby all subwatersheds are subjected to a Tier One Subwatershed Stress Assessment and if stress is low during all months of the year, no further assessment is required. If stress levels are shown to be either moderate or significant, a more robust Tier Two Subwatershed Stress Assessment is completed and, similarly if that reveals moderate or significant stress, a Tier Three Local Area Risk Assessment must be undertaken

The subwatershed analyzed to assess quantity stress related to the City of North Bay supply is a combination of the contributing areas to both Trout Lake and Turtle Lake, herein referred to as the Trout/Turtle Lake subwatershed.

The channel between the two lakes was previously lowered by blasting and the outlet of Turtle Lake is controlled by a stop-log dam such that the water surface of both lakes is contiguous. The Trout/Turtle subwatershed from which the City of North Bay draws its water underwent all three tiers of analysis for water quantity. The Tier One Subwatershed Stress Assessment was completed by Gartner Lee Ltd (2008b). The Tier Two Subwatershed Stress Assessment and Tier Three Local Area Risk Assessment were undertaken by AquaResource (2010). For the Tier Two and Three studies, in addition to a surface water flow model, a reservoir routing model was developed enabling verification of model results to a secondary dataset to increase confidence. Since there are no hydrometric gauges on the Trout/Turtle outflow, the adjacent LaVase River and Chippewa Creek subwatersheds were both modelled and the water budget components applied as appropriate to model the Trout/Turtle subwatershed. Further detail is provided below, while a comprehensive description of the approach used for water budget modelling is provided in Appendix B of the Trout/Turtle Lake Tier Two Subwatershed Stress Assessment and Tier Three Local Area Risk Assessment report, available at www.actforcleanwater.ca.

To further understand the nature of the hydrologic flows within a subwatershed and protect vulnerable areas, there is also a need to identify Significant Groundwater Recharge Areas (SGRAs). These are areas which typically facilitate the transmission of precipitation to recharge the aquifer. SGRAs for the Trout/Turtle Lake subwatershed were identified using the threshold of 115% as per Rule 44(1), further described below.

The purpose of this analysis is to make sure that the dynamics of the system area are well enough understood to ensure the water supply is well managed now and into the future. Ontario Regulation 287/07 Section 1.1(1) identifies 21 prescribed drinking water threats for the purpose of defining “drinking water threat” under the *Clean Water Act (2006)* subsection 2(1).

Two of these relate to water quantity threats as follows:

- an activity that takes water from an aquifer or surface water body without returning the water taken to the same aquifer or surface water body; and
- an activity that reduces the recharge of an aquifer.

The City of North Bay withdraws drinking water from Trout Lake in the Ottawa River watershed and returns the treated wastewater to Lake Nipissing in the Great Lakes watershed. This practice significantly predates the Great Lakes Charter Annex (2001) (see Section 2.8 Great Lakes Agreements) and is permitted under Ontario Permit To Take Water 6565-7T6PTN. All such inter-basin transfers do constitute a prescribed threat as per clause 19 above. Further, Trout Lake is located in the headwaters of the Mattawa River and it depends on a relatively small basin to capture precipitation to maintain lake levels. This makes it more vulnerable to over-exploitation; however the City of North Bay has in place policies and practices intended to minimize over use and loss.

Historically, the Trout Lake water level has never dropped below the drinking water intake. The intake is located in Delaney Bay of Trout Lake at a depth of 21.5 m. Therefore the lake can function as a reservoir for significant periods continuing to provide water to the North Bay system even if the level of the lake was dropping. Therefore, the tiered assessments focus on scenario two and three: percent water demand under normal conditions and the drought assessment scenario as necessary.

A subwatershed's potential for stress is estimated by comparing the amount of water consumed to the amount of water flowing through the subwatershed. Estimated consumptive demand, when divided by the available water supply, minus a reserve term (to allow for other users and ecological demands), and expressed as a percentage, results in a value known as Percent Water Demand. If the moderate or low threshold is surpassed at the Tier One level, a Tier Two assessment is required. The Provincial Thresholds are shown in Table 6-1 below:

Table 6-1. Thresholds for Stress Levels based on Percent Water Demand

Surface Water Potential Stress Level Assignment	Maximum Monthly (%) Water Demand
Significant	≥ 50%
Moderate	> 20% and < 50%
Low	≤ 20%

The percent water demand calculations and threshold values in a Tier Two Subwatershed Stress Assessment are the same as a Tier One Subwatershed Stress Assessment. However, the Tier Two assessment uses more refined water demand estimates as well as a more advanced water budget model, including both a continuous surface flow model and a groundwater flow model. For the Trout/Turtle Lake subwatershed, there are no permitted groundwater takings and the sole municipal water supply is from Trout Lake. As such, a groundwater flow model was not considered.

Municipal water supplies within a confirmed Moderate or Significant potential for stress at the Tier Two level proceed to a locally focused Tier Three Local Area Risk Assessment. The object of the Tier Three Assessment is to estimate the likelihood that municipalities will be able to meet current and future water quantity requirements, while meeting the needs of other water uses. Water budget modelling at the Tier Three level is even more sophisticated than the other Tiered Assessments.

The tasks required to assess the Risk level of each Local Area within a Tier Three Local Area Risk Assessment are listed below:

1. Local Area Delineation. The Local Area for a surface water intake is referred to as an intake protection zone for water quantity, abbreviated as "IPZ-Q". IPZ-Qs are delineated by determining the total drainage area that provides water to a municipal intake located within subwatersheds identified through a Tier Two Subwatershed Stress Assessment as having a Moderate or Significant potential for stress.
2. Assign Tolerance Level. Tolerance is defined as the municipal system's ability to meet peak water demands. If the municipal system is able to meet peak water demands, a Tolerance level of "High" is assigned. If the municipal system is not able to meet the peak water demands, a Tolerance level of "Low" is assigned.
3. Assign Exposure Level. Exposure evaluates whether a Local Area can supply sufficient water to meet the demands of the municipal system, and other water users. Four scenarios are tested to determine the resiliency of the Local Area to drought conditions, increased municipal takings and potential future changes in land use. If the Local Area can supply sufficient water to the municipal system, without causing adverse effects on other water users, an Exposure level of "Low" is assigned. If the Local Area cannot

supply sufficient water, without causing adverse effects to other water users, an Exposure level of "High" is assigned.

4. Assign Risk Level. The Risk Level is essentially the potential that a municipal water supply will not be able to meet its planned pumping rates. Based on the classification of Tolerance and Exposure, the Risk level is assigned to the Local Area. The Risk level for the Local Area may be classified as "Low", "Moderate" or "Significant".

The Risk Level of the Local Area is a combination of the Tolerance and Exposure levels. The Technical Rules (MOE, 2009) outline how Tolerance and Exposure are used to assign Risk. As per Part IX.1 Rule 98, a Local Area related to a surface water intake is assigned a risk level in accordance with the following:

1. Significant, if the local area has an Exposure level of High and the system has a Tolerance of Low;
2. Moderate, if the local area has an Exposure level of High and the system has a Tolerance of High;
3. Moderate, if the local area has an Exposure level of Low and the system has a Tolerance of Low; or
4. Low, if the local area has an Exposure level of Low and the system has a Tolerance level of High.

Municipal System Description

The MOE has granted the City of North Bay a Permit-To-Take-Water for a maximum taking of 79.5 ML/d from Trout Lake for its municipal water supply. Lake water is supplied to the water treatment plant through a 1.2 m diameter intake pipe extending into Delaney Bay of Trout Lake. The 300 m long inlet pipe terminates at an intake crib, which is placed at an elevation of 180.3 mASL (21.5 m below the low lake level).

The City of North Bay's current population is 56,000, with a service-based population of 53,000 which includes 1,000 un-serviced residents. A new water treatment facility, completed in October 2009 and in operation since early 2010, has capacity to supply water to over 80,000 people, with a maximum water supply capacity of 115.9 ML/d (Veritec, 2008a). A new Permit to Take Water would be needed to provide the additional supply necessary to service the additional people. The water treatment facility consists of membrane filtration combined with ultraviolet light disinfection and chlorination.

The City's water distribution system has 14,800 connections, servicing residential and industrial/commercial/institutional (ICI) water users. Approximately 9% of the connections (predominantly ICI water users) are metered and are charged on a volumetric basis. The remaining unmetered connections, mostly residential, are currently charged a flat rate. In 2010, North Bay City Council approved the installation of water meters for the services population as a measure to reduce consumption.

Municipal water use can be divided in the following categories: residential water demand, ICI water demand, distribution system losses, distribution system flushing, and water meter under-reporting. This breakdown, as estimated by Veritec (2008a) is included in Table 6-2.

Table 6-2. Estimated Breakdown of Water Use for City of North Bay for 2006

	Estimated Water Volume (ML/yr)	Per Capita Rate (L/d/cap) based on 54,000 pop.	Percent of Total (%)
ICI	3,582	182	27%
Residential	4,569	232	34%
System Flushing	1,468	74	11%
Leakage & Losses	3,661	186	27%
Water Meter Under-Reporting	126	6	1%
Total	**13,406**	**680**	**100%**

The estimated breakdown of water use for the City of North Bay, as presented above, may contain uncertainties. To estimate the water use, Veritec relied upon empirical relationships because of limited availability of metering data. To estimate the residential portion of water use, meters were installed on a small number (10) of residential connections. These meters were monitored and the results were scaled up to estimate the total City residential water demand. Due to this extrapolation, the values reported in Table 6-2 may have significant uncertainties associated with them, and should be considered estimates.

Veritec estimated that residential and ICI water demand comprises approximately 34% and 27%, respectively, of the total pumped water. The remaining 39% is considered “Non-Revenue Water”, as it is not provided to a customer. This Non-Revenue Water is comprised of water meter under-reporting (1%), flushing required for distribution system maintenance (11%), and distribution system losses (27%). The City of North Bay is currently working on measures to identify and minimize system leakage and losses.

6.2.1 Stress Assessment Results

Tier One and Two Subwatershed Stress Assessments and a Tier Three Local Area Risk Assessment were completed for the Trout/Turtle Lake subwatershed following the Technical Rules (MOE, 2009b) and Guidance Module #7 (MOE, 2007).

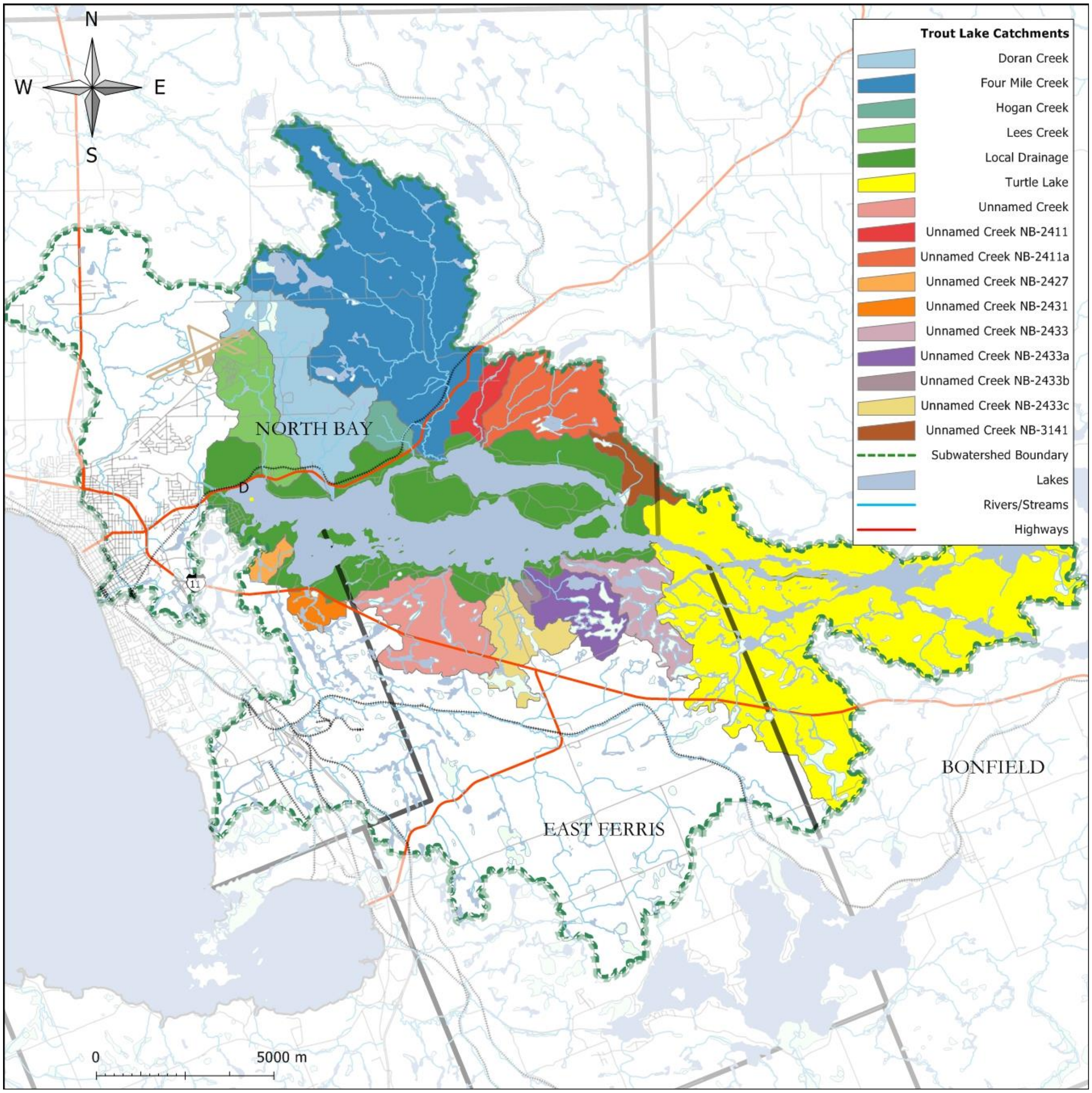
6.2.1.1 Tier One Subwatershed Stress Assessment Results

This Tier One Subwatershed Stress Assessment utilizes available data, first collected and analyzed in the Conceptual Water Budget, to evaluate the cumulative stress within a subwatershed. The screening assessment includes estimating a monthly percentage of the consumptive amount of a water supply that is demanded by water users (Percent Water Demand). In accordance with Part III.3 of the Technical Rules, results of the Percent Water Demand calculations for an existing system will assign a surface water stress level of significant, moderate or low, and determine whether or not to proceed to a further Tier Two Subwatershed Stress Assessment.

Trout/Turtle Lake subwatershed includes the water that falls within the catchment area feeding both Trout and Turtle Lakes (Figure 6-1), which comprises approximately 181 km^2. In the

Trout/Turtle Lake subwatershed water pathways are essentially surface driven. That is, the low permeability bedrock outcrops drive much of the water to runoff to the watercourses. Water that does infiltrate recharges the shallow, more permeable, soil and then follows short groundwater pathways discharging to the watercourses as baseflow. Hence, over a long period of time the change in groundwater storage is essentially zero, and the surface watercourses eventually receive and convey all the water which is not evaporated or transpired.

Figure 6-1. Trout/Turtle Lake Subwatersheds



The Tier One Subwatershed Stress Assessment used an approach that estimated the various components of the hydrologic cycle, including precipitation (P), and evapotranspiration (ET). These were calculated using available precipitation and temperature data (1971-2000) collected during the North Bay–Mattawa Conceptual Water Budget (see Section 2.5 for more details). The calculations were conducted on a monthly basis. Water surplus (precipitation minus actual evapotranspiration) was calculated using the methodology of Thornthwaite and Mather (1957), which took into account mean monthly temperature and precipitation for climate stations within or near the North Bay–Mattawa SP Area.

In addition, the Tier One Subwatershed Stress Assessment takes into account the seasonal variability in streamflow, and is therefore evaluated using expected monthly values. Since none of the contributing streams in Figure 6-1 are gauged, nor is the outlet of Trout or Turtle Lakes, an assessment of the total discharge was made assuming that the watershed was in balance (i.e. inputs = outputs). Downstream on the Mattawa River, below Bouillon Lake is the nearest long term HYDAT gauging station (Number 02JE020). This station relates to a 951.5 km^2 total catchment area which includes the areas of the Trout/Turtle Lake subwatershed. Assuming that the physiography of these areas is quite similar, a proportional analysis of the HYDAT data was done to estimate the outflow characteristics of the subwatershed.

Water reserve is an estimate of the amount of streamflow or lake water that needs to be reserved to support other uses of water within the watershed, including both ecosystem requirements as well as other human uses. Typically the MOE requires considering a 10% reserve for surface water systems to provide supply to the downstream users of the surface water system. However the outlet of Turtle Lake is always observed to be flowing, even when there is no overflow from the dam. That is, the leakage from the dam through the stop logs is significant and is driven by the total head behind the dam, and not the incremental change at the crest. Likewise, the watershed that supplies Trout and Turtle lakes are upstream of the water taking and therefore not affected by the reserve. As a result, reserve was not considered in the percent water demand calculation. NBMCA acknowledges that the Technical Rules require consideration of water reserve, but since the Trout/Turtle Lake subwatershed was determined to proceed to a further more detailed Tier Two assessment, the current analysis within this Tier One level was considered acceptable.

Table 6.3 shows the precipitation, evapotranspiration, surplus, and streamflow results for the Trout/Turtle Lake subwatershed. The average annual precipitation falling on the Trout/Turtle Lake subwatershed is 5.64 m^3/s. Approximately 3.05 m^3/s (or approximately 54% of annual precipitation) is lost through evapotranspiration and 2.59 m^3/s (or approximately 46% of annual precipitation) of water remains as surplus. The amount of surplus is assumed to reach the lake more quickly through runoff and more slowly through groundwater pathways. The total streamflow should theoretically be equal to the surplus, given that groundwater storage changes are negligible over longer periods of time. In this subwatershed, estimated surplus matches with streamflow within about 11%, which is reasonable given the variability of precipitation volumes.

Table 6-3. Monthly and Annual Water Budget Components of Trout/Turtle Lake Subwatershed

Month	Precipitation (m^3/s)	Actual ET (m^3/s)	Surplus (m^3/s)	Streamflow (m^3/s)
January	4.59	0	4.59	1.78
February	3.86	0	3.86	1.65
March	4.46	0	4.46	2.74
April	4.59	1.51	3.07	8.55
May	5.59	5.24	0.35	5.06
June	6.23	7.56	Deficit (-1.33)	2.24
July	6.77	8.32	Deficit (-1.56)	1.57
August	6.42	7.17	Deficit (-0.75)	1.39
September	7.88	4.75	3.14	1.7

Month	Precipitation (m^3/s)	Actual ET (m^3/s)	Surplus (m^3/s)	Streamflow (m^3/s)
October	6.41	2.06	4.36	2.67
November	6.12	0	6.12	3.73
December	4.76	0	4.76	2.75
Annual Average	**5.64**	**3.05**	**2.59**	**2.99**

Percent Water Demand calculations require a quantitative assessment of both the water supply and demand. Water demand was quantified based on the Ministry of Environment Permit to Take Water (PTTW) database for the North Bay - Mattawa SP Area (Table 6-4). The database revealed permit holders located within the Trout Lake subwatershed, including the City of North Bay's municipal water supply, the Department of National Defense for industrial cooling water, a small communal water supply and an agricultural permit for irrigation. The quantities of permitted water taking as reported in the PTTW database are generally presented as maximum allowable takings over a period of time and do not usually reflect the actual taking which is usually lower. As a result, using permitted water takings to estimate water demand typically overestimates the actual demand. Actual water takings for the North Bay Water Treatment Plant were available, and therefore used in this assessment, while the maximum permitted values for the remaining Permits were used as a conservative approach towards estimating water demand.

Table 6-4. Total Water Demand (Takings) of the Trout/Turtle Lake Subwatershed

Month	Water Treatment Plant (m^3/s)	Industrial Cooling (m^3/s)	Communal Water Supply (m^3/s)	Agriculture (m^3/s)	Total Demand (m^3/s)
January	0.424	0.1236	0.0006	0	**0.5483**
February	0.4306	0.1236	0.0006	0	**0.5549**
March	0.43	0.1236	0.0006	0	**0.5543**
April	0.42	0.1236	0.0006	0	**0.5443**
May	0.465	0.1236	0.0006	0	**0.5893**
June	0.5117	0.1236	0.0006	0.0075	**0.6435**
July	0.4836	0.1236	0.0006	0.0075	**0.6154**
August	0.5078	0.1236	0.0006	0.0075	**0.6396**
September	0.4414	0.1236	0.0006	0	**0.5657**
October	0.4013	0.1236	0.0006	0	**0.5256**
November	0.4013	0.1236	0.0006	0	**0.5256**
December	0.3826	0.1236	0.0006	0	**0.5069**
Annual Avgerage	**0.4416**	**0.1236**	**0.0006**	**0.0019**	**0.5678**

The Percent Water Demand calculation is as follows: *Percent Water Demand = Demand/ (Supply-Reserve)*100*. As already mentioned, water reserve was not included in this assessment.

Surface water stress levels are determined using assigned threshold values based on the maximum monthly Percent Water Demand calculations, where:

1. % Water Demand >=50% is Significant stress
2. % Water Demand 20-50% is Moderate stress
3. % Water Demand <=20 is Low stress

Based on the Percent Water Demand calculations, the findings of the Tier One water budget for Trout/Turtle Lake, as shown in Table 6-5 below, indicated Moderate levels of hydrologic stress in January through March, and June through September. This resulted in a classification of the system as Moderate potential for stress and warranted proceeding to a Tier Two Subwatershed Stress Assessment without the need to model a drought scenario.

Table 6-5. Tier One Level Percent Water Demand and Stress Level of Trout/Turtle Lake Subwatershed

Month	Total Supply (Streamflow) (m^3/s)	Total Demand (takings) (m^3/s)	% Water Demand	Stress Level Assignment
January	1.781	0.5483	31	Moderate
February	1.651	0.5549	34	Moderate
March	2.742	0.5543	20	Moderate
April	8.545	0.5443	6	Low
May	5.063	0.5893	12	Low
June	2.242	0.6435	29	Moderate
July	1.565	0.6154	39	Moderate
August	1.389	0.6396	46	Moderate
September	1.698	0.5657	33	Moderate
October	2.670	0.5256	20	Low
November	3.728	0.5256	14	Low
December	2.750	0.5069	18	Low

Tier One Uncertainty

The Tier One Subwatershed Stress Assessment for North Bay is considered to have a high uncertainty, due to:

1. Precipitation varies as much as 25% between meteorological stations in the North Bay–Mattawa SP Area
2. Streamflow data was pro-rated to calculate water supply in the lake based on a gauge (02JE020 on the Mattawa River) some 28 km downstream of Trout Lake

Regardless, the decision to proceed to a Tier Two Subwatershed Stress Assessment will further refine this analysis with greater details and precision, and as such reduce the uncertainty posed within this Tier One assessment.

6.2.1.2 Tier Two Subwatershed Stress Assessment Results

The Tier Two Subwatershed Stress Assessment is meant to be a confirmation of the Tier One Subwatershed Stress Assessment results, using more refined water demand estimates and a more advanced water budget model than those used for the Tier One Assessment.

Tier Two Subwatershed Stress Assessments are developed at the subwatershed scale, similar to the Tier One, and use a continuous surface water model and, where necessary, a groundwater flow model, in their development (where the latter was not the case for the Trout/Turtle Lake subwatershed). Municipal water supplies located within subwatersheds that are confirmed to have a Moderate or Significant potential for stress proceed to a locally-focused Tier Three Local Area Risk Assessment.

The Tier Two Stress Assessment described herein was completed using a numerical surface water flow model and a reservoir routing model. These modelling tools provide a physical means of quantifying flow through the Trout/Turtle Lake subwatershed for use in the Stress Assessment calculations. The Stress Assessment includes consideration of the following conditions:

1. Existing System Average - Percent Water Demand calculations;
2. Planned System Demand - Percent Water Demand calculations;
3. Existing System Future Demand - Percent Water Demand calculations; and
4. Existing or Planned System Drought Conditions.

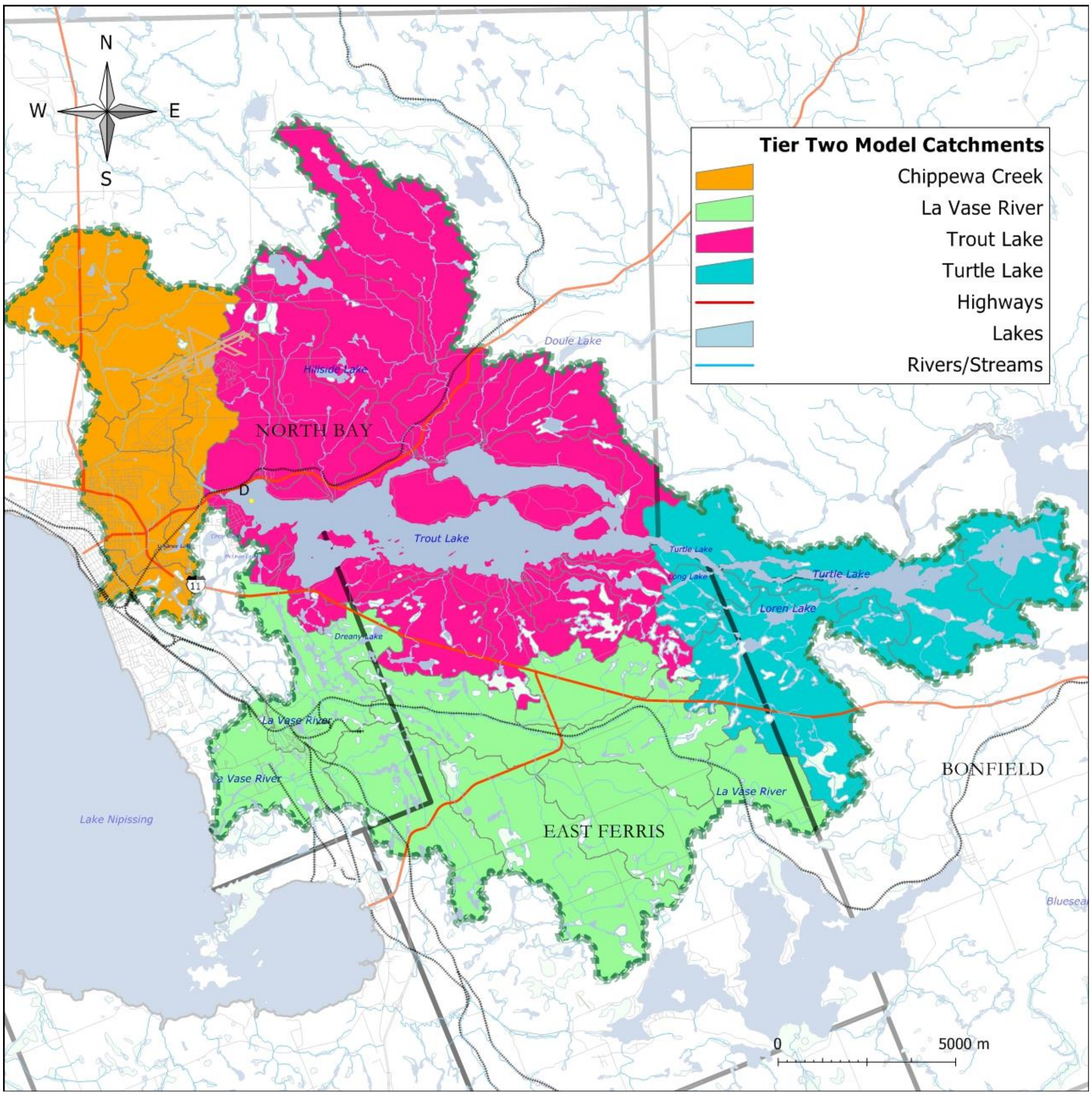
Any one of the above conditions that determines the subwatershed to be at a moderate or significant degree of stress is sufficient to identify that subwatershed as requiring a Tier Three Local Area Risk Assessment.

The Tier Two Subwatershed Stress Assessment begins with the collection and interpretation of maps and data relating to the hydrological system. These data include geologic mapping, land use and vegetation mapping, topographic data, and surface water drainage maps.

The hydrological information is then used to develop and calibrate the hydrologic model. Continuous hydrologic flow models are typically used to describe and quantify water budget components including evapotranspiration, overland runoff, groundwater recharge, and total streamflow. As part of this project, the Guelph All-Weather-Sequential-Events Runoff (GAWSER) model was chosen to simulate the hydrology of the Trout/Turtle Lake subwatershed. As there are no surface water stream gauges within the Trout/Turtle Lake subwatershed, the hydrologic model also included the adjacent La Vase River and Chippewa Creek subwatersheds. Observed streamflows from Water Survey of Canada stream gauges on the La Vase River and Chippewa Creek were used to calibrate and verify the hydrologic model. The location of these two subwatersheds in relation to the Trout/Turtle Lake subwatershed is shown in Figure 6-2.

Following model calibration, hydrologic parameters for these watercourses were transferred to hydrologically similar areas in the Trout/Turtle Lake subwatershed, allowing the representation of the hydrology using physical parameters that represent local conditions as accurately as possible. As an additional measure of model performance, inflows to Trout/Turtle Lake generated through a reservoir routing model were used to estimate lake levels, which allowed comparison against MNR observed lake levels. Verifying model results to a secondary dataset increases the confidence associated with model results.

Figure 6-2. Trout/Turtle Lake Subwatershed in Relation to La Vase River/Chippewa Creek Subwatersheds



The Percent Water Demand calculation methods are the same as those used in the Tier One Subwatershed Stress Assessment, where: *Percent Water Demand = Demand/ (Supply-Reserve)*100*. Similarly, surface water stress levels are determined using the same threshold values as in the Tier One level. Ie. stress levels are assigned based on the maximum monthly Percent Water Demand calculations, where:

1. % Water Demand >=50% is Significant stress;
2. % Water Demand 20-50% is Moderate stress; and
3. % Water Demand <=20 is Low stress

Hydrologic Modelling

As already mentioned, there are no surface water stream gauges within the Trout/Turtle Lake subwatershed. In turn the hydrologic model included the adjacent La Vase River and Chippewa Creek subwatersheds. The Trout/Turtle Lake subwatershed covers an area of 176 km^2 (further refined from the Tier One Subwatershed Stress Assessment). Annual and mean annual precipitation as recorded at the North Bay Airport station from 1950-2005 was used in the modeling; this climate station is located in the Chippewa Creek subwatershed, adjacent to the Trout Lake subwatershed. An upward trend in precipitation is evident, with a mean annual precipitation of 1,070 mm over the last 30 years (1975-2005).

Land cover is one of the primary factors that influence how a subwatershed will respond to a precipitation event and as such is a critical component of the modelling. Land cover for the study area was taken from the 2000 Edition of the Ontario Provincial Land Cover Database (Table 6-6). As there have been no significant land use changes over the last decade, it is assumed this data is representative of current conditions. Approximately 70% of the Trout/Turtle Lake and the La Vase River subwatersheds are forested. These subwatersheds also contain numerous small lakes and wetlands. Approximately half of Chippewa Creek subwatershed is forested with the remaining half being urban lands associated with the City of North Bay.

Table 6-6. Land Cover as a Percentage of Total Area for Trout/Turtle Lake, Chippewa Creek and La Vase River Subwatersheds

Land Cover	Trout/Turtle Lake	Chippewa Creek	La Vase River
Water	17%	1%	1%
Settlement/Infrastructure	4%	49%	6%
Bedrock	0%	1%	0%
Forest Sparse	6%	5%	14%
Forest Dense Deciduous	27%	14%	15%
Forest Dense Mixed	30%	24%	37%
Forest Dense Coniferous	6%	5%	5%
Bog - Treed	2%	0%	3%
Agriculture - Pasture	6%	1%	12%
Cloud/Unknown	2%	0%	7%

(Based on 2000 Ontario Provincial Land Cover Database (Spectranalysis, 2004))

Surficial geology is another crucial component of the watershed characterization and subsequent modelling, as it determines the rate and volume of water that penetrates the soil surface. The surficial geology illustrates two main geologic regions within the study area. The regions are separated by the North Bay Escarpment, which runs along the north shore of Trout/Turtle Lake. The area above the Escarpment, the northern half of Chippewa Creek subwatershed and the area northwest of Trout/Turtle Lake, has a thicker overburden that is characterized by coarser grained materials such as sands and gravels, deposited as till and glaciofluvial outwash. The area below the Escarpment, the area south and east of Trout/Turtle Lake, consists of bedrock with very thin overburden. There are pockets of glaciolacustrine and organic deposits throughout the study area, which are comprised of finely grained materials such as clays.

Hydrologic modelling is required to estimate streamflow, reservoir water levels, and major water budget components such as evapotranspiration, direct overland runoff and groundwater recharge. Model calibration involves adjusting hydrologic parameters to best reflect the observed hydrologic conditions. Following calibration, the model is then tested to confirm that the parameter adjustments are representative of major hydrologic processes; this modeling procedure is called verification.

The results of the calibration and verification phase demonstrated that the model reasonably replicates the major hydrologic processes in the Chippewa Creek and the La Vase River subwatersheds. As such, the model parameters for Chippewa Creek and the La Vase were transferred to the Trout/Turtle Lake subwatershed with confidence that natural conditions were being reasonably replicated. The model parameters applied to Trout/Turtle Lake subwatershed were validated by comparing simulated streamflow at five locations in Trout/Turtle Lake subwatershed against observed spot flow measurements taken by NBMCA in May, June, July, and August 2008.

A reservoir routing model was created to validate estimated inflows to Trout/Turtle Lake. This routing model considers inflows, withdrawals, evaporative losses, and level-storage-discharge relationships to generate a daily time series of Trout/Turtle Lake water levels. The 1995-2005 time period used for this analysis coincides with the calibration period used for the hydrologic model. The reservoir routing model produced simulated reservoir levels generally consistent with observations of the Trout/Turtle Lake water levels recorded at the Turtle Lake Dam; this can also be considered a secondary validation of the simulated Trout/Turtle Lake inflows.

The mean annual water budget (precipitation, evapotranspiration, runoff, and recharge) based on the GAWSER model was calculated on a subwatershed basis for the 1975-2005 study period (Table 6-7). The four water budget components are described below:

1. Precipitation – Depth of water that reaches the ground surface via rainfall or snowmelt, based on reported climate data.
2. Evapotranspiration – Depth of water that leaves the subwatershed via evaporation, transpiration, and sublimation.
3. Direct Overland Runoff – Depth of water that does not infiltrate the soil, but reaches the surface water system via overland flow.
4. Groundwater Recharge – Depth of water that infiltrates into and past the evaporative root zone and enters the groundwater flow system. This water is returned to the surface water system via groundwater discharge, and sustains dry weather streamflow (baseflow).

Table 6-7. Mean Annual Water Budget on a Subwatershed Basis

Subwatershed	Mean Annual Water Budget for 1975-2005 in mm/yr and

	(% of Precipitation)			
	Precipitation	Evapo-transpiration	Overland Runoff	Groundwater Recharge
Trout/Turtle Lake	953	568 (60%)	246 (26%)	139 (15%)
Chippewa Creek	1,027	523 (51%)	316 (31%)	188 (18%)
LaVase River	924	549 (59%)	282 (31%)	93 (10%)

Water Demand

Two surface water permits are located within the Trout/Turtle Lake subwatershed: the City of North Bay permit with a maximum rate of 79.5 ML/d (920 L/s); and the Canadian Forces Base industrial cooling permit with a maximum rate of 10.7 ML/d (124 L/s). There are no permitted groundwater takings within the subwatershed. These two water takings result in an annual average rate of water withdrawal from Trout/Turtle Lake subwatershed of 44.9 ML/d (520 L/s); representing about half of the maximum permitted water withdrawal rate. Applying a consumptive factor (percentage based on the net amount of water taken from a source and not returned to the source in a reasonable time) of 2% to the cooling taking, and 100% to the municipal supply (since water withdrawn from Trout Lake is diverted into Lake Nipissing), yields a consumptive withdrawal of 34.6 ML/d (398 L/s) from the subwatershed.

Using output from the hydrologic model, and reported water withdrawals from the City of North Bay, the Tier Two Subwatershed Stress Assessment was completed by comparing the consumptive water demand within the subwatershed to the total streamflow entering the subwatershed, on a monthly basis (Table 6.8). This comparison results in the Percent Water Demand, which when compared to Provincial thresholds, determines if the subwatershed has a Significant, Moderate or Low potential for stress.

Table 6-8. Existing Conditions Tier Two Assessment for Trout/Turtle Lake Subwatershed

Term	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Consumptive Water Demand [1] (m^3/s)	0.39	0.39	0.38	0.38	0.39	0.41	0.42	0.42	0.44	0.39	0.38	0.39
Water Supply [2] (m^3/s)	0.74	0.64	2.39	5.97	2.81	1.95	1.65	1.37	1.81	2.09	2.48	1.47
Water Reserve [3] (m^3/s)	0.43	0.33	0.38	1.12	0.92	0.78	0.43	0.42	0.51	0.62	0.85	0.84
Water Supply - Reserve (m^3/s)	0.31	0.30	2.01	4.85	1.89	1.17	1.21	0.95	1.31	1.47	1.63	0.63
Percent (%) Water Demand [4]	128	129	19	8	21	35	35	44	34	27	23	62

Definitions:
[1]- 2008 Mean Monthly Municipal Water Demand + Permitted Industrial Cooling Consumptive Demand

[2]- Median Monthly Streamflow (1975-2005)

[3]- 90th Percentile Exceedance Streamflow (1975-2005)
[4]- Percent Water Demand = Consumptive Demand / (Supply-Reserve) x 100%

The Tier Two Subwatershed Stress Assessment results for the Trout/Turtle Lake subwatershed indicated that the subwatershed has a **Significant** potential for stress in January, February and December, and a **Moderate** potential for stress from May to November. The *Clean Water Act* Technical Rules (MOE, 2009), requires any municipal system located within a subwatershed that has a Moderate or a Significant potential for stress at the Tier Two level to undergo a Tier Three Local Area Risk Assessment.

As the Trout/Turtle Lake subwatershed is classified as having a **Significant** potential for stress under existing system demand conditions, the Percent Water Demand for planned or future system conditions did not need to be calculated. Likewise, a existing or planned drought system conditions for the Trout/Turtle Lake subwatershed was not necessary.

Tier Two Uncertainty

The uncertainty assigned to this classification by AquaResource (2010) was Low, mostly based on the facts that:

1. Consumptive demand was determined using actual pumping data from the City of North Bay rather than maximum permitted amounts;
2. High quality local meteorological data was available from the weather station at the North Bay Jack Garland Airport; and the findings of the reservoir routing model were consistent with those of the surface flow model.

Significant Groundwater Recharge Areas (SGRA)

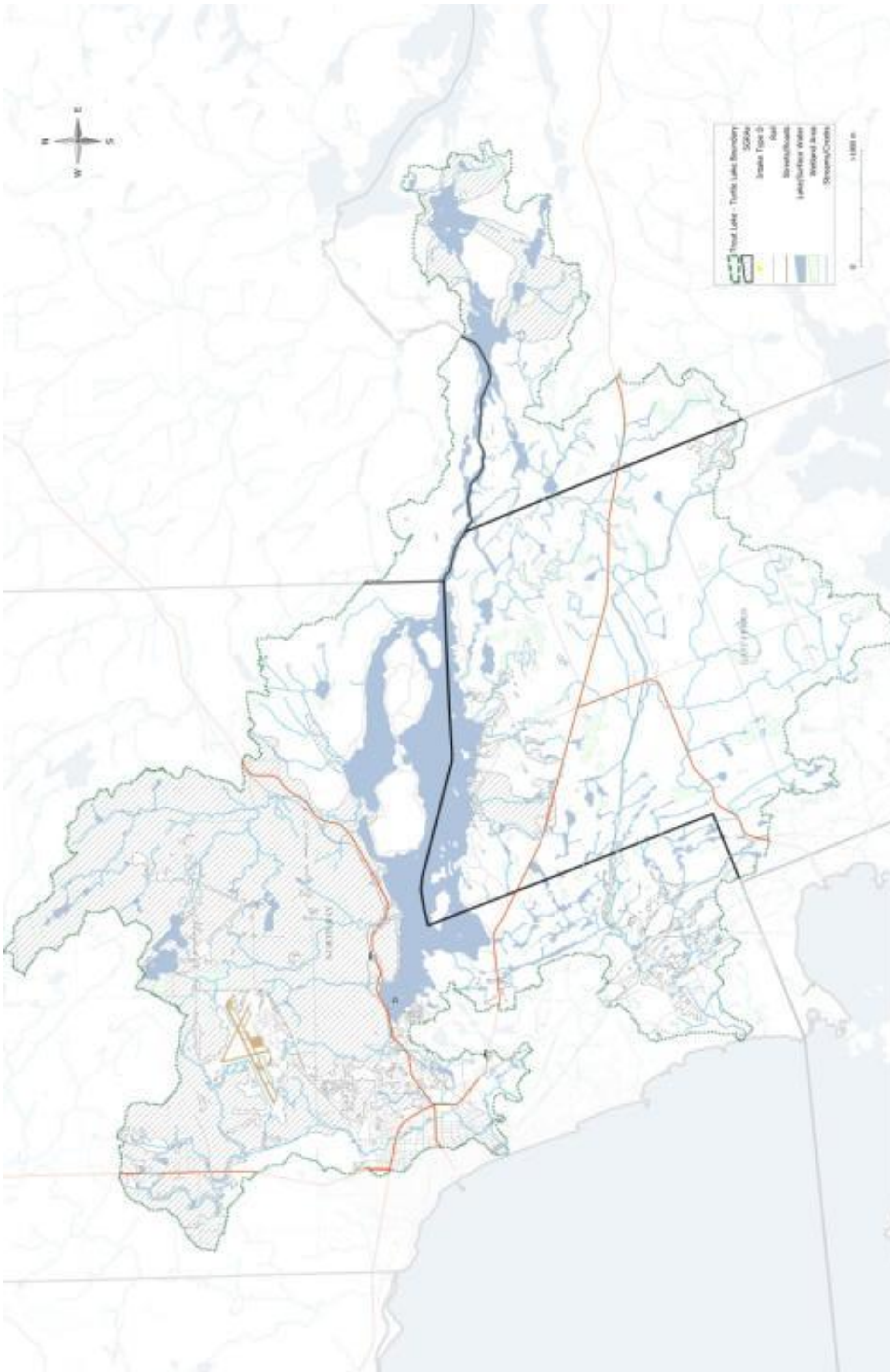
Significant Groundwater Recharge Areas (SGRA), as delineated using the methodology prescribed by Technical Rule 44(1), are presented in Figure 6-3. Large portions of the Four Mile Creek and Doran Creek subwatersheds are identified as SGRAs. Plans for aggregate and other resource extraction, and development in those areas will need to consider its vulnerability with respect to maintenance of the aquifer and baseflow to Trout/Turtle Lake. It should be noted, however, that when relying on the SGRA map to support water quantity or water quality protection activities, there is a need to consider some of the assumptions and limitations associated with the delineated SGRAs. They are as follows:

1) Significant volumes of groundwater recharge may occur in areas that are not classified as SGRAs. Estimated groundwater recharge rates in some areas may be high, but just below the SGRA threshold.

2) The hydrologic model is calibrated to achieve the best overall fit to measured streamflow. Within a specific watershed, there is a wide range of estimated groundwater recharge rates depending on local geologic type and land cover. While the calibration process addresses the confidence of the hydrologic simulation within a subwatershed, the water budget parameters for a specific Hydrologic Response Unit are not calibrated and the results should only be considered as a relative measure of hydrologic processes.

Figure 6-3. Significant Groundwater Recharge Areas (SGRA) in the Trout/Turtle Lake Subwatershed

Note: larger 11" x 17" version is available in Appendix A.



6.2.1.3 Tier Three Local Area Risk Assessment Results

The objective of the Tier Three Local Area Risk Assessment is to estimate the likelihood that municipalities will be able to meet current and future water quantity requirements. The Tier Three Assessment is a more detailed study carried out on all municipal water supplies located in subwatersheds that were classified in the Tier Two Subwatershed Stress Assessment as having a Moderate or Significant potential for hydrologic stress. The goal of this assessment is to determine significant or moderate threats to water quantity, so to prioritize the risk management measures that should be applied to reduce the level of risk associated with a municipal water supply system not being able to meet current or future water demands.

As described previously, the tasks required to assess the Risk level of each Local Area include:

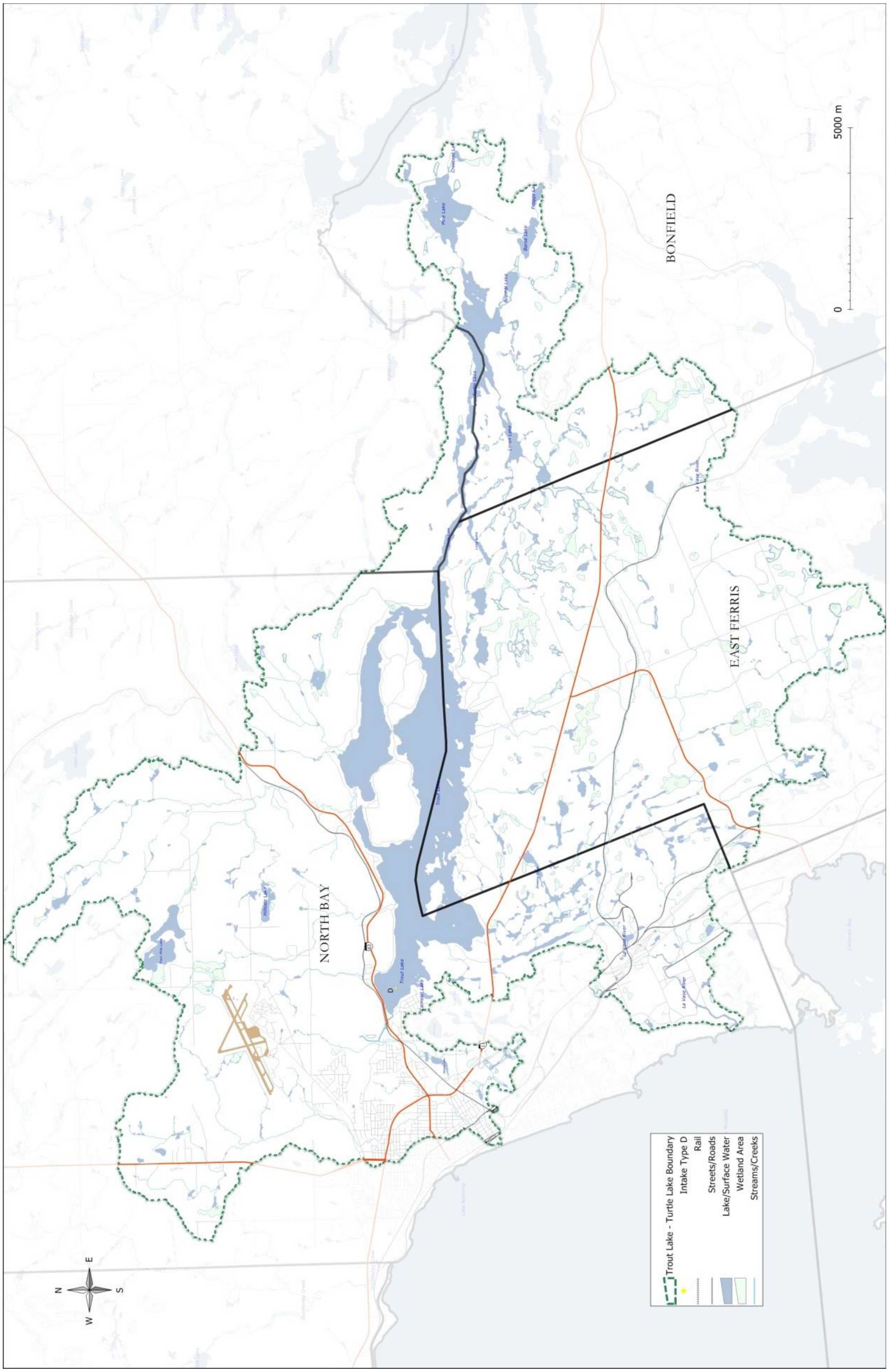
1. Determine Local Area Delineation;
2. Assign Tolerance Level;
3. Assign Exposure Level; and
4. Assign Risk Level

Local Area Delineation (IPZ-Q)

The first task in the Tier Three Local Area Risk Assessment is determining the total drainage area that provides water to the municipal intake, or the local area delineation (IPZ-Q). In the case of the North Bay intake, the drainage area contributing to the intake includes the entire Trout/Turtle Lake subwatershed. This is shown in Figure 6-4.

Figure 6-4. North Bay Intake Total Drainage Area

Note: larger 11" x 17" version is available in Appendix A.



Assigning Tolerance Level

The Tolerance level of a municipal drinking water supply system is defined as its ability to meet peak demands. A municipal system within a Local Area (IPZ-Q) is classified as having either a Low or High tolerance level depending on the municipal water supply system's ability to supply water to users during peak demand periods. Specifically, Part IX.3 Rule 107 of the Technical Rules (MOE, 2009) outlines how Tolerance is assigned to a municipal drinking water system.

The North Bay intake is located 23 m below the observed Trout Lake low water level elevation (201.8 masl). Considering the volume of Trout Lake alone, it is estimated that the volume of water contained between the intake elevation and the standard operating level is 270,000 ML. Conservatively, assuming no inflow to the lake at all, this volume of water would sustain the City of North Bay's 2008 average withdrawal (~425 L/s, or 37ML/d) for approximately 20 years.

While the storage held in the lake below the standard operating level is sufficient to sustain the municipal taking for a significant period of time with zero inflow, the severe impacts of such a situation occurring should be recognized. In addition to discharge from Turtle Dam ceasing and affecting downstream lakes and rivers, recreational use, aquatic and wetland habitats within Trout/Turtle Lake would be significantly impacted as lake levels are drawn down. It is recommended that the City of North Bay continue to manage municipal water demand with the aim to maintain lake levels within historical ranges.

To assess the City's ability to withdraw sufficient water to meet peak demands, while remaining within PTTW restrictions, peak municipal demands were compared to the maximum permitted withdrawal rate associated with the water treatment plant. The City of North Bay experienced a peak day demand in the summer of 2001 that was approximately 90% of the City's maximum permitted withdrawal rate (North Bay, 2003). As a result of this event, the City instituted an outdoor water use by-law to restrict outdoor water use to every other day. Water withdrawal reports from the City of North Bay indicate that following implementation of the outdoor water use bylaw, 2002-2008, the maximum daily demand between 2002 and 2008 has been less than 70% of the permitted withdrawal rate. This indicates that the water treatment plant is able to withdraw sufficient water from Trout Lake to meet peak demands, while remaining in compliance with the PTTW.

Due to the volume of water stored within Trout/Turtle Lake, and the ability of this storage to supply sufficient water to the municipal intake to meet peak demands, as well as the ability of the City to withdraw peak demands within their current PTTW, a Tolerance classification of **High** is assigned to the North Bay municipal drinking water system.

Assigning Exposure Level

The next step is to determine Exposure Levels. When assessing the Exposure level, Part IX.2 of the Technical Rules (MOE, 2009B) require that four circumstances for a surface water intake be considered as follows:

1. Long term average climate period, existing/current system, average daily pumping;
2. Drought period, existing/current system, average daily pumping;
3. Long term average climate period, committed/future demand, average daily pumping during period of committed/future demand; and,
4. Drought period, committed/future demand, average daily pumping during period of committed/future demand.

Note that the Technical Rules requires an assessment of future demand as either a planned system or an existing system with a committed demand. Through consultation with the City of North Bay, there are no planned systems associated with the North Bay municipal system; any references to a "planned system" within this Tier Three assessment actually refers to an existing system with a committed/future demand.

The following Sections document each of the components of the above four scenarios. Assumptions related to each component are also documented.

1. Long Term Average Climate Period

Similar to the Conceptual Water Budget and Tier Two Subwatershed Stress Assessment, the Tier Three assessment used a 30-y period from 1975-2005. Simulated stream flow into Trout/Turtle Lake, estimated by the GAWSER model over this time period, was used when determining lake levels (AquaResource, 2010).

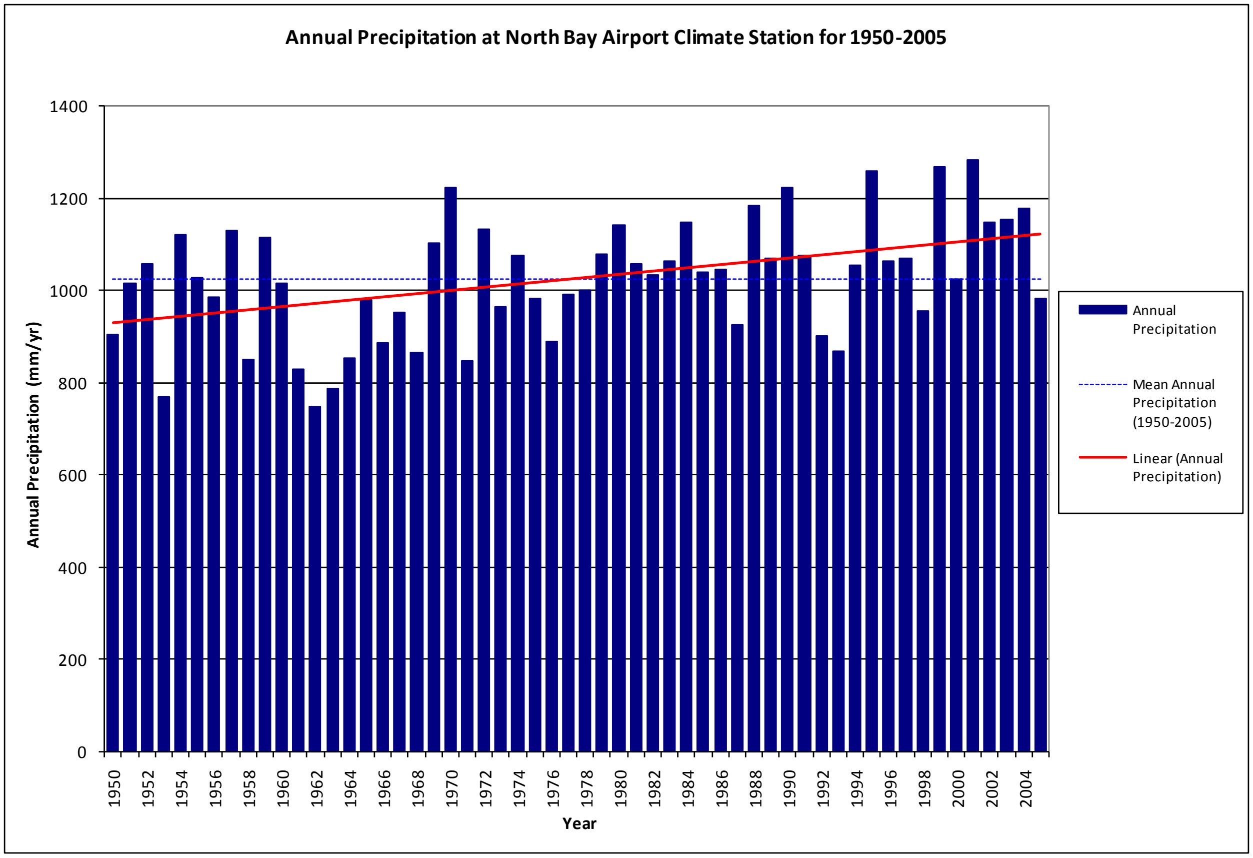
2. Drought Period

The Tier Three Local Area Risk Assessment requires consideration of a drought scenario. The drought scenario is meant to evaluate the possibility of short-term climate variability triggering an Exposure exceedance. The Technical Rules specify that the drought period considered for surface water systems is the continuous ten-year period with the lowest mean annual precipitation; however, MNR subsequently provided direction that a shorter two-year period is more appropriate to evaluate drought impacts on surface water bodies. As such, a two-year period was used to evaluate drought impacts.

An in-filled dataset for the North Bay Airport, distributed by the Ministry of Natural Resources was used for this Assessment (as developed by Schroeter and Associates, 2007). The period of record associated with this station is 1950-2005, and through this period there were two major drought periods (as seen on Figure 6-5); one in the 1960's, and the second during the late 1990's/early 2000's.

A two year running average was applied to the North Bay climate dataset to determine the period for use in the drought scenario. The lowest continuous two-year period within the 1950-2005 period was 1962-1963, with an average total precipitation of 654 mm/yr, which represents 64% of the long term (1970-2005) average precipitation. Inflows to Trout/Turtle Lake estimated by the GAWSER model for this time period were used to determine corresponding lake levels.

Figure 6-5. Annual Precipitation Recorded at North Bay Airport Meteorological Station for 1950-2005



3. Existing Pumping

Consistent with the Tier Two Assessment, reported withdrawal rates from 2008 were used at the Tier Three level for the existing pumping scenario.

4. Committed/Future Pumping

Planned system rates are defined as the groundwater or surface water pumping rates used for a drinking water system that is planned to be established, with one of the following approvals: an individual Environmental Assessment (EA) approval; or if the system has been identified as the preferred solution within a completed planning process with an approved Class EA; or the system would serve a First Nation Community as defined in the Indian Act; Canada (MOE, 2006). According to this definition, and through consultation with the City of North Bay, there are no planned systems associated with the North Bay municipal system.

The current drinking water treatment plant and permit to take water have sufficient capacity to provide drinking water to the City of North Bay now, and into the foreseeable future. As such, the future pumping scenarios within this assessment apply to an existing system with a committed demand, as per the Technical Rules. The committed water demand is associated with planned or approved developments which will be serviced by the municipal drinking water supply. The City of North Bay has estimated the number of building lots which have been approved for development to be approximately 1,400. It should be noted that this may include lots within developments already under construction, which would be already accounted for in the 2008 population estimate. As such, 1,400 additional building lots are considered a conservatively high estimate. Statistics Canada has reported an average of 2.4 people per dwelling for the City of North Bay (Statistics Canada, 2007), resulting in a committed population increase of 3,360 people.

To evaluate the impacts of planned population growth on Trout/Turtle Lake water levels, and to determine if lake levels will remain above the Exposure threshold, the approved population increase, along with the future per capita rate of 680 L/day/cap was used. As the City of North Bay is currently implementing a number of conservation measures that will reduce water consumption, future estimates evaluated in the Exposure scenarios also included the effects of these measures. Although the consideration of conservation measures is beyond the requirements of the *Clean Water Act*, these factors are expected to be in place during the time period of the committed/future demand scenario described below. For this reason, conservation measures are included within this assessment as a more representative prediction of future pumping rates. A second scenario, not considering the impact of the infrastructure upgrades was also included. The pumping rates for the two scenarios are included in Table 6.9.

Table 6-9. Planned Pumping Scenarios

	Per Capita Rate without Conservation (680 L/d)	Per Capita Rate with Conservation (458 L/d)
	Average Taking MLD(L/s)	
Committed Serviced Population (58,360)	40 (459)	27 (309)

Planned Land Use

When evaluating Exposure, the Technical Rules (MOE, 2009B) require consideration of future land use developments, as well as committed pumping. Land use changes, particularly urban development, have the potential to impact the hydrologic cycle, and will often result in changes to available water, both in terms of total volume of streamflow, as well as the seasonal distribution of streamflow.

The North Bay Official Plan (North Bay, 2003) describes and outlines how and where future development will be accommodated. The City of North Bay recognized the importance of Trout Lake, both for recreational and water supply aspects, and incorporated policies into the Official Plan that aimed to protect the Lake. The following text was taken from Section 2.1.15 of the Official Plan, and describes the development controls placed on lands within the Trout/Turtle Lake subwatershed.

> *"This Official Plan recognizes that Trout Lake is a valuable community resource in that it is the sole source of drinking water for the City of North Bay as well as for private systems which draw their water directly from the lake; that this water body is a significant recreational resource at the fringe of the urban area which offers unique opportunities not found in such close proximity to most Canadian communities; that the shoreline of this water body has a special aesthetic appeal for the development of seasonal and permanent residential uses; and that the general population of North Bay wishes to see that special care is taken through strict lake and watershed development controls to maintain or improve its existing level of water, aesthetic and fishery quality.*
>
> ...

> *This Plan recognizes that all lands located within the Trout Lake watershed are connected to Trout Lake by surface and ground water drainage, and that all uses in the watershed directly or indirectly influence Trout Lake.* ***It is the intent of this Plan to strictly control or limit the nature and extent of development*** *along the shoreline of Trout Lake, including second tier or back lot development, development on islands in Trout Lake, development along streams flowing into Trout Lake, and development in the Trout Lake watershed in general."*

This intent by the City to limit development within the Trout Lake watershed is evident by the land area where urban services are provided. Serviced land is typically required for urban development. Only a small portion of the urban serviced area lies within the Trout/Turtle Lake Watershed. This area is located in the easternmost portion of the City, adjacent to Delaney Bay, and is 0.9 km^2 in area. As this area is currently fully developed, and no other lands within the Trout/Turtle Lake watershed are serviced, it is expected there will be negligible land use change within the City of North Bay portion of Trout/Turtle Lake watershed.

Municipalities lying adjacent to Trout or Turtle Lakes include the Township of East Ferris, Township of Bonfield and Phelps Township, are predominantly rural townships, with no urban areas within the Trout/Turtle Lake subwatershed. Due to the lack of urban centres, it is expected that there will be no significant land use change within these municipalities. Despite the measures outlined above, some minor land use change is expected within the Trout/Turtle Lake subwatershed. These anticipated land use changes include a 45 ha (112 acres) industrial development within Lees Creek subwatershed (City of North Bay, 2009), as well as a 0.2 ha (0.5 acres) peat extraction site, and a 6.5 ha (16 acres) aggregate extraction site, both of which are within Doran Creek subwatershed (North Bay-Mattawa Conservation Authority, 2009). These developments represent approximately 0.3% of the Trout/Turtle Lake drainage area.

These developments were considered within the GAWSER model by modifying the hydrologic response unit (HRU) classification for the affected subwatersheds (Lees and Doran Creeks). The industrial development was represented by assuming a typical impervious percentage for industrial developments (90%) and increasing the impervious HRU class by the corresponding area. The peat extraction site was represented by transferring land area from the wetland class to the open water class. The aggregate extraction site was simulated by utilizing a high infiltration, low storage, low evapotranspiration HRU class, which supplies infiltrated water quickly to the watercourse. As the Technical Rules require no mitigative measures to be considered when assessing the level of Risk, no best management measures, such as maintaining recharge volumes, were considered during this analysis.

Included in Figure 6-6 and Figure 6-7 is the mean monthly flow under pre-development and post-development conditions for Lees and Doran Creeks, respectively.

Figure 6-6. Planned Land Use Scenario - Lees Creek

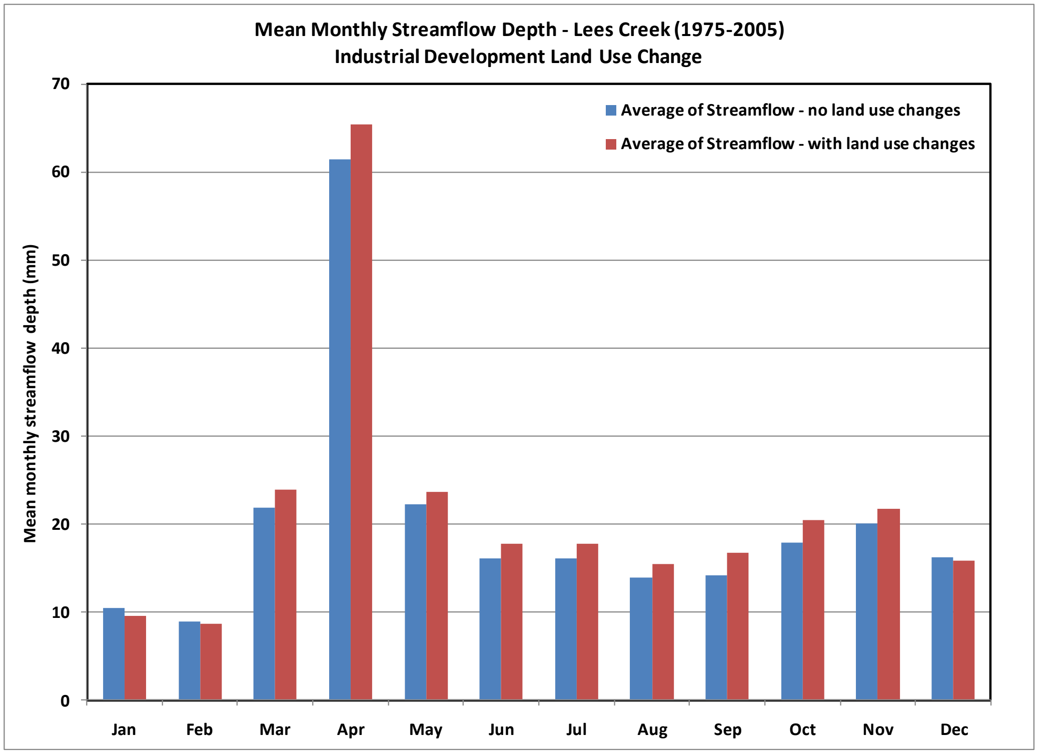
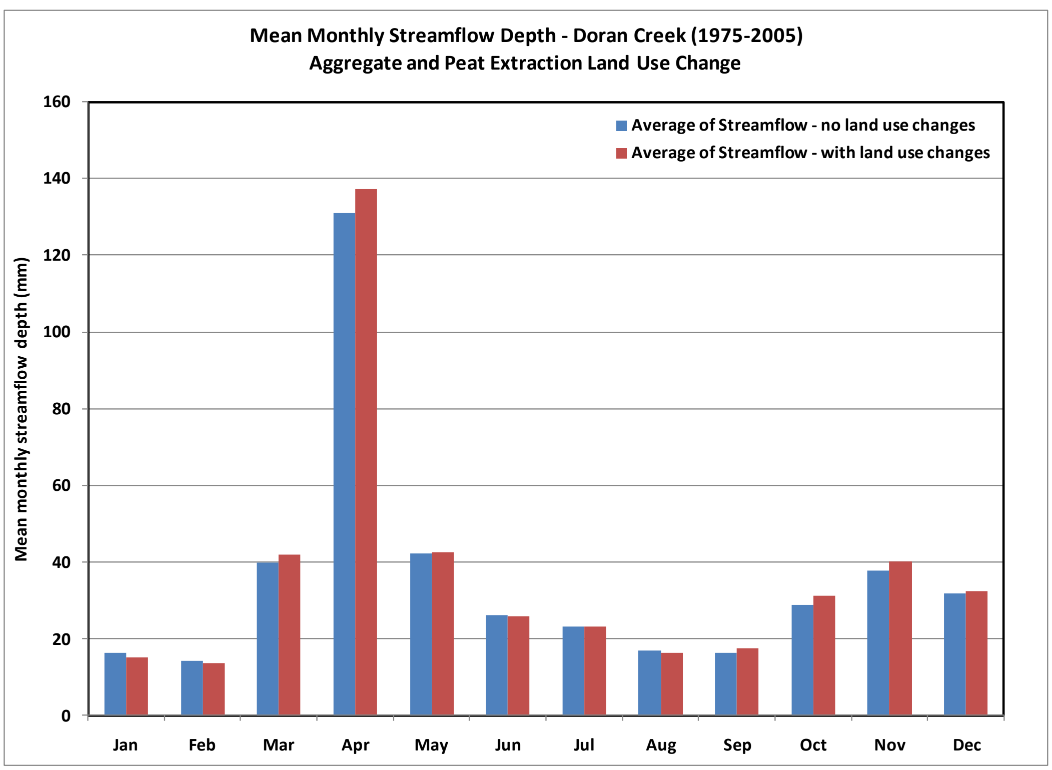


Figure 6-7. Planned Land Use Scenario - Doran Creek



As shown on Figure 6-6, the industrial development in Lees Creek results in increases in streamflow for most months. This is due to the impervious area added by the industrial development causing the majority of rainfall or snowmelt to become overland runoff, reducing the amount of infiltration, and subsequently reducing evapotranspiration. The industrial development also reduces the amount of groundwater recharge generated, and therefore lowers streamflow during months that experience limited overland runoff (e.g. December-February). The industrial development would also impact streamflow during drought periods, where the majority of streamflow would be derived from groundwater discharge. As the volume of groundwater recharge is reduced by impervious land cover, groundwater discharge would be reduced.

The impact of the aggregate and peat extraction land use scenario on Doran Creek generally results in a quicker responding system (Fig. 6-7). Streamflow during the spring months is generally higher as water is routed through to the watercourse faster, with lower summertime streamflow. Streamflow recovers quicker in the fall from the traditional summertime lows; however, streamflow during the months of January and February will be lower.

Land use policies contained within the City of North Bay Official Plan, will limit or control land development within the Trout/Turtle Lake subwatershed. Despite these controls, a small number of developments have previously been approved. To maintain Trout/Turtle Lake levels, these developments should be required to implement best management practices such as maintaining groundwater recharge volumes and managing storm runoff to maintain, or even enhance, dry weather streamflow.

Trout/Turtle Lake simulated inflow hydrographs from the planned land use scenario were used to represent the changes in hydrology that could be expected given approved developments.

Results of Exposure Scenarios

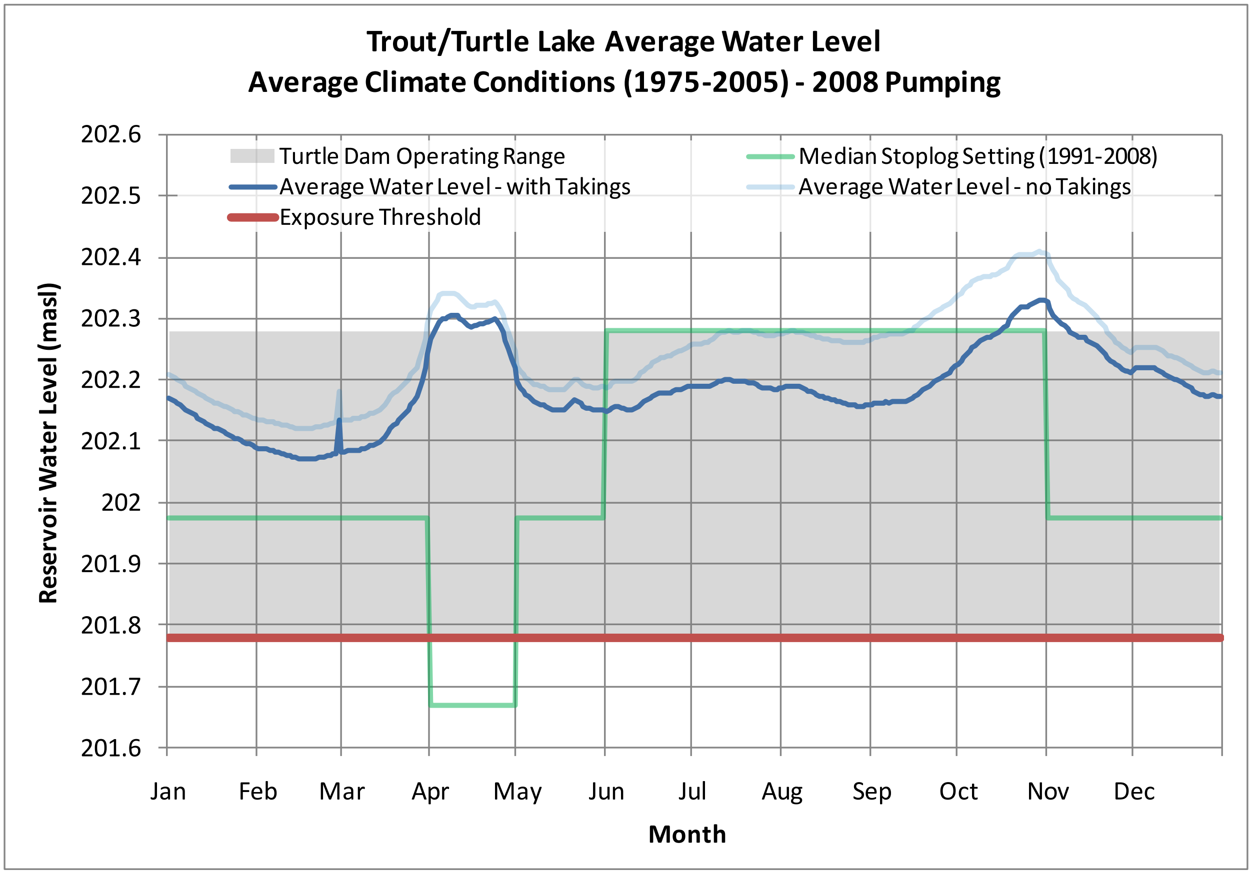
Using the reservoir routing model, lake levels for each of the four Exposure scenarios were estimated using pumping records from City of North Bay, and simulated inflows calculated by the GAWSER model. Recorded stop log settings for Turtle Dam were used to specify dam operations where records existed (1991-2005).

Scenario 1: Average climate conditions, existing pumping

Figure 6-8 illustrates the simulated average daily water levels for the 1975-2005 period. Also included in the figure is the operating range of Turtle Dam, as well as the median stop log setting for Turtle Dam.

Average water levels, with municipal pumping, remain below the Exposure threshold of 201.78 mASL (metres Above Sea Level). As a result, an Exposure classification of “Low” was assigned to the Local Area for Scenario 1.

Figure 6-8. Exposure Scenario #1 Results



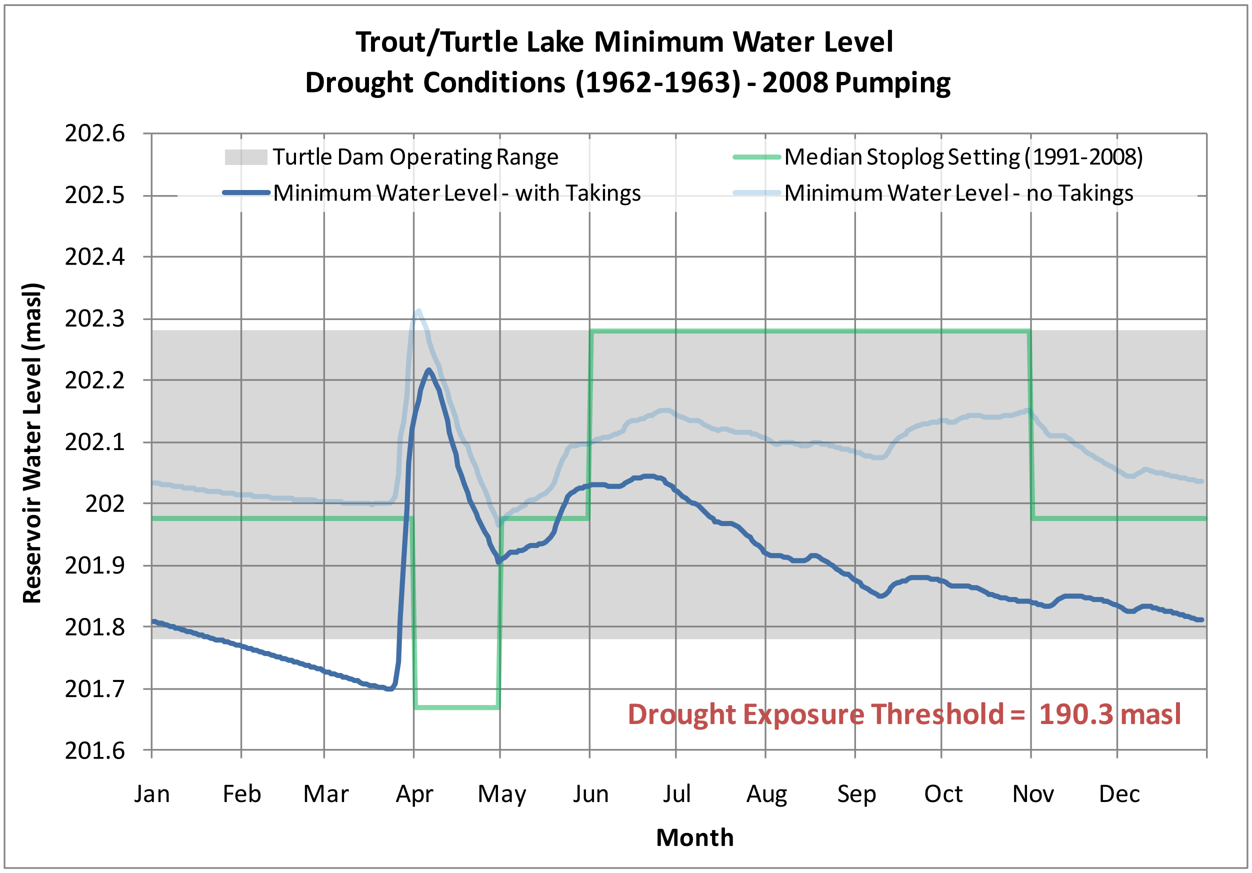
To assess the impact of municipal pumping on lake levels, another scenario was investigated with water withdrawals turned off. Comparison of the simulated water levels for the two series on Figure 6-8 shows the maximum impact of the water withdrawal is approximately 10 cm, and is seen in the late summer/fall months. This difference is largely reduced through the late fall and winter months as higher inflows replenish reservoir storage.

Scenario 2: Drought climate conditions, existing pumping

Figure 6-9 illustrates the minimum simulated daily water level over the 1962-1963 drought period. Minimum, rather than the average, lake levels are considered for the drought scenarios. This is due to the threshold for drought scenarios being the ability of the North Bay intake to withdraw water. Should the intake, at any time in the two year drought period, be exposed or otherwise unable to withdraw water, an Exposure classification of High would be assigned.

Using inflows simulated to occur using climate data from 1962-1963, minimum lake levels are predicted to drop to approximately 201.78 mASL, approximately 11 m above the drought Exposure threshold of 190.3 mASL. Based on this analysis, an Exposure level of “Low” was assigned to the Local Area for Scenario 2.

Figure 6-9. Exposure Scenario #2 Results

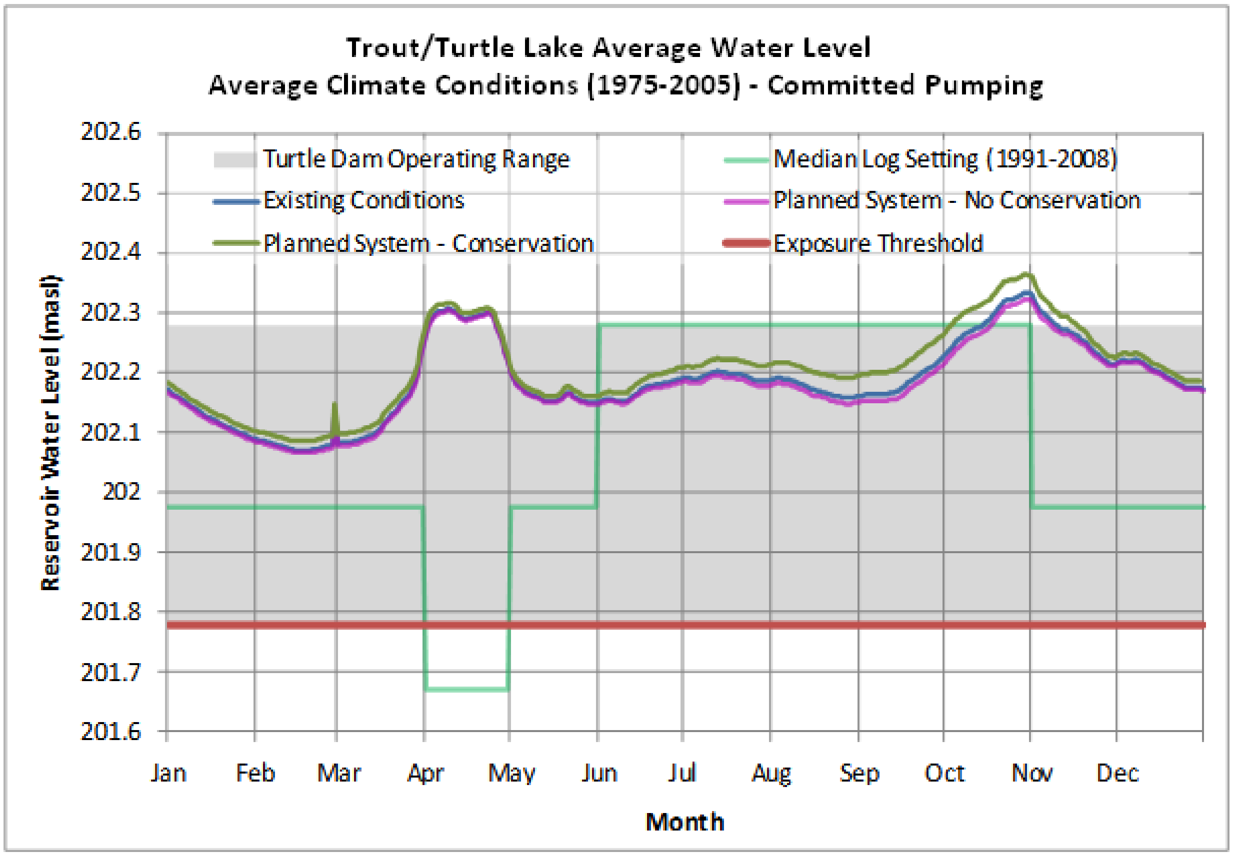


Similar to Scenario 1, a separate analysis was conducted to determine the impact of municipal takings during a drought period. In the absence of municipal pumping, the minimum water level generally remains above 202.0 mASL. A difference of up to 30 cm is noted in the fall months between the simulated water levels with and without municipal pumping. When compared to the impact as shown in Figure 6-8, this indicates that the municipal water taking has a larger impact on water levels during a drought year than an average year.

Scenario 3: Average climate conditions, committed pumping and planned land use

Figure 6-10 illustrates the results of Scenario 3. Simulated water levels include existing pumping, planned land use, as well as the existing system with a committed demand (shown as a "Planned System" within the figure), with and without conservation measures which include anticipated reductions due to metering and the associated ability to detect and address system leakage. Simulated water levels under both committed/planned pumping scenarios are comparable to water levels with existing municipal pumping; the maximum difference is approximately 3 cm, and all water levels remain above 201.78 mASL during all months. Based on results of this analysis, an Exposure classification of "Low" was assigned to the Local Area for Scenario 3.

Figure 6-10. Exposure **Scenario** #3 Results

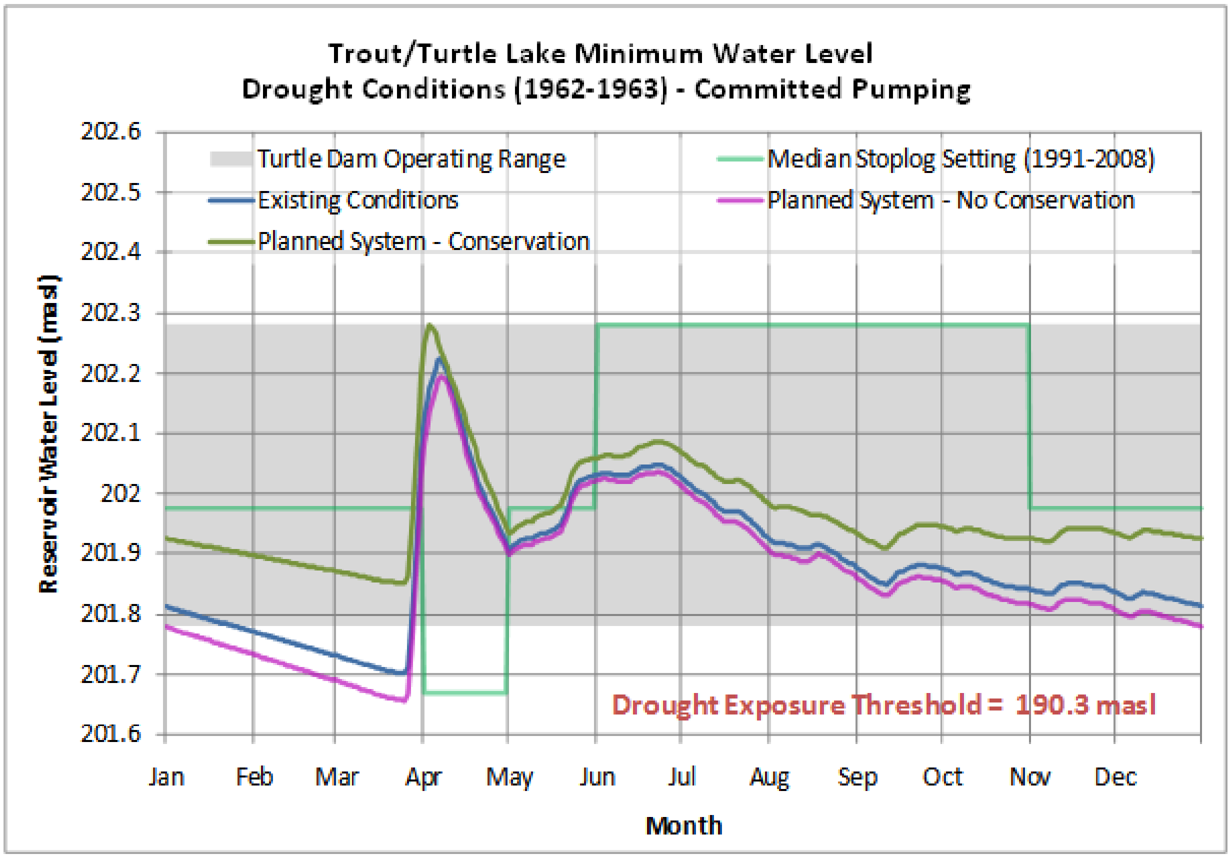


For long term average conditions, it is estimated that the conservation measures currently being implemented by the City of North Bay will result in Trout/Turtle Lake water levels being up to five centimetres higher than future water levels without the planned upgrades. This increase in water levels would occur primarily during the late summer/fall months, and would be a benefit to the recreational use of Trout/Turtle Lake. It is recommended that the City of North Bay continue to implement aggressive water conservation measures, as reducing water withdrawals from Trout Lake will result in higher and more stable Trout/Turtle Lake water levels.

Scenario 4: Drought climate conditions, committed pumping and planned land use

Simulated water levels for committed pumping under drought conditions are illustrated on Figure 6-11. Water levels for existing pumping, planned land use, and the existing system with a committed demand (shown as a "Planned System" within the figure), are presented (Figure 6-11). Scenarios with and without conservation measures are also available in this figure. As with the drought scenario for existing pumping, water levels remain well above the drought Exposure threshold of 190.3 mASL. Consequently, an Exposure classification of "Low" was assigned to the Local Area for Scenario 4.

Figure 6-11. Exposure Scenario #4 Results



For drought conditions, the impact of reduced pumping caused by the conservation measures is more pronounced than for average annual conditions; simulated water levels under committed/planned pumping (with conservation) are approximately 10 cm higher than water levels under existing pumping. The higher water levels caused by water conservation measures would typically be observed in the late summer, fall and winter months.

Exposure Summary

All four scenarios, required by the Technical Rules (MOE, 2009B), result in an Exposure classification of “Low”. These results are due to the large volume of water held in storage by Turtle Dam, and the ability of this storage to buffer the impacts of municipal withdrawals, as well as extreme droughts. Based on the results of all four scenarios, the Exposure classification assigned to the City of North Bay municipal intake is **Low**.

Tier Three Water Quantity Risk Determination

The Risk Level of the Local Area is a combination of the Tolerance and Exposure levels. The Technical Rules (MOE, 2009B), outlines how Tolerance and Exposure are used to assign risk. As per Part IX.1 Rule 98, a Local Area related to a surface water intake is assigned a risk level in accordance with the following:

1. Significant, if the local area has an Exposure level of High and the system has a Tolerance of Low;

2. Moderate, if the local area has an Exposure level of High and the system has a Tolerance of High;
3. Moderate, if the local area has an Exposure level of Low and the system has a Tolerance of Low; or
4. Low, if the local area has an Exposure level of Low and the system has a Tolerance level of High.

Results of the Risk Score calculations are shown in Table 6-10. Due to the ability of Trout/Turtle Lake to meet the peak demands placed on the municipal intake, a **High** Tolerance was assigned to the City of North Bay municipal system. Simulated water levels within Trout/Turtle Lake were analyzed within four scenarios required by the Technical Rules for a surface water intake; all scenarios resulted in a **Low** Exposure level.

Table 6-10. Results of Tier Three Water Quantity Risk Scenarios

Water Quantity Risk Determination	Tolerance Level	Exposure Level	Risk Level
Scenario 1: Average climate, existing pumping	High	Low	Low
Scenario 2: Drought climate, existing pumping	High	Low	Low
Scenario 3: Average climate, committed pumping and planned land use	High	Low	Low
Scenario 4: Drought climate, committed pumping and planned land use	High	Low	Low

Based on the results of the four scenarios, a **High** Tolerance and **Low** Exposure levels result in a **Low** Risk level for the Local Area, and the City of North Bay municipal system. Due to the Local Area having a Low Risk Level, there are **no** water quantity threats identified with the North Bay system.

Tier Three Uncertainty

Similar to the Tier Two Subwatershed Stress Assessment, the Technical Rules require that the Tier Three Assessment results be examined with regard to uncertainty. This qualitative assessment considers four factors: (1) the available input data; (2) the ability of the model to replicate major hydrologic processes; (3) the quality assurance and quality control procedures; and (4) the extent and level of model calibration achieved.

Uncertainty associated with each of the four factors with respect to the Tier Two Assessment and tools produced an uncertainty rating of low for the Tier Two Assessment. Since the tools developed for the Tier Two Subwatershed Stress Assessment were applied in the Tier Three Local Area Risk Assessment, the rationale is applicable to the uncertainty associated with the Tier Three Assessment.

An additional source of uncertainty associated with the Tier Three Assessment is the selection of the Exposure threshold. The Technical Rules prescribe the methodology for determining the Exposure threshold as the amount of water used by other water users within the time period of 2003-2007. Water level records for Trout/Turtle Lake facilitated the Exposure threshold to be estimated, and related directly to water surface elevation. The availability of historical water levels reduces the uncertainty associated with the Exposure threshold, and subsequently the Exposure analysis. Due to the above considerations, the uncertainty associated with the Tier Three Assessment is **Low**.

6.2.2 Water Quantity Conclusions and Recommendations

The methodology followed in this report is consistent with the Technical Rules prepared by the Ministry of Environment (MOE, 2009B) for the preparation of Assessment Reports under the *Clean Water Act (2006)*. The relevant Sections in the Technical Rules can be found in *Part III.3 – Subwatershed stress levels – Tier One Water Budget, Part III.4 – Subwatershed Stress Levels – Tier Two Water Budgets*, and *Part IX.1 – Risk level, local area*.

To meet the requirements of the *Clean Water Act (2006)*, a Tier One Subwatershed Stress Assessment, Tier Two Subwatershed Stress Assessment, and a Tier Three Local Area Risk Assessment were each completed for the Trout/Turtle Lake subwatershed. The Trout/Turtle Lake subwatershed, which contains the City of North Bay municipal water intake, was identified as having a Moderate potential for stress in the Trout/Turtle Lake Tier One Subwatershed Stress Assessment (Gartner Lee, 2008b). Similarly, a further refined Tier Two Subwatershed Stress Assessment identified the Trout/Turtle Lake subwatershed as having both a Significant and Moderate potential for water quantity stress in certain months (AquaResources, 2010). As such, a Tier Three level of assessment was required.

The required Tier Three Local Area Risk Assessment was meant to assess the risk of a water source not being able to meet the demands of the municipal system, as well as other water users. Using the tools generated as part of the Tier Two Subwatershed Stress Assessment, a Tier Three Local Area Risk Assessment was completed for the City of North Bay municipal water intake. The assessment involved determining if water takings cause Trout/Turtle Lake water levels to drop below water level thresholds. As per the requirements of the *Clean Water Act (2006)* Technical Rules, four scenarios were investigated.

All four scenarios indicated that Trout/Turtle Lake has sufficient storage volume to meet the current demands and committed/future demands of the North Bay municipal system, while maintaining critical lake levels. As a result of this analysis, the Trout/Turtle Lake subwatershed, and the City of North Bay municipal intake has a Water Quantity Risk level of **Low**. As such, there are no Moderate or Significant water quantity threats within the Trout/Turtle Lake subwatershed.

As part of the Tier Two Subwatershed Assessment and Tier Three Local Area Risk Assessment, the Technical Rules (MOE, 2009b) specifies that Significant Groundwater Recharge Areas (SGRAs) be delineated. This study follows a straightforward and reproducible procedure for delineating SGRAs as described in the Technical Rules (MOE, 2009b). The Technical Rules allow two methodologies for identifying SGRAs; Based on consultation with the Water Budget Peer Review Committee, the 115% of average groundwater recharge was selected for delineating SGRAs. SGRAs present a good opportunity to address the need to protect groundwater quantity within the Source Protection Planning Process, but this opportunity needs to address both the value of total groundwater recharge across a subwatershed as well as those areas having higher than average values.

6.2.3 Data Gaps/Limitations

The primary data gaps identified through the Trout/Turtle Lake Tier Two and Tier Three investigation was the lack of continuous records for both flow (lake inflow and outflow) and lake level. Through use of data collected from adjacent watersheds, and measurements collected as part of the NBMCA's spot flow program as well as the MNR's operational records for Turtle Dam, this data gap was managed. Specific recommendations for addressing this data gap are included below.

6.2.4 Recommendations

The following recommendations are taken from the Trout/Turtle Lake Tier Two Subwatershed Stress Assessment and Tier Three Local Area Risk Assessment Report by AquaResource (2010):

Continued Use and Improvement of Numeric Models

As part of the study, numeric models were created that are able to quantify water budget components for the Trout/Turtle Lake subwatershed, as well as estimate changes to lake levels given changes in inflow, water withdrawals, or land use change. These numeric models can, and should, be used for a variety of other water management investigations. Such investigations include, but are not limited to: impact assessment and analysis; support for permit to take water applications; subwatershed studies; lake studies; and supporting water quality investigations.

As additional data is collected through current, or expanded, monitoring programs, the numeric models should be verified/validated and if necessary, revised. These additional verification/validation exercises would improve the model over time, and result in an overall increase confidence in simulated results.

Additional Monitoring

Model calibration within the Trout/Turtle Lake subwatershed was limited due to the lack of observed water level and flow data. Due to the importance of Trout and Turtle Lakes to the City of North Bay, both for water supply and recreational purposes, it is recommended that existing data collection programs be continued or expanded into the future. Specific recommendations are included below:

1. Continuous water levels should be collected for Trout/Turtle Lake. This recommendation could be met by the installation of a low cost level logger on the upstream face of Turtle Dam.

2. The NBMCA should continue, and if possible expand, the spot flow monitoring program for Trout/Turtle Lake tributaries. This monitoring program is currently the sole source of information on inflow characteristics to Trout/Turtle Lake, and is critical to understanding the volume and spatial distribution of inflow to Trout/Turtle Lake.

3. Should site conditions allow, it is recommended that a stream gauge station be constructed downstream of Turtle Dam. Having continuous time series for both lake levels and dam discharge would greatly assist water managers in making effective water management decisions.

Water Conservation Measures

The municipal drinking water system for the City of North Bay is responsible for 99.5% of all consumptive withdrawals from Trout/Turtle Lake. The analysis indicated that reducing the per capita water consumption rate to 450 L/d from the current 680 L/d could result in significant increases in lake levels, particularly during drought periods. It is expected that this reduction could be obtained by fully implementing the following conservation measures:

1. outdoor water use restrictions;
2. installation of water meters on all connections; and
3. adoption of a volumetric billing approach.

It is strongly recommended that the City of North Bay continue to implement these water conservation measures. Furthermore, it is recommended that the City of North Bay investigate the feasibility of additional measures to further reduce water withdrawals from Trout Lake, such as an aggressive leak detection and water fixture retrofit (e.g. toilet) programs.

Land Development within Trout/Turtle Lake Subwatershed

Land use policies contained within the City of North Bay Official Plan, will strictly limit or control land development within the Trout/Turtle Lake subwatershed. Despite these controls, a small number of developments have previously been approved. These developments include an industrial subdivision and peat/aggregate extraction sites. To maintain lake levels within Trout/Turtle Lake, it is recommended that these developments be required to implement best management practices such as maintaining groundwater recharge volumes and managing storm runoff to maintain, or even enhance, dry weather streamflow.

6.3 North Bay Intake Characterization

Source Water

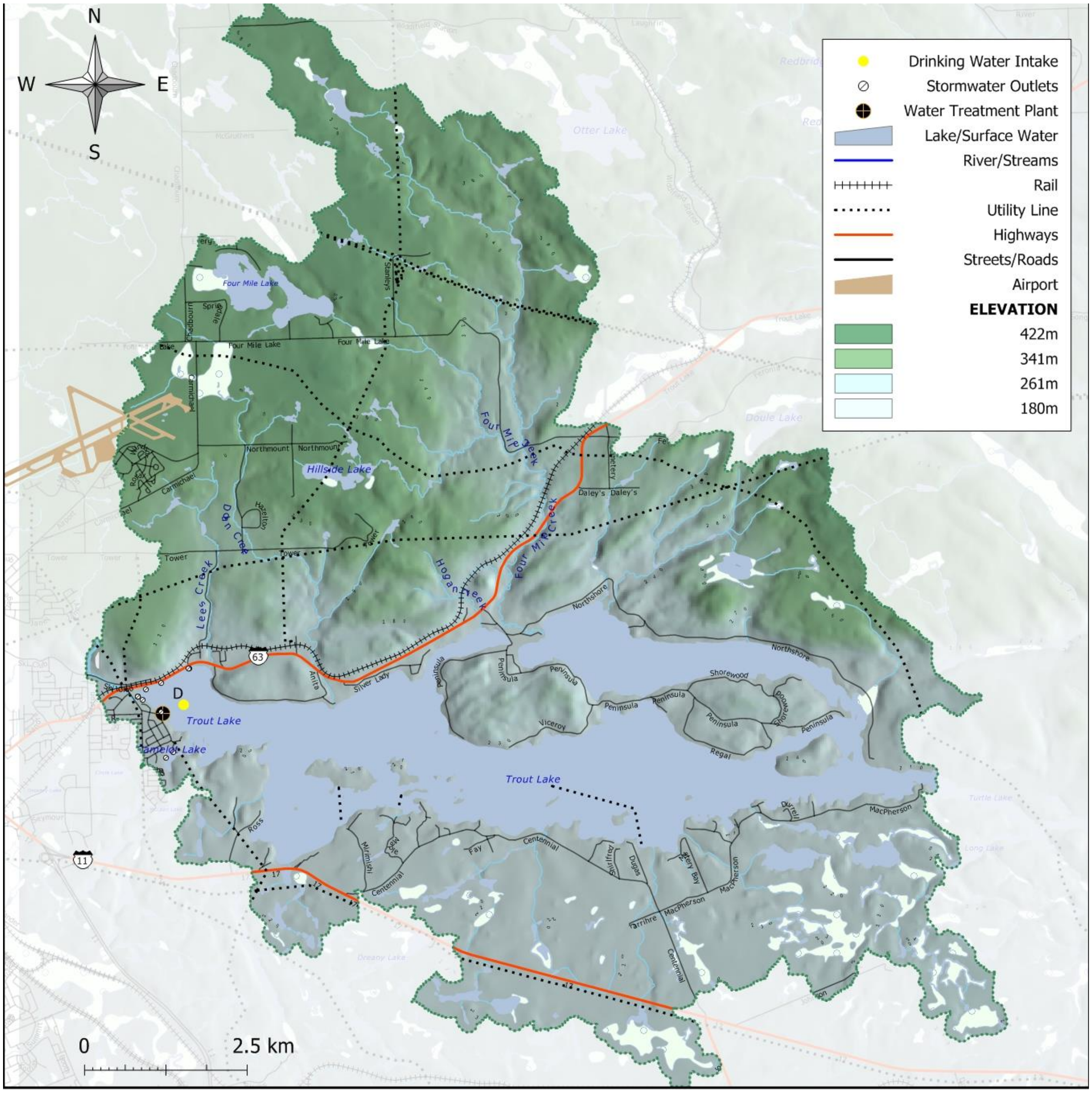
The North Bay municipal drinking water intake is classified as Type D, inland water intake, and is located near the centre of Delaney Bay, 314 m from the treatment plant, in the western basin of Trout Lake. It is set at a depth of about 22 m and is raised 3.4 m above the bottom. The Trout Lake watershed is 106 km^2 in size and includes 14 stream subwatersheds. (Fig. 6-12).

Hydrology

Most of the watershed is forested, with some urban/residential and agricultural areas in the west and northwest portions. Trout Lake is made up of three sub-basins including Four Mile Bay, One Mile Bay, and the ‘main basin’, which includes Delaney Bay located at the extreme west end of Trout Lake. For the most part, limnological conditions of Trout Lake are typical of large, deep Precambrian Shield lakes. It is oligotrophic: biologically unproductive with low concentrations of nutrients. Mean annual concentrations of total phosphorus for the main basin and Delaney Bay averaged 0.0056 mg/L from 1996 to 2005. (Provincial Water Quality Objectives target an upper limit of 0.020 mg/L to limit the excessive proliferation of algae.) Spring overturn concentrations collected under the MOE Lake Partner Program from 1975 to 2005 are similar and display no directional trends over time. As with most deep, northern temperate lakes, Trout Lake undergoes thermal stratification during the open water season.

The upper layer (epilimnion) averages about 20 º C and the lower layer (hypolimnion) about 15 m below averages between 5º and 7 º C. Following the melting of ice on Trout Lake in early to mid-April, spring turnover (mixing) begins and usually extends into May until surface waters warm sufficiently to cause the lake to stratify. Once this happens the two layers do not mix until fall turnover. This provides the intake with a significant degree of protection from surface contaminants.

Figure 6-12. North Bay Study Area



Water System Details

The City of North Bay water treatment plant is located at 248 Lakeside Drive and is operated by the Ontario Clean Water Agency (OCWA). The original treatment plant was built in 1929 and upgraded in 1972. In August 2002, the primary disinfectant was changed to ultraviolet sterilization instead of chlorine and the chlorination point was moved to the outer end of the intake to increase contact time. The treated water is chlorinated again just prior to entering the distribution system in order to maintain a chlorine residual. A new water treatment plant has been completed and has been online since early 2010. This new plant is equipped with chemically assisted membrane filtration with the ability to add coagulant if required. It can therefore treat for particulates including *Giardia* and *Cryptosporidium* cysts, but not for dissolved substances, taste and odour compounds, or soluble chemicals which could originate from spills.

Plant capacity is rated at 79,500 m^3/day. The intake features an on-line turbidity monitor that samples from the bell chamber ahead of the first chlorination point via a separate sampling line that also serves to collect raw water for chemical analyses. Travel time for raw water from the intake to reach the chamber of the water treatment plant ranges from approximately 15 to 30 minutes, averaging about 20 minutes. In case of emergency, the drinking water plant can be shut down within 15 minutes.

6.4 Delineation and Assessment of Vulnerable Areas

As described in Section 3.1 Surface Water Methodology, Source Protection Planning specifies that three intake protection zones should be identified and protected in order to maintain water quality at the intake location. These were delineated in accordance with Part VI of the Technical Rules for a Type D intake.

6.4.1 Defining Vulnerable Areas (Intake Protection Zones)

Intake Protection Zone 1 (IPZ-1) for the North Bay intake is defined as the surface area of Trout Lake within a 1-km radius of the drinking water intake in Delaney Bay, and where this area abuts land, includes a setback of 120 m inland measured from the high water mark. Of the three protection zones, IPZ-1 is the most vulnerable to contamination. If a contaminant entered this zone, there would be relatively little time to respond and limited potential for the contaminant to be diluted before it reached the intake. (Fig. 6-13)

The IPZ-2 is intended to provide a minimum two-hour response time to shut down the treatment plant in case of an emergency. There are no known hydrodynamic studies of water flow or measurements of surface currents in Trout Lake. Therefore, time of travel to the intake was estimated using major limnological principals guiding wind-driven surface water current speeds using the maximum wind speed recorded by the North Bay Airport weather station during the period 1971-2000. This analysis indicated that it would take longer than two hours for a contaminant released at the outer limit of IPZ-1 to reach the intake, so the IPZ-2 within Trout Lake does not extend beyond the IPZ-1 (with the exception of the transport pathways described below.

The IPZ-2 must also consider transport pathways extending inland from the shoreline. The IPZ-2 for the North Bay drinking water intake (Fig. 6-14) consists of the following areas:

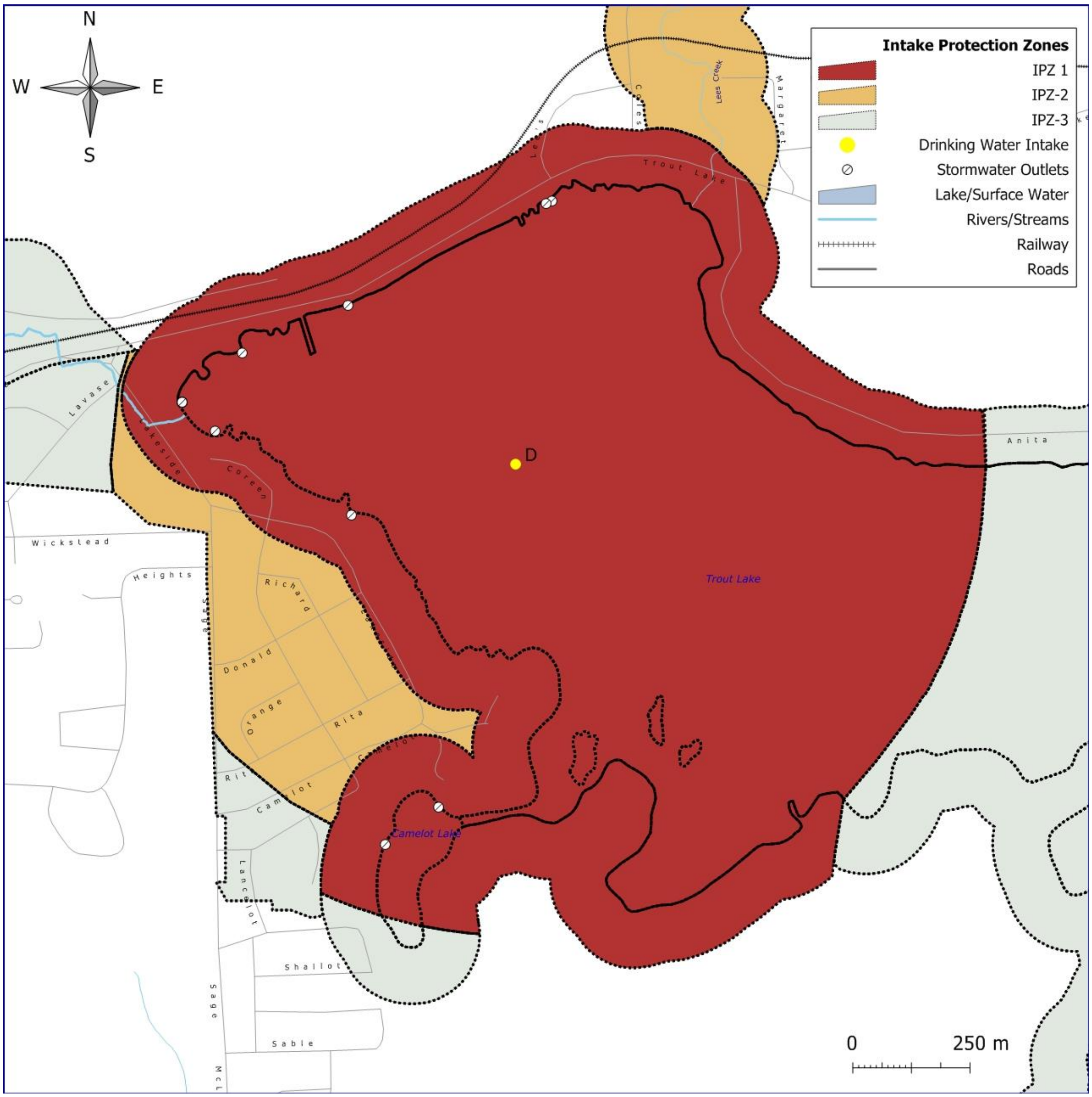
- The area of the stormwater system draining to Delaney Bay that lies within 864-m of the intake (to approximate a two hour time-of-travel to the intake in accordance with Rule 65(2)). Time-of-travel in the stormwater system is unknown, but is likely to be much slower than that which occurs due to wind driven surface currents in Delaney Bay (overland flows are generally slower than surface water currents). The 846-m distance to the intake, which was estimated using the maximum current speed that would occur in Delaney Bay, is therefore a conservative estimate to approximate the necessary two hour time-of-travel to the intake from the stormwater system area.

- The portion of the natural transport pathway, Armstrong Creek and associated 120-m setback that lies within 846-m of the intake, which approximates the maximum two hour time-of-travel to the intake (as described below).

- Lees Creek and associated 120-m buffer inland from the high water mark of the creek and extending upstream to a widening of the creek where water flows would be attenuated. Lees Creek is the only tributary that outlets to Trout Lake within the two hour time-of-travel distance to the intake. No known data exist for Lee's Creek to calculate flow velocities under storm conditions, but the suggested IPZ-2 delineation most likely encompasses the necessary minimum two hour time-of-travel requirements set out in the Rules. Under maximum estimated wind driven surface currents, the time-of-travel from the outlet of Lees Creek to the intake would be ~1.5 hours, requiring the IPZ-2 delineation to extend upstream in Lees Creek to encompass a 0.5 hour time-of-travel. The IPZ-2 extends 2,100 m upstream in Lees Creek, which would require a very high velocity of 1.2 m/s for a contaminant entering the creek to reach the intake within two hours.

- The extent of two transport pathways that drain to Lees Creek near its outlet to Delaney Bay in Trout Lake (as described below).

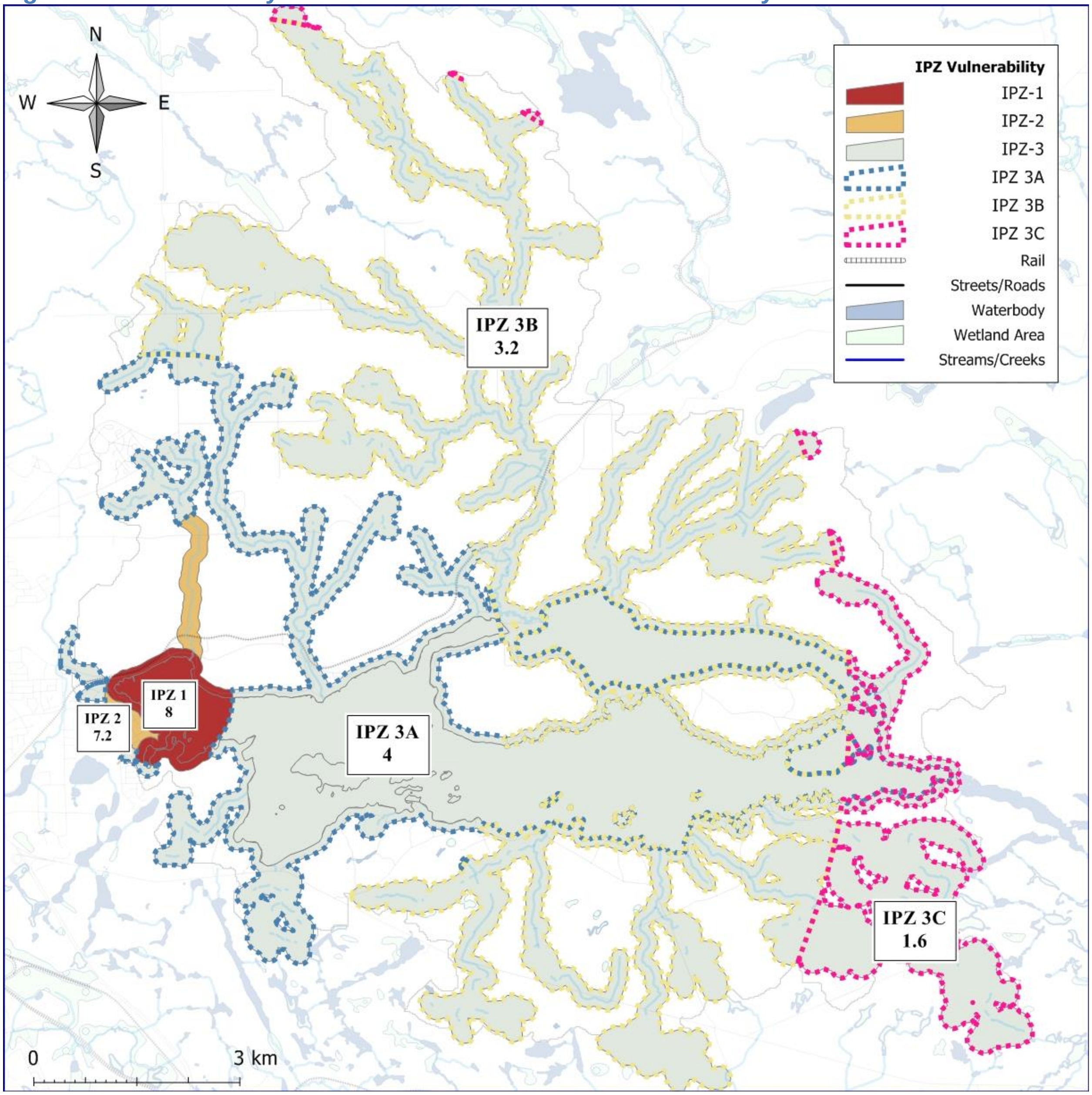
Figure 6-13. North Bay Intake Protection Zone-1



The IPZ-3 protects water quality of the drinking water source from long-term chronic exposure of contaminants and other materials that can have a negative impact on drinking water quality at the intake.

The IPZ-3 is defined by the Technical Rules (Part VI.5) as the area within each surface water body that may contribute water to the intake. This includes areas that contribute water via a transport pathway, and where this area abuts land, a setback area of not more than 120 m inland measured from the high water mark of the surface water body encompassing the area where overland flow drains into the surface water body. The IPZ-3 does not include areas of land or water that lie within an IPZ-1 or IPZ-2. The IPZ-3 for North Bay therefore includes the surface area of Trout Lake, all water bodies draining to Trout Lake and associated 120-m setbacks on land exclusive of those areas encompassed by the IPZ-1 and IPZ-2 as illustrated in Figure 6-14.

Figure 6-14. North Bay Intake Protection Zone and Vulnerability Scores



Transport pathways are natural or constructed pathways that facilitate the transport of contaminants to the intake. The shoreline area of Delaney Bay and the area surrounding the lower reaches of Lees Creek were surveyed during two site visits in the summer of 2007 to identify transport pathways. The position of each of the pathways was determined using a hand held GPS unit. Several constructed transport pathways were identified within the IPZ-1 that can act to direct potential contaminants to Delaney Bay and the intake (Figure 6-13).

These include:

- five stormwater outlets that drain urban areas of North Bay and form part of the City's stormwater system; three of which discharge directly to Delaney Bay, and two discharge to the bay via a narrow inlet from Camelot Lake;

- six stormwater outlets that drain areas along the north end of Delaney Bay (including the ONR line and areas of Highway 63 (Trout Lake Road) within the IPZ-1 between Lakeside Drive and Anita Avenue, and a parking lot of the National Defence installation);
- three ditches that capture and direct flow to Delaney Bay from high elevations on the north side of Anita Avenue; and
- two ditches on either side of Birchaven Cove Beach that capture and direct drainage to Delaney Bay from residential areas and a parking lot.

Natural preferential pathways to Trout Lake include the 14 inlet creeks identified from GIS mapping (MNR base mapping, resolution = 20 m). Three additional creeks, Armstrong and Margaret Creeks and an unnamed creek that drains to Lees Creek (which drains into the north shore of Delaney Bay), are not visible on the GIS mapping or available orthophotos. The exact locations of these creeks and their outlets were confirmed by GPS during field site visits (June 22 and 29, 2007).

Armstrong Creek enters Trout Lake at the extreme westerly end of the lake within Delaney Bay at Olmsted Beach. It is an intermittent watercourse, which drains portions of Ski Hill Road and crossing under the ONR line, Highway 63 (Trout Lake Road) and Lakeside Drive. The IPZ-2 was extended to include this natural pathway and associated 120-m maximum setback within a two hour time-of-travel to the intake (area of the creek that lies within 846 m of the intake), based on the same principal as the time-of-travel estimate for the stormwater system). The remaining upstream portion of Armstrong Creek was included as part of the IPZ-3 delineation.

Margaret Creek drains to Lees Creek near its outlet into Delaney Bay via a culvert that passes under Hwy. 63. The unnamed creek bed drains areas along the east side of Lees Creek where it outlets just upstream of Margaret Creek. The IPZ-2 area was extended to include these two creeks and associated 120-m setbacks.

Of all the creeks draining directly to Trout Lake, only Armstrong and Lees Creeks have outlets to Delaney Bay and influence the IPZ-1. While considered natural pathways, these creeks have been significantly altered by road and land development. (Lees Creek was used historically to transport logs down the escarpment during forestry operations). The remaining creeks discharge to the main basin of Trout Lake or to Four Mile Bay outside of IPZ-1 and IPZ-2. No additional natural (surface) pathways were identified during a walked shoreline survey of the east and north shoreline of Delaney Bay extending from the Camelot Lake inlet to near the inlet from Doran Creek.

6.4.2 Vulnerability Scoring

Vulnerability scores were used to assess the likelihood that a contaminant originating within the intake protection zones would reach the intake. These scores were based on:

- the percentage of the area that is composed of land;
- land cover, soil type, permeability of the land, and the slope of setbacks;
- hydrological and hydrogeological conditions in the area that contributes water to transport pathways;
- depth of the intake from the surface;
- distance of the intake from land; and
- history of water quality concerns at the intake.

Vulnerability scores provide a comparative assessment of the likelihood that a contaminant originating within the Intake Protection Zones could reach the North Bay intake. Vulnerability scores are calculated by multiplying the Source Vulnerability Factor by the Area Vulnerability Factor (Rule 87). Guidance for calculating these vulnerability factors is provided in Part VIII.2 and Part VIII.3 of the Technical Rules.

The Source Vulnerability Factor is based on characteristics of the intake and ranges between 0.8 and 1.0. Scoring it considers the following:

- the depth of the intake from the surface of the water;
- the distance of the intake from land; and
- the history of drinking water concerns relating to the intake.

The North Bay intake is relatively far from shore (approximately 314 m) and deep (22 m), drawing water for most of the ice-free season from the hypolimnion, and thereby reducing the potential for contaminants at the surface to reach the intake. Trout Lake provides excellent quality raw water. Any potential concerns regarding turbidity have been effectively addressed by the new chemically assisted membrane filtration system which came online in early 2010. Given these considerations, the lowest source vulnerability factor of 0.8 was assigned for the North Bay drinking water intake.

Area Vulnerability Factors were assigned to the IPZs in accordance with Technical Rules 88-93. The area vulnerability factor is fixed at a value of 10 for the IPZ-1. For the IPZ-2 and IPZ-3, the Area Vulnerability Factors consider the following aspects:

1. the percentage of area that is composed of land, where a greater land area increases vulnerability
2. land cover, soil type, permeability of the land and the slope of any setbacks;
3. hydrological and hydrogeological conditions in the area that contribute water to the area through transport pathways; and
4. in respect of the IPZ-3, the proximity of the area of the IPZ-3 to the intake.

The specific methodology for assigning area vulnerability factors for each of the surface water intakes in provided in section 3.1. For each of the subzones, the Area Vulnerability Factor was calculated as the sum of individual scores (0, 1 or 2) assigned for each of the four aspects listed above. This procedure weighted all factors equally. The maximum aspect score that could be generated is 6 for the IPZ-2 (three aspects times maximum score of 2) and eight for the IPZ-3 subzones (four aspects times maximum score of 2). The aspect score was prorated to determine the Area Vulnerability Factor for each zone.

An Area Vulnerability Factor of 9 from a possible range of 7 to 9 was assigned for IPZ-2. This score reflects the following:

- most of the IPZ-2 is comprised of land; a large portion of the area in the stormwater system draining into Delaney Bay is comprised of urban and residential lands that have high runoff generation potential and has setback areas along Lees Creek that include steep-sided riverbanks, and
- there are numerous transport pathways that direct drainage to the IPZ-1 including tributaries and stormwater drains and ditches (Figure. 6-13).

Given the large area encompassed by the IPZ-3, different Area Vulnerability Factors were assigned to areas within the IPZ-3 dependent upon their distance to the intake. With increasing distance from the intake there is reduced potential for contamination and thus a lower vulnerability score is warranted. Area Vulnerability Factors for North Bay were assessed for three subzones of the IPZ-3 using each of the four aspects listed above. The breakdown and rationale for the scoring is provided in Table 6-11. The resulting Vulnerability Scores are listed in Table 6-12 and illustrated in Figure 6-14.

Table 6-11. North Bay IPZ-3 Area Vulnerability Factors

Factors to Consider	IPZ-3 Factor Scores			Rationale
	Areas within 5 km of the intake	Areas within 10 km of the intake	Areas beyond 10 km of the intake	
% land area	1	1	1	Approximately equal proportions of land and water
Land cover, soils, permeability, slope of setbacks	1	1	1	Land cover mostly forested; good permeability of soils in many areas, but some outcrops with little to no soils; some high slopes of setbacks in areas north of Trout Lake
Transport pathways	0	0	0	Some transport pathways exist but flow is strongly directed away from the intake toward the outlet
Proximity to the intake	2	1	0	IPZ3 boundary extends to only 1-km from the intake (near the mouth of Delaney Bay increasing the score; with increasing distance from the intake there is reduced potential for contamination and thus a lower vulnerability score
Total Aspect Score	4/8 = 50%	3/8 = 38 %	2/8 = 25%	
Possible AVF Range	1 to 8	1 to 8	1 to 8	
Area Vulnerability Factor (calculated as: % Aspect score x difference between maximum and minimum AVF range + minimum possible AVF score	5 (50%x7+1)	4 (38%x7+1)	3 (25%x7+1)	

Table 6-12. Vulnerability Scores for the North Bay Intake Protection Zones

Zone	Source Vulnerability Factor (Vfs)	Area Vulnerability Factor (Vfa)	Vulnerability Score (V)
IPZ-1	0.8	10	8.0
IPZ-2	0.8	9	7.2
IPZ-3 within 5 km of the intake	0.8	5	4
IPZ-3 within 10 km of the intake	0.8	4	3.2
IPZ-3 beyond 10 km of the intake	0.8	3	2.4

6.4.3 Uncertainty Analysis

Part I.4 of the Technical Rules requires that an uncertainty rating of high or low be provided with respect to the delineation of the surface water intake protection zones (Rule 13 (3)) and the assessment of vulnerability of the zones (Rule 13(4)). Based on the consideration of factors set out in Rule 14, an overall low uncertainty is given to all of the IPZ delineations and the associated vulnerability scores. There are data gaps that result in some uncertainty, but these are unlikely to result in any significant changes in the delineation or vulnerability scoring of the IPZs, as described below.

Intake Protection Zone Delineations – The location of the intake is known within a few metres because the direction of the pipe can be seen in aerial photographs a substantial distance from shore and the length is known based on engineering reports. Because the intake is less than 1 km from shore in most directions, only the downstream boundary of the IPZ-1 at the mouth of Delaney Bay (and associated setback) would be altered by a change in the position of the intake. The delineation of the IPZ-2 would not be affected by a small difference in the position of the intake because the IPZ-2 does not extend beyond the IPZ-1 within Trout Lake (with the exception of the transport pathways, all of which have been considered).

There is some uncertainty associated with the methods used to delineate the IPZ-2 due to the lack of a current hydrodynamic model for Trout Lake and flow data for tributaries to estimate time-of-travel to the intake. A conservative approach was used to delineate the IPZ-2 with knowledge of major flow direction in Trout Lake, dominant wind directions and speeds, and observed time-of–travel for turbidity to reach the intake from the outlet of Lees Creek (12 hours). The use of a hydrodynamic model and flow data from Lees Creek would refine the IPZ-2 delineation. Since a conservative approach was used, refinement could reduce the extent of the IPZ-2 along Lees Creek.

The vulnerability scoring requires knowledge of water quality as it relates to drinking water issues (see Section 6.5). Raw water records and treated water records from the Water Treatment Plant did not encompass the entire operational history of the plant. Treated water records prior to 2006 and raw water records post 2006 were not reviewed in this assessment creating some uncertainty in the data and the ability to validate the drinking water issues. Despite this, available records were adequate to evaluate the tested parameters as drinking water issues in relation to the ODWQS (Ontario Drinking Water Quality Standards).

6.5 Issues Identification

Details on methodology are provided in Section 3.1 of this report. Additionally, readers are referred to the AECOM (2010a) report as referenced in Section 6.1 above.

Drinking water issues, as defined in Part XI.1 of the Technical Rules relate to the presence of a listed parameter in water at the intake either at a concentration that may affect the use of the water as a drinking water source, or there is evidence of an increasing trend. Chemical contaminants and pathogens must both be considered. The investigation for issues affecting source water at the North Bay intake included reviews of the following:

- Drinking Water Surveillance Program (DWSP) Monitoring Data
- Drinking Water Information System (DWIS) Monitoring Data
- O. Reg 170/03 Annual Reports (2006-2008)
- Trout Lake Parasite Study (Miller Environmental Services Inc., 2000)

All potential issues were identified and further investigated. Chemical parameters requiring follow-up included colour, a single high reading of antimony, detection of 2,4-dichlorophenol above aesthetic objectives, and turbidity.

Although colour consistently exceeded the aesthetic objective in the raw water between 1990 and 2005, there is no increasing trend, colour has been maintained below the objective in treated water, and the cause of the colour is considered to be natural due to moderately high concentrations of dissolved organic carbon (DOC) and naturally occurring iron concentrations. The single high antimony reading was most likely due to laboratory error.

Chlorophenols can cause an unpleasant taste or odour. The five times between 1994 and 1996 that 2,4-dichlorophenol was measured in raw water above the aesthetic objectives of 0.0003 mg/L but well below the drinking water standard (ODWQS) of 0.9 mg/L were suspected to be incorrectly recorded and actually intended to reflect the laboratory detection limit at the time. The Technical Advisory Committee for the 2010 study summarized herein concluded that there is insufficient evidence to list 2,4-dichlorophenol as a drinking water issue under Rule 114.

Turbidity levels in raw water had to be very low, below 1 NTU, to ensure effective disinfection with either ultraviolet light or chlorine when the City of North Bay did not have filtration. There were several incidents where reported turbidity levels became a concern; however, there was no trend in mean turbidity for the 1990 to 2005 period. The new plant which came online in 2010 includes membrane filtration and is capable of producing water with a maximum turbidity of 0.3 NTU, which is sufficient to delist turbidity as a drinking water issue.

6.6 Threats Identification and Assessment

There were two approaches used to identifying threats; the *threats approach*, which is based on the vulnerability scores of the vulnerable areas and the *issues approach*, based on activities or conditions that contribute to existing drinking water issues listed under Rule 114. A third approach, the *events-based approach*, is based on modelling that demonstrates a chemical or pathogen release from an activity that could result in the deterioration of source drinking water. This approach was not used in the identification of threats.

Conditions, as defined by Part XI.3 of the Technical Rules, refer to past activities that have produced contaminants that may result in significant drinking water threats. Ontario Regulation 287/07 Section 1.1 (1) under the *Clean Water Act (2006)* lists 19 activities that may result in threats to drinking water quality. (Two additional prescribed activities pose threats to quantity.) (See Section 3, Table 3-1)

Part XI.4 of the Technical Rules describe the methods for identifying significant, moderate and low drinking water threats related to activities in the vulnerable area of a drinking water intake. A threat is deemed significant, moderate or low depending on:

- the vulnerable area in which the activity occurs or would occur,
- the vulnerability score of the vulnerable area
- a set of prescribed activities and corresponding circumstances that constitute a threat

The Technical Rules require activities that would be a significant, moderate or low drinking water threat within the vulnerable areas to be listed in the Assessment Report, *regardless of whether or not the activities presently exist in the vulnerable area.*

Lists of significant, moderate and low drinking water threats related to chemicals and pathogens were compiled for each of the vulnerable areas of the North Bay drinking water intake based on the MOE Tables of Drinking Water Threats.

Evaluation of threats posed by pathogens were limited to E. coli and total coliforms. ODWQS for total coliforms and E. coli are that they should be undetectable in treated water, but both are naturally occurring bacteria in surface water. They are typically detected in raw water samples at the North Bay intake, therefore exceeding the ODWQS for treated water. Based on available data, there are no apparent trends in maximum or mean annual E. coli counts. E. coli and total coliforms are not considered to be drinking water issues for the North Bay intake because:

- they have maintained relatively low levels in raw water at the intake without evidence of an increasing trend, and
- there have been no reported adverse water quality incidents related to total coliforms or E. coli in treated or distribution water from 2006-2008 suggesting that the plant is capable of effectively treating the levels of these bacteria that presently occur in the source water.

6.6.1 Threats Approach

The threats evaluation for Source Protection Planning involves the identification of activities or conditions within vulnerable areas that could cause contamination of drinking water by a chemical or pathogen. As previously stated there are no known conditions relevant to the North Bay intake.

Threats Approach - Potential Activities & Circumstances

Based on the resulting vulnerability scores (Table 6-12) the possible threat levels (Table 6-13) were identified for each of the vulnerable areas. Due to the vulnerability scores within the IPZs, only IPZ-1 may contain potential significant chemical or pathogen threats. Refer to Figure 6-14 above for further support of the vulnerable areas where activities are or would be significant, moderate or low drinking water threats.

While Table 6-13 lists the IPZs where significant, moderate and low threats could be found in the North Bay IPZs, Table 6-14 lists the number of chemical and pathogen threats which could be significant, moderate or low within each of the IPZ according to the MOE Tables of Drinking Water Threats. There are 13 potential significant chemical threats and 40 potential pathogen threats in the North Bay IPZ-1.

Table 6-13. Areas within North Bay Intake Protection Zone where Activities are or would be Significant, Moderate and Low Drinking Water Threats

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemicals	IPZ-1	8	✓	✓	✓
	IPZ-2	7.2		✓	✓
	IPZ-3a	4.0			
	IPZ-3b	3.2			
	IPZ-3c	2.4			
Pathogens	IPZ-1	8	✓	✓	✓
	IPZ-2	7.2		✓	✓

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
	IPZ-3a	4.0			
	IPZ-3b	3.2			
	IPZ-3c	2.4			

The circumstances under which these threats may be considered as significant, moderate or low are referenced in the MOE Provincial Table of Circumstances. These tables can be used to help the public determine where activities are or would be significant, moderate and low drinking water threats. A summary of the list of Provincial Tables relevent to each vulnerable area in Mattawa is provided in Table 6-14.

The Provincial Table headings listed within Table 6-14 (i.e. CIPZWE8S) are one of 76 tables and are titled using a combination of acronyms explained in the chart below. The Provincial Tables of Circumstances can be found at:

http://www.ene.gov.on.ca/environment/en/legislation/clean_water_act/STDPROD_081301.html

Acronym	Definition
C	Chemical
P	Pathogen
W	Wellhead protection area
IPZ	Intake protection zone
IPZWE	IPZ and WHPA-E
(number)	Vulnerability score
S	Significant
M	Moderate
L	Low

For example: CIPZWE8S is a table of:
C - **C**hemical Threats in an
IPZ - **I**ntake **P**rotection **Z**one or
WE- **W**ellhead Protection Area-**E** with a vulnerability score of
8 - **Eight**, categorized as a
S - **S**ignificant threat

Table 6-14. Summary of Tables of Circumstances Related to Threat Levels and Vulnerability Scores for the North Bay Intake Protection Zone

Vulnerability Score	Significant	Moderate	Low
8	CIPZWE8S PIPZWE8S	CIPZWE8M PIPZWE8M	CIPZWE8L PIPZWE8L
7.2	NA NA	CIPZWE7.2M PIPZWE7.2M	CIPZWE7.2L PIPZWE7.2L
4.0	NA	NA	NA
3.2	NA	NA	NA
2.4	NA	NA	NA

Table 6-15 provides the activities and total number of circumstances relating to significant drinking water threats in the City of North Bay. There is one prescribed activity, with 13 associated circunstances, that is or would be a significant chemical drinking water threat in the IPZ-1 of the North Bay intake, "the establishment, operation or maintenance of a system that collects, stores, transmits, or treats or disposes of sewage". There are 7 prescribed activities, with 40 associated circumstances, that are or would be significant threats in the IPZ-1 of the North Bay intake. There are no threats that are or would be significant in the IPZ-2 or IPZ-3 due to the low vulnerability of those areas.

Table 6-15. Enumeration of Circumstances under whch Prescribed Activities are or would be Significant Threats to the North Bay Drinking Water Intake.

Activities Prescribed to be Drinking Water Threats	# of Significant Threat Circumstances	
	Chemical	Pathogen
The application of agricultural source material to land.		1
The application of non-agricultural source material to land.		1
The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.	13	4
The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act.		1
The handling and storage of non-agricultural source material.		1
The storage of agricultural source material.		2
The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.		2
Number of circumstances under which the threat is or would be significant	**13**	**12**

Threats Approach - Existing Significant, Moderate and Low Threats

Rule 9(e) requires that the Assessment Report list the number of locations at which an activity that is a significant drinking water threat is being engaged in. A comprehensive threats list was compiled in a draft report by Gartner Lee Limited (2007b). This list was based on a desktop research approach, including the following sources:

- Class Environmental Assessment to Service Anita Avenue, North Bay, Ontario with Sanitary Sewer Servicing. City of North Bay, 1993.
- Trout Lake Parasite Study (Miller Environmental Services Inc., 2000)
- Delaney Bay Spills Contingency Plan (Aquafor Beech Limited, 2001)
- Lees Creek and Golf Club Creek Tributary: Subwatershed/Stormwater Management Plans. (Aquafor Beech Limited, 2001)
- Ontario Base Mapping.
- North Bay (31 L/6) 1:50,000 National Topographic Series map.
- Federal Contaminated Sites Inventory.
- National Priority Release Inventory.
- Ontario Environmental Registry.

- Ontario PCB database.
- Ontario Environmental Compliance Reports
- Department of National Defense
- Ontario Ministry of the Environment, North Bay
- City of North Bay
- Personal communications

In addition, site investigations were conducted in July and August, 2007 as well as discussions with the Source Protection Committee. Since the vulnerability scores of the IPZ-2 and IPZ-3 are all below 8, no activities in these areas would be significant threats based on the MOE's Tables of Drinking Water Threats.

In the draft report by Gartner Lee Limited (2007b), 61 possible drinking water threats were identified for the North Bay intake based on previous MOE guidance for Source Protection Planning. The threats identified in the 2007 Gartner Lee draft report were re-evaluated as threats based on the current Technical Rules. It was confirmed that all potential activities prescribed to be drinking water threats were encompassed by the 2007 Gartner Lee draft report, with the exception of the application of road salt and the storage and handling of road salt.

None of the potential threats inventoried in the Gartner Lee (2007b) report met the circumstances that would result in a significant threat in the IPZ-1. Given the low vulnerability scores assigned to the IPZ-2 and IPZ-3, there are no activities that could be considered as significant in these zones.

Based on this evaluation, there are no existing significant drinking water threats related to either chemicals or pathogens for the City of North Bay.

6.6.2 Issues Approach to Threat Identification

In addition to the above noted threats related to activities, Rule 115 requires that threats be listed for those drinking water issues listed under Rule 114 that result from, or partially result from human activities. There are no known issues in the North Bay IPZ.

6.6.3 Conditions

There are no known conditions that would be significant threats to drinking water for the North Bay intake as defined by Rule 140.

Three potential conditions related to past activities were identified within the vulnerable areas for the North Bay intake in an earlier threats inventory that was based on previous MOE guidance (Gartner Lee Limited, 2007b; Table 6-13). There are no known monitoring data that exist to confirm the presence of contaminants resulting from these past activities; therefore they cannot be confirmed as conditions in accordance with Rule 126. Regardless, the maximum threat posed by any of these would be moderate if monitoring confirmed their presence.

Table 6-16. Potential Conditions, Hazard Ratings, Risk Scores that Could be Significant, Moderate or Low Drinking Water Threats.

Past Activity	Contaminant of Concern	Location Within the Vulnerable Area	Vulnerability Score	Risk Hazard	Risk Score	Significant, Moderate or Low Threat

Copper Ore Spill from Train Derailment	Copper	IPZ-2	7.2	8.5	61.2	Moderate
Milne Lumber Company Mill	NAICS various chemicals	IPZ-1	8	8	64	Moderate
Montreal Smelting and Reduction Refinery	NAICS various chemicals	IPZ-1	8	8	64	Moderate

Based on this evaluation, no conditions were identified in the vulnerable areas for the City of North Bay intake.

6.6.4 Local Threat Considerations

The North Bay-Mattawa Source Protection Committee is concerned about the threat posed by the transportation of hazardous substances along highway and rail corridors within the City of North Bay Intake Protection Zone which creates the potential for a spill to occur in the vulnerable area.

Although there is no prescribed threat activity related to the transportation of hazardous substances under the Clean Water Act., Technical Rule 119 allows Source Protection Committees to request that an activity be listed as a drinking water threat if:

1. The activity has been identified by the Source Protection Committee as an activity that may be a drinking water threat; and
2. The Director indicates that the chemical or pathogen hazard rating for the activity is greater than 4.

The Source Protection Committee submitted a formal request to the Ministry of Environment for the addition of transportation of hazardous substances as a non-prescribed (local) drinking water threat in the SP Area. This request was approved by the Director on February 8, 2011 (Appendix F). Included in the approval are the circumstances and hazard ratings for the activities considered.

Table 6.17 shows where significant, moderate and low threats relating to the transportation of hazardous substances are located in the North Bay IPZs. There are no significant threats relating to the transportation of hazardous substances for the North Bay intake.

Table 6-17. Areas within North Bay Intake Protection Zone where Transportation of Hazardous Substances are Considered a Significant, Moderate or Low Drinking Water Threat

Threat Type	Vulnerable Area	Vulnerability Score	Threat Level Possible		
			Significant	Moderate	Low
Chemicals	IPZ-1	8		✓	✓
	IPZ-2	7.2			✓
Pathogens	IPZ-1	8		✓	
	IPZ-2	7.2		✓	

6.7 Gap Analysis and Recommendations

As stated in the Uncertainty Analysis, there are data gaps that result in some uncertainty but improved data are unlikely to result in any significant changes in either the delineation or scoring of the IPZs.

The use of a hydrodynamic model and flow data from Lees Creek would refine the IPZ-2 delineation. A conservative approach was used to delineate the IPZ-2 using knowledge of major flow direction in Trout Lake, dominant wind directions and speeds, and observed time-of-travel for turbidity to each the intake from the outlet of Lees Creek.

The vulnerability scoring requires knowledge of water quality as it relates to drinking water issues. Treated water records prior to 2006 and raw water records post 2006 were not reviewed in this assessment creating some uncertainty in the data and the ability to validate the drinking water issues assessment. Despite this, available records were adequate to evaluate the tested parameters as drinking water issues in relation to the ODWQS (Ontario Drinking Water Quality Standards).

The investigation of existing activities was adequate to confirm the conclusions that there are no existing significant threats to the North Bay intake related to either chemicals or pathogens.

In 2013 TransCanada began work on a proposal for the conversion of a natural gas pipeline to carry crude oil including diluted bitumen. The pipeline in question runs through the northern portion of the Trout Lake watershed and IPZ-3. Further information will be required to assess the risk posed by the transportation of crude oil as proposed.